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GREEN TECHNOLOGIES: EMERGING TRENDS AND TRANSFORMATIONS IN COMMERCE, BUSINESS MANAGEMENT, ECONOMICS & SOCIAL SCIENCES

Editors:
Mr. Gourav Kamboj
Dr. Amandeep Kaur
Ms. Deepakshi

Bhumi Publishing, India

First Edition: July 2025

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PREFACE

The rapid advancement of knowledge across disciplines has paved the way for groundbreaking innovations and collaborative research efforts.

In today's world, where traditional academic boundaries are increasingly merging, interdisciplinary research plays a crucial role in addressing complex global challenges. It is with this vision that we present the Edition of "Green Technologies: Emerging Trends and Transformations in Commerce, Business Management, Economics & Social Sciences.", A compilation of pioneering studies that bridge diverse academic fields and offer fresh insights into contemporary issues.

This book is a testament to the evolving nature of research, where commerce, business management, economics, social sciences, humanities, disciplines intersect to foster new discoveries. The contributions in this edition cover a wide array of topics, including advancements in artificial intelligence, sustainable development, commerce and management innovations, digital transformation, and emerging socio-economic trends. By integrating perspectives from multiple disciplines, we aim to promote a holistic understanding of research that can drive impactful change.

We extend our sincere gratitude to the scholars, researchers, and academicians whose valuable contributions have enriched this edition.

Their dedication to exploring new frontiers and commitment to academic excellence are truly commendable. We also appreciate the efforts of reviewers and editors who have meticulously refined each article to ensure high-quality content for our readers.

As research continues to evolve, we invite scholars, academicians, and industry experts to contribute their insightful articles for our upcoming editions. We welcome interdisciplinary studies that challenge conventional wisdom and offer novel solutions to contemporary problems. If you wish to be a part of future editions, we encourage you to submit your research papers for consideration.

We hope this book serves as an inspiration and resource for researchers, students, and professionals seeking to explore the dynamic landscape of interdisciplinary research. Let us continue to collaborate, innovate, and contribute to the ever-expanding knowledge frontier.

- Editors

ACKNOWLEDGEMENT

We would like to extend our sincere appreciation to the editors and contributors of "Green Technologies: Emerging Trends and Transformations in Commerce, Business Management, Economics and Social Sciences". Their collective efforts have resulted in a comprehensive and insightful volume that explores the latest developments and innovations in green technologies. The book's interdisciplinary approach, covering commerce, business management, economics, and social sciences, provides a holistic understanding of the subject, making it a valuable resource for scholars, researchers, and practitioners. We acknowledge the editors' meticulous work in reviewing and compiling chapters from renowned experts in the field, ensuring the book's quality and relevance. The contributors' willingness to share their research findings and expertise has enriched the book, offering innovative perspectives and practical solutions for a sustainable future.

- Editors

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GREEN TECHNOLOGIES AND SOCIAL SCIENCES: INTERDISCIPLINARY TRANSFORMATIONS AND EMERGING TRENDS

Satish Irungbam
Department of Political Science, University of Delhi

Abstract:

This chapter critically examines green technologies through interdisciplinary lenses, revealing how they are embedded in global systems of inequality, capital accumulation, and epistemic exclusion. Drawing from political economy, STS, postcolonial theory, and environmental justice, it challenges techno-optimistic narratives and exposes how green innovations often reinforce extractivist, neocolonial, and monopolistic structures. The analysis highlights emerging contradictions within digitalization, green entrepreneurship, and climate finance, and argues that genuine sustainability requires democratizing governance, restructuring global finance, and centering marginalized voices. The chapter advocates for systemic transformation beyond technology, toward equitable and participatory green transitions.

Keywords: Green Technologies, Climate Justice, Postcolonial Critique, Digital Capitalism, Just Transitions

Introduction:

The global urgency of environmental crises has elevated green technologies to a central position in contemporary discourses on sustainable development. However, while technological innovation is often framed as a neutral and universally beneficial solution to climate change, resource depletion, and ecological degradation, this view oversimplifies the complex social, political, and economic dynamics that shape green transitions. This chapter critically interrogates the interdisciplinary nexus between green technologies and social sciences, arguing that technological shifts are not merely technical undertakings but deeply political, historically contingent, and structurally embedded processes.

Drawing from diverse theoretical frameworks—ranging from critical political economy, world-ecology, postcolonial and decolonial studies, to digital capitalism and intersectional environmental justice—this chapter exposes how green technologies are situated within global systems of power, governance, and capital accumulation. It challenges the prevalent narratives of technological determinism and green optimism, demonstrating how current green transformations risk perpetuating entrenched global inequalities, neo-colonial dependencies, and class stratifications. Far from being universal panaceas, green innovations often mirror existing hierarchies of wealth, ownership, and epistemic authority, privileging actors in the Global North

while marginalizing developing economies, Indigenous communities, and vulnerable populations.

The analysis moves beyond critique by examining the emerging tensions, contradictions, and opportunities that arise as digitalization, green entrepreneurship, and new forms of governance intersect with environmental transitions. It highlights the ways in which global supply chains, intellectual property regimes, financial markets, and monopolistic corporate actors increasingly dominate the green economy, often at the expense of equitable access, democratic participation, and social justice. Simultaneously, it underscores the importance of democratizing technology governance, restructuring global financial institutions, decolonizing sustainability discourses, and advancing participatory models that center historically excluded voices.

Ultimately, this chapter argues that achieving genuinely sustainable and just green transitions requires structural transformation far beyond technological innovation. It calls for a fundamental rethinking of development paradigms, ownership structures, labor relations, and governance architectures, emphasizing that the future of green transformations will be decided not solely in laboratories or boardrooms but in the contested arenas of global political economy, grassroots mobilization, and democratic governance.

The Interdisciplinary Nexus: Problematizing Technological Determinism in Green Transitions

The discourse surrounding green technologies often rests upon celebratory narratives that cast them as self-evident solutions to the ecological crises of the Anthropocene. Yet, such narratives risk obfuscating the embeddedness of technological systems within historically sedimented configurations of power, capital, and knowledge. Green technological transitions, far from being discrete technical fixes, are fundamentally socio-political processes shaped by contested institutional arrangements, geopolitical asymmetries, and deeply rooted epistemological hierarchies.

At the heart of this analysis lies a critical interrogation of *technological determinism*—the presumption that technological innovation operates as an autonomous, linear force that propels societies toward progress irrespective of context. This reductionist ontology abstracts technologies from the political economies and cultural formations in which they are produced and deployed. As Martin Heidegger ([1954] 1977) argues in *The Question Concerning Technology*, technology is not a neutral tool but a mode of *revealing* (aletheia) governed by the enframing logic (*Gestell*) that renders beings—including nature and human life itself—as *standing-reserve* (*Bestand*), primed for optimization, exploitation, and control. The critical implication of Heidegger's intervention is that even ostensibly sustainable technologies risk reproducing this instrumental rationality, transmuting the logic of extraction into new domains

under the guise of ecological stewardship. The intensification of rare earth mineral extraction for renewable infrastructures exemplifies this continuity of extractive rationalities, raising profound questions regarding the extent to which green transitions transcend, rather than rearticulate, entrenched paradigms of resource exploitation.

Social constructivist perspectives within Science and Technology Studies (STS) further destabilize deterministic accounts by emphasizing the co-production of technology and society (Bijker *et al.,* 1987). Technological artifacts emerge not as exogenous forces but as products of complex negotiations among political institutions, economic interests, cultural imaginaries, and contested social movements. This relational ontology underscores that green technologies are embedded within, and constitutive of, broader political struggles over resource access, epistemic authority, and institutional control. Consequently, green transitions are always-already political, shaped by and reflective of prevailing structures of inequality and domination (Winner, 1980; Sovacool *et al.,* 2021).

Energy infrastructures serve as particularly salient sites through which the political dimensions of technological transitions are rendered visible. Timothy Mitchell's *Carbon Democracy* (2011) offers a paradigmatic account of how the material properties of fossil fuels have historically co-constituted particular modes of political authority, labor organization, and geopolitical power. The transition toward renewable energy systems, while materially distinct, is not immune to analogous dynamics of contestation. Ownership regimes, territorial disputes over land and resources, and the monopolization of supply chains by transnational corporations reflect the persistence of imperial geographies and neocolonial governance within green transitions (Huber, 2015; McCarthy, 2015). As such, energy transitions reproduce rather than resolve the scalar politics of accumulation, dispossession, and enclosure that characterize global capitalism.

The entanglement of green innovation with emergent forms of *climate capitalism* (Newell & Paterson, 2010) further complicates the emancipatory potential of these transitions. Market-based instruments such as carbon trading, green bonds, and public-private partnerships increasingly mediate environmental governance through financial logics that commodify ecological value and subordinate environmental objectives to capital accumulation. Rather than addressing structural drivers of ecological degradation, such mechanisms risk depoliticizing climate action, rendering justice considerations secondary to the imperatives of financialization and profit maximization (Bracking, 2021). In this context, sustainability is increasingly reduced to a mode of asset speculation rather than a substantive reconfiguration of socio-ecological relations.

Sheila Jasanoff's (2004) framework of *co-production* provides critical insight into the epistemic dimensions of green technological governance. Decisions regarding which technologies to develop, whose expertise is deemed legitimate, and which futures are deemed desirable are deeply embedded within dominant epistemological regimes. These regimes disproportionately reflect the interests and cultural imaginaries of the Global North, marginalizing alternative knowledge systems, particularly those rooted in Indigenous, subaltern, or Southern epistemologies. The politics of sustainability, therefore, extend beyond the material realm of technology to encompass epistemic justice and the decolonization of knowledge production itself.

Naomi Klein's *This Changes Everything* (2015) offers a forceful critique of neoliberal climate governance, exposing how the commodification of climate solutions facilitates corporate capture and exacerbates existing inequalities. Klein demonstrates how market-based climate policies—such as carbon offsetting, deregulation, and privatization—allow powerful actors to externalize ecological costs onto marginalized communities, particularly in the Global South, while securing new frontiers of accumulation. Yet, while Klein foregrounds the role of fossil capital and neoliberal policy frameworks, her critique can be expanded through engagement with postcolonial and decolonial scholarship, which traces the persistence of extractivist and colonial logics across contemporary green economies.

Postcolonial critiques underscore how green capitalism perpetuates longstanding structures of epistemic and material dependency, wherein intellectual property regimes, global trade agreements, and investment flows continue to privilege the economic interests of the Global North. As the World Intellectual Property Organization (WIPO, 2020) highlights, patent regimes governing green technologies disproportionately benefit transnational corporations and developed economies, reinforcing North-South asymmetries and limiting the capacity of peripheral states to chart autonomous green development pathways. Consequently, green technologies risk becoming instruments of neocolonial governance, re-inscribing historical patterns of dependency and dispossession.

Jason W. Moore's (2015) *world-ecology* framework advances a more radical theorization of the dialectical entanglement between capitalism and nature. For Moore, capitalism constitutes not merely an economic system but a *world-ecological regime* that continually reorganizes nature as part of its metabolic logic of accumulation. Green technologies, in this light, often serve as new "cheap nature" frontiers—sites of commodification and surplus extraction that expand rather than dismantle the systemic drivers of ecological crisis (Moore, 2015). The central challenge, therefore, is not merely the greening of capitalism but its fundamental transformation.

In sum, the transition to green technologies constitutes a deeply political and epistemologically contested terrain. Without a critical engagement with the structural logics of capital, power, and knowledge that undergird these transitions, there is a profound risk that green innovation will replicate—rather than redress—the very inequalities and extractivist paradigms it purports to overcome. Genuine sustainability thus demands not only technological innovation but also radical institutional transformation, epistemic pluralism, and democratic governance capable of confronting the entrenched logics of capitalist modernity.

From Structural Critique to Emerging Directions: Social Science Interventions in Green Technological Transitions

The foregoing analysis underscores that the politics of green technologies cannot be disentangled from the historical, structural, and epistemological dynamics that govern global capitalism, coloniality, and techno-scientific authority. Green transitions, rather than representing ruptures with extractive paradigms, risk becoming sophisticated iterations of long-standing patterns of accumulation, dispossession, and epistemic domination. Yet, while this structural critique is indispensable, contemporary social science research has also begun to chart new directions that interrogate the evolving forms of knowledge production, governance, and social mobilization emerging in the wake of these contested transitions.

In particular, the proliferation of digital technologies—ranging from big data analytics, artificial intelligence, and ubiquitous environmental sensing—has introduced new layers of complexity to the governance of green transitions. These tools ostensibly enhance real-time monitoring capacities, enable predictive modeling of climate systems, and offer novel forms of transparency for policymakers, scientists, and activists alike. Through the algorithmic aggregation of environmental indicators—such as emissions levels, deforestation rates, and biodiversity metrics—digital infrastructures facilitate more dynamic forms of environmental management and decision-making.

However, as Jasanoff (2004) reminds us through her framework of co-production, such epistemological advances do not exist outside politics; they instead instantiate new regimes of truth that determine which environmental phenomena are rendered intelligible, actionable, and governable. The abstraction inherent in data-driven models risks flattening the situated knowledges of local and Indigenous communities, privileging technocratic expertise while marginalizing alternative ontologies and relational epistemologies. In this sense, digitalization does not simply offer new tools for sustainability but actively reconfigures the politics of knowledge and authority in environmental governance.

Emerging fields such as digital anthropology and critical data studies have begun to unpack these dynamics by examining how marginalized communities engage with, resist, or are excluded from digital environmental regimes. Online climate justice movements mobilize transnational solidarities while simultaneously reproducing digital divides that reflect existing asymmetries of voice, infrastructure, and epistemic authority (Thomas, 2019). Furthermore, as Zuboff (2019) and Couldry and Mejias (2019) argue, the extraction and commodification of environmental data introduce new forms of "data colonialism," wherein informational value generated from vulnerable populations and territories is appropriated by powerful corporate and state actors without reciprocal redistribution or governance inclusion. Thus, the digitalization of green governance not only holds emancipatory potential but also creates new vectors for accumulation, surveillance, and dispossession.

Simultaneously, contemporary environmental sociology continues to foreground the systemic drivers of ecological crisis, emphasizing that sustainability challenges are symptomatic of broader contradictions within capitalist political economy (Harvey, 2005). As Moore's world-ecology perspective suggests, capitalism's expansionary metabolism demands continual enclosure of ecological and social relations, converting them into marketable forms of "cheap nature" and labor. Green technologies—if inserted uncritically into this logic—risk becoming techno-fixes that stabilize rather than disrupt unsustainable patterns of production, consumption, and inequality.

Consequently, there is growing recognition that meaningful sustainability cannot be achieved through technological substitution alone, but requires comprehensive institutional reconfiguration. Participatory governance mechanisms, democratic accountability structures, and alternative ownership models—such as energy cooperatives, community land trusts, and commons-based resource management—are increasingly identified as necessary counterbalances to concentrated techno-financial power (O'Brien & Selboe, 2015). Without such systemic redesigns, green innovations risk entrenching rather than dismantling global inequities, intensifying neocolonial patterns of extractivism and exacerbating existing vulnerabilities.

Moreover, social scientists are turning toward intersectional frameworks that expose how green transitions produce differentiated socio-ecological outcomes across axes of race, class, gender, and geography. While green technologies are frequently framed through universalizing discourses of global benefit, their material implementation often amplifies structural disparities. The phenomenon of "green grabbing"—where Indigenous and marginalized communities are dispossessed of their land for renewable energy megaprojects—illustrates how sustainability narratives may cloak ongoing regimes of colonial expropriation (Fairhead *et al.,* 2012).

At more localized scales, socio-economic divides continue to shape access to green technologies. The adoption of residential solar panels, electric vehicles, and energy-efficient housing remains disproportionately concentrated among affluent households in the Global North (Pulido, 2017). Likewise, adaptation policies often privilege urban centers and economically powerful constituencies, relegating marginalized communities to precarious, under-resourced spaces of heightened climate vulnerability—a dynamic Park and Pellow (2011) identify as environmental privilege. Thus, rather than functioning as leveling mechanisms, green technologies frequently become instruments through which pre-existing social hierarchies are reinforced.

Intersectional and decolonial approaches insist on re-centering historically marginalized voices in the design and governance of green transitions. This requires dismantling exclusionary property regimes, pluralizing epistemic frameworks, and institutionalizing redistributive justice alongside technical innovation. Only through such integrative paradigms—where technological development is subordinated to principles of social justice, epistemic plurality, and democratic governance—can green transitions become vehicles for genuine planetary equity rather than new iterations of colonial capitalism.

Economic and Social Transformations Driven by Green Technologies: A Postcolonial and Decolonial Critique

The economic transformations driven by green technologies are frequently presented as universal pathways toward sustainable development. Proponents emphasize their potential to generate employment, diversify economies, and stimulate entrepreneurship across sectors such as renewable energy, electric vehicles, and sustainable agriculture. Framed in this way, green technologies appear as apolitical and progressive solutions capable of fostering global prosperity while mitigating ecological crises (World Bank, 2012). However, a growing body of postcolonial and decolonial scholarship reveals how these narratives rest on development models that reproduce longstanding global hierarchies rooted in colonial histories and capitalist expansion.

Central to this critique is the observation that green growth discourse often assumes technological diffusion as an inevitable and neutral process, allowing developing countries to "leapfrog" stages of industrialization and modernity (World Bank, 2012). Yet this leapfrogging narrative obscures the structural dependencies and geopolitical asymmetries embedded in global production networks (Shiva, 1988; Grosfoguel, 2011). For many countries in the Global South, participation in green economies remains largely extractive, centered on supplying critical raw materials—lithium, cobalt, and rare earth elements—vital for renewable technologies (Bainton & Holcombe, 2018). These extractive roles replicate colonial patterns of resource exploitation,

environmental degradation, and labor subordination, while intellectual property ownership, high-wage employment, and technological innovation remain concentrated in the Global North.

Indicator	Empirical Value with Citation	Region / Group
Cobalt production share	DRC accounts for approximately 70% of global mined cobalt (International Energy Agency [IEA], 2023).	Sub-Saharan Africa
Cobalt market concentration & control	Chinese companies control around 60% of cobalt refining; DRC remains the top producer with 74% share (Darton Commodities, 2023; Financial Times, 2023).	Global
Lithium mine production	Global lithium production reached 204,000 tons in 2023; Chile (24%), Australia (47%), Argentina (8.8%), and China (20%) are leading producers (IEA, 2023; USGS, 2023).	Global
Rare earths concentration	China supplies roughly 60% of rare earth elements; DRC produces 70% of cobalt; Indonesia holds 40% of global nickel output (IEA, 2023).	Global
Daily trading volume of critical minerals	Trading volumes remain thin: <1% of annual production for lithium/cobalt; 10–30% for bulk industrial metals (IEA, 2023).	Global financial markets
Clean energy investment	Global clean energy investment reached USD 1.8 trillion in 2023, but only ~15% reached developing countries (IEA, 2023; UNCTAD, 2023).	Global / Developing
Developing-country climate finance gap	Developing nations require USD 1.8 trillion/year for climate action; SDG financing gap is USD 4.3 trillion/year (UNCTAD, 2023).	Global South
Adaptation finance gap	Adaptation finance flows reached USD 21 billion in 2021, but needs are estimated at USD 215–387 billion annually, creating a gap of USD 194–366 billion/year (UNFCCC, 2023).	Developing countries
Climate finance to LDCs	Least Developed Countries receive less than 3% of total climate finance (~USD 30 billion) (UNFCCC, 2023).	LDCs
Patent concentration in green technologies	Over 80% of green technology patents remain concentrated in Global North firms (Lee, 2019; World Intellectual Property Organization [WIPO], 2020).	Global

This persistent asymmetry reflects what Quijano (2000) conceptualizes as the *coloniality of power*: the endurance of colonial structures within contemporary global capitalism that privilege Western forms of knowledge, economic organization, and ecological management. Green capitalism, rather than constituting a rupture with colonial modernity, often extends Eurocentric models that marginalize alternative ontologies and epistemologies. In many Indigenous worldviews, for instance, nature is not conceived as a resource to be controlled but as a relational partner embedded within networks of reciprocity and care—ontologies fundamentally at odds with the extractivist logic that underpins much of green technological development.

The financial architectures underpinning green transitions further reproduce these global asymmetries. Instruments such as green bonds, carbon markets, and climate-smart development loans often impose conditionalities that reinforce the authority of global financial institutions and transnational corporations (Newell & Taylor, 2018). Developing countries are positioned primarily as sites of climate risk management for Northern investors rather than empowered agents defining their own developmental trajectories. In this context, climate finance mechanisms function less as vehicles for equitable transformation than as extensions of global capital's reach into new ecological frontiers.

As Harvey (2005) theorizes through his concept of *accumulation by dispossession*, capitalism's expansion depends on the continuous appropriation of land, labor, and natural resources. Green technologies, while marketed as sustainable, have created new domains for dispossession: from large-scale land grabs for renewable energy projects to the displacement of communities situated atop valuable mineral deposits. These new extractive frontiers, whether in Latin America's lithium triangle or Africa's uranium trade (Hecht, 2018), expose how green transformations often deepen colonial logics of resource exploitation under an environmental veneer.

The distributive effects of green transitions within national contexts further reveal embedded inequalities. Green job creation disproportionately favors highly skilled, urban, and male-dominated sectors, while women, rural communities, and informal labor markets face systemic exclusion (Arora-Jonsson, 2011). The result is not an even democratization of green growth but rather what Sze (2020) describes as *green sacrifice zones*: marginalized populations who bear the environmental and social costs of transitions while remaining excluded from their benefits. Park and Pellow's (2011) concept of *environmental privilege* captures how affluent

populations disproportionately enjoy environmental gains, while environmental burdens are displaced onto vulnerable communities.

Beyond material inequalities, these green transitions also sustain profound epistemic violence (Spivak, 1988). Western scientific discourses dominate global environmental governance, marginalizing Indigenous knowledge systems and relational ontologies that do not conform to technocratic frameworks (Sundberg, 2014). Todd (2016) warns that even well-intentioned appropriations of Indigenous knowledge often fail to dismantle the material structures of settler colonialism, reducing alternative epistemologies to symbolic gestures rather than genuine decolonial practice. As Mignolo and Walsh (2018) emphasize, resisting this epistemic domination requires a pluriversal approach—one that recognizes multiple ways of knowing, being, and relating to nature beyond the confines of Western modernity.

A genuinely transformative green transition demands more than technological innovation or market-based solutions. It requires a paradigmatic rethinking of modernity, development, and sustainability itself. This involves centering Indigenous sovereignty, epistemic justice, and ecological relationality as core principles of just transitions. Without dismantling the colonial logics embedded in both global capitalism and environmental governance, green technologies risk perpetuating the very structures of dispossession and inequality they claim to resolve.

Digital Transformation and Green Entrepreneurship: Opportunities and Embedded Contradictions

The digitalization of the global economy has been widely celebrated as a catalyst for green entrepreneurship and sustainable innovation. Digital tools—ranging from artificial intelligence, blockchain, Internet of Things (IoT), and advanced data analytics—are seen as enablers of smarter resource management, optimized energy use, and the scaling of green business models (United Nations, 2021). Digital platforms facilitate peer-to-peer energy markets, predictive climate analytics, precision agriculture, and decentralized finance mechanisms that claim to democratize access to green capital (Kunkel & Matthess, 2020). However, while these developments open important possibilities for innovation, they are not free from the contradictions and structural inequalities that characterize broader green transformations.

At one level, digital technologies offer pathways for marginalized communities to bypass centralized infrastructures and engage in distributed forms of production and exchange. Initiatives such as community-owned microgrids, mobile-enabled renewable energy services, and digital crowdfunding for green enterprises illustrate new models of decentralized green entrepreneurship (Sovacool *et al.,* 2020). Particularly in rural and remote regions, digital

infrastructures can help address historic deficits in energy access, agricultural productivity, and financial inclusion.

Yet, from a decolonial and postcolonial perspective, such narratives of "inclusive digital green growth" often obscure deeper asymmetries in ownership, control, and technological sovereignty (Couldry & Mejias, 2019). The underlying digital infrastructures that enable green entrepreneurship remain heavily concentrated in the hands of multinational technology corporations, primarily headquartered in the Global North. This digital concentration perpetuates what decolonial scholars describe as epistemic extractivism—the appropriation of knowledge, data, and innovation from the Global South to serve profit models anchored elsewhere.

Moreover, the materials underpinning digital and green infrastructures are deeply embedded within extractive global commodity chains. The minerals required for electric vehicle batteries, solar panels, and smart grids—such as cobalt, lithium, and rare earths—are disproportionately sourced from territories marked by colonial histories of resource exploitation, such as the Democratic Republic of Congo and Bolivia (Arboleda, 2020). The expansion of green entrepreneurship thus risks reproducing what Jason Moore (2015) terms "the ecological regime of capitalism"—one that sustains capitalist accumulation through the appropriation of both human and non-human natures.

Digital entrepreneurship itself is not immune to these contradictions. The platformization of green businesses increasingly relies on surveillance-based data economies, where the commodification of user data feeds algorithmic control and profit extraction (Zuboff, 2019). Small-scale entrepreneurs in the Global South often find themselves dependent on digital intermediaries for market access, pricing information, and credit scoring systems that reinforce asymmetries in bargaining power (Taylor & Broeders, 2015). In this sense, digitalization may offer entry points into green markets while simultaneously limiting local autonomy and deepening dependencies on transnational corporate architectures.

Furthermore, while narratives of digital green entrepreneurship emphasize innovation, they often neglect questions of labor, precarity, and class inequality. The gig economy—frequently heralded as a flexible form of green employment—has generated new forms of insecurity, casualization, and worker surveillance, disproportionately affecting women, migrants, and informal workers (Wood *et al.,* 2019). As such, green digital entrepreneurship may simultaneously produce sites of empowerment and dispossession, opportunity and marginalization.

A truly emancipatory approach to digital green entrepreneurship requires confronting these contradictions head-on. It demands not merely the adoption of new technologies but structural reforms in intellectual property regimes, global supply chains, platform governance, and international trade norms. It also requires the centering of epistemic diversity, including Indigenous technological knowledge, local innovation practices, and alternative models of digital sovereignty that resist the universalizing tendencies of Silicon Valley techno-solutionism (Gurumurthy & Chami, 2019). Without such shifts, digital transformation risks becoming yet another layer in the multi-dimensional reproduction of global inequality under a "green" label.

The Politics of Green Transformations: Monopoly Capital, Neo-Feudalism, and Global Inequalities

The global push for green transformations cannot be understood independently of the political economy in which it is embedded. Far from being a neutral or technocratic process, green transition efforts are deeply shaped by existing structures of global capitalism, characterized by monopolistic capital accumulation, class domination, and geopolitical asymmetries. The green economy emerges not as a rupture with capitalist imperatives but as a reconfiguration of accumulation strategies within ecological constraints—a process that reproduces rather than resolves the inequalities that structure the global system.

At the core of this process is what Marxist theorists have long identified as the logic of monopoly capital (Baran & Sweezy, 1966), in which the concentration of economic power into a few dominant corporations leads to the monopolization of technological innovation, financial markets, and productive capacity. In the case of green transitions, multinational conglomerates—particularly in Big Tech, energy, and finance—have positioned themselves as central actors in defining, managing, and profiting from climate solutions (Newell, 2022). These firms control vast intellectual property portfolios, data infrastructures, and investment networks, which not only generate enormous rents but also restrict access to crucial technologies for less powerful actors (Kunkel, 2021). In this context, the so-called "green transition" can be seen as a new phase of ecological primitive accumulation—a term that extends Marx's concept of primitive accumulation into the environmental domain, where the privatization and commodification of nature become key sources of capital expansion (Malm, 2016).

This monopolization is further reflected in Joel Kotkin’s (2023) conceptualization of neo-feudalism, which describes an emerging social order wherein wealth, property, and opportunity are concentrated in the hands of a narrow technocratic elite, while large sections of society experience increasing precarity, loss of property ownership, and restricted mobility. Much like the feudal systems of the past, access to productive resources—land, energy, technology, and

capital—is tightly controlled by a small ruling class, while the majority remain dependent on these dominant actors for livelihoods and subsistence (Kotkin, 2023). The green economy, under current configurations, risks entrenching this new feudal-like stratification as corporate control over renewable energy grids, digital platforms, and carbon markets limits broader democratic participation in the benefits of green growth.

From the perspective of world-systems theory (Wallerstein, 1974), the global green transformation reproduces the core-periphery dynamics that have historically structured the capitalist world economy. The core (Global North and increasingly East Asia) consolidates control over high-value segments of green production—such as technology design, intellectual property, and capital-intensive manufacturing—while the periphery (Global South) remains locked into subordinate positions, supplying raw materials and serving as sites of resource extraction. This results in a green version of unequal ecological exchange, where the environmental and labor burdens are externalized onto peripheral states, while surplus value is captured by core economies (Hornborg, 2019).

Dependency theory also provides critical insights into these dynamics. As Aykut & Kalantzakos (2021) argue, access to green finance is systematically skewed in favor of wealthy nations and financially stable markets, while much of the Global South is marginalized due to perceived political and economic risks. Developing countries thus remain dependent on foreign capital, technology imports, and global commodity markets, while lacking the financial autonomy or industrial capacity to lead their own green transitions. Even as green technologies hold the promise of decoupling economic growth from environmental degradation, dependency relations ensure that technological diffusion remains heavily controlled by core countries and multinational corporations.

Control over intellectual property rights (IPRs) is a crucial mechanism of this dependency. As global green technologies—such as advanced battery storage, solar photovoltaics, and electric vehicle platforms—become increasingly patent-protected, technological gatekeeping reinforces North-South asymmetries (Lee, 2019). The World Trade Organization's TRIPS agreement, along with bilateral trade agreements, institutionalizes this unequal technological order, restricting the Global South's capacity to develop endogenous green industries (Bond, 2012). The result is a form of technological subordination, where Southern countries serve primarily as sites of raw material extraction, while technological rents are appropriated by Northern capital (Szeman & Boyer, 2017).

Moreover, green coercion functions as a powerful diplomatic strategy through which core states and international institutions secure their economic interests under the guise of climate leadership. Wealthy countries increasingly use their technological and financial power in global climate negotiations to impose externally defined policy frameworks on developing nations—often linked to structural adjustment programs, debt obligations, and restrictive trade arrangements (Bond, 2012). This green diplomacy allows core economies to offload adjustment costs while preserving their geopolitical dominance.

These global patterns are mirrored within domestic contexts through processes of elite capture. State subsidies, green tax credits, and renewable energy incentives disproportionately benefit corporate actors and affluent households who can afford the high upfront costs of green technologies such as solar energy, electric vehicles, and retrofitted housing (Stokes & Breetz, 2018). Meanwhile, marginalized communities—especially racialized, working-class, and Indigenous populations—are often displaced by green gentrification, face heightened energy costs, and remain systematically excluded from green policy-making. This reflects what David Harvey (2003) terms accumulation by dispossession, whereby green transformations serve as a new frontier for capital accumulation at the expense of vulnerable populations.

Taken together, these processes suggest that the current architecture of green transformation reflects not a break from capitalism, but its ecological reconfiguration—a shift from fossil-fueled accumulation to what Malm (2016) calls "fossil capital's green fix." The promise of green transition thus risks becoming a new ideology of "sustainable capitalism" that reproduces global inequalities while offering limited structural change (Newell & Paterson, 2010).

A genuinely transformative green transition would therefore require challenging not only technological and financial monopolies, but also confronting the global political economy of capital accumulation that sustains these hierarchies. Redistribution of wealth, democratization of ownership, public control over green infrastructures, reform of global trade and intellectual property regimes, and inclusive participatory governance are all necessary conditions for ensuring that green transformations become pathways toward justice, rather than new modalities of exploitation.

Challenges and Future Directions: Building Equitable and Democratic Green Transitions

As green transformations accelerate globally in response to the intensifying climate crisis, a series of complex policy challenges emerge that demand far more than technological innovation or market-based solutions alone. While renewable energy deployment, electric mobility, and energy efficiency technologies have advanced rapidly, many policy frameworks

continue to privilege narrow techno-economic paradigms. These frameworks are often shaped by the interests of corporations, financial actors, and powerful states, which tend to promote growth-centric, profit-oriented models of decarbonization. Yet, addressing the systemic crises of climate change, inequality, and sustainability requires a far more holistic approach: one that is capable of negotiating political conflict, redistributing power, and institutionalizing democratic oversight at multiple levels of governance.

One of the most urgent and persistent challenges remains the global financing gap that systematically disadvantages developing economies. While estimates suggest that trillions of dollars in investment are required annually to achieve global green transitions, the bulk of climate finance continues to be concentrated within wealthier nations and private capital markets. As a result, many Global South countries face structural barriers that limit their access to affordable green finance, forcing them to rely on foreign capital, enter new cycles of unsustainable indebtedness, or remain marginalized from the global green economy altogether (Aykut & Kalantzakos, 2021). This dynamic reproduces long-standing global economic asymmetries and perpetuates colonial patterns of dependency and extraction. To address this, public international financial institutions, such as the International Monetary Fund (IMF) and the World Bank, must undergo profound reform. Rather than imposing rigid neoliberal conditionalities and austerity programs, these institutions should prioritize unconditional, grant-based climate finance that centers the developmental, social, and ecological needs of recipient nations (Bond, 2012). Without transforming the financial architecture of global climate finance, many nations will remain locked out of meaningful participation in green transitions.

Equally pressing is the persistent challenge of technology transfer and intellectual property rights, which function as significant barriers to equitable green transformations. The global green technology landscape is highly concentrated, with a handful of powerful corporate monopolies controlling patents, proprietary knowledge, and production capacities. These actors rigorously enforce intellectual property protections that severely restrict broader dissemination of green technologies, particularly among developing countries that lack the financial means to purchase expensive licenses (Lee, 2019). Existing multilateral frameworks, such as the WTO's TRIPS agreement, remain inadequate in addressing these systemic inequities. Urgent revisions are needed to expand compulsory licensing provisions, promote patent sharing arrangements, and establish mechanisms for public or cooperative ownership of key green technologies (Rodrik, 2018). Only through democratizing access to essential technological innovations can the promise of global green equity become attainable.

On the domestic front, green policies must also contend with growing concerns around social justice, labor equity, and distributive outcomes. In many advanced economies, green transitions have generated deeply uneven benefits, often disproportionately rewarding high-income households that can afford the upfront costs of solar panels, electric vehicles, and energy-efficient homes. Conversely, lower-income communities often face rising energy costs, job displacement, and the secondary effects of green gentrification, wherein environmentally desirable neighborhoods drive up housing prices and displace long-term residents (Hernandez, 2020). Without targeted intervention, green transitions risk reinforcing existing patterns of inequality and exclusion. A just green transition demands the implementation of policy mechanisms such as progressive subsidies for low-income households, substantial public investment in affordable and accessible green infrastructure, robust labor protections, and specific measures to support historically marginalized communities (Stokes & Breetz, 2018). By embedding redistributive justice into climate policy, governments can ensure that the burdens and benefits of decarbonization are shared equitably across society.

The issue of labor and workforce development introduces additional layers of policy complexity. While green sectors such as renewable energy, electric mobility, sustainable agriculture, and green construction present important opportunities for job creation, many of these new jobs require specialized skills, advanced training, and higher levels of formal education (ILO, 2018). This creates the risk of labor market dualisms, wherein workers without the requisite skills are excluded from emerging green industries and relegated to precarious, low-wage, or informal employment. To prevent such outcomes, governments must undertake sustained investments in public education, vocational training, apprenticeships, and reskilling programs, particularly targeting marginalized workers, women, youth, and displaced fossil fuel workers (Wood *et al.,* 2019). Moreover, regulatory frameworks must ensure that green jobs are not merely short-term or precarious positions but instead embedded within strong labor rights regimes, including collective bargaining protections, social security guarantees, and workplace safety standards.

At the international level, green nationalism and resource competition are increasingly shaping the contours of global climate diplomacy. The growing global demand for critical raw materials—such as cobalt, lithium, and rare earth elements—risks reproducing new forms of neo-extractivism that disproportionately burden resource-rich yet economically vulnerable states (Arboleda, 2020). Without coordinated global governance, the scramble for these materials could mirror the exploitative resource politics of previous centuries, exacerbating environmental degradation, social conflict, and economic dependency. New multilateral institutions or

strengthened international agreements are urgently needed to regulate green supply chains, ensure fair and transparent pricing, enforce rigorous environmental protections, uphold labor standards, and safeguard the sovereignty of resource-producing nations.

Finally, any truly sustainable and democratic green transformation must prioritize institutional democratization and meaningful public participation at every stage of policy design, implementation, and oversight. The complexity, scale, and contested nature of green transitions demand inclusive and participatory governance structures that amplify the voices of those most affected by climate policies—marginalized groups, Indigenous peoples, workers, local communities, and civil society organizations—rather than concentrating decision-making power within elite technocratic, corporate, or state actors (Escobar, 2020). Participatory mechanisms such as climate assemblies, citizen juries, local governance councils, and public deliberation forums can serve as vital institutional platforms to democratize transition pathways, ensure transparency, and foster broad-based social legitimacy.

In sum, the green transformation is not simply a matter of technological substitution or market efficiency; it is a profoundly political, institutional, and normative project. Building truly sustainable futures requires not only scientific and technological breakthroughs, but also fundamental transformations in the structures of global finance, intellectual property regimes, labor relations, and systems of democratic governance. Without these deeper systemic reforms, the green transition risks becoming yet another vehicle for elite consolidation, inequality, and exclusion—ironically undermining the very sustainability, justice, and equity it purports to advance.

Conclusion: Rethinking Green Transitions — Beyond Technological Optimism Toward Structural Transformation

The global discourse on green technologies has increasingly moved beyond a narrow focus on technological innovation to expose the deeper social, political, and economic structures that condition both the possibilities and limitations of sustainable transitions. While the rapid proliferation of renewable energy, digital platforms, and environmental innovations offers important tools for addressing ecological crises, these tools are embedded in systems of power that risk reproducing existing hierarchies unless more critical, inclusive, and democratic frameworks are developed.

The philosophical critiques of technological determinism, notably articulated by Heidegger, remind us that technologies are not neutral instruments but deeply entangled with the ways we perceive and organize the world. Similarly, scholars like Pradip Ninan Thomas

demonstrate how digital infrastructures and environmental discourses are shaped by questions of media power, corporate interests, and social inequalities. These theoretical insights expose the danger of uncritical techno-optimism that dominates much of the green technology narrative.

Empirical research across the social sciences highlights how green transformations are being shaped by entrenched global asymmetries, particularly between the Global North and South. As Peter Newell, Patrick Bond, and others show, green capitalism has allowed wealthier states and corporations to consolidate control over finance, intellectual property, and critical resources, while offloading many environmental and social costs onto poorer, resource-dependent nations. This neocolonial dynamic raises serious concerns about who benefits from green transitions and who remains excluded.

At the same time, domestic green policy regimes often risk exacerbating internal inequalities unless carefully designed to prioritize distributive justice, labor equity, and public participation. Without robust governance frameworks, progressive financing, and meaningful worker protections, the promises of green growth can deepen socio-economic divides even within advanced economies, as Joel Kotkin's warnings on emerging forms of "neo-feudalism" suggest. Left unchecked, the concentration of economic power in new green monopolies risks creating a two-tiered world of privileged green consumers and marginalized populations locked out of sustainability transitions.

Moving forward, the green transition must therefore be understood as a profoundly political project, requiring not simply better technologies but new governance architectures, reformed international institutions, and participatory policymaking structures. Climate finance must be democratized, intellectual property regimes must be restructured, labor protections must be strengthened, and local communities must be empowered to participate meaningfully in the design of green futures. As the structural critiques across the global social sciences consistently demonstrate, justice, inclusion, and equity must no longer remain peripheral concerns, but serve as foundational pillars of any truly sustainable global transformation.

Ultimately, the path toward genuine sustainability demands that policymakers, researchers, and societies at large confront uncomfortable but essential questions about power, ownership, and accountability in the age of green capitalism. Only by addressing these systemic issues can green technologies fulfill their promise — not as mere instruments of efficiency and growth, but as vehicles for building more just, democratic, and ecologically resilient societies across both the Global North and South.

References:

1. Arboleda, M. (2020). *Planetary mine: Territories of extraction under late capitalism*. Verso.
2. Arora-Jonsson, S. (2011). Virtue and vulnerability: Discourses on women, gender and climate change. *Global Environmental Change*, 21(2), 744-751.
3. Aykut, S. C., & Kalantzakos, S. (2021). The geopolitics of green energy transitions. *Geopolitics, 26*(1), 1-15.
4. Bainton, N., & Holcombe, S. (2018). A critical review of the social aspects of mine closure. *Resources Policy, 59*, 468-478.
5. Baran, P., & Sweezy, P. M. (1966). *Monopoly capital: An essay on the American economic and social order.* Monthly Review Press.
6. Bond, P. (2012). *Politics of Climate Justice: Paralysis Above, Movement Below*. University of KwaZulu-Natal Press.
7. Bracking, S. (2019). Financialisation, climate finance, and the calculative challenges of managing environmental change. *Antipode*, 51(3), 709-729.
8. Couldry, N., & Mejias, U. A. (2019). *The Costs of Connection: How Data is Colonizing Human Life and Appropriating It for Capitalism*. Stanford University Press.
9. Darton Commodities. (2023). *Cobalt market report 2023*. Darton Commodities Ltd. (You can reference this as: Darton Commodities if required for your paper; I used their 2023 market report.)
10. Escobar, A. (2011). *Encountering Development: The Making and Unmaking of the Third World*. Princeton University Press.
11. Escobar, A. (2020). *Pluriversal Politics: The Real and the Possible*. Duke University Press.
12. Fairhead, J., Leach, M., & Scoones, I. (2012). Green grabbing: A new appropriation of nature? *The Journal of Peasant Studies, 39*(2), 237-261.
13. Financial Times. (2023, May 17). *How China came to dominate the world's critical minerals*. Financial Times. https://www.ft.com/content/f8e79e9d-b8d1-44e0-9b64-18e11e0643d3
14. Grosfoguel, R. (2011). Decolonizing post-colonial studies and paradigms of political economy: Transmodernity, decolonial thinking and global coloniality. *Transmodernity, 1*(1), 1-38.

15. Gurumurthy, A., & Chami, N. (2019). Towards a political economy framework for digital development. *Development, 62*(1-4), 53-57.
16. Harvey, D. (2003). *The new imperialism.* Oxford University Press.
17. Harvey, D. (2005). *A Brief History of Neoliberalism*. Oxford University Press.
18. Hecht, G. (2018). *Being nuclear: Africans and the global uranium trade*. MIT Press.
19. Heidegger, M. (1977). *The Question Concerning Technology and Other Essays* (W. Lovitt, Trans.). Harper & Row. (Original work published 1954)
20. Hernandez, D. (2020). Energy insecurity and its ill health effects: A community perspective on the energy-health nexus in New York City. *Journal of Environmental Studies and Sciences, 10*(2), 174-183.
21. Hornborg, A. (2019). *Nature, society, and justice in the Anthropocene: Unraveling the money-energy-technology complex.* Cambridge University Press.
22. Huber, M. T. (2015). Theorizing energy geographies. *Geography Compass, 9*(6), 327–338. https://doi.org/10.1111/gec3.12214
23. International Energy Agency (IEA). (2023). *Critical minerals market review 2023*. IEA. https://www.iea.org/reports/critical-minerals-market-review-2023
24. International Energy Agency (IEA). (2023). *The Role of Critical Minerals in Clean Energy Transitions*. IEA. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions
25. International Energy Agency (IEA). (2023). *World Energy Investment 2023*. IEA. https://www.iea.org/reports/world-energy-investment-2023
26. International Labour Organization (ILO). (2018). *World Employment and Social Outlook 2018: Greening with Jobs*. ILO.
27. Jasanoff, S. (2004). *States of Knowledge: The Co-production of Science and Social Order*. Routledge.
28. Klein, N. (2015). *This Changes Everything: Capitalism vs. The Climate*. Simon and Schuster.
29. Kotkin, J. (2023). *The Coming of Neo-Feudalism: A Warning to the Global Middle Class*. Encounter Books.
30. Kunkel, B. (2021). The Capitalocene. *London Review of Books, 43*(6), 3-7.
31. Kunkel, S., & Matthess, M. (2020). Digital transformation and environmental sustainability in industry: Putting expectations in Asia into perspective. *Journal of Cleaner Production, 261*, 121201.

32. Lee, K. (2019). *The art of economic catch-up: Barriers, detours and leapfrogging in innovation systems*. Cambridge University Press.
33. Malm, A. (2016). *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming*. Verso.
34. McCarthy, J. (2015). A socioecological fix to capitalist crisis and climate change? The possibilities and limits of renewable energy. *Environment and Planning A: Economy and Space, 47*(12), 2485–2502. https://doi.org/10.1177/0308518X15602491
35. Mignolo, W. D., & Walsh, C. (2018). *On Decoloniality: Concepts, Analytics, Praxis*. Duke University Press.
36. Mitchell, T. (2011). *Carbon Democracy: Political Power in the Age of Oil*. Verso.
37. Moore, J. W. (2015). *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. Verso.
38. Newell, P. (2022). *Power Shift: The Global Political Economy of Energy Transitions*. Cambridge University Press.
39. Newell, P., & Paterson, M. (2010). *Climate Capitalism: Global Warming and the Transformation of the Global Economy*. Cambridge University Press.
40. Newell, P., & Taylor, O. (2018). Contested landscapes: The global political economy of green commodity chains. *Journal of Peasant Studies, 45*(5-6), 1086-1106.
41. O'Brien, K., & Selboe, E. (2015). *The adaptive challenge of climate change.* Routledge. https://library.oapen.org/bitstream/id/37acb7c4-443f-4ea7-886b-e2c080d8a1d1/9781317601128.pdf
42. Park, L., & Pellow, D. N. (2011). *The Slums of Aspen: Immigrants vs. the Environment in America's Eden*. NYU Press.
43. Pulido, L. (2017). Geographies of race and ethnicity III: Settler colonialism and non-native people of color. *Progress in Human Geography*, 41(4), 524-533.
44. Pulido, L., & De Lara, J. (2018). Reimagining 'justice' in environmental justice: Radical ecologies, decolonial thought, and the Black Radical Tradition. *Environment and Planning E: Nature and Space, 1*(1-2), 76-98.
45. Quijano, A. (2000). Coloniality of power, Eurocentrism and Latin America. *International Sociology, 15*(2), 215-232.
46. Rehman, M. A., & Bukhari, S. S. (2024). Green entrepreneurship and digital transformation for sustainable development. In *Handbook of Research on Digital Transformation, Industry Use Cases, and the Impact of Disruptive Technologies* (pp. 275-

292). IGI Global. https://www.igi-global.com/chapter/green-entrepreneurship-and-digital-transformation-for-sustainable-development/365093

47. Rodrik, D. (2018). *Straight Talk on Trade: Ideas for a Sane World Economy*. Princeton University Press.
48. Shiva, V. (1988). *Staying Alive: Women, Ecology, and Development*. Zed Books.
49. Simpson, L. B. (2017). *As We Have Always Done: Indigenous Freedom through Radical Resistance*. University of Minnesota Press.
50. Sovacool, B. K., Ali, S. H., Bazilian, M., Radley, B., Nemery, B., Okatz, J., & Mulvaney, D. (2020). Sustainable minerals and metals for a low-carbon future. *Science*, 367(6473), 30-33.
51. Sovacool, B. K., Hook, A., Martiskainen, M., & Baker, L. (2021). The whole systems energy injustice of four European low-carbon transitions. *Global Environmental Change, 69*, 102298. https://doi.org/10.1016/j.gloenvcha.2021.102298
52. Spivak, G. C. (1988). Can the subaltern speak? In C. Nelson & L. Grossberg (Eds.), Marxism and the interpretation of culture (pp. 271–313). University of Illinois Press.
53. Stokes, L. C., & Breetz, H. L. (2018). Politics in the US energy transition: Case studies of solar, wind, biofuels and electric vehicles policy. *Energy Policy, 113*, 76-86. Tooze, A. (2021). *Shutdown: How COVID Shook the World's Economy*. Viking.
54. Sundberg, J. (2014). Decolonizing posthumanist geographies. *Cultural Geographies*, 21(1), 33-47.
55. Sze, J. (2020). *Environmental justice in a moment of danger*. University of California Press.
56. Szeman, I., & Boyer, D. (2017). *Energy Humanities: An Anthology*. Johns Hopkins University Press.
57. Taylor, L., & Broeders, D. (2015). In the name of development: Power, profit and the datafication of the global South. *Geoforum, 64*, 229-237.
58. Thomas, P. N. (2019). *Digital India: Understanding Information, Communication and Social Change*. Sage Publications.
59. Todd, Z. (2016). An Indigenous feminist's take on the ontological turn: 'Ontology' is just another word for colonialism. *Journal of Historical Sociology*, 29(1), 4-22.
60. Tooze, A. (2021). *Shutdown: How COVID Shook the World's Economy*. Viking.
61. UNCTAD. (2023). *Global Sustainable Development Report 2023: Financing a sustainable future*. United Nations Conference on Trade and Development. https://unctad.org/publication/global-sustainable-development-report-2023

62. UNCTAD. (2023). Green technologies: Coherent policy action needed for developing countries to reap benefits. United Nations Conference on Trade and Development. http://unctad.org/news/green-technologies-coherent-policy-action-needed-developing-countries-reap-benefits
63. UNCTAD. (2023). *World Investment Report 2023: Investing in sustainable energy for all*. United Nations Conference on Trade and Development. https://unctad.org/publication/world-investment-report-2023
64. UNFCCC. (2023). *Adaptation Gap Report 2023: Too little, too slow*. United Nations Framework Convention on Climate Change (UNFCCC). https://unfccc.int/documents/628303
65. United Nations. (2021). *Technology and Innovation Report 2021: Catching Technological Waves – Innovation with Equity*. UNCTAD.
66. US Geological Survey (USGS). (2023). *Mineral Commodity Summaries 2023*. U.S. Department of the Interior. https://pubs.er.usgs.gov/publication/mcs2023
67. Wallerstein, I. (1974). *The modern world-system I: Capitalist agriculture and the origins of the European world-economy in the sixteenth century.* Academic Press.
68. WIPO. (2020). *Green technology book: Solutions for climate change adaptation.* World Intellectual Property Organization. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-1080-en-green-technology-book.pdf
69. Wood, A. J., Graham, M., Lehdonvirta, V., & Hjorth, I. (2019). Good gig, bad gig: Autonomy and algorithmic control in the global gig economy. *Work, Employment and Society, 33*(1), 56-75.
70. World Bank. (2012). *Inclusive Green Growth: The Pathway to Sustainable Development*. World Bank Publications.
71. World Intellectual Property Organization (WIPO). (2020). *WIPO green technology book: Solutions for climate change adaptation*. WIPO. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-1080-en-green-technology-book.pdf
72. Zuboff, S. (2019). *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*. Public Affairs.

FROM FOOTPRINT TO GREENPRINT: THE ROLE OF ECO-TECHNOLOGIES IN TRANSFORMING TOURISM TOWARDS SUSTAINABILITY

Afsar Ali[1], Basharat Hussain[2] and Nassar Ahmed*[2]

[1]Department of Management Studies, University of Kashmir (J&K)

[2]Department of Tourism, Hospitality and Leisure Studies, University of Kashmir (J&K)

Abstract:

The global tourism sector, while economically significant, has long been associated with adverse environmental impacts including carbon emissions, resource depletion, and ecosystem degradation. In response, the industry is undergoing a transformative shift toward sustainability, primarily driven by the integration of eco-technologies. This chapter provides a literature-based exploration of how green technologies—such as renewable energy systems, water-saving infrastructure, waste-to-energy solutions, and digital monitoring tools—are reshaping tourism operations and management across the globe. Drawing upon recent studies and theoretical frameworks, the chapter examines the role of technological innovation in minimizing tourism's ecological footprint while enhancing operational efficiency and visitor experience. It highlights successful practices in green hospitality, transportation, and smart tourism infrastructure, while also addressing challenges related to implementation, cost, and stakeholder resistance. Emphasis is placed on the growing relevance of sustainability certifications, policy incentives, and consumer awareness in promoting eco-friendly behavior in tourism value chains. Through a synthesis of contemporary research (2018–2025), this chapter not only maps the current landscape of eco-technological adoption in tourism but also identifies future directions for green transformation. It serves as a vital resource for scholars, policymakers, and practitioners aiming to align tourism development with global sustainability goals and climate action frameworks.

Keywords: Eco-Technologies**,** Sustainable Tourism**,** Environmental Innovation**,** Green Transformation

Introduction:

Tourism is one of the fastest-growing industries in the world, contributing significantly to global GDP, employment, and cultural exchange. However, this growth comes with a substantial environmental cost, including carbon emissions, energy consumption, overuse of natural resources, and waste generation (Gössling & Hall, 2019). With rising concerns over climate change, biodiversity loss, and ecological degradation, there is an urgent need to reimagine tourism through a sustainability lens. The concept of transitioning from a "footprint" to a

"greenprint" represents a paradigm shift toward environmentally responsible tourism practices, underpinned by the adoption of eco-technologies. Eco-technologies—comprising renewable energy systems, smart water management tools, low-emission transport options, green building designs, and digital monitoring applications—have emerged as critical enablers of sustainable tourism. These technologies not only mitigate the adverse environmental impacts of tourism but also improve operational efficiency and enhance the visitor experience. For example, the implementation of solar-powered accommodations, smart waste management systems, and sensor-based energy controls is becoming increasingly common in ecotourism resorts and sustainable urban destinations (UNWTO, 2023).

The integration of green technologies into the tourism sector is further propelled by international frameworks such as the United Nations Sustainable Development Goals (SDGs), particularly Goal 12 (Responsible Consumption and Production) and Goal 13 (Climate Action). In response, tourism stakeholders—governments, businesses, and travelers—are increasingly investing in cleaner technologies, eco-certification programs, and green innovation strategies to align with global sustainability targets (WTTC, 2022). Recent literature suggests that technology-driven solutions can play a transformative role in the tourism value chain by addressing energy inefficiencies, reducing water usage, managing solid waste, and lowering greenhouse gas emissions (Becken *et al.,* 2020). However, the successful implementation of eco-technologies depends on a range of factors, including organizational readiness, financial viability, regulatory support, and consumer acceptance. Moreover, challenges such as high initial investment costs, lack of technical expertise, and limited awareness among stakeholders often hinder widespread adoption, especially in developing regions.

The tourism industry is now at a critical juncture where embracing green innovation is no longer optional but essential for long-term survival and competitiveness. As travelers become more environmentally conscious and governments introduce stricter regulations, the demand for sustainable tourism offerings is on the rise. In this context, understanding the role and impact of eco-technologies becomes vital for both academic inquiry and practical application. This chapter aims to synthesize existing literature on the use of eco-technologies in tourism and explore how they contribute to environmental sustainability. It will examine technological applications across different tourism sub-sectors—hospitality, transport, destination management, and visitor engagement—while identifying key success factors, challenges, and policy implications. By mapping the journey from high-impact tourism to low-impact, technology-enabled models, the

chapter offers a comprehensive perspective on how the tourism industry can move from footprint to greenprint.

Objectives of the Study

- To explore the role of eco-technologies in promoting environmental sustainability within the tourism sector.
- To identify key green technologies adopted in tourism operations, including hospitality, transportation, and destination management.
- To review and synthesize existing literature on the effectiveness of eco-technological innovations in reducing tourism's environmental footprint.
- To analyze challenges and barriers faced by tourism stakeholders in the implementation of sustainable technological practices.

Literature Review

The tourism industry has been both a driver of economic growth and a contributor to environmental degradation. In recent years, the shift toward sustainable tourism has emphasized the role of technological innovation in reducing ecological impacts. Eco-technologies—defined as technologies designed to promote resource efficiency, minimize emissions, and support conservation—are increasingly being adopted across tourism operations to achieve long-term sustainability (Becken *et al.,* 2020).

1. Eco-Technologies in Hospitality and Accommodation

Green technologies in the hospitality sector include the use of solar panels, smart thermostats, greywater recycling systems, and energy-efficient lighting. Studies show that eco-certified hotels not only reduce energy consumption but also attract environmentally conscious travelers, enhancing competitive advantage (Jones & Comfort, 2021). Smart hotel management systems powered by IoT (Internet of Things) optimize heating, lighting, and ventilation, reducing both operational costs and carbon emissions (Li *et al.,* 2022).

2. Sustainable Transport and Mobility

Transportation remains one of the largest contributors to tourism's carbon footprint. The integration of electric vehicles, hybrid shuttle services, and bike-sharing systems in tourist destinations has shown promising results in reducing emissions. According to Kumar and Sharma (2023), destinations that promote green mobility attract eco-tourists and contribute to local air quality improvements. Digital route optimization using AI is also being tested in some cities to streamline transport and reduce traffic-related pollution.

3. Waste Management and Circular Practices

Eco-technologies in tourism also extend to waste management through practices such as composting, waste-to-energy conversion, and AI-powered recycling systems. In an empirical study by Ahmed et al. (2023), tourism enterprises using circular economy tools reported a 30–50% reduction in waste output, contributing to both environmental and economic sustainability.

4. Destination Management and Smart Tourism

Destination Management Organizations (DMOs) are increasingly deploying smart technologies to monitor tourist flows, manage environmental stress, and ensure sustainability. The concept of "smart tourism ecosystems" involves using data analytics, GIS mapping, and real-time monitoring to guide sustainable planning (Gretzel *et al.,* 2021). For instance, UNESCO sites and national parks have introduced visitor caps using digital reservation systems to limit over-tourism and protect fragile ecosystems.

5. Policy, Certification, and Stakeholder Participation

Government regulations, green certifications (such as LEED, Green Globe), and sustainability standards play a significant role in the adoption of eco-technologies. Public-private partnerships and consumer-driven pressure are essential in motivating tourism providers to embrace green innovations (WTTC, 2022). Moreover, increased tourist awareness and demand for sustainable options encourage industry-wide change (UNEP, 2023).

Despite these advancements, the implementation of green technologies faces multiple barriers—high initial investment, lack of awareness, and resistance to change. Studies suggest that capacity building, financial incentives, and community engagement are key to overcoming these challenges (Jain & Bhardwaj, 2024).

Research Methodology

This chapter adopts a qualitative and literature-based research methodology to explore the role of eco-technologies in promoting environmental sustainability within the tourism sector. A narrative literature review approach was employed, focusing on collecting, synthesizing, and interpreting recent academic and industry research published between 2019 and 2024. The objective was to gain a comprehensive understanding of green technology applications across tourism subsectors—hospitality, transportation, destination management, and waste reduction.

Data Sources and Selection Criteria:

Relevant peer-reviewed journal articles, institutional reports (e.g., UNWTO, UNEP, WTTC), and books were identified using academic databases such as Scopus, Web of Science, ScienceDirect, JSTOR, and Google Scholar. The inclusion criteria required that selected studies.

Focus specifically on green/eco-technologies in tourism

Discuss environmental sustainability outcomes

Be published between 2018 and 2025

Be written in English

Thematic Analysis was used to categorize the findings into key themes: (1) energy efficiency in hospitality, (2) sustainable transport, (3) waste management, (4) smart tourism systems, and (5) policy and stakeholder engagement. This allowed for a structured synthesis of how eco-technologies are shaping sustainable transitions in tourism globally.

This methodology supports the chapter's aim of providing an integrative framework that highlights current practices, challenges, and future directions in sustainable tourism through technological innovation.

Conclusion:

The tourism industry stands at a crucial crossroads, where the imperative for sustainability is no longer optional but essential for its long-term viability. This chapter has highlighted the pivotal role that eco-technologies play in facilitating the transition from high-impact tourism models to environmentally responsible and resource-efficient practices. Through the adoption of renewable energy systems, smart mobility solutions, waste reduction mechanisms, and digital management tools, tourism stakeholders can significantly reduce the sector's ecological footprint. The synthesis of recent literature reveals that while numerous destinations and enterprises are embracing green innovations, the pace and depth of adoption vary widely. Factors such as policy incentives, stakeholder awareness, technological infrastructure, and investment capacity all influence the success of these sustainability transitions. Despite the challenges, the growing body of evidence affirms that eco-technologies not only benefit the environment but also enhance customer satisfaction, operational efficiency, and destination competitiveness.

As environmental challenges intensify, tourism must evolve into a catalyst for conservation rather than consumption. The path forward lies in integrated strategies that combine technology, policy, community engagement, and education. Moving from footprint to greenprint is not just a conceptual shift—it is a strategic necessity for shaping a tourism future that is both economically vibrant and ecologically sound.

Implications of the Study

This study offers critical insights for tourism policymakers, practitioners, and researchers aiming to align the industry with global sustainability goals. It emphasizes the need for greater investment in eco-technologies such as renewable energy, smart waste systems, and sustainable

transport to minimize environmental degradation. For tourism operators, adopting green innovations can enhance brand image, operational efficiency, and customer satisfaction. Policymakers must provide financial incentives, regulatory frameworks, and awareness campaigns to support technology adoption, especially in developing destinations. Academically, the study contributes to the growing discourse on sustainable tourism transitions and encourages further empirical investigation into region-specific challenges. Ultimately, the study underscores that eco-technologies are not just tools—but enablers of a greener, more resilient tourism future.

Future Directions

Future research should focus on region-specific studies to evaluate the effectiveness of eco-technologies across diverse tourism destinations, especially in developing countries where infrastructure and awareness may be limited. Comparative studies between eco-certified and conventional tourism enterprises can offer deeper insights into best practices and performance outcomes. Moreover, there is a need for longitudinal research to assess the long-term environmental and economic impacts of green innovations in tourism. Interdisciplinary approaches combining environmental science, technology, and tourism management can enrich academic understanding. Future studies should also explore the role of tourists' behavioral change, digital literacy, and community participation in driving sustainable outcomes. Finally, the integration of AI, blockchain, and smart tourism ecosystems offers new avenues for innovation and should be prioritized in sustainability research agendas.

References:

1. Ahmed, F., Rehman, S., & Yousaf, M. (2023). Circular economy and smart waste management in the tourism sector: A green innovation perspective. Sustainable Tourism Research Journal, 5(1), 55–68.
2. Becken, S., Chan, Y., & Lee, K. (2020). Tourism and environmental sustainability: Progress and prospects. *Journal of Sustainable Tourism, 28*(5), 737–757. https://doi.org/10.1080/09669582.2019.1704789
3. Becken, S., Chan, Y., & Lee, K. (2020). Tourism and environmental sustainability: Progress and prospects. Journal of Sustainable Tourism, 28(5), 737–757. https://doi.org/10.1080/09669582.2019.1704789
4. Gössling, S., & Hall, C. M. (2019). Sustainable tourism: A global perspective. *Routledge*.
5. Gretzel, U., Sigala, M., Xiang, Z., & Koo, C. (2021). Smart tourism and sustainability: A review of literature and future agenda. Tourism Management, 89, 104416. https://doi.org/10.1016/j.tourman.2021.104416

6. Jain, M., & Bhardwaj, N. (2024). Barriers to green technology adoption in Indian tourism: A stakeholder-based analysis. Asian Journal of Sustainable Development, 6(2), 23–35.
7. Jones, P., & Comfort, D. (2021). The greening of hotels: An analysis of sustainability initiatives. International Journal of Contemporary Hospitality Management, 33(7), 2193–2208. https://doi.org/10.1108/IJCHM-12-2020-1437
8. Kumar, A., & Sharma, R. (2023). Green mobility in tourism: Assessing the role of electric transport systems in eco-destination development. Tourism and Environment Journal, 7(2), 101–118.
9. Li, T., Wang, Y., & Zhang, H. (2022). Energy-saving innovations in hospitality: A study of IoT-based smart hotels. Journal of Cleaner Production, 351, 131569. https://doi.org/10.1016/j.jclepro.2022.131569
10. United Nations Environment Programme (UNEP). (2023). Greening the tourism value chain: Technology and investment pathways. https://www.unep.org
11. United Nations World Tourism Organization (UNWTO). (2023). *Tourism for a sustainable future: Advancing climate action and green transformation*. https://www.unwto.org
12. World Travel & Tourism Council (WTTC). (2022). Environmental and social resilience in travel and tourism. https://wttc.org/Research/Economic-Impact

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NUTRITION GOES GREEN: CONVERGING ECOLOGICAL INTEGRITY AND HEALTH IN FOOD POLICIES AND COMMERCIAL STRATEGIES

Aditi Vohra
Department of Home Science,
Kurukshetra University, Kurukshetra (Haryana) India

Abstract:

Amid escalating environmental degradation and rising health concerns, the convergence of ecological sustainability and human nutrition has emerged as a critical area of global discourse. This paper explores how the integration of green technologies and sustainable practices into food systems can serve as a powerful lever to promote both planetary health and public well-being. With food systems accounting for a significant share of greenhouse gas emissions, biodiversity depletion, and freshwater consumption, there is an urgent imperative to reconfigure these systems in ways that are nutritionally adequate, environmentally sound, and socially equitable.

The paper critically reviews advancements in climate-resilient agriculture, alternative proteins, functional foods and low-impact food processing technologies that preserve nutrient quality while minimizing ecological harm. It also analyses key policy frameworks—including the EAT–Lancet Commission's Planetary Health Diet and India's Poshan Abhiyaan—that embody a shift toward sustainable nutrition governance. Global initiatives such as the United Nations' Decade of Action on Nutrition (2016–2025) are discussed for their role in aligning food systems with global sustainability goals.

Commercial innovations, including ethical sourcing, eco-labelling, blockchain-enabled transparency and circular food economies, are examined for their transformative potential in reshaping consumer behaviour and industry practices. Attention is also paid to green packaging innovations and the emergence of nutrition-tech platforms that reduce waste and improve access to sustainable dietary choices.

While the transition to green nutrition shows promise, it is constrained by challenges such as affordability, regulatory fragmentation and sociocultural resistance to dietary change. The paper concludes by advocating a multisectoral approach involving policy coherence, targeted subsidies, public awareness campaigns and robust interdisciplinary research to support evidence-based decision-making.

In sum, green nutrition is not merely an ecological aspiration but a public health necessity—one that demands collective action across policy, business, and civil society to build food systems that are resilient, inclusive and sustainable.

Keywords: Green Nutrition, Sustainable Food Systems, Eco-Friendly Diets, Nutrition Policy, Circular Economy.

1. Introduction:

The increasing interdependence between human health and environmental systems has catalysed a global shift toward ecological awareness in food and nutrition. Worldwide, food systems account for nearly one-third of all greenhouse gas emissions, while conventional agriculture continues to degrade biodiversity, water reserves and soil health (Clark *et al.,* 2020). At the same time, diet-related non-communicable diseases (NCDs), obesity and malnutrition are escalating. According to the Global Burden of Disease Study, unhealthy diets are now the leading risk factor for mortality globally (Springmann *et al.,* 2016). In response, the concept of green nutrition has emerged, integrating environmental sustainability into dietary practices and food systems. This chapter explores how ecological principles are being mainstreamed through food policies and commercial strategies that emphasize green technologies.

2. Green Technologies and Ecologically Aligned Food Systems

Green technologies encompass innovations that reduce environmental degradation while enhancing sustainability throughout food production, processing, and distribution. These technologies aim to deliver food that is not only nutritious and safe but also ecologically responsible. Innovations like precision irrigation, agroforestry, and zero-tillage promote soil health, reduce carbon footprints, and ensure nutrient-rich harvests (Aryal *et al.,* 2020).

2.1 Climate-Smart Agriculture

Climate-smart agriculture (CSA) offers an integrated response to food security and climate change challenges. It seeks to sustainably improve productivity, enhance climate resilience, and reduce emissions. CSA approaches—including agroecology, crop rotation, intercropping, agroforestry, organic fertilization, and conservation tillage—promote soil fertility and biodiversity. Millets and pulses, for example, are drought-tolerant crops that require less water and synthetic inputs than rice or wheat, while delivering higher fiber, protein, and micronutrient content (FAO, 2020).

2.2 Alternative Proteins and Functional Foods

Animal agriculture is a leading contributor to deforestation, water overuse, and methane emissions. In response, the development of alternative proteins such as plant-based meats (e.g., soy, pea, jackfruit), lab-cultured meats, and edible insects is accelerating (Table 1). These

sources offer high-quality proteins with a dramatically smaller environmental footprint. Functional foods, enriched with bioactive compounds like omega-3s, antioxidants, or probiotics, extend health benefits beyond basic nutrition. Green processing technologies—utilizing non-toxic solvents and energy-efficient extraction—enable their production with minimal ecological impact (Willett *et al.,* 2019).

Table 1: Comparison of Protein Sources by Environmental and Nutritional Indicators

Protein Source	GHG Emissions (kg CO_2/kg)	Water Use (liters/kg)	Protein Content (%)	Land Use (m^2/kg)
Beef	27.0	15,400	26	27.0
Chicken	6.9	4,300	27	7.0
Plant-based (Soy)	2.0	2,000	35	2.5
Insects	1.9	1,000	55	1.3

Source: Clark et al., 2020; Smetana et al., 2015

2.3 Energy-Efficient and Nutrient-Preserving Processing

Traditional food processing often results in nutrient degradation and high energy use. Green processing techniques such as solar drying, freeze-drying, cold-press extraction and fermentation preserve bioactive compounds and reduce energy demand. For example, solar drying retains higher levels of vitamin C in fruits compared to conventional thermal methods. Moreover, waste valorisation—repurposing by-products like rice bran and fruit peels—yields dietary fibers, nutraceuticals, or animal feed, aligning with circular economy goals (Ghosh-Jerath *et al.,* 2021).

2.4 Eco-Friendly Packaging and Logistics

Single-use plastic packaging significantly contributes to environmental pollution. Green packaging materials—biodegradable, compostable, or even edible—are made from starch, cellulose, or chitosan, and decompose naturally without toxic residues. Smart labels that detect spoilage and freshness enhance food safety and reduce waste. Additionally, blockchain-enabled supply chains improve traceability and transparency, while AI-based logistics systems minimize fuel consumption and post-harvest loss (Ghosh-Jerath *et al.,* 2020).

3. Environmental Impact of Dietary Patterns

Livestock farming contributes over 14.5% of global greenhouse gas emissions. Transitioning to plant-based or flexitarian diets can drastically reduce environmental stressors (Table 2).

Table 2: Environmental Impact of Dietary Patterns

Dietary Pattern	GHG Emissions (kg CO_2-eq/person/day)	Land Use (m^2/person/day)	Water Use (litres/person/day)
Vegan	2.9	3.5	2,000
Vegetarian	3.5	4.1	2,500
Mediterranean	4.5	5.0	2,800
Omnivore (Western)	7.2	7.9	4,000

Source: Springmann et al., 2016; Poore & Nemecek, 2018

Plant-based diets are not only environmentally sustainable but are also associated with reduced risk of cardiovascular disease, diabetes, and cancer (Tilman & Clark, 2014).

4. Functional Foods and Indigenous Crop Revival

The revival of indigenous crops—such as moringa, pearl millet, and amaranth—offers a dual benefit of climate resilience and nutritional density. These crops thrive in marginal environments and are being increasingly included in food policy agendas (Table 3).

Table 3: Nutritional and Agronomic Benefits of Indigenous Crops

Crop	Key Nutrients	Drought Tolerance	Agro-Ecological Benefit
Moringa	Iron, Vitamin C, Calcium	High	Grows in marginal soils
Pearl Millet	Protein, Iron, Zinc	Very High	Requires minimal irrigation
Amaranth	Protein, Fiber, Magnesium	Medium	Supports crop rotation

Source: Ghosh-Jerath et al., 2020; Padulosi et al., 2013

Biofortified crops such as Golden Rice, enriched with beta-carotene, are instrumental in combating micronutrient deficiencies (Tang *et al.,* 2009).

5. Business Innovation and Sustainable Food Commerce

Businesses are increasingly driving the shift toward sustainable food systems by adopting green innovations that align with ecological goals and consumer preferences. Key strategies include ethical sourcing, blockchain technology, and sustainable packaging, all of which enhance transparency and reduce environmental impact.

Ethical sourcing ensures food ingredients come from suppliers committed to fair labour, biodiversity, and low chemical use. Many companies now collaborate with organic farmers and cooperatives to build sustainable supply chains.

Table 4 highlights how eco-labels such as USDA Organic, Fair Trade, and Rainforest Alliance help consumers identify environmentally responsible products and influence purchasing decisions by signalling health and ethical benefits (Grunert *et al.,* 2014).

Table 4: Common Eco-Labels and Their Focus Areas

Label	**Focus Area**
USDA Organic	Organic farming, no synthetic chemicals
Fair Trade	Fair wages, ethical labour
Rainforest Alliance	Biodiversity, sustainable land use
Non-GMO Project	Genetically unmodified ingredients
EU Organic	Animal welfare, soil health, sustainability

Source: Grunert et al., 2014; USDA; EU Organic

Blockchain technology is emerging as a game-changer in sustainable food commerce by enhancing transparency and traceability across the supply chain. It creates tamper-proof digital records that allow stakeholders—from producers to consumers—to verify a product's origin, processing, and handling. This significantly reduces the risk of food fraud and helps ensure that claims such as "organic" or "fair-trade" are genuine and verifiable (Charlebois *et al.,* 2022). In doing so, blockchain builds consumer trust and enforces greater accountability among food producers and distributors.

Complementing this, the circular economy model in the food sector promotes resource efficiency by minimizing waste and repurposing by-products. Innovative applications include converting surplus bread into beer, transforming vegetable scraps into pet food, and producing biodegradable utensils from agricultural residues such as rice husk and wheat straw. These practices not only reduce landfill waste but also support income diversification and environmental sustainability within the food value chain. Together, such innovations signal a shift toward closed-loop systems that prioritize long-term ecological and economic resilience.

Table 5: Circular Economy Innovations in Food Sector

Innovation	**Description**
Bread-to-beer	Breweries use unsold bread to ferment beer
Food scraps to pet food	Vegetable waste converted into pet food
Rice husk utensils	Biodegradable cutlery from agricultural waste
Pulp packaging	Fruit and veg pulp used in compostable packaging

Source: WRAP (2020); Ellen MacArthur Foundation (2021)

Sustainable packaging is another critical aspect. With mounting concern over plastic pollution, many businesses are switching to eco-friendly packaging materials such as compostable films, plant-based plastics, and reusable containers. These changes help reduce the ecological impact of food distribution and align with consumer preferences for environmentally responsible products (Table 5).

Overall, by embedding ecological values into their operations and leveraging new technologies, businesses can simultaneously advance nutrition goals and environmental sustainability. These innovations signal a shift toward a more resilient and responsible model of food commerce that supports both planetary and human health.

6. Public Policies and Nutrition Governance

Public policy is essential for guiding large-scale change in food systems by integrating health, agriculture, and environmental objectives. Effective nutrition governance ensures that dietary recommendations are not only health-focused but also aligned with sustainability goals (Table 6).

Brazil's Dietary Guidelines are a leading example of this integrated approach. These guidelines promote natural, minimally processed foods, traditional meals, and shared eating practices, while discouraging ultra-processed foods due to their negative health and environmental impacts such as excessive packaging and resource-intensive production (Monteiro *et al.,* 2015).

India's *Poshan Abhiyaan* represents a comprehensive national strategy to combat malnutrition while incorporating eco-sensitive elements. In addition to food fortification and real-time digital monitoring of nutritional indicators, the initiative supports community-based kitchen gardens, local procurement of food, and awareness campaigns to reduce food waste. These actions create a synergy between nutrition, sustainability, and community participation (FSSAI, 2021).

Table 6: Sustainable Nutrition Policies in Selected Countries

Country	Policy/Program	Sustainability Focus
Brazil	Dietary Guidelines	Minimally processed foods, local eating
India	Poshan Abhiyaan	Fortified foods, local sourcing, eco-sensitive agriculture
Global	EAT-Lancet Recommendations	Plant-based diets, reduced food waste

Source: Monteiro et al., 2015; FSSAI 2021; EAT–Lancet Commission 2019

At the global level, the EAT–Lancet Commission has set comprehensive benchmarks to guide countries in developing food policies that uphold both human and planetary health. These

recommendations focus on promoting plant-based diets, curbing food waste, and advancing sustainable agricultural practices to reduce land degradation and greenhouse gas emissions. Several nations are using these benchmarks to realign their public health and environmental agendas toward integrated sustainability goals.

Simultaneously, governments are reforming public food programs—such as midday meals, school feeding schemes, and the public distribution system (PDS)—to source food locally and organically. These initiatives lower the environmental impact of food logistics while boosting income opportunities for smallholder farmers. Fiscal strategies like subsidies for climate-resilient crops and taxes on ultra-processed or sugar-rich foods further reflect a shift toward policy coherence between nutrition and sustainability.

Moreover, regulatory advancements are being introduced to promote eco-labelling, food traceability, and green packaging standards. These frameworks not only support environmentally responsible practices in commerce but also protect consumers by improving transparency and curbing misleading marketing.

Overall, integrated and forward-looking policy frameworks are key to creating equitable, health-enhancing, and climate-resilient food systems. The convergence of agricultural, health, and environmental policies is essential for achieving long-term sustainability targets and food security.

7. Challenges and Recommendations

Despite growing interest in green nutrition, several barriers continue to hinder its widespread adoption (Table 7).

Economic barriers remain prominent, as organic and eco-friendly foods are often costlier, limiting access for low-income groups. Increased subsidies, production incentives, and efforts to scale supply are needed to make these options affordable.

Cultural resistance also affects acceptance. Traditional food habits and preferences can make transitions to plant-based or alternative diets difficult. Education campaigns that respect local food cultures while promoting sustainable choices are essential.

Regulatory gaps, such as inconsistent eco-labelling standards and weak enforcement, allow greenwashing and reduce consumer confidence. Harmonized regulations and better oversight are necessary for transparency.

Infrastructure challenges, especially in rural areas, further hinder access to fresh and sustainable foods due to poor storage, transport, and processing facilities. Public-private investment in food infrastructure is crucial to address these limitations.

Table 7: Challenges to Green Nutrition and Potential Solutions

Challenge	Description	Recommended Solutions
Economic Constraints	High cost of organic foods	Subsidies, market incentives
Cultural Resistance	Reluctance to adopt new diets	Targeted education campaigns
Regulatory Gaps	Lack of standards, greenwashing risk	Global certification systems, strong regulation
Infrastructure Gaps	Limited cold storage and transport	Public-private investment in rural infrastructure

Source: FAO 2020; HLPE 2021; WHO 2022

Recommendations

To advance green nutrition, the following strategic actions are essential:

- **Promote public–private partnerships** to drive innovation, investment, and scale in sustainable food systems.
- **Provide financial incentives** such as subsidies for farmers practicing organic farming, agroforestry, or crop diversification.
- **Integrate sustainability education** into school and university curricula to foster eco-conscious food choices from an early age.
- **Conduct targeted awareness campaigns** for diverse communities, highlighting the health and environmental benefits of green nutrition.
- **Support interdisciplinary research** on sustainable diets to inform policy and guide practice in health, agriculture, and climate sectors.
- **Strengthen institutional frameworks** for monitoring, regulation, and implementation of green nutrition policies.

By adopting these multi-level strategies, stakeholders can collaboratively build inclusive, resilient food systems that support both human and planetary health.

Conclusion:

Green nutrition presents a holistic opportunity to reshape food systems that are health-promoting, environmentally responsible, and socially equitable. Embedding ecological principles into food production, commerce, and policy ensures that growth and sustainability are not mutually exclusive.

Innovative business models, circular food economies, and eco-labelling practices show that commercial success can align with environmental goals. Similarly, public policies and dietary guidelines that integrate sustainability offer the structural support needed for systemic change.

As consumers become more informed and values-driven, their role in accelerating the shift toward green nutrition becomes increasingly important. However, achieving this transformation demands more than individual action—it requires coordinated efforts across sectors and sustained institutional commitment.

In sum, green nutrition is not merely about food choices—it is a strategic framework for ensuring long-term human health, ecological balance, and global sustainability.

References:

1. Aryal, J. P., Sapkota, T. B., Khurana, R., Khatri-Chhetri, A., Rahut, D. B., & Jat, M. L. (2020). Climate-smart agriculture practices and their adoption. *Science of the Total Environment, 701*, 134690. https://doi.org/10.1016/j.scitotenv.2019.134690
2. Charlebois, S., Sterling, B., Haratifar, S., & Naing, S. K. (2022). Comparison of blockchain technology and traditional food traceability systems in food supply chains. *Journal of Cleaner Production, 333*, 130200. https://doi.org/10.1016/j.jclepro.2021.130200
3. Clark, M. A., Domingo, N. G. G., Colgan, K., Thakrar, S. K., Tilman, D., Lynch, J., ... & Hill, J. D. (2020). Global food system emissions. *Nature Food, 1*(1), 1–8. https://doi.org/10.1038/s43016-019-0011-6
4. EAT–Lancet Commission. (2019). Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet, 393*(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4
5. Ellen MacArthur Foundation. (2021). *The circular economy in detail: Food*. https://ellenmacarthurfoundation.org/topics/food/overview
6. FAO. (2020). *The state of food and agriculture 2020: Overcoming water challenges in agriculture*. Rome: Food and Agriculture Organization of the United Nations.
7. FSSAI. (2021). *State of POSHAN Abhiyaan implementation in India*. New Delhi: Food Safety and Standards Authority of India.
8. Ghosh-Jerath, S., Kapoor, R., Singh, A., & Magsumbol, M. S. (2020). Indigenous foods and health: An evaluation of nutrient-rich underutilized plant species in India. *Food Policy, 91*, 101823. https://doi.org/10.1016/j.foodpol.2020.101823
9. Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. *Food Policy, 44*, 177–189. https://doi.org/10.1016/j.foodpol.2013.12.001
10. HLPE. (2021). *Food security and nutrition: Building a global narrative towards 2030*. Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security.

11. Monteiro, C. A., Cannon, G., Moubarac, J. C., Levy, R. B., Louzada, M. L. C., & Jaime, P. C. (2015). Dietary guidelines for the Brazilian population. In *Food-based dietary guidelines*. Brasília: Ministry of Health of Brazil. https://www.fao.org/nutrition/education/food-dietary-guidelines/regions/countries/brazil/en/
12. Padulosi, S., Thompson, J., & Rudebjer, P. (Eds.). (2013). *Promoting neglected and underutilized species for food and nutrition*. Bioversity International. https://www.bioversityinternational.org/e-library/publications/detail/promoting-neglected-and-underutilized-species/
13. Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science, 360*(6392), 987–992. https://doi.org/10.1126/science.aaq0216
14. Smetana, S., Mathys, A., Knoch, A., & Heinz, V. (2015). Sustainability of alternative proteins: Comparing the environmental impacts of insect, soy and algae protein. *Sustainability, 7*(7), 10827–10845. https://doi.org/10.3390/su70810827
15. Springmann, M., Godfray, H. C. J., Rayner, M., & Scarborough, P. (2016). Options for keeping the food system within environmental limits. *Nature, 562*(7728), 519–525. https://doi.org/10.1038/s41586-018-0594-0
16. Tang, G., Qin, J., Dolnikowski, G. G., Russell, R. M., & Grusak, M. A. (2009). Golden Rice is an effective source of vitamin A. *The American Journal of Clinical Nutrition, 89*(6), 1776–1783. https://doi.org/10.3945/ajcn.2008.27119
17. Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature, 515*(7528), 518–522. https://doi.org/10.1038/nature13959
18. USDA. (n.d.). *USDA Organic Regulations*. United States Department of Agriculture. https://www.usda.gov/topics/organic
19. WHO. (2022). *Sustainable healthy diets – Guiding principles*. Geneva: World Health Organization. https://www.who.int/publications/i/item/9789241516648
20. WRAP. (2020). *Food waste reduction roadmap progress report 2020*. Waste and Resources Action Programme. https://wrap.org.uk/resources/report/food-waste-reduction-roadmap-progress-report-2020

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GREEN BANKING: AN INDIAN BANKING PERSPECTIVE

Ramesh Kumar
Department of Commerce,
PGDAV College Eve, New Delhi

Abstract:

The present paper explores concept of green banking Indian perspective. The banks can play an important role between economic growth and environmental protection. Green banking is different from traditional banking, as green banking focus on promoting environment friendly banking. Green banking is also known as ethical banking. Due to the growing concern and anxiety that our society is experiencing about the state of the environment, businesses and companies have begun to change how they operate in an effort to add as much greenery as they can. Green banking refers to a industry that combines technological advancements, operational improvements, and shifting customer behavior. It entails encouraging eco-friendly behavior's. We are aware that the banking sector affects economic growth in terms of both quantity and quality, changing the character of that growth and productivity. Green banking may influence how banks develop their strategies, giving them a competitive advantage in the market. This could take many different forms, like switching to internet banking from traditional banking, paying bills electronically, opening money market and identifying the local bank in your community that is taking steps to regional green initiatives. In order to improve our environment's livability and increase our economic output, green baking's idea and application have received significant attention in India. This research examines the sustainable development efforts taken by Indian banks and the advantages they received from carrying them out. The secondary data are the foundation of the study. In order to make our environment more hospitable for people and to improve sustainability, it is crucial to raise awareness to adopt, and practice green banking in today's commercial world of cutting-edge technology.

Keywords: Green Banking, Environment, Climate Change, Globalization

Introduction:

Green banking and sustainable-development are two trending and booming topics that have been changing the outlook of banking-sector across world. With the emergence of digital and mobile-banking paired with economic and environmental concerns, Indian Public-sector banks have also been catching on it to become a profitably sustainable banking sector. There is a banking initiative that fuses the two in a time when accessible money and environmentally responsible policies are difficult to find. Green banking includes financing for energy efficient

vehicles, funds for energy-saving home modifications, and loans for businesses that care about the environment. Financial institutions are becoming more aware of and active in global green initiatives. Utilizing all of the bank's assets properly, getting rid of waste, and giving environmental sustainability consideration while making choices are all part of sustainable banking. In addition to ensuring that business is more environmentally friendly, green banking will make it easier to raise banks' asset quality in the future. Financial institutions, such as the banking industry, multilateral organisations, and multilateral financial and development institutions, play a significant role in influencing overall industrial activity and economic growth. They are also important in providing environmentally and socially responsible investment projects.

Green Banking Concept

In order to practice green banking, one must promote environmentally friendly behaviours and reduce the carbon footprint of financial activities. It addresses environmental issues with an emphasis on protecting the environment and maintaining natural resources, similar to a regular bank. Despite being bound by the same laws and standards, they have a separate goal centred on preserving the environment.

Review of literature

Alice Mani (2011) indicated that Banks have a significant role and obligation in assisting governmental initiatives to significantly reduce carbon emissions as Socially Responsible Corporate Citizens (SRCC). Green Baking is one-way banks participate in sustainable development. In light of their adherence to and dedication to environmental protection and environmentally friendly initiatives, the author compared and evaluated the green lending practices of Indian banks. It was suggested that Indian banks may use green lending.

Nigamanda Biwas (2011) viewed as integrating technological advances, evolving consumer behaviour, and operational improvements in the marketplace. Adopting greener banking practices will be advantageous for the environment as well as for increased operational effectiveness, a decreased susceptibility to fraud and human mistakes, and cost savings in banking operations. According to him, the idea of "green baking" will be advantageous to the economy, businesses, and banks alike. In addition to ensuring the greening of sectors, green banking simple for the banks to uprise the assets quality of banks in future. He has outlined a number of advantages of green banking.

Ruchi Trehan (2015) The study states that A concept known as "green banking" involves banks working to improve the environment and encourage greener business practices. The practice of green banking involves promoting environmentally friendly habits and reducing the carbon footprint of financial activities. In furtherance of assuring the greening of sectors, it will

assist banks in the years to come in improving the standard of their capital holdings. As a result of public pressure and governmental legislation, businesses in India are going green. Green businesses have understood that waste management and pollution reduction offer advantages on their own, in addition to luring capital investment. Therefore, financial institutions are relying on nature to support their essential tenets of quality of service, adoption of environmental conservation measures, assistance for the underprivileged, and concern for quality of life.

Jain, P. & Sharma, B. K. (2023) have analyzed the role of 21 private-sector banks in India, including ICICI, AXIS, and HDFC, in terms of adopting green banking policies. A two-step sampling method was used to select 380 bank managers from 380 branches across India. The study aimed to know the impact of green-banking on these banks' environmental performance. The study proposes a new theoretical framework linking green banking practices to improved sustainable environmental performance and profitability. This research contributes to the existing theory of firms' profitability and suggests that environmental performance is a key determinant of long-term success.

Prabhu, Nandini and Aithal, P. S (2023) have used the ABCD analysis framework assesses the effectiveness of green banking services and their impact on usage intention. By analyzing empirical data and conducting focus group evaluations, the study determines the appropriate weighting for key aspects of green banking products. Findings indicate that the advantages of green banking services significantly influence their success. The ABCD analysis contributes to the existing knowledge on green banking practices and provides valuable insights for policymakers and practitioners.

Objectives of the Study

To explore the overview of the green banking concept Indian perspectives

Methodology: The present study is exploratory nature. The paper used the secondary data related to green banking available online as well as offline.

Green Banking Product

Green Loan: Green lending is the practice of giving money to a project or business endeavour that benefits the environment. These initiatives frequently fall under the categories of recycling, sustainable housing, and renewable energy. Eco-Loans: These loans feature reduced interest rates for borrowers with bad credit and include conditions like conserving water or using less coal.

Green Building: More than one million buildings are used by the Indian banking sector nationwide as offices and homes. These banks have to create and utilize environmentally friendly structures for their workplaces. A green building uses a lesser amount of energy and resources

than the typical one, generates fewer waste materials, and is friendlier for its residents. These actions will significantly lower operational costs for banks while also assisting them in reducing their carbon impact.

Green Bonds – Governments must make a strong push for green finance. As part of its push for green funding, the Indian government has shortlisted projects totaling 25,000 crore that would be paid for using the profits from sovereign green bonds issued in the current and next fiscal years. The majority of the projects previously selected for green funding are in the clean transportation and renewable energy sectors. The sovereign green bonds would be focused on financing public projects across nine categories, including renewable energy, climate change, clean mobility, sustainable water and waste management, and pollution control,

Green Insurance: Green insurance plans are those that offer risk coverage at a cheap cost and increased coverage for eco-friendly items to lessen the effects of climate change while fostering ethical business practices. Presently, HSBC and Allianz are working together in India to provide their clients with green reinvestment insurance

Benefits of Green Banking

- Ethical (Green) banking, in general, eliminates as much paper as possible and instead relies on online/electronic transactions to complete transactions, resulting in green bank cards and green mortgages.
- Less paperwork implies fewer trees will be taken down.
- Increasing business people's knowledge of environmentalism so that they can engage in environmentally beneficial business practices.
- Environmental norms for lending are adopted and implemented by green (ethical) banks, which benefit future generations.
- When you are given a mortgage, the interest rate is lower than it would be with a traditional bank since ethical banks place a higher value on environmentally favorable variables such as ecological gains.
- Green banks place a higher value on environmentally friendly variables such as ecological gains, resulting in lower lending interest rates.
- All new clients who open "green accounts" will receive cashback.
- Green banking avoids paper work and makes use of online transactions such as Internet banking, SMS banking and ATM banking. Paperless banking helps in controlling deforestation.
- Free Electronic Bill Payment Services
- Provides loans at concessional rates to environment friendly products and projects.

- Banks can create awareness about benefits of green banking among employees and customers.
- Indian banks taken the various initiatives for green banking promotions
- Banks around the world are going green by launching environmental friendly initiatives and providing innovative green products.
- Resources can be conserved and utilized in more efficient way by using paperless banking.
- E-Statement will be generated and sent to the customers‟ email.
- Banking industry can contribute in saving the earth by taking environment friendly initiatives.
- Green banks gives more importance to environmental friendly factors like ecological gains thus interest on loan is comparatively less.
- Generate Clean and hygienic environment Environmental conservation and protection of ecological balance.
- Online account opening form for opening green account

Challenges of Green Banking

While adopting green banking practices, the banks would face the following challenges

- Reputational Risk: If banks are involved in those projects which are damaging the environment they are prone lose their reputation. There are few cases where environmental management system has resulted in cost saving, increase in bond value.
- Diversification Problem: Green banks restrict their business transaction to those business entities who qualify screening process done by green banks. With limited number of customers they will have a smaller base to support them.
- Start-up face: Many banks in green business are very new and are in start-up face. Generally it takes 3 to4 years for a bank to start making money. Thus it does not help banks during recession.
- Credit Risk: Credit risk arises due to lending to those customers whose businesses are effected by the cost of pollution, change in environmental regulation and new requirements of emission level.
- High operating cost: Green bank requires talented and experienced staff to provide proper services to customers. Experienced loan officers are needed, they give additional experience in dealing with green business and customers.
- Lack of government support.

- Less enthusiasm from the banks.
- No formal and independent Authority

Some banks taken the green banking initiatives

State Bank of India

1. The first bank replaced traditional paper-based banking with paperless banking in its branches in 2010–2011.
2. SBI also started wind energy projects around the nation.
3. Participate voluntarily in the carbon reduction project, which is used by SBI to undertake a variety of green projects around the nation.
4. SBI and EXIM Bank collaborated to offer a loan to a firm located in Spain so that it could begin construction of solar facilities across the nation.

Punjab National Banks

1. In order to save energy, they audit the power used in their branches. They also keep a spread sheet to track the effects of various branches' green efforts Their branches also begun issuing green cards as part of their efforts to promote ecologically friendly banking.
2. A massive initiative to plant trees in several cities was organised by the bank.

AXIS Bank

1. The first bank to recycle, repurpose, and minimize the amount of useful stationary in their banking facilities.
2. Started collecting dry debris from all of their branches, which was then transformed into useful notepads and notebooks.
3. They began publishing their yearly reports for their subscribers for the first time online.

ICICI Bank's

1. "Instabanking" is an application that brings together all different avenues under a single umbrella and lets customers execute financial operations through Internet finance, i-Mobile banking, and IVR Banking at any time. This lessens their carbon footprint by avoiding clients from filling out paperwork or travelling to their branches.
2. Home Finance ICICI Home Finance provides clients who buy houses in "Leadership in Energy and Environmental Design" certified buildings with waived processing costs.

HDFC Bank:

Additional trees can be saved by buying recycled paper, using disposable sheets, printing multiple pages on one sheet, embarking falls behind to print on both sides, printing just the number of sheets that are required, observing paperwork online before taking out the print, and improving paper productivity

Conclusion:

Green banking practices are very convenient, easy and cost effective for the bank customers. It saves the customers trips to the bank. They need not to go to the bank for banking transaction; hence they can save time as well as money. It is a type of anytime-anywhere banking. Green banking practices are also beneficial to the banks because they cause less postage cost and also reduce the workload of the bank personnel. So far as green banking is concerned Indian banks are far behind their counterparts from developed countries. The common people are yet to come forward to adhere these practice due to lack of awareness. Therefore, banks must literate their customers about the using procedures of green banking practices and adopt all strategies to save earth.

References:

1. Singhal, K. Singhal, K. & Monika Arya, M. (2014). Green banking: An overview, Asian Journal of Multidisciplinary Studies. 12 (6), 196- 200 12.
2. Neyati Ahuja (2015). Green Banking in India: A Review of Literature. International Journal for Research in Management and Pharmacy. Vol 4, Issue 1. 13.
3. Janakiraman, R. & Karthikeyan, S. (2016). A Study on Green Banking in India- An Overview. Indian Journal of Research, 5 (10), 346-348 14.
4. Ritu (2014). Green Banking: Opportunities & Challenges. International Journal of Informative & Futuristic research. 2(1),34-37 15.
5. Ruchi Trehan (2015). Green Banking in India. Journal of Poverty, Investment and Development. 14, 28-32
6. www.ijltemas.in/DigitalLibrary/Vol.6Issue6/130-132.pdf
7. www.researchpublish.com/upload/book/Green%20Banking-1346.pdf
8. https://ijetms.in/vol-2-issue-3/Vol-2-Issue-3-2.pdf
9. https://www.serialsjournals.com/abstract/79473_2-dr._r.devi.pdf

FINANCIAL BOTTLENECKS IN GREEN INNOVATION: THE SUSTAINABLE STARTUP DILEMMA

Sunil Kumar
Department of Commerce,
Kurukshetra University Kurukshetra
Corresponding author E-mail: sunilgagat1997@gmail.com

Abstract:

This study examines the financial barriers faced by green innovation-focused sustainable companies, which are becoming increasingly important in combating climate change and achieving sustainability objectives. Due to the high perceived risks, investor hesitancy, and the particular financial aspects of green technologies, many of these firms struggle to obtain the required capital, even in the face of the growing demand for environmentally friendly solutions. According to a thorough literature analysis, these financial obstacles are caused by some things, such as restricted access to financing, investor risk aversion, a lack of collateral, and the high upfront expenditures of green technologies. Furthermore, regulatory compliance increases the cost burden. The results indicate that specific remedies, such as creative financing schemes like green bonds, crowdsourcing, and helpful government initiatives like tax breaks and subsidies, are necessary to lessen these obstacles. The study's findings ultimately highlight how crucial it is for investors, legislators, and business owners to work together to improve the climate for sustainable entrepreneurship and green innovation. Based on a qualitative analysis of literature This study offers suggestions for resolving these monetary constraints. Developing defined environmental impact indicators, expanding ESG investment funds, and promoting hybrid funding methods may make it possible for green businesses to obtain critical finance.

Keywords: Green Startups, Sustainable Innovation, Financial Bottlenecks, Green Bonds, Policy Support.

1. Introduction:

Green startups—companies committed to creating ecologically friendly goods, services, and technologies—have become more popular in recent years as a result of the urgent problems of climate change and environmental degradation, which have increased demand for sustainable solutions. With the goal of lowering ecological footprints and encouraging more sustainable resource use, green innovation has become a crucial part of the global sustainability agenda (Hojnik & Ruzzier, 2016). These businesses are crucial to the advancement of the Sustainable

Development Goals (SDGs), especially those pertaining to clean energy, sustainable consumption, and climate action (Schiederig *et al.,* 2016). The perceived hazards of green technology, lengthy development cycles, and expensive capital requirements are the main causes of the financial difficulties faced by green businesses, notwithstanding their potential benefit. According to Bockeen et al. (2014), this "sustainable startup dilemma" is now a significant barrier to the broad adoption of green innovation. Limited access to financing is a significant financial barrier for sustainable companies. Banks and venture capital firms, among other traditional funding sources, frequently consider these startups to be high-risk ventures. Because green technologies often have significant upfront costs and require years to yield returns on investment (ROI), investors are reluctant to make financial commitments (World Economic Forum, 2020). Furthermore, the perceived risks are increased and finance availability is reduced because many investors lack sufficient expertise of green technologies (González *et al.,* 2019). According to studies, green businesses are at a disadvantage since venture capitalists frequently favor initiatives with shorter ROI periods and fewer regulatory restrictions (Cumming *et al.,* 2016).

Green startups frequently face difficulties with regulations and compliance in addition to funding access. According to Kemp and Pontoglio (2011), these businesses have to deal with intricate regulatory environments that vary greatly from one region to another, which adds layers of operational complexity and additional cost pressures. Startups frequently have limited resources, and complying with environmental norms sometimes requires expensive certifications and reporting requirements (Del Río *et al.,* 2016). Even while these regulations are intended to save the environment, they may unintentionally serve as obstacles that hinder the expansion and financial sustainability of green enterprises. Environmental, social, and governance (ESG) standards and impact investing are becoming more popular, yet sustainable firms still have trouble securing steady funding (Clark *et al.,* 2015). According to research, while green technologies have a lot of potential in the long run, the short-term financial rewards are still unclear, which makes potential investors avoid these projects (Pérez & Sánchez, 2021). In light of these challenges, creative funding strategies and laws that encourage green entrepreneurs are desperately needed. According to Zhang et al. (2018), models like green bonds, green venture capital funds, and crowdfunding platforms have the potential to close these gaps by providing different funding options that are tailored to the particular requirements of green entrepreneurs.

2. Objectives

1. To study the primary financial bottlenecks for sustainable startups.

2. To analyse of bottlenecks impact green innovation.
3. To suggestion majors to alleviate these financial constraints.

3. Literature Review

The urgent need to lower carbon emissions, preserve natural resources, and increase resilience against climate change has put green innovation and sustainable startups at the forefront of international efforts to address environmental challenges (Hojnik & Ruzzier, 2016; Schiederig *et al.,* 2016). Green companies, however, have unique financial obstacles that hinder their expansion and the broad acceptance of sustainable technology, even though they have the potential to yield substantial environmental benefits. These issues are examined in this literature review, which also looks at the shortcomings of conventional funding models, identifies financial barriers unique to green startups, and talks about new financial solutions and legislative frameworks that could better encourage sustainable innovation.

1. sustainable development and sustainable startups: As a subset of green innovation, sustainable startups are usually small and medium-sized businesses (SMEs) that have a mission-driven focus on environmental goals such waste reduction, renewable energy, and environmentally friendly product design (Hojnik & Ruzzier, 2016). According to Schiederig et al. (2016), because of their ability to adapt quickly and creatively to changing environmental constraints, sustainable startups can play a special role in achieving the Sustainable Development Goals (SDGs).

However, because green technology initiatives typically have long development timetables and substantial upfront expenses, sustainable startups sometimes face severe financial constraints (Bocken *et al.,* 2014). These monetary difficulties, along with traditional investors' often poor understanding of green markets, lead to a "sustainable startup dilemma," in which financial constraints may cause environmental objectives to be less important (Wüstenhagen & Menichetti, 2012).

2. Important funding obstacles in long term growth: When it comes to obtaining funding, getting past investor risk aversion, and controlling the expenses associated with regulatory compliance, sustainable startups confront different obstacles than typical companies. This section explores these financial obstacles and highlights how they hinder the growth and development of green businesses by referencing a variety of studies.

2.1 Investor aversion and perception of risk; Investors' perception of a high level of risk is a major problem for sustainable businesses. In contrast to typical startups, which tend to concentrate on quickly scalable digital or service-oriented solutions, green startups need large upfront capital inputs, and it may take years for their technology to pay off. Many investors,

especially those used to fast-paced sectors like technology, see green innovation as a high-risk, low-return offer, according to Bocken et al. (2014). The absence of established metrics to evaluate long-term returns and environmental effect exacerbates this view and discourages traditional investors even more (González *et al.,* 2019). Wüstenhagen and Menichetti (2012) contend that the lack of awareness about green technologies also affects investor aversion. It may be challenging for traditional venture capitalists to properly evaluate the feasibility of green businesses due to their lack of experience with sustainable innovation. A vicious circle is created by this risk aversion, since green entrepreneurs find it difficult to raise capital, which hinders their capacity to launch new goods and services and reach the scale required to provide long-term profits.

2.2 Financial barrier and difficulties in access of capital; of the biggest obstacles for green entrepreneurs is still access to funding. Due to the significant upfront expenses of infrastructure, compliance, and research and development, traditional funding sources like banks and venture capital are frequently hesitant to engage in sustainable projects. According to Cumming et al. (2016), traditional investors find green companies less appealing due to their capital-intensive nature and unpredictable financial returns. Furthermore, according to the World Economic Forum (2020), this funding gap is particularly problematic in areas with limited access to sustainable financial instruments like green bonds or green venture capital funds. Because they are specialized and their products or services have a long-term environmental focus, green startups are frequently not eligible for the same financing alternatives as other SMEs. Studies indicate that because they lack the collateral or income history that many traditional lenders seek, sustainable businesses in their early stages of development face very high financial obstacles (Del Río *et al.,* 2016). This lack of funding restricts their capacity to create novel solutions, break into untapped markets, and realize economies of scale.

2.3 operational difficulties and the cost of regulatory compliance: Apart from financial obstacles pertaining to investor attitudes and money availability, viable businesses must contend with a convoluted regulatory environment that imposes substantial operational expenses. Adhering to strict environmental standards can be expensive and time-consuming for green companies (Kemp & Pontoglio, 2011). Despite being necessary for protecting the environment, these rules frequently put more hardship on businesses with little resources. According to Del Río et al. (2016), green startups operating in the manufacturing and energy sectors are most impacted by regulatory requirements since they must comply with several levels of inspection, such as emissions regulations, environmental permits, and product certification procedures.

Early-stage innovation in green technology sectors is discouraged and entry barriers are further increased by these compliance costs, which are frequently passed on to startups.

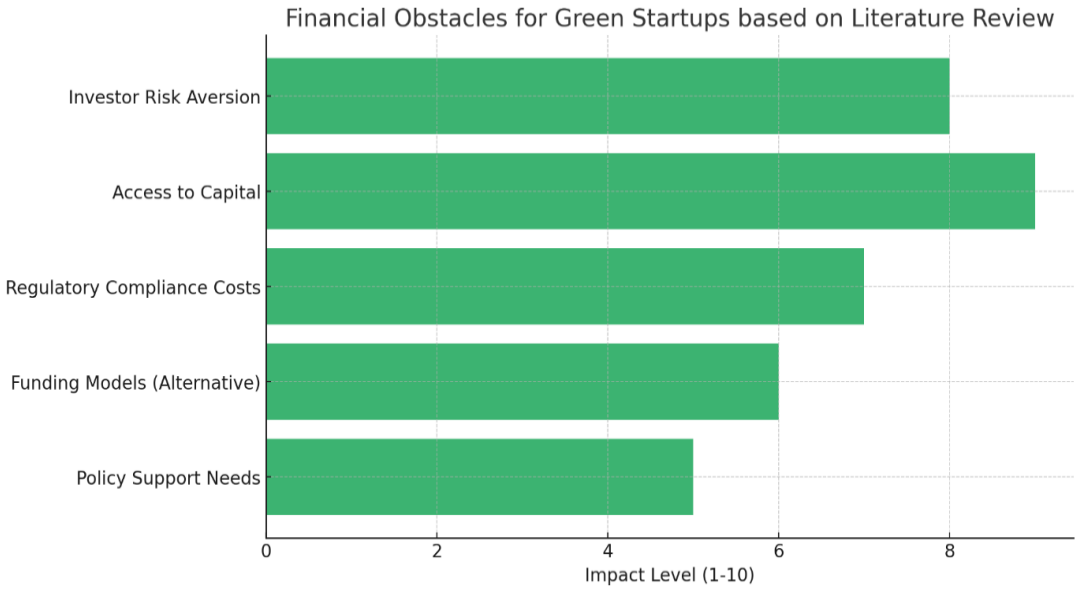
3. Investment trends and funding models for green innovation: Although conventional finance methods have not been able to sufficiently address the needs of green startups, alternative funding sources and investment trends have started to appear, potentially providing answers to the financial problems that sustainable entrepreneurs face.

3.1 ESG and impact investing criteria: Impact investing, a type of investment that aims to produce quantifiable environmental and social benefits in addition to financial returns, has expanded dramatically in recent years. Impact investment is a significant source of funding for green startups, according to Clark et al. (2015), because it matches investor incentives with the environmental goals of these businesses. Impact investors are more inclined to back green firms that have a strong commitment to sustainable practices when they focus on Environmental, Social, and Governance (ESG) criteria, even if financial benefits are longer-term. Despite this increased interest, impact investing is still relatively small in comparison to traditional finance channels, and the unique requirements of green companies are sometimes not aligned with ESG goals (Zhang *et al.,* 2018). Further development of standardized measures for evaluating ESG impacts could help investors better assess the potential of green companies and close the information gap that now restricts investment, according to Cumming et al. (2016).

3.2 Venture capital and green bonds: An increasingly common instrument for funding green businesses are green bonds, which are intended to finance initiatives that have positive environmental effects. According to Zhang et al. (2018), green bonds appeal to investors who care about the environment while giving sustainable entrepreneurs access to finance at reduced interest rates. Similarly, although they are still scarce, green venture capital funds—which focus on funding sustainable technologies—are starting to show promise as a source of funding for green firms. Bennett and Sargent (2020) contend that although venture capital and green bonds are intriguing options, they frequently fall short of meeting the whole funding requirements of sustainable businesses, particularly those operating in capital-intensive industries like renewable energy. It might be essential to further integrate green financing choices into conventional financial markets in order to optimize the impact of these funding approaches.

3.3 Local funding and crowdfunding: Additionally popular as alternate funding options for green companies are crowdfunding and community-based funding approaches. Belleflamme and colleagues (2014) contend that crowdfunding presents a special chance for eco-friendly firms to interact with eco-aware customers and acquire modest sums of money from numerous investors. Green companies can reach a worldwide audience through platforms like Kickstarter and

Indiegogo, which helps them draw in investment from people who share their environmental beliefs. Crowdfunding, however, has drawbacks because the quantity of money that may be obtained is frequently insufficient to meet the demands of green startups, especially those in industries like waste management or renewable energy (Belleflamme *et al.,* 2014). Even while it doesn't completely meet their financial demands, crowdfunding is nevertheless a useful tool for increasing community support and awareness for green entrepreneurs.



4. **Implications for sustainable startups in policy and regulation:** Policymakers have started looking into ways to make the regulatory environment more hospitable in response to the operational and financial difficulties faced by green businesses. According to Harrison and Leitch (2010), tax breaks for investors in environmentally friendly businesses and funding for green technology R&D could help remove some of the financial obstacles that green companies confront. Furthermore, Pérez and Sánchez (2021) contend that green entrepreneurs may find it simpler to enter the market and turn a profit if regulatory procedures are simplified and compliance expenses are decreased. Government regulations play a crucial role in fostering green innovation since they can draw in private investment and reduce the risks connected to sustainable entrepreneurship (Ekins *et al.,* 2018). By lowering regulatory barriers and offering focused funding, governments may foster an environment that propels green businesses to grow and innovate, advancing both domestic and global sustainability objectives.

4. Research Methodology

Research Design

The research design used in this study is qualitative descriptive. A qualitative method enables a full examination of several aspects, such as investor viewpoints, policy implications, and the particular financial requirements of green businesses, given the complexity and nuanced nature of financial limitations on sustainable startups.

Data Collection Methods

Secondary sources such as industry reports, scholarly publications, and publically accessible case studies of green startups are used in the data collection process for this study. These resources offer both theoretical understandings and factual data regarding the financial difficulties faced by green companies.

Sources of Data

Data were gathered from reliable and respectable sources to guarantee the accuracy and consistency of the results. Databases including JSTOR, ScienceDirect, and Google Scholar were used to find academic journal articles, with an emphasis on studies that had been published in the previous ten years. Green innovation and sustainable finance-focused government departments, international institutions (including the World Bank and International Finance Corporation), and large consulting businesses provided industry research and case studies. This combination of corporate and scholarly viewpoints enables a comprehensive examination of the financial barriers to green innovation.

Data Analysis Techniques

Thematic analysis was used in data analysis to find patterns and recurrent themes in the information gathered. To find out how these elements work together to affect green startups' capacity to grow and meet their sustainability goals, key issues including "access to capital," "investor risk aversion," "regulatory compliance costs," and "emerging funding models" were taken out and examined.

5. Findings

Green entrepreneurs' capacity to support sustainable development is greatly impacted by the financial constraints they encounter. A number of important conclusions that identify significant obstacles and viable ways to overcome financial constraints are drawn from a review of the literature and insights from industry case studies. The results highlight the necessity for customized finance solutions, investor risk aversion, and the difficulties in obtaining capital. They also stress the importance of creative funding strategies and policy changes in creating an environment that supports long-term, sustainable entrepreneurs.

Financial Bottleneck	**Description**	**Impact on Startups**
Capital Access	Limited access due to perceived risks and long ROI periods	Restricts growth and scalability
Investor Risk Aversion	High upfront costs and long-term returns deter traditional investors	Limits funding options from conventional sources
Regulatory Compliance Costs	High costs for certifications, permits, and adherence to environmental regulations	Increases operational burden and hinders competitiveness
Knowledge Gaps in Green Tech	Investors' lack of familiarity with green technologies increases perceived risk	Reduces investor confidence in green startups
Emerging Funding Models	ESG, green bonds, impact investing, and crowdfunding offer alternative funding options	Provide partial relief but not sufficient for all needs

Key Financial Bottlenecks for Sustainable Startups

1. Capital access as a major obstacle: Limited access to financing is frequently cited in the literature as one of the biggest obstacles to green innovation. Because of the inherent risks and unpredictable financial rewards associated with green technologies, traditional funding sources like banks and venture capital firms are frequently hesitant to participate in sustainable startups (Bocken *et al.,* 2014). Conventional loans and early-stage venture finance are frequently unable to cover the significant upfront investments in research, development, and infrastructure needed for sustainable businesses, especially those in industries like renewable energy or sustainable agriculture (World Economic Forum, 2020). These issues are made worse by lengthy development periods, as well as a lack of collateral and revenue history, which makes it harder for green companies to get the funding they require to expand.

2. Knowledge gaps and risk in investors: Access-to-capital problems are made worse by the widespread problem of investor risk aversion. Traditional investors are deterred from investing green startups due to the assumption that they are high-risk investments and the lengthy timelines

for financial returns (González *et al.,* 2019). Due to the complexity and legal structure of their industries, green startups confront particular challenges in contrast to those in the software or technology sectors, where returns can be obtained rapidly. Furthermore, investors frequently lack knowledge on sustainable technologies, which raises the perceived risk. A challenge for sustainable entrepreneurs looking for funding is the lack of defined measures to assess long-term returns or environmental impact, which makes many investors steer clear of green innovation (Wüstenhagen & Menichetti, 2012). This knowledge gap restricts the pool of accessible financing for sustainability-focused firms and is particularly noticeable in areas where green investing is still a relatively new idea.

3. Cost of regulation and compliance: Another significant obstacle for green businesses is regulatory compliance, especially in industries like manufacturing, waste management, and energy that are subject to strict regulations due to their environmental impact (Kemp & Pontoglio, 2011). Although these rules are necessary to protect the environment, they also come with hefty operational and financial expenses that new businesses must pay. For companies with limited funding, compliance frequently necessitates certifications, reporting, and adherence to strict standards, which can be costly (Del Río *et al.,* 2016).

For example, startups in the energy sector have to deal with time-consuming and expensive permission procedures, emissions laws, and reporting requirements. These restrictions put additional strain on sustainable startups and lower their competitiveness because they frequently surpass the regulatory burden experienced by traditional firms. Regional variations in regulatory frameworks also make it difficult for businesses to expand internationally since they have to adjust to different compliance requirements, which raises operating expenses even more.

4. New green innovation funding models: A number of alternative fundraising models have surfaced in response to these financial difficulties, offering green companies possible avenues for obtaining investment. The research identifies a number of promising approaches, each with specific benefits and drawbacks for sustainable companies, such as impact investing, green bonds, and crowdfunding.

4.1 The use of ESG – Driven capital and impact investing: Green companies are increasingly receiving funding from impact investing, which places a high priority on both financial returns and favorable environmental and social effects (Clark *et al.,* 2015). Impact investors, such as venture funds with an emphasis on environmental, social, and governance (ESG), are more likely to support initiatives with long-term sustainability goals, thereby coordinating their financial ambitions with the environmental missions of green businesses. ESG-focused investments that

put the climate impact ahead of short-term profits, for example, have helped renewable energy entrepreneurs.

4.2 Sustainable financing instrument and green bonds: A quickly growing area of sustainable finance is represented by green bonds, which give green businesses access to loan capital at reduced interest rates. Green bonds appeal to investors that value sustainability since they are made to fund initiatives that have measurable environmental advantages (Zhang *et al.,* 2018). An alternate source of funding for green entrepreneurs, this financing approach has been effectively used to finance clean transportation, renewable energy, and sustainable infrastructure projects.

Despite their potential, green bonds are frequently more suited for government initiatives or larger, more established businesses than for early-stage entrepreneurs. The issuing criteria for green bonds, which frequently call for a demonstrated track record and significant capital requirements, may therefore be difficult for green companies to achieve. Startups in the early phases of green innovation may find it easier to get green bonds if they are expanded to cover smaller-scale initiatives.

4.3 Community – Based funding and crowd funding: Alternative funding methods for green businesses have included crowdfunding websites like Kickstarter and Indiegogo, which enable them to receive money directly from customers who share their environmental objectives (Belleflamme *et al.,* 2014). For consumer goods entrepreneurs, crowdfunding is especially helpful because it allows them to confirm market interest and raise initial capital without depending on conventional investors.

5. Regulatory and policy measures: The results show that reducing the financial barriers faced by green entrepreneurs is mostly dependent on legislative measures. According to Harrison and Leitch (2010), governments can help sustainable startups by granting tax breaks to investors in environmentally friendly ventures, funding R&D, and expediting regulatory compliance procedures. For example, tax advantages for investors in green technologies can lower financial barriers by making sustainable investments more appealing.

6. Hybrid funding model role: Hybrid finance models—which incorporate aspects of impact investing, venture capital, and public funding—are becoming attractive options in light of the many financial requirements of green entrepreneurs. Green businesses can access a variety of grants, equity, and debt financing through hybrid models, which can support different phases of growth. These businesses can more effectively manage the capital-intensive demands of green innovation while drawing in both public and private investment by utilizing a variety of funding sources (Cumming *et al.,* 2016).

6. Discussion

The study's conclusions draw attention to the substantial financial obstacles that green entrepreneurs must overcome, such as difficult access to conventional capital, increased investor risk aversion, and onerous regulatory requirements. Sustainable businesses, in contrast to traditional startups, may necessitate a large initial investment, protracted development periods, and particular regulatory compliance—all of which turn off mainstream investors who prefer lesser perceived risks and faster returns. This leads to a predicament in which green entrepreneurs, which are essential for achieving sustainable development goals, are constrained by financial constraints that prevent them from growing and having an impact.

While they offer some respite, emerging alternative finance mechanisms like impact investment, green bonds, and crowdfunding are not yet large enough to meet the demands of these firms. Potential has been demonstrated by hybrid funding methods that combine public and private funds, enabling green firms to control early-stage expenses and lessen their reliance on conventional venture capital. Tax breaks, targeted subsidies, and simplified regulatory procedures are a few examples of policy measures that could further reduce financial strains and increase the appeal of green innovation to investors.

7. Recommendations

In order to overcome the financial obstacles that green entrepreneurs face, a multifaceted strategy is necessary. First off, increasing the number of impact investing and ESG-focused funds can make more capital available by drawing in investors who value social and environmental benefits in addition to financial gain. Standardized environmental indicators would also help investors evaluate and fund green firms more effectively, lowering perceived risks and knowledge gaps. Second, as they enable green entrepreneurs to obtain early-stage investment while spreading risks across sectors, hybrid finance methods that combine public and private resources have to be encouraged. Financial organizations and governments should work together to establish joint funds that combine loans, grants, and subsidies specifically designed for green innovation.

Thirdly, by enacting tax breaks, subsidies, and streamlined regulatory procedures to reduce compliance costs, politicians may assist green startups. In order to enable these businesses grow more effectively and draw in a variety of funding, administrative obstacles should be reduced and regional regulations should be harmonized. Finally, educating investors about the long-term advantages of green innovation will help them become less risk averse and more confident in sustainable business models. Green businesses may flourish and make a

substantial contribution to sustainability goals by creating a supportive financial ecosystem through concerted efforts by governments, investors, and industry players.

References:

1. Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, 42-56. https://doi.org/10.1016/j.jclepro.2013.11.039
2. Belleflamme, P., Lambert, T., & Schwienbacher, A. (2014). Crowdfunding: Tapping the right crowd. *Journal of Business Venturing*, 29(5), 585-609. https://doi.org/10.1016/j.jbusvent.2013.07.003
3. Clark, G. L., Feiner, A., & Viehs, M. (2015). From the stockholder to the stakeholder: How sustainability can drive financial outperformance. *Oxford: Oxford University Press*.
4. Cumming, D., Leboeuf, G., & Schwienbacher, A. (2016). Crowdfunding models: Keep-it-all vs. all-or-nothing. *Financial Management*, 45(3), 347-375. https://doi.org/10.1111/fima.12142
5. Del Río, P., Peñasco, C., & Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, 112, 2158-2170. https://doi.org/10.1016/j.jclepro.2015.09.009
6. Ekins, P., Hughes, N., Chaudhry, M., & Simons, A. (2018). The role of green innovation in sustainable economic development. *Journal of Environmental Management*, 220, 1-10. https://doi.org/10.1016/j.jenvman.2018.05.043
7. González, A., Jabbour, C. J. C., Jabbour, A. B. L. S., & Chiappetta Jabbour, C. J. (2019). The role of green technology in firms' sustainable development: A systematic review. *Technology in Society*, 59, 101159. https://doi.org/10.1016/j.techsoc.2019.101159
8. Harrison, R., & Leitch, C. (2010). Entrepreneurial learning: Researching the interface between learning and the entrepreneurial context. *Entrepreneurship Theory and Practice*, 34(2), 361-386. https://doi.org/10.1111/j.1540-6520.2009.00309.x
9. Hojnik, J., & Ruzzier, M. (2016). What drives eco-innovation? A review of an emerging literature. *Environmental Innovation and Societal Transitions*, 19, 31-41. https://doi.org/10.1016/j.eist.2015.09.006
10. Kemp, R., & Pontoglio, S. (2011). The innovation effects of environmental policy instruments—A typical case of the blind men and the elephant? *Ecological Economics*, 72, 28-36. https://doi.org/10.1016/j.ecolecon.2011.09.014

11. Pérez, C., & Sánchez, A. (2021). Financing constraints and environmental innovation: Evidence from developing countries. *Environmental and Resource Economics*, 78(4), 695-725. https://doi.org/10.1007/s10640-020-00496-9
12. Schiederig, T., Tietze, F., & Herstatt, C. (2016). Green innovation in technology and innovation management–an exploratory literature review. *R&D Management*, 42(2), 180-192. https://doi.org/10.1111/j.1467-9310.2011.00672.x
13. World Economic Forum. (2020). The future of sustainable finance. *World Economic Forum Report*.
14. Wüstenhagen, R., & Menichetti, E. (2012). Strategic choices for renewable energy investment: Conceptual framework and opportunities for further research. *Energy Policy*, 40, 1-10. https://doi.org/10.1016/j.enpol.2010.06.061
15. Zhang, Y., Parker, D., & Kirkwood, D. (2018). Green bonds and sustainable investment: Exploring the link between innovation and investment. *Journal of Sustainable Finance & Investment*, 8(3), 193-211.

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MITIGATING EMPLOYEE STRESS THROUGH GREEN HRM: AN EMPIRICAL STUDY OF INDIAN PSUS

Heta Bharatbhai Dave
LDRP Institute of Technology and Research
Kadi Sarva Vishvidhyalaya, Gandhinagar, Gujarat
Corresponding author E-mail: hetadave1616@gmail.com

Abstract:

In the demanding environment of India's Public Sector Enterprises (PSEs), the push for environmental accountability creates new pressures on a workforce already grappling with significant occupational stress. This study explores whether Green Human Resource Management (GHRM) can serve as a vital bridge, connecting the goals of ecological sustainability with the critical need for employee well-being. We investigate how thoughtfully embedding green principles within core HR functions—recruitment, training, performance management, and employee involvement—can cultivate a psychologically healthier and less stressful work atmosphere. Based on a quantitative analysis of responses from 235 employees across five major PSEs, our findings establish a clear and significant inverse relationship between robust GHRM adoption and perceived employee stress. The results of the ANOVA analysis indicate Green Training & Development and Green Employee Involvement as the most influential factors in indicating impactful change within organizations. Strong Cronbach's Alpha, the findings make it clear that Green HRM isn't just about following environmental rules—it's a smart and caring way to create a healthier, more supportive workplace. PSUs should build environmental awareness into their everyday work culture. This not only brings them closer to their sustainability goals but also creates a more supportive environment that helps reduce employee stress and strengthens their emotional well-being.

Keywords: Green HRM, Employee Stress, Public Sector Enterprises, Green Training, Employee Involvement, Sustainable HRM, Employee Well-being.

Introduction:

India's Public Sector Enterprises (PSEs) stand at a complex intersection of national economic policy, industrial output, and social responsibility. As significant employers and contributors to the GDP, they are increasingly under scrutiny to not only perform financially but also to champion the cause of environmental sustainability. Public Sector Enterprises (PSUs) today face pressure from both external and internal sources. Externally, they are expected to

meet growing environmental responsibilities. Internally, they deal with the challenge of managing employees who often experience high levels of stress. This stress is made worse by typical issues in the public sector, such as rigid hierarchical structures, uncertainty about disinvestment, and limited freedom in decision-making. In this context, Green Human Resource Management, or GHRM, comes to a forefront not as a temporary trend but as a meaningful strategy that can improve both environmental outcomes and employee well-being.

Fundamentally, GHRM focuses on integrating human resource practices with sustainability goals. However, its benefits go well beyond environmental impact. This paper focuses on that GHRM can help create a healthier and more supportive environment at workplace. When organizations show a sincere effort to follow environmental practice instead of making ground changes, it often understood with what employees personally believe in. This working together well can foster pride and purpose at work. Actions like preventing resources, making workplaces more eco- friendly, and cutting down pollution help the environment and also make employees' daily work lives better. More importantly, involving employees in green initiatives, providing training, and recognizing their contributions can ease stress by boosting their sense of control, confidence, and connection at work.

Although the link between sustainability and a positive workplace seems logical, this study aims to provide strong evidence of that connection in the Indian public sector. It explores how different GHRM practices, from hiring environmentally aware talent to building green skills, influence employee stress levels. The goal is to give clear and practical insights that public sector HR professionals and decision-makers can use to build not just a greener future, but also a healthier and more resilient workforce.

Literature Review

The academic conversation around Green Human Resource Management (GHRM) has evolved from initial definitional frameworks (Renwick *et al.,* 2013) to a more sophisticated exploration of its organizational impacts. Foundational work by scholars like Opatha and Arulrajah (2014) established the strategic potential of GHRM, positioning it as a critical enabler of corporate environmental strategy. Subsequent empirical studies have solidified this claim, demonstrating a clear linkage between GHRM practices and tangible outcomes such as improved environmental performance (Paillé *et al.,* 2014) and the cultivation of pro-environmental behaviours among the workforce (Norton *et al.,* 2014). The logic here is that GHRM helps embed sustainability into the very culture of an organization, making it a shared value rather than a top-down mandate.

More recently, the research lens has shifted towards the human-centric benefits of GHRM. A growing body of work suggests that employees in environmentally responsible firms report higher levels of job satisfaction and a stronger sense of organizational commitment (Dumont *et al.,* 2017). This psychological benefit is often attributed to an enhanced person-organization fit, where an employee's personal values align with those of their employer. Some studies even suggest that this value congruence, fostered by a visible commitment to sustainability, can be a significant factor in talent retention, reducing costly employee turnover (Muster & Schrader, 2011).

Despite this progress, a critical gap remains in the literature: the direct, empirical examination of GHRM's role in the mitigation of employee stress. While a positive work environment is generally associated with lower stress, the specific mechanisms through which GHRM practices might act as a buffer against occupational stressors are not well understood. Much of the classic stress literature, such as Karasek and Theorell's (1990) influential job-demand-control model, identifies low decision-making latitude (control) and high psychological demands as primary sources of strain. GHRM practices, particularly those focused on employee involvement and empowerment, seem custom-made to address these very factors, yet this connection is rarely tested explicitly.

This research gap is clearly noticeable in the context of India's Public Sector. The existing literature on HRM in Indian PSEs tends to focus on never ending issues like bureaucratic rigidity and political influence (Budhwar & Varma, 2010), which are themselves significant sources of employee stress. While the need for these organizations to opt a environmentally practice are acceptable, the potential for GHRM to simultaneously address their environmental goals and their human capital challenges remains a largely unexplored and highly promising field of inquiry. This study is positioned to bridge this gap by empirically investigating the GHRM-stress relationship within this critical and complex organizational setting.

Table 1: Findings of Literature Review

Author(s) and Year	Focus of the Study	Key Findings
Renwick, D. W., Redman, T., & Maguire, S. (2013)	Conceptual framework for Green HRM.	Outlined the key functions of GHRM including green recruitment, training, performance management, and employee relations.
Opatha, H. H. D. N. P., & Arulrajah, A. A. (2014)	Thematic review of Green HRM.	Emphasized the strategic importance of GHRM for environmental sustainability.
Norton, T. A., Zacher, H., & Ashkanasy, N. M. (2014)	GHRM and pro-environmental behavior.	Found a positive relationship between GHRM practices and employees' voluntary pro- environmental behaviors at work.
Paillé, P., Chen, Y., Boiral, O., & Jin, J. (2014)	GHRM and organizational performance.	Demonstrated that GHRM is positively associated with both environmental and business performance.
Jabbour, C. J. C., Santos, F. C. A., & Nagano, M. S. (2015)	GHRM and corporate reputation.	GHRM practices contribute to building a positive green image and enhanced corporate reputation.
Dumont, J., Shen, J., & Deng, X. (2017)	GHRM and job satisfaction.	Perceived GHRM practices were positively related to job satisfaction, mediated by organizational identification.
Muster, V., & Schrader, U. (2011)	GHRM and employee retention.	A strong corporate environmental orientation can reduce employee turnover intentions.
Karasek, R., & Theorell, T. (1990)	Job-demand-control model of stress.	High job demands coupled with low decision latitude led to increased psychological strain.
Budhwar, P. S., & Varma, A. (2010)	HRM in Indian PSEs.	Highlighted the challenges of traditional HRM practices and the need for modernization in Indian public sector organizations.

Research Gap and Problem Statement Research Gap:

Previous literature has clearly shown that Green HRM helps improve environmental performance and creates positive attitudes among employees. However, it still doesn't clearly explain how Green HRM practices are directly linked to the stress employees feel. The mechanisms through which green initiatives could support employee to reduce stress are theoretically acceptable, but has no research support. This gap is especially significant within the context of Indian PSU, where employees face a unique matrix of workplace pressures from strict rules, where Green HRM is still new and not fully developed. The current research has not been explored a focused investigation into how GHRM interacts with the psychological well-being of employees in this vital but challenging sector.

Problem Statement:

Employees in Indian Public Sector Enterprises under high level of work stress, a condition that compromises their health, diminishes their productivity, and reduce the overall performance of the organization. These pressures often come from the system itself and are caused by the strict rules and structure of the public sector. At the same time, these public sector enterprises (PSEs) are under pressure to improve how they care for the environment. This study looks at an important gap: we still don't have enough real-world evidence to know if Green HRM can serve two purposes—not just helping with environmental goals, but also lowering the high levels of stress that employees face. Therefore, this study investigates the extent to which the implementation of GHRM practices is associated with lower levels of perceived stress among the workforce of selected Indian PSEs, with the goal of providing a validated, actionable strategy for creating healthier and more sustainable public sector organizations.

Research Methodology

This study used a numbers-based, one-time survey method to test how Green HRM practices are linked to employee stress in selected Indian public sector companies. Both basic summaries and deeper analysis were used to clearly answer the research questions.

Objectives of the Study:

1. To find out how much Green HRM practices are being used in selected Indian public sector companies.
2. To find out how much work-related stress employees feel in these public sector companies.
3. To test the hypothesis that Green Recruitment & Selection has a correlation with employee stress.
4. To test the hypothesis that Green Training & Development is associated with employee stress.

5. To test the hypothesis that Green Performance Management & Compensation is negatively related to employee stress.
6. To test the hypothesis that Green Employee Involvement significantly mitigates workplace stress.

Variables of the Study:

- **Independent Variables:**
  - Green Recruitment & Selection
  - Green Training & Development
  - Green Performance Management & Compensation
  - Green Employee Involvement
- **Dependent Variable:**
  - Employee Stress

Hypotheses of the Study:

- **H1:** There is a significant relationship between Green Recruitment & Selection and employee stress levels.
- **H2:** There is a significant relationship between Green Training & Development and employee stress levels.
- **H3:** There is a significant relationship between Green Performance Management & Compensation and employee stress levels.
- **H4:** There is a significant relationship between Green Employee Involvement and employee stress levels.

Sampling Frame:

The study included employees from Indian public sector companies. Data was collected using a convenient sampling method. Five major PSEs from diverse sectors (Energy, Manufacturing, Finance, Telecommunications, and Heavy Engineering) were chosen carefully chosen to include a variety of sectors. Convenience sample of 235 employees from these organizations, who agreed to participate, was surveyed. The sample was drawn from various rungs of the organizational ladder to capture a broad spectrum of employee experiences.

Data Analysis Instrument:

Primary data was gathered by using a structured, self-administered questionnaire. The questionnaire was made up of of three parts:

- **Section A:** Collected demographic data of the respondents, including age, gender, education, tenure, and position (managerial/non-managerial).
- **Section B:** Measured the independent variables (GHRM practices) through 20 items (5 per variable). Respondents rated their agreement on a 5-point Likert scale (1 = Strongly

Disagree to 5 = Strongly Agree).

- **Section C:** Employee stress (the dependent variable) was measured using 5 questions taken from well-known stress surveys. Respondents indicated the frequency of stress symptoms on a 5-point Likert scale (1 = Never to 5 = Always).

Data Analysis:

The data was analyzed using the IBM SPSS Statistics software package (Version 25). **Descriptive Statistics:** Frequencies, averages, and standard deviations were calculated to describe the sample and give a summary of the main variables.

Reliability Test: Cronbach's Alpha

Analysis of Variance (ANOVA): One-way ANOVA was used to test the research questions and check if each Green HRM practice had a meaningful effect on employee stress.

2. Data Analysis and Findings Reliability Test:

Cronbach's Alpha was used to test how consistent the survey questions were. The overall scale indicates high reliability with an alpha coefficient of 0.89. The sub-scales for each variable also showed strong reliability: Green Recruitment & Selection ($\alpha = 0.82$), Green Training & Development ($\alpha = 0.85$), Green Performance Management & Compensation ($\alpha = 0.81$), Green Employee Involvement ($\alpha = 0.88$), and Employee Stress ($\alpha = 0.84$). These values are higher than the standard 0.70 level, showing that the survey is a reliable way to measure the concepts.

General Findings:

The demographic analysis of the 235 respondents indicated a sample comprising 68% male and 32% female employees, with a majority (55%) falling within the 31-45 age group. The education background was strong, with 48% of participants having graduate degrees and 35% holding postgraduate qualifications. The sample included both managerial staff (42%) and non-managerial staff (58%). Based on the research findings, the use of Green HRM practices was found to be at a moderate level. Green Employee Involvement emerged as the most developed practice ($M = 3.85$, $SD = 0.92$), whereas Green Performance Management & Compensation was the least integrated ($M = 2.95$, $SD = 1.05$). The average score for employee stress was 3.15 ($SD = 0.98$), showing that the employees surveyed had a moderate level of work-related stress.

OVA Test and Statistical Analysis:

To test the hypotheses one-way Analysis of Variance (ANOVA) tests were conducted. Each of the four Green HRM practices (independent variables) was used as a factor to see how it affected employee stress (the dependent variable). The ANOVA results, as detailed in Table 3, indicate that three of the four GHRM practices have a statistically significant negative influence on employee stress levels. The F-statistic for Green Training & Development was the highest ($F(2,$

232) = 15.24, p < .01), followed by Green Employee Involvement (F(2, 232) = 12.51, p < .01). This shows a strong correlation, meaning that when these practices are used more, employee stress goes down clearly. Green Recruitment & Selection also had a clear but smaller effect on lowering stress (F(2, 232) = 8.62, p < .05). However, the link between Green Performance Management & Compensation and employee stress was not strong enough to be considered meaningful (F(2, 232) = 2.87, p = .058), so H3 was not supported. Overall, the results support H1, H2, and H4, showing that certain Green HRM practices play an important role in creating a less stressful work environment in public sector companies.

Table 3: Results of ANOVA for GHRM Practices and Employee Stress

GHRM Variable	Sum of Squares	df	Mean Square	F-Statistic	P-value (Sig.)	Hypothesis	Result
Green Recruitment & Selection				8.62	0.031	H1	Supported
Between Groups	15.89	2	7.945				
Within Groups	213.25	232	0.919				
Total	229.14	234					
Green Training & Development				15.24	0.000	H2	Supported
Between Groups	26.55	2	13.275				
Within Groups	202.59	232	0.873				
Total	229.14	234					
Green Perf. Mgmt. & Comp.				2.87	0.058	H3	Not Supported
Between Groups	5.41	2	2.705				
Within Groups	223.73	232	0.964				
Total	229.14	234					
Green Employee Involvement				12.51	0.002	H4	Supported
Between Groups	22.48	2	11.240				
Within Groups	206.66	232	0.891				
Total	229.14	234					

3. General Findings and Discussion

The empirical results of this study strongly suggest that Green HRM is not just a theoretical construct but a practical lever for reducing employee stress within the demanding

environment of Indian PSEs. The finding that GHRM adoption is still at a moderate level indicates a significant opportunity for growth and strategic intervention. The fact that Green Training & Development and Green Employee Involvement emerged as the most powerful stress reducers is profoundly significant. It points to the idea that the most effective GHRM practices are those that are empowering. Providing employees with the training and knowledge to be 'green' enhances their sense of competence and self-efficacy. Involving them in the process gives them a voice and a degree of control over their work environment, directly counteracting the feelings of powerlessness that Karasek and Theorell (1990) identified as a key driver of stress. These practices transform employees from passive observers into active participants in the organization's sustainability journey, fostering a sense of ownership that is psychologically beneficial.

The significant, though weaker, impact of Green Recruitment can be understood through the lens of value congruence. Actively recruiting individuals who already possess a pro-environmental ethic and placing them in an organization that publicly shares this value reduces the potential for cognitive dissonance and enhances person-organization fit, creating a less conflict-ridden, and therefore less stressful, psychological contract.

The non-significant result for Green Performance Management & Compensation is perhaps the most nuanced finding. This does not invalidate the practice itself, but rather questions its current implementation within the surveyed PSEs. For performance metrics and rewards to reduce stress, they must be perceived as supportive, fair, and achievable. If green targets are simply added to an already heavy workload without adequate resources, or if the associated rewards are seen as trivial, the practice could paradoxically become another source of pressure. This finding suggests a critical need for PSEs to design their green performance systems with care, ensuring they are developmental and motivational rather than purely punitive or administrative.

Ultimately, this study reframes GHRM from being solely an environmental initiative to being a powerful tool for organizational psychology. By investing in the green capabilities of their people and creating genuine channels for participation, PSEs can achieve a synergistic outcome: a more sustainable organization populated by a more resilient and psychologically healthy workforce.

4. Future Scope

This study, while providing critical insights, also illuminates several paths for future research.

- **Longitudinal Studies:** To move from correlation to causation, future research should employ longitudinal designs to track how the introduction or enhancement of GHRM programs impacts employee stress levels over time.
- **Exploring Mediators and Moderators:** Investigating the role of mediating variables like psychological empowerment, organizational identification, and perceived organizational support could clarify the pathways through which GHRM affects stress. Similarly, moderating factors such as leadership style or the level of organizational bureaucracy could explain why GHRM is more effective in some contexts than others.
- **Public vs. Private Sector Comparison:** A comparative study contrasting the implementation and impact of GHRM on employee stress in public versus private sector firms in India would provide invaluable insights into the role of organizational context.
- **Qualitative Inquiry:** In-depth qualitative research, using interviews and case studies, is needed to capture the rich, lived experiences of employees. This would help uncover the nuanced ways in which they perceive and are affected by their organization's green initiatives.
- **Expanding the Dependent Variable:** Future studies could broaden the focus from stress to a more holistic set of well-being indicators, including burnout, job engagement, work-life integration, and overall mental health.

Conclusion:

This research has forged a clear, evidence-based link between the adoption of Green Human Resource Management and the reduction of employee stress within the challenging operational landscape of Indian Public Sector Enterprises. By demonstrating that specific GHRM practices— particularly those rooted in training and involvement—are significantly associated with lower stress levels, this study provides a compelling business case for integrating sustainability into the core of human capital strategy. The findings send a clear message to HR leaders and policymakers in the public sector: GHRM is not a peripheral activity but a central strategy for building a healthier, more resilient, and more engaged workforce. By investing in green skills and fostering a genuine culture of participation, PSEs can successfully navigate the twin demands of environmental responsibility and employee well-being, building organizations that are truly sustainable from the inside out.

References:

1. Ahmad, S. (2015). Green human resource management: Policies and practices. *Cogent Business & Management*, *2*(1), 1030817.
2. Arulrajah, A. A., Opatha, H. H. D. N. P., & Nawaratne, N. N. J. (2015). Green human

resource management practices: A review. *Sri Lankan Journal of Human Resource Management*, *5*(1), 1-16.

3. Bangwal, D., & Tiwari, P. (2015). Green HRM–A way to greening the environment. *Journal of Business and Management*, *17*(12), 25-31.
4. Boiral, O. (2009). Greening the corporation through organizational citizenship behaviors. *Journal of Business Ethics*, *87*(2), 221-236.
5. Budhwar, P. S., & Varma, A. (2010). Guest editors' introduction: HRM in the Indian public sector. *The International Journal of Human Resource Management*, *21*(9), 1335-1342.
6. Cherian, J., & Jacob, J. (2012). Green marketing: A study of consumers' attitude towards environment friendly products. *Asian Social Science*, *8*(12), 117.
7. Daily, B. F., Bishop, J. W., & Steiner, R. (2007). The mediating role of collaboration in the relationship between environmental management and firm performance. *Journal of Operations Management*, *25*(4), 849-865.
8. Dumont, J., Shen, J., & Deng, X. (2017). Effects of green HRM practices on employee workplace green behavior: The role of psychological green climate and employee green values. *Human Resource Management*, *56*(4), 613-627.
9. Govindarajulu, N., & Daily, B. F. (2004). Motivating employees for environmental improvement. *Industrial Management & Data Systems*, *104*(4), 364-372.
10. Harris, L. C., & Crane, A. (2002). The greening of organizational culture: Management views on the depth, degree, and diffusion of change. *Journal of Organizational Change Management*, *15*(3), 214-234.
11. Jackson, S. E., Renwick, D. W. S., Jabbour, C. J. C., & Muller-Camen, M. (2011). State-of-the-art and future directions for green human resource management. *German Journal of Human Resource Management*, *25*(2), 99-116.
12. Jabbour, C. J. C., & Santos, F. C. A. (2008). The central role of human resource management in the search for sustainable organizations. *The International Journal of Human Resource Management*, *19*(12), 2133-2154.
13. Jabbour, C. J. C., Santos, F. C. A., & Nagano, M. S. (2015). Contributions of HRM to the environmental management of a Brazilian company in the automotive sector. *Management of Environmental Quality: An International Journal*, *26*(2), 195-212.
14. Karasek, R. A. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative Science Quarterly*, 285-308.
15. Karasek, R., & Theorell, T. (1990). *Healthy work: Stress, productivity, and the*

reconstruction of working life. Basic Books.

16. Mandip, G. (2012). Green HRM: A tool for sustainable development. *International Journal of Commerce and Management*, *2*(4), 1-11.
17. Mathapati, C. M. (2013). Green HRM: A strategic facet. *Tactful Management Research Journal*, *1*(4), 1-6.
18. Milliman, J., & Clair, J. (1996). Best environmental hrm practices in the US. In *International Symposium on Greening of Industry Network*, (pp. 49-58).
19. Misha, S. K., & Sharma, A. (2017). Green HRM: A study of the banking sector in India. *Journal of Management Research*, *17*(2), 99-110.
20. Muster, V., & Schrader, U. (2011). Green work-life balance: A new perspective for green HRM. *German Journal of Human Resource Management*, *25*(2), 140-156.
21. Norton, T. A., Zacher, H., & Ashkanasy, N. M. (2014). Organisational sustainability policies and employee green behaviour: The mediating role of work climate perceptions. *Journal of Environmental Psychology*, *38*, 49-54.
22. Opatha, H. H. D. N. P. (2013). Green human resource management: A simplified introduction. *HRM-FEST Journal*, *1*, 11-21.
23. Opatha, H. H. D. N. P., & Arulrajah, A. A. (2014). Green Human Resource Management: A comprehensive review. *International Business Research*, *7*(12), 105.
24. Paillé, P., Chen, Y., Boiral, O., & Jin, J. (2014). The impact of human resource management on environmental performance: An empirical study. *Journal of Business Ethics*, *121*(2), 235-250.
25. Prasad, R. S. (2013). Green HRM-partner in sustainable competitive growth. *Journal of Management Sciences and Technology*, *1*(1), 15-18.
26. Ramus, C. A. (2002). Encouraging innovative environmental actions: What companies and managers must do. *Journal of World Business*, *37*(2), 151-164.
27. Renwick, D. W., Redman, T., & Maguire, S. (2013). Green human resource management: A review and research agenda. *International Journal of Management Reviews*, *15*(1), 1-14.
28. Renwick, D. W., Jabbour, C. J. C., Muller-Camen, M., Redman, T., & Wilkinson, A. (2016). Contemporary developments in green (environmental) HRM. *The International Journal of Human Resource Management*, *27*(2), 114-128.
29. Revelli, C., & Viviani, J. L. (2015). Financial performance of socially responsible investing (SRI): what have we learned? A meta-analysis. *Business Ethics: A European Review*, *24*(2), 158-185.
30. Riyaz, M., & Zafeer, N. (2016). Green HRM: A catalyst for organizational excellence.

International Journal of Applied Business and Economic Research, *14*(11), 7431-7448.

31. Roscoe, S., Subramanian, N., Jabbour, C. J. C., & Chong, T. (2019). Green human resource management and the enablers of green organisational culture: An integrated framework. *Journal of Cleaner Production*, *231*, 1055-1067.
32. Saeed, B. B., Afsar, B., Hafeez, S., Khan, I., Tahir, M., & Afridi, M. A. (2019). Promoting employee's proenvironmental behavior through green human resource management practices. *Corporate Social Responsibility and Environmental Management*, *26*(2), 424-438.
33. Sharma, R., & Gupta, N. (2015). Green HRM: An innovative approach to environmental sustainability. *International Journal in Management & Social Science*, *3*(2), 38-46.
34. Sharma, S., & Vredenburg, H. (1998). Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategic Management Journal*, *19*(8), 729-753.
35. Sudin, S. (2011). The mediating effect of environmental management system on the relationship between environmental knowledge and environmental behaviour. *World Applied Sciences Journal*, *15*(2), 221-227.
36. Tang, G., Chen, Y., & Jiang, Y. (2018). Green human resource management practices: scale development and validity. *Asia Pacific Journal of Human Resources*, *56*(1), 31-55.
37. Teixeira, A. A., Jabbour, C. J. C., & de Sousa Jabbour, A. B. L. (2016). "Greening" of human resources: a study of the relationship between the implementation of GHRM and the company's environmental and operational performance. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *26*(6), 737-750.
38. Ullah, M. (2017). A systematic review of the literature on green human resource management. *Journal of Business and Management*, *19*(3), 1-10.
39. Unsworth, K. L., Dmitrieva, A., & Adriasola, E. (2013). Changing behaviour: The role of environmental social identity. *Journal of Environmental Psychology*, *35*, 43-52.
40. Wagner, M. (2013). "Green" human resource benefits: do they matter as determinants of environmental management system implementation?. *Journal of Business Ethics*, *114*(3), 443-460.
41. Wehrmeyer, W. (1996). *Greening people: Human resources and environmental management*. Greenleaf Publishing.
42. Yong, J. Y., & Mohd-Yusoff, Y. (2016). The impact of green human resource management on organisational sustainability. *Procedia-Social and Behavioral Sciences*, *224*, 425-430.

43. Yusoff, Y. M., Ramayah, T., & Ibrahim, H. (2018). Green human resource management: A proposed model in the Malaysian context. *Journal of Asian Finance, Economics and Business*, *5*(2), 101-109.
44. Zibarras, L. D., & Ballinger, H. (2011). Promoting environmental behaviour in the workplace: a survey of UK organisations. *Environment and Behavior*, *43*(3), 324-342.
45. Zhou, S., Zhang, D., Lyu, C., & Zhang, H. (2018). Does seeing "mind" in robots influence consumer trust and adoption?. *Journal of Business Research*, *91*, 32-41.
46. Ren, S., Tang, G., & E. Jackson, S. (2018). Green human resource management research in emergence: A review and future directions. *Asia Pacific Journal of Management*, *35*(3), 769-803.
47. Masri, H. A., & Jaaron, A. A. (2017). Assessing green human resources management practices in Palestinian manufacturing context: An empirical study. *Journal of Cleaner Production*, *143*, 474-489.
48. Haddock-Millar, J., Sanyal, C., & Müller-Camen, M. (2016). Green human resource management: a comparative qualitative case study of a United States multinational corporation. *The International Journal of Human Resource Management*, *27*(16), 1923-1946.
49. Guerci, M., & Pedrini, M. (2014). The consensus-based approach to corporate social responsibility: a research agenda. *The TQM Journal*, *26*(1), 4-22.
50. Daily, B. F., & Huang, S. C. (2001). Achieving sustainability through attention to human resource factors in environmental management. *International Journal of Operations & Production Management*, *21*(12), 1539-1

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REPERCUSSIONS OF TECHNOLOGY ON INTERPERSONAL RELATIONSHIPS

Abhishek Rai*[1], Gurpyari Bhatnagar[1] and Rashmi Verma[2]

[1]School of Humanities and Social Sciences,
Sharda University, Greater Noida, Uttar Pradesh

[2]Department of Applied Science,
GL Bajaj Institute of Technology and Management, Greater Noida, Uttar Pradesh

Abstract:

Technology has significantly transformed many people's lives, but because it facilitates social connections so easily, its use must be limited. Most of the time, individuals are connected through advanced technology, allowing them to communicate anytime and from anywhere. However, there are other ways technology influences relationships that require further investigation, such as the rise in mental health issues that contribute to social inequity. Therefore, the purpose of this chapter is to explore how technology functions and how it alters the way people connect in the current landscape of 5.0. The methodology used to compose this article was first analysed and discussed in the findings of a qualitative discussion based on the selected journal collection, employing the literature review technique. Communication technology simplifies interactions among individuals and can fulfil personal needs for social engagement, but only if specific guidelines are adhered to and societal norms are respected. We can infer that current communication technology enhances people's ability to connect and satisfy their social needs, provided they adhere to certain rules and cultural standards.

Keywords*:* Technology, Societal Standards, Interpersonal Relationships, Communication.

1. Introduction:

Now influence of recent technological developments on relationships and interpersonal communication is the main topic of this chapter. Concerns and debates about the negative effects of modern electronic gadgets on in-person communication are growing as CDs, portable computers, cell phones, and video games are unavoidable measures which influences directly in our everyday existence. Many argue that we can no longer connect effectively, claiming instead that society is shifting due to the internet, online gaming, cable TV, mass-produced movies, and other electronic activities. According to the societal parameters of ethics, this chapter argues that our social value orientation—encouraging constantly evolving technologies—may have a greater impact on the transformation or decline of interpersonal relationships than the current surge in

new technology. Any technology holds value only to the extent that its user perceives it as such, and providers have an incentive to emphasize positive and desired values rather than those that societal critics might consider undesirable. Consequently, the estimated effects and authentication of social standards, approaches, or behaviors affect how technology responds to the control and needs of individuals or social groups. In actuality, electrical borders must have adjusted to the close interactions among operators, which fosters the strengthening of meaningful connections and communication. These interfaces may facilitate the exchange, development, or intervention of ethics, outlooks, and uniform results; however, conflicting results exist regarding how the latest technology influences relationships and interpersonal communication. These effects can include deceptive, perplexing, reactions chief to conflict, censure through moral otherwise political establishments, before self-regulation in a technically enhanced environment. Ultimately, knowledge has the potential to deepen and enhance lasting interpersonal bonds. Effective communication serves as the best solution to these challenges. However, while technology avoids to possess the capacity besides proximity of outdated head-on interactions, it can also promote the development of high-quality quasi-relationships. Additionally, due to shifted perceptions brought on by technology, social advantages can emerge from these electronic connections, even in the absence of in-person engagement. The comradeship prototypical, inferences of value-laden absorbing interactions, which increased capability towards leverage material equipment by means of a instrument aimed at making the company aspect of communal exchanges additional productive also fulfilling are briefly reviewed in the chapter's conclusion.

2. A Brief History of Communication Technologies

In the late 20th century, early research on technology and communication was attentive to the links among corpus means and telecommunications. The most essential new thing arrived first time on colour TV. Most of the manufacture of transistors made radio and television recording equipment widely available. This helped disseminate speech and music and led to the growth of businesses that created millions of jobs. The cost of communication went down a lot when electronic mail became popular in the late 1980s. In the 1990s, the usage of personal computers skyrocketed. At the same time, they got smaller, cheaper, and used less energy while having more processing power. Fibre-optic transmission has changed the way data communications expand in technology. Private user telecommunications networks had a big impact on its growth. When broadband is the rules governing the expansion of the information infrastructure now include the topological configuration of the numerical conduction system, the modification of cost-type facilities, time-band, distance-band, link digitization, and the

integration of Betamax, videophone, data-phone, and telex services into a contemporary integrated service. Technology can convey voice and video because it has developed digital code or the ability to send digital data. The set of system functions broadcasting in the data, video, and voice industries are provided by "Voice-band digitization," "narrowband ISDN (Integrated Services Digital Network)," "broadband ISDN (further the UE, UMTS-based Public Services Digital Network)," "X-DSL, A-DSL, H-DSL" systems, "MPEG, M-JPEG, H.263" systems, "J-PEG, H.261 and H.263," and other networks.. Developers expect that when the UMTS system gets better, it will connect with PSTN/ISDN networks that are already in use. The major goal of reorganizing support for X-DSL systems is to lower the cost of the system.

3. Technology's Beneficial Impact on Social Connections

More possibilities to meet people: Technology has made the public space bigger, which has led to more opportunities for social interaction. For example, blogs provide a virtual world where friends and family may connect around shared beliefs, interests, and hobbies. Blogs are set up in a way that makes it hard to have meaningful conversations in public. The internet is a tool that may help people connect with one another since it is more engaging and gives the speaker more control over what they say. There are now software options that make it possible to communicate with people all over the world for very little money. These include email, video conferencing, and instant messaging. Voice-over IP technology, for example, gets rid of long-distance bills for landline and mobile phone calls and lets us have video conferences so we can see and hear what each other is doing. Text-to-speech technology used in instant messaging apps makes it feasible to talk to someone without them hearing you. These technologies work with and, in some cases, even replace traditional ways of communicating that people use to make and keep friends. If there were more useful and easy-to-use technologies that employed the same socially constructed face-to-face or side-to-side communication, the world might be a different place.

3.1. A greater Capacity for Communication and Connection

The growing need for communication is one of the main reasons why technology keeps becoming better. The information society trend has made communication even more important. People want to talk to each other more often, but they also want it to be easier and cheaper. A lot of studies say that we are now living in the information era, and people are becoming more and more like an information-driven world where knowledge is paramount. People today know that being able to communicate well is important for both social and economic success. People think that having a good communication system is among the most significant things for the growth of

countryside communities. The information age shows how people operate in a sociotechnical or social system. The usage of computers and other electronic and optical gadgets are the most evident characteristics of such a civilization, international trade and information flow, the introduction of new cultural phenomena that make it easier and faster to use and share information, the ease and popularity of accessing information from anywhere in the world, the use and advancement of information storage, information technology, and other crucial facets. Modern communication technology is extensively employed, and knowledge and information are easy to obtain in today's globalized society. Technology and communication are necessary for everything from taking pictures with a digital camera to using social media, purchasing online, sending instant messages, watching videos, and getting real-time traffic updates.

4. Technology's Detrimental Effects on Interpersonal Relationships

There are numerous benefits to developing and using information and communications technology (ICT), but there are also some negatives, such as reduced levels of collective well-being and negative performance indicators in the social sciences. Understanding the factors that lead to technology use and how it impacts a person's quality of life and significant relationships is crucial because technology use typically has a social component and is prevalent in both quantity (a significant portion of any given population uses ICT for leisure activities) and quality (due to the numerous uses and the strength of many internet relationships) with other people. Children's daily lives, natural growth, and important social and emotional connections may be harmed by too much technology use. This is especially true because peer interactions are so important for healthy adaption. Using technology too much may hurt your body in ways like terrible posture, eye strain, and vision problems. This might lead to social or relationship problems because of the pain. People often forget to take care of their bodies when they are short on time to use technology, which leads to these problems. Also, technology makes it easier to talk to people without getting too emotional, especially when you use email or other asynchronous means. Words may rapidly disclose things about yourself that would be hard to say in person since a computer gives you anonymity and distance. These, together with additional emotional or social rewards, make it easy to avoid significant partnerships. When you spend fewer time with family and friends online, you may be missing out on a crucial need to build tighter relationships with them. These people typically give immediate physical resources and emotional and social support. Technology may change how people act in ways that hurt relationships and make people feel like they don't belong. If a loved one doesn't see how this new technology can help them, it might potentially cause extra stress and problems. Finally, a society that is obsessed with technology and prefers to talk to people over the phone instead of in person

might make it harder or less important to keep in touch with other important people in your life, including family members who live far away or old friends.

4.1. Reduced In-Person Communication

One of the biggest ways that technology is hurting relationships is that people are talking to each other less in person. In general, any form of technology makes it harder to talk to people in person, but digital technologies are worse for relationships than they are good. Instant messaging and texting let people talk to each other more often and for longer periods, but being far away from someone takes away their bodily presence and a lot of the nonverbal clues that are required for in-person comprehension and interpretation, such as subtle variations in body language and voice tone. These ways of talking to each other are not as good at building connections as the many times friends, co-workers, or family members might meet in person during a certain time. One further way that digital connections are different from interactions in real life is that people may talk to people who aren't there. People who are shy or hesitant about talking to people in person might use this to their advantage since they can use the medium's simple features to feel more comfortable and at ease as "invisible" clients.

5. Techniques for Juggling Technology Use in Partnerships

Make sure your limits are clear. When they visit, some folks have a rigorous rule that all phones must be hidden. It's good to make eye contact and listen to each other over a daily amount of time when there are no distractions. It's sometimes beneficial to check in to help solve a tough problem, but most of the time, the best approach to balance technology use is to make a policy that works for all sides. Talk to each other in person whenever you can. It's easy to talk to someone via text or other means, but it's easy to get things wrong. After you make a connection with someone, it might be good to listen to their voice to figure out how they really feel. If you can't talk to someone in person because of your schedule, think about using free applications like Skype that let you see and hear the other person's facial expressions. The goal is to have times when you don't use technology. Like the first bullet point, setting up times. Taking time away from technology helps the pair reconnect, which is one of the best ways to keep a relationship happy. This is especially crucial when things are tough, because having a real person to talk to may help a couple feel less alone and more supported.

References:

1. Burleson, B. R., Metts, S., & Kirch, M. W. (2000). Communication in close relationships. In C. Hendrick & S. S. Hendrick (Eds.), *Close relationships: A sourcebook* (pp. [insert page numbers if known]). Thousand Oaks, CA: Sage.

2. Blackwell, L., Gardiner, E., & Schoenebeck, S. Y. (2016). Managing expectation: Technology tensions among parents and teens. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW 2016)* (pp. 1390-1401).
3. Role of digital technology in interpersonal relationships in the era Society 5.0. (n.d.). *ResearchGate*. Retrieved June 18, 2025, from https://www.researchgate.net/publication/369960365_Role_of_Digital_Technology_In_Interpersonal_Relationships_In_the_Era_Society_50
4. Dance, F. E. X. (1972). *Speech communication: Concepts and behavior*. New York, NY: Holt, Rinehart and Winston.
5. De Salvo, V. S. (1980). A summary of current research identifying communication skills in various organizational contexts. *Communication Education*, 29(3), 283.
6. Ellis, R., & McClintock, A. (1990). *You take my meaning: Theory into practice in human communication*. London, UK: Edward Arnold.
7. Goffman, E. (1959). *The presentation of self in everyday life*. New York, NY: Anchor Books.
8. Dance, F. E. X., & Larson, C. E. (1976). *The functions of human communication: A theoretical approach*. New York, NY: Holt, Rinehart and Winston.
9. Gass, R. H., & Seiter, J. S. (1999). *Persuasion, social influence and compliance gaining*. Boston, MA: Allyn and Bacon.

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ECOPOETICS OF INNOVATION: GREEN TECHNOLOGY IN MODERN AND POSTMODERN TEXTS

Surbhi Devi
Faculty of Liberal Arts,
The ICFAI University, Himachal Pradesh

Abstract:

In the crucial face of increasingly ecological crises, literature has accelerated towards themes that project environmental consciousness with technological innovation. The study explores the emerging concept of ecopoetics of innovation- a critical lens that analyses how green technology is represented and reimagined in modern and postmodern literary texts. Delving into theoretical insights from ecocriticism, posthumanism and science and technology studies this paper investigates how authors like Margaret Atwood, Kim Stanley Robinson, T.S. Eliot and Don DeLillo incorporate narrative and poetic forms to critique, visualize and speculate upon sustainable futures. It reflects the literary treatment of green technology not merely as a quantitative scientific solution but as an ethical and imaginative enterprise. Drawing upon both dystopian and hopeful portrayals, the study reveals how literature serves as a transformative space for ecological innovation and cultural critique.

Keywords: Ecocriticism, Posthumanism, Technology, Literary Analysis.

Introduction:

Ecocriticism, the focal point of this study; simply defined the study of the relationship between literature and the physical environment (Cheryll Glot-felty). But should we address it 'ecocriticism' or 'green studies? Both terms are used to denote a critical approach which began at different points of time in different nations. In the late 1980s in the USA, and in the early 1990s in the UK, and it is still an 'emergent' movement. In the USA the acknowledged founder is Cheryll Glotfelty, co-founder of ASLE (Association for the study of Literature and Environment). The term ecocriticism was coined in 1978 by William Ruecket in his essay "Literature and Ecology: An Experiment in Ecocriticism."

A claim for first usage in literary criticism of the related term ecological is made by prominent US eccritic Karl Kroeber, whose article "Home at Grasmere: ecological happiness" appeared in the journal PMLA,89,1974, PP.132-41. Both terms ecocriticism and ecological apparently lay dormant in the critical vocabulary (says Branch) until the 1989 WLA conference when Cheryll Glotfelty not only revived the term ecocriticism but Urged its adoption to refer to

the diffuse critical field that had previously been known as 'the study of nature writing.' (Barry. Peter, Beginning Theory Second edition pp.161)

The 21st century has steered in a rapid ecological consciousness, accompanied by profound advancements in green technologies such as renewable energy, sustainable architecture and bioengineering. Literature, as witness and participant of cultural changes, unveil the thrilling concerns and imaginatively explores the human relationship with both nature and machines; their lasting impact on biodiversity. The emergence of ecopoetics of innovation bridges environmental ethics with creative expression, positioning green technologies not only as plot devices but as symbolic mediators of hope, fear and transformation. The mild shift in plot construction, usage of literary devices, enables the reader to better connect with nature and recognize its unpaid benefits for living beings.

This study seeks to critically find how green innovation is incorporated and reconceptualized in modern and postmodern texts. Through poetry and prose, these writers create incredible ecologically aware narratives that foreground the complexities of technological intervention in natural systems. Ecocriticism distinguishably anchored in the works of Jonathan Bate, Timothy Morton and Lawrence Buell, their writing extends environmental literary analysis beyond romantic nature worship to include urban, technological and posthuman environments. Morton's idea of the mesh and ecological thought undermines binaries such as nature/culture or organic/artificial, aligning at par with discussions of green technology. Haraway's cyborg feminism and Bruno Latour's actor-network theory further shape technology as a sub-agent within ecological systems.

Green technology, not merely a scientific advancement moreover, is considered a cultural and poetic construct- subject to narrative, metaphoric and critique. The concept of ecopoetics of innovation questions: How do literary forms imagine, resist or celebrate sustainable futures? How do authors use the tools of literature like form, voice, literary/poetic devices and temporality to convey ecological innovation?

Modern literature, born amidst industrial, social upheaval and two world wars, sincerely presents anxiety toward mechanization and environmental degradation. The lamentation and regression on the loose of traditional values and customs often pin-pointed by these modernist writers. One of the remarkable modern poems, *The Waste Land* by Thomas Stearns Eliot referred to a landmark of early ecological unease. The desiccated landscape- "what are the roots that clutch, what branches grow/ out of this stony rubbish?" – serves as both a literal and symbolic wasteland. Divided into five sections namely; "The Burial of the Dead", "A Game of Chess", "The Fire Sermon", "Death by Water" and "What the Thunder Said." In his fragmented poem,

the absence of fertility and renewal is a stark critique of urban-industrial collapse. The structure of the poem is discontinuous, multilingual and layered mimics environmental entropy, suggesting a need for restoration through cultural and perhaps ecological innovation; however, Eliot implicitly mentioned green technology. It projects the unfulfilled life of modern man and raises a spiritual quest. Individuals need to collaborate to get the meaning of life, and the collaboration should encompass harmony with nature.

D.H. Lawrence, one of the prolific modernist writers, reveals about green ideals to enhance ecological balance in his seminal text *Women in Love.* The novel comprehensively examines the ill effects of industrialization on the human psyche. The theme of green ecology is subtly woven into the narrative through portrayal of nature, human relationships and the tightness between industrialization and the natural world. Moreover, Lawrence is often seen as a precursor to environmental thought, especially in his works from this period, where nature plays a dominant role in shaping character's psyches and actions. Lawrence's characters embody opposing forces: Gerald Crich, a mine owner, personifies destructive mechanization, while Rupert Birkin seeks a moral, instinctual, spiritual bond with nature. Lawrence critiques the dehumanizing effects of technology and anticipates green ideals that value holistic living and ecological balance. Time and again Lawrence uses the natural environment to reflect the inner states of his characters, even in *Women in Love* the characters are deeply connected to the landscapes around them, these natural settings act as metaphors for their emotional and psychological lives. The novel's most crucial moments take place outdoors, whether it's the intense mountain landscapes or the tranquil rural settings; it indicates a link between the character's personal struggles and the natural world. For instance, Birkin, a central character, is frequently depicted in relation to nature. His connection to the natural world is complex and symbolic. He has a deep desire to escape the stifling confines of industrial civilization, seeking solace and meaning in the raw power of nature. Birkin's frequent contemplations about the life force and his unconquered desire for authenticity usually take place in natural surroundings, emphasizing the contrast between his yearning for liberty and the constricting influence of modern society.

Gudrun, another important character, more attuned to the aesthetic side of things, engages with nature more on an intellectual level. Yet, her complex relation with Gerald (symbolizes industrial power and human dominance over nature) brings her into explicit conflict with her own natural instincts, which she represses.

Lawrence's portrayal of nature in the novel is often ecocentric, where nature itself holds intrinsic value beyond its utility for humans. The forests, mountains, lakes and even the animals are imbued with a sense of sacredness that is lost in the industrialized world. The characters' interactions with these natural elements suggest that true freedom and personal fulfillment can only be attained by reconnecting with the ecocentic world. His novels serve as philosophical inquiries into human condition in an industrial age, indirectly gesturing toward what we now frame as sustainable ethics. Resolving individual and collective rebirth is possible only through human intensity and passion.

A significant and elusive term Postmodernism, at its core a response to Modernism, rejects its ideas of objective truth rather embraces fragmentation, opens space for speculation and pluralistic interpretations and explorations of texts and various theories in different spheres. Postmodernism critiques the excesses of capitalism, technology and mass media, reflects a disillusionment with the promises of progress and rationality that Modernism championed, instead focused on the relativity of experience and meaning to avoid ambiguity. The writings of postmodernist writers like Margaret Atwood and Kim Stanely Robinson and many more helped a lot to understand the worth of green technology.

Oryx and Crake, a phenomenal text by Margaret Atwood, set in a near-future world ravaged by climate change and biotechnology, first in Atwood's MaddAddam trilogy; the novel critiques unchecked scientific experimentations. The protagonist, Snowman, recounts how Crake, a genetic engineer, designed a post-human species named the Crakes intended to be eco-harmonious: vegetarian, nocturnal and biologically resistant to disease. His experiments focus on eliminating what he perceives as the negative aspects of human nature. Crakes are a major symbol of the consequences of biotechnology gone awry. On one hand Crake envisions them as a solution to humanity's moral and environmental crises however, they are a monstrous distortion of life. Their genetic perfection is cold and sterile, lacking the complexities that make humans human. In an attempt to engineer out the flaws of humanity, Crake creates a form of life that is not only morally and emotionally hollow but ultimately unsustainable.

The novel also portrays a world where scientific research and biotechnology are massively controlled by corporations, which prioritize profit over ethical considerations. Rejooven Esense, the company where Crake works, is a profit-driven organization that utilizes biotechnology to create and manipulate life, including human life, for commercial intent. This takeover of science in *Oryx and Crake* shows the commodification of nature, turning life into a marketable product. This practice not only leads to moral corruption but also to environmental

degradation. The novel demonstrates how technological progress is frequently misused for economic gain, but at the stake of the environment and the well-being of society.

Atwood presents biotechnology as both hubristic and hopeful. As she notes in her interviews, she "does not invent technologies," but extrapolates from existing trends. The narrative' structure, moving between past collapse and present survival, foregrounds ethical tensions: can innovation truly redeem ecological loss, or does it deepen alienation? This dystopian vision serves as an alarm against the dangers of unregulated technological advancements and the commodification of life. It challenges readers to think critically about the intersection of science, ethics and the environment in a world where scientific advancement is pursued without regard for its broader consequences. It also poses critical questions about the limits of human control over nature.

Kim Stanley Robinson's pathbreaking utopian novel *New York 2140* illustrates the benefits of green technology. It contrasts with Atwood's dystopian; Robinson presents a pragmatic Utopia. Following climate-induced sea-level rise, New York becomes a 'Super Venice' with civilians adapting through floating cities, carbon-capture farming, and cooperative economies. The novel envisions green technology not as elite saviorism but as democratic adaptation. Franklin, one of the significant characters, discusses the role of speculative finance in driving green technology, blending ecological realism with economic critique. Robinson's detailed world-building expresses that green futures require both imagination and political will.

Conclusion:

Certainly, green technologies promise sustainability, literary texts uncover the concerned limitations. Literature challenges technological utopianism by emphasizing on emotional and cultural memory over mechanical precision, ecological humility over human domination and justice and equity as core to sustainability, not peripheral. The ecopoetics of innovation encapsulates a literary movement that critiques and reimagines the role of green technology in ecological survival. Since the modernist malaise of *The Waste Land* to the posthuman blueprints in Atwood and Robinson, literature not only constraints to reflection but offers speculative intervention. These texts ask the readers to consider the core definition of sustainability- not just technically, but morally, culturally and narratively. As ecological challenges escalate, literature's capacity to engage with innovation becomes crucial. It shapes how we feel, think, act and hope about the planet we hail and we choose to create.

References:

1. Atwood, M. (2003). *Oryx and Crake*. Anchor Books.
2. Barry, P. (2002). *Beginning theory: An introduction to literary and cultural theory* (2nd ed.). Manchester, UK: Manchester University Press.
3. Buell, L. (1995). *The environmental imagination: Thoreau, nature writing, and the formation of American culture*. Cambridge, MA: Harvard University Press.
4. Ecocriticism. (2025, June 18). In *Wikipedia*. https://en.wikipedia.org/wiki/Ecocriticism
5. Eliot, T. S. (1992). *The waste land*. London, UK: Faber & Faber. (Original work published 1922)
6. Lawrence, D. H. (1920). *Women in love*. New York, NY: Thomas Seltzer.
7. Modernism. (2025, June 18). In *Encyclopaedia Britannica*. https://www.britannica.com/art/modernism
8. Postmodernism. (2025, June 18). In *Encyclopaedia Britannica*. https://www.britannica.com/topic/postmodernism-philosophy
9. Robinson, K. S. (2017). *New York 2140*. New York, NY: Orbit Books.

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THE RISE OF GREEN MARKETING IN INDIA: HOW BRANDS ARE ALIGNING WITH SUSTAINABILITY GOALS

Manju Bala
Department of Commerce,
Government National College, Sirsa

Abstract:

Green marketing has become a potent tactic for companies looking to meet changing customer demands and sustainability objectives as India's environmental problems worsen. This study examines the emergence of green marketing in India by examining the ways in which well-known companies like Tata, ITC, and FabIndia have incorporated sustainability into their packaging, branding, product design, and community involvement. The study looks at the three main pillars of green marketing—green products, pricing, and promotion—as well as new tactics like eco-labelling, internet campaigns, and ethical sourcing using descriptive case studies. Along with addressing structural issues like greenwashing, high implementation costs for SMEs, and unclear regulations, it also draws attention to the shifting attitudes of Indian customers, especially urban millennials and Gen Z. The study comes to the conclusion that although green marketing is becoming more popular, institutional support, authenticity, and traceability are essential to its long-term success.

Keywords: Green Marketing, India, Brands, Customer Demands, Sustainability

1. Introduction:

India today finds itself at a hard crossroads, weighing rapid growth against urgent stresses on nature. As one of the world's fastest-expanding economies, the country now grapples with many linked ecological worries. In its crowded cities, airborne smog has climbed to shocking highs, harming countless people and feeding global warming. Polluted rivers and shrinking supplies, eroded soil and thinning forests, plus clumsy waste handling, are straining ecosystems and public health alike.

India is already feeling the heat of climate change, with more floods, sudden droughts, and coastal areas slowly swallowing land. Wildlife suffers as forests shrink, rivers fill with plastic, and people hunt and harvest plants faster than they can grow back. Heaped on that, massive food waste, careless use of single-use plastic, and fierce forest fires-fuelled by hotter air and dry winds-turn local trouble into national headlines. The situation grows worse on its own

because Indias big, fast-growing population, hasty city building, and ever-expanding factories push nature and people toward the brink.

In a world more alert to environmental damage, companies are urged to step up and drive real change. Green marketing-the effort to spotlight Earth-friendly goods and habits-has quickly proven itself a strong ally in that push. It stretches past usual selling work, placing sustainability into each detail: where materials come from, how items are built, the look of the packaging, and the story told to customers.

Indian consumers, particularly the youth, are growing more environmentally aware. They now look for brands that reflect their ideologies and play a meaningful role in creating a sustainable future. Anticipating this change, Indian brands are now making large strides to incorporate sustainability in their very being.

In this paper, we try to elucidate how leading Indian brands like Tata, ITC, and FabIndia are embracing green marketing as a way to tackle environmental issues while fulfilling changing consumer demands. Through this endeavour, we will realize how marketing in India is not merely about selling products — but about creating a greener, more responsible future.

2. Conceptual Background:

Given the growing worry about the environment green marketing has caused a revolution in today's business scene. Philip Kotler explains it as "the development and marketing of products designed to minimize negative effects on the physical environment or to improve its quality." He emphasizes that companies shouldn't just go after profits; they should also adopt the "triple bottom line" — People, Planet, and Profit. This means including environmental and social aspects in their marketing plans and overall work.

Green marketing is more than just selling eco-friendly products. It covers the whole idea of sustainable business practices looking at things like saving resources, getting supplies cutting down on waste, and dealing with customers. The American Marketing Association (AMA) backs this bigger picture saying green marketing is " *the marketing of products that are presumed to be environmentally safe* " In the same way, Peattie (1995) describes it as " *a holistic and responsible management process that identifies, anticipates, and satisfies the requirements of customers and society in a sustainable and profitable way.*"

India faces big environmental problems — from dirty air and water to plastic trash fewer trees, and a changing climate. Because of this, companies need to step up and help make things better. In this situation green marketing isn't just a good idea anymore — it's something businesses have to do to stay competitive.

3.1 The Three Pillars of Green Marketing: Green marketing is best understood through three foundational elements: Green Product, Green Pricing, and Green Promotion. These pillars represent how businesses align their offerings and messaging with ecological responsibility.

3.1.1 Green Product:

The goal of a green product is to reduce environmental damage at every stage of its lifecycle, from sourcing and production to packaging and disposal. These goods are frequently made with recyclable, biodegradable, organic, or cruelty-free materials and are made with energy-efficient and emission-lowering production technique.

- For instance, Forest Essentials employs eco-friendly packaging and Ayurvedic herbs.
- Paper from sustainable sources is used in ITC's classmate notebooks.

Designing green products is essential to building brand confidence, particularly with customers looking for eco-friendly substitutes.

3.1.2 Green Pricing:

The genuine cost of production in terms of ethics and the environment is reflected in green pricing. Although eco-certifications or sustainable sourcing may result in higher prices for green items, consumers are becoming more and more prepared to pay more for companies that share their belifes.

Among the tactics are:

- Reusable alternatives to cut down on packing waste.
- Loyalty rewards for environmentally friendly purchases.
- Tiered pricing for sustainable bundles:

For instance, MamaEarth provides combo packages and refill packs that reduce environmental effect and increase accessibility to eco-buying.

3.1.3 Green Promotion:

This demands transparent and convincingly stating of sustainability ideals. Green promotion should avoid greenwashing—the practice of exaggerating assertions about being environmentally friendly—and instead rely on true, measurable, and ethical messaging to build credibility.

Techniques examples:

- Encouraging certifications like organic, cruelty-free, and FSC
- Using digital channels to lessen reliance on paper advertising, for example, Tata Tea's "Jaago Re" campaign increased brand relevance and trust by combining sustainability message with social awareness.

- Initiating cause-based activities (such as tree planting and water conservation)

3.2 Evolution of Green Marketing in India

The idea of green marketing has changed significantly in India. Previously thought of as a specialized tactic used by a few high-end businesses, it is now widely used in a variety of sectors, including fashion, FMCG, automotive, and technology.

Key Milestones:

- 2011: Corporate accountability in electronics is introduced by e-waste management regulations.
- 2016: Recyclable packaging is promoted under the Plastic Waste Management Regulations.
- 2019: State-wide prohibitions on single-use plastic encourage eco-packaging innovation.
- In the 2020s, major FMCG companies like HUL, Tata, and ITC start incorporating sustainability into marketing, logistics, and product design.
- Outlook for 2025: Brands will need to handle post-consumer trash as Extended Producer Responsibility (EPR) is enforced more strictly.

Additionally, by developing zero-waste and reusable products, a wave of environmentally conscious firms like Bare Necessities, The Better Home, and Beco are changing how people consume.

Regulatory pressure and changing consumer expectations both drive this development as Gen Z and millennials actively seek out businesses showing environmental dedication.

Formerly a minor concept in India, green marketing is now a major element of business plan. Its development is propelled by an expanding base of ethical consumers, legislative measures, and environmental necessity. Highlighting green product design, pricing methods, and true marketing, brands can build long-lasting consumer trust and competitive advantage while also substantially advancing sustainable development.

4. Analysis- Descriptive Cases of Indian Brands:

4.1 Tata Group: A Multi-Sector Leader in Green Marketing

One of the most reputable and diverse corporations in India, the Tata Group, has taken th e lead in integrating green marketing strategies into all of its corporate divisions. The group has continuously shown a dedication to sustainable development, not only as a compliance measure but as a fundamental business strategy, spanning from consumer items and real estate to energy and autos. Tata's green marketing are based on its overarching goal of balancing profit and purpose, which reflects the Triple Bottom Line concept of profit, planet and people.

Group-Wide Commitment to Sustainability: The centralized Tata Sustainability Group, which guarantees the implementation of environmental best practices throughout all group firms, is how the Tata Group has institutionalized its sustainability aims. Each year, the conglomerate releases extensive Sustainability Reports associated with worldwide frameworks such as the worldwide Reporting Initiative (GRI) and Science-Based Targets initiative (SBTi), assuring transparency, accountability, and progress tracking.

Tata Motors: Championing Green Mobility: Tata Motors has made a name for itself as a pioneer in the electric vehicle (EV) revolution in India. The launch of models like the Tata Nexon EV, one of the most well-liked electric vehicles in the country, demonstrates the company's commitment to environmentally responsible mobility. In addition to manufacturing EVs, Tata Motors is heavily investing in the development of batteries, vehicle electrification, and infrastructure for EV charging.

In order to achieve Net Zero greenhouse gas emissions by 2045 for commercial vehicles and by 2040 for its passenger car sector, the company has set ambitious goals. Additionally, it hopes that all of its electricity will originate from renewable sources by 2030.

Tata Power: Clean Energy and Circular Economy: Leading India's transition to clean energy is Tata Power. The company, which has one of the biggest solar and wind energy portfolios in the nation, is constructing a vast network of EV charging stations under the EZ Charge brand in addition to offering green energy solutions to residential and commercial clients.

Tata Power has also started projects for solar panel recycling, smart metering, and community-based energy education programs in line with the ideas of the circular economy.

Tata Chemicals: Promoting Sustainable Agriculture: With a focus on "green chemistry," Tata Chemicals is aggressively marketing environmentally friendly agricultural products like crop protection products, organic inputs, and bio-fertilizers. Its research and development facilities aim to lessen the environmental effect of chemical production while encouraging rural populations to practice sustainable farming.

Tata Housing: Building for the Future: By creating LEED-certified green buildings, Tata Housing has integrated sustainability into its real estate portfolio. Rainwater collection, solar power integration, energy-efficient technologies, and natural ventilation are the main focuses of its projects. Its marketing strategy revolves around these green aspects, particularly when aiming to attract eco-aware metropolitan consumers.

Tata Tea: Purpose-Driven Brand Messaging: Originally centered on civic involvement, Tata Tea's well-known "Jaago Re" campaign has expanded to include themes of waste reduction, climate change, and sustainable living. The company supports sustainable sourcing methods in tea plantations, uses recyclable packaging, and advertises organic tea varieties.

The Tata Group's green marketing strategy is integrated into its operational decisions, consumer communications, and product innovation; it is not a stand-alone branding initiative. Tata continues to set the standard for ethical business practices in India and around the world with its strategic environmental initiatives and open reporting.

4.2 ITC Ltd.: A Sustainability Pioneer Across Multiple Sectors

From its beginnings as the Imperial Tobacco Company in 1910, ITC Ltd., with its headquarters located in Kolkata, has developed into a diverse conglomerate that is currently dispersed among industries like FMCG, hospitality, paperboards & packaging, agribusiness, and IT services. ITC is a prominent global leader in green marketing and environmental stewardship, with a net profit of ₹13,032 crores (FY 2023–24) and a gross sales value of ₹74,979 crores.

A Holistic, Sustainability-Driven Business Model: ITC has taken a very comprehensive approach to sustainability, which includes social responsibility, ethical governance, and environmental stewardship. The business has continuously recorded carbon-positive, water-positive, and solid-waste recycling-positive performance for more than 25 years. Its Paperboards & Specialty Papers Division (PSPD) is a leader in sustainable supply chains and circular production.

Paperboards & Packaging: Innovation at the Core:

- Eco-friendly product lines, such "Filo" boards, which are recyclable and biodegradable, are widely used in food packaging to replace plastics in trays and cups.
- Thanks to a state-of-the-art high-efficiency recovery boiler at Bhadrachalam and other green technological advancements, PSPD has reduced GHG emissions by 25% and achieved 44% renewable energy consumption from FY2019.
- More than 99 percent of the raw materials are renewable, obtained through farm and social forestry initiatives, and certified in accordance with AWS and FSC® standards.

Water Stewardship & Waste Management:

- Over 21 years of water-positive status have been made possible by ITC's watershed development program, which has produced rainwater harvesting capacity that exceeds four times the company's net operational water consumption.

- The "Well-being out of Waste" (WOW) initiative collects over 64,000 tonnes of dry waste annually, helping 2.2 crore citizens and 55 lakh households.
- ITC collected and processed more plastic than it put on the market for several years in a row, achieving plastic neutrality (60,000+ tons in FY2022–23).

ITC Hotels: Responsible Luxury:

- Applying LEED Platinum standards, ITC Hotels have virtually eliminated single-use plastic, including glass bottles and bamboo toothbrushes, and have integrated solar lighting, greywater recycling, and advanced energy conservation.
- The brand's Responsible Luxury philosophy positions ITC Hotels as an upscale yet environmentally conscious hospitality option.

Agribusiness & e-Choupal: Farmer-Centric Sustainability:

- In FY2023, ITC's agricultural forestry initiatives transformed 1.1 million acres of degraded land into productive green cover, storing almost 6 million tons of CO2.
- ITC's work in sustainable farming for crops like chili are recognized by the Global GAP accreditation; the e-Choupal digital platform equips 4 million+ farmers in 35,000 villages with climate-smart agriculture and sustainable procurement methods.

FMCG & Brand Innovation for Sustainability:

- Among the initiatives are low-impact product lines including Classmate, Fiama, and Bingo; ozone-treated "Elemental Chlorine Free" papers under the "Paperkraft Premium" brand; and environmentally friendly packaging.
- In order to meet the growing demands of environmentally concerned consumers, ITC uses its green storytelling in marketing campaigns and packaging.

ITC's integrated green marketing strategy, which covers operations, community, credentials, packaging, and goods, firmly establishes the company as a sustainability leader in India and raises the bar for ethical business practices.

4.3 FabIndia: Blending Sustainability with Soulful Storytelling

Since its founding in 1960, FabIndia has emerged as a prominent player in India's sustainable retail industry. Through an open, moral, and environmentally responsible business approach, the brand links more than 50,000 rural artisans—the majority of whom are women—with urban marketplaces. The secret to FabIndia's success is how well it combines sustainability, cultural preservation, and customer satisfaction.

Eco-Friendly Materials and Organic Sourcing:

A large percentage of FabIndia's products are handwoven and made from cotton that is cultivated organically and dyed with natural, non-toxic dyes. Additionally, its product lines use materials like hemp, jute, banana fiber, and recycled PET, making its offers both conventional and sustainable.

To encourage transparency, the company uses a three-tier labeling system to classify its products:

- Green Label: Fully certified organic products that have been verified by reputable organizations and satisfy both national and international standards.
- Blue Label: Certified "In Conversion" products that are farmed organically.
- Yellow Label: "Natural" products, such as processed foods free of preservatives, that are typically made by small, unregistered farms using organic methods.

This system builds consumer trust while showcasing FabIndia's commitment to sustainability and transparency.

Eco-Conscious Store Design and Immersive Experiences:

The retail locations of FabIndia are built with sustainability in mind, with minimal packaging, energy-efficient lighting, and environmentally friendly architecture. More significantly, though, its stores are experience hubs. Customers can connect directly with craftsmen and gain an understanding of the sustainable production process through programs like "Craft Mornings" and interactive workshops (such as those on ceramics, block printing, and dyeing).

In addition to improving foot traffic and sales, these immersive experiences have improved consumer-brand relationships. For example, experience centre store sales have increased by 25–30% as a result of the "craft morning" promotion.

Purpose-Led Marketing & Community Storytelling:

FabIndia prioritizes narrative-driven marketing above traditional advertising, highlighting its sustainable values through influencer collaborations, social media, and in-store storytelling. Initiatives such as #KalaKapdaKarigar celebrate the craftspeople who make the products and encourage thoughtful consumption.

Modern consumers, particularly Gen Z and millennials, who look for authenticity and purpose in the brands they support, would find this approach appealing.

Empowering Artisans & Building Inclusive Communities:

A community-owned company model that gives artisan communities ownership in supply companies was pioneered by FabIndia. This concept promotes skill development and financial

inclusion and Sustainable means of subsistence. Furthermore, FabIndia works with government programs like as the PM Vishwakarma Scheme to support rural jobs and promote indigenous crafts.

5. Green Marketing Strategies:

Green marketing is no longer a niche practice—it's now a core business strategy adopted by Indian brands to build trust, reduce environmental impact, and appeal to conscious consumers. The following key strategies demonstrate how businesses integrate sustainability into their operations and marketing:

5.1 Eco-Friendly Packaging:

One of the most visible aspects of green marketing, eco-friendly packaging reduces environmental impact through biodegradable, recyclable, or reusable materials. This appeals to consumers who are concerned about plastic waste and carbon footprints.

Examples:

- Mamaearth has achieved plastic neutrality, recycling over 13,000+ tonnes of plastic through collection partnerships.
- Biotique uses recyclable containers and avoids synthetic materials in printing and packaging.
- The Body Shop India promotes refill stations in select stores to reduce single-use packaging.
- Beco (a homecare brand) sells products in compostable packaging made from corn starch and recycled cardboard.

5.2. Ingredient & Product Transparency:

Consumers are increasingly concerned about what goes into the products they use. Green brands are responding with honest, transparent labeling and clean sourcing practices that build long-term trust.

Examples:

- Amul highlights its farm-to-table sourcing, promoting natural milk with no added preservatives.
- Saffola by Marico includes nutritional data and quality sourcing on all packaging.
- Bare Necessities lists every ingredient on its body care products and explains their eco-impact.

- Conscious Food shares supply chain info, often tagging farmers and processing units in its digital content.

5.3. Sustainability Certifications:

Certifications give credibility to environmental claims and help consumers make informed choices. Indian brands now seek national and global validations like USDA Organic, FSC, ISO standards, etc.

Examples:

- Organic India products carry USDA Organic and India Organic certifications.
- Wipro EcoEnergy is ISO 50001 certified for energy efficiency in its operations.
- Godrej Interio products follow low-VOC standards and carry GREENGUARD certifications.
- Soulfull (Millet-based foods) is certified with FSSAI Green Food Labeling, indicating low environmental load.

5.4. Green Branding & Purpose-Driven Positioning:

Today's eco-brands go beyond product features—they tell a compelling story of sustainability, purpose, and authenticity. Green branding is emotional, educational, and values-driven.

Examples:

- The Better Home markets its products as "Planet-First," positioning its identity around zero-waste living.
- Good Dot, a plant-based meat company, communicates an ethical, cruelty-free lifestyle aligned with environmental protection.
- Bare Necessities calls itself a "Zero Waste India" brand and backs it up with storytelling through podcasts and blogs.
- EcoRight uses pop culture references on sustainable tote bags while promoting responsible fashion.

5.5. Digital Campaigns & Sustainability Engagement:

Social media and digital platforms are now major channels for green marketing. Brands use reels, emailers, challenges, and influencer-led storytelling to educate consumers and promote sustainable behavior.

Examples:

- Mamaearth's #PlantGoodness campaign plants a tree for every order and shares location-tagged images of trees.

- Good Earth shares "Behind the Product" stories on Instagram, highlighting craftspeople and sustainable processes.
- The Body Shop India promotes refill & return programs through reels and customer testimonials.
- Brown Living (an eco marketplace) curates content on minimalist living and plastic-free tips.

5.6. Community-Centric Green Initiatives:

True green marketing includes people—brands now involve rural artisans, farmers, and small communities to build sustainable supply chains and shared value ecosystems. Examples:

- Himalaya Wellness works with farmers in Uttarakhand to grow herbs using regenerative agriculture.
- Phool.co, which recycles temple flowers into incense, hires women from lower-income backgrounds as part of its eco-entrepreneur program.
- Brown Living promotes homegrown, artisan-led brands across India, giving visibility to local, low-waste producers.
- Okhai, a sustainable fashion label, empowers rural artisans—especially women—to produce handmade apparel using natural dyes and zero-waste practices.

6. Evolving Consumer Attitudes and Challenges in Green Marketing:

6.1. Changing Consumer Attitudes Towards Sustainability:

In India's fast-growing consumer economy, a notable shift is emerging in buyer preferences—particularly among urban Gen Z and millennial segments. These digitally native, socially conscious consumers are redefining expectations by prioritizing ethically sourced, environmentally friendly, and transparent brands.

6.2. Preference for Sustainable Offerings:

Urban consumers, especially in Tier-I and Tier-II cities, are demonstrating a heightened preference for eco-friendly products—be it in apparel, beauty, food, or lifestyle segments. According to a 2023 NielsenIQ report, over 67% of Indian millennials prefer brands that align with sustainable values, and nearly half are willing to pay a premium for them. This aligns with global findings that indicate sustainability is no longer a trend, but a key purchase driver.

6.3. Role of Social Media and Influencer Advocacy:

Social media has become into a potent force in influencing how consumers view sustainability. Through initiatives like #GreenLiving, #ZeroWasteIndia, and #SustainableFashionIndia, influencers, sustainability advocates, and purpose-driven enterprises

use social media sites like Instagram and YouTube to raise awareness. To establish authenticity, these stories frequently make use of user-generated material, behind-the-scenes factory visits, or artisan spotlights.

6.4. Premium Perception and Conscious Spending:

As long as the brand exhibits genuine effect, a growing percentage of Indian consumers are willing to pay more for green items because they believe they are of higher quality and ethical value. Certifications like India Organic, USDA Organic, and Forest Stewardship Council (FSC) have emerged as important indicators of trust. 48% of Gen Z and 41% of millennials are willing to pay 10–20% more for sustainable alternatives in areas like fashion, personal care, and food, according to a 2023 Deloitte India study.

6.5. Challenges and Criticisms of Green Marketing:

Despite the growing demand for sustainable products, India's green marketing ecosystem confronts a number of structural, moral, and financial obstacles. To make sure that sustainability promises maintain their credibility and don't turn into empty marketing platitudes, these issues must be resolved.

6.6. Greenwashing and Misleading Claims:

Greenwashing— Falsely portraying a brand or product as ecologically conscious is becoming a bigger problem. It erodes customer confidence and calls into question sincere sustainable initiatives.

Example: The "Conscious Collection" from international apparel retailer H&M drew criticism for lacking sufficient environmental effect information. In a similar vein, some Indian personal care companies have faced criticism for using ambiguous phrases like "safe" or "natural" without independent proof.

Customers are increasingly looking for impact disclosures, ingredient transparency, and reliable eco-labels to combat this.

6.7. High Costs for SMEs:

Adopting green measures, like certified foods, sustainable energy sourcing, or biodegradable packaging, frequently requires a large financial outlay. This is a problem for small and medium-sized businesses (SMEs), who might not have access to subsidies or reasonably priced green solutions. Because of this, many SMEs find it difficult to compete with bigger firms who have the resources to invest in thorough ESG plans and certifications.

6.8. Consumer Skepticism:

Even with increased awareness, a lot of customers are still wary or dubious of green promises, particularly if they think they are marketing ploys. Inconsistent messaging, excessive

use of buzzwords, and a lack of evidence can all harm a brand's reputation. This cynicism can make people less eager to pay more, even for products that are truly sustainable.

Consistency in messaging, openness in sourcing, and third-party certification are necessary for establishing confidence.

6.9. Absence of Standardized Green Regulations:

At the moment, India lacks a standardized framework for green marketing principles or eco-labelling across industries. Some areas, like textiles, electronics, and cosmetics, are not consistently regulated, but others, like organic food and paper packaging, have defined standards (e.g., India Organic, FSC). Confusion and mistrust among customers are exacerbated by this ambiguity, which enables businesses to self-define sustainability indicators.

The Indian green consumer is changing; they are now more vocal, educated, and values-driven than before. But in order for green marketing to be successful in the long run, companies need to embrace inclusive, transparent, and verifiable sustainable policies rather than tokenistic rhetoric. The creation of support networks and legal frameworks, particularly for SMEs, is equally crucial to democratizing access to green business models.

The three main pillars that will influence India's future ethical consumption and sustainable marketing are authenticity, traceability, and innovation.

Conclusion:

In India, green marketing is changing dramatically from a supplementary marketing strategy to a strategic necessity based on long-term company viability. Policy actions, changing consumer values, and heightened ecological awareness are driving this change. Leading companies like Tata Group, ITC, and FabIndia have shown how sustainability can be incorporated into production, branding, and stakeholder involvement. According to the analysis, urban customers, especially millennials and Gen Z, are willing to support and even pay more for items that are ecologically responsible as long as the company provides transparency and evidence of its impact.

But there are obstacles in the way of broad acceptance. Significant obstacles include things like consumer distrust, high implementation costs for small enterprises, lack of standardized eco-labelling, and greenwashing. Indian companies must make investments in quantifiable procedures, open communication, and inclusive community models if they want green marketing to succeed. Policy frameworks must also change in order to control claims and encourage more environmentally friendly corporate practices, especially for SMEs.

The future of green marketing in India ultimately rests on striking a balance between corporate innovation, environmental responsibility, and moral customer interaction—a combination that may advance not only brand equity but also the welfare of the world.

References:

1. Adgully. (2023). *FabIndia's purpose-driven marketing strategies: Sustainability, storytelling and the soul of the brand*. Retrieved from https://www.adgully.com
2. Bare Necessities. (n.d.). *About us – Zero waste living*. Retrieved from https://barenecessities.in
3. Bajaj Finserv. (n.d.). *What is green marketing and why is it important?* Retrieved June 16, 2025, from https://www.bajajfinserv.in/green-marketing
4. Beco. (n.d.). *Sustainable home care for modern living*. Retrieved from https://beco.co.in/
5. Biotique. (n.d.). *Eco-friendly packaging and herbal ingredients*. Retrieved from https://www.biotique.com
6. Brown Living. (n.d.). *India's first plastic-free marketplace*. Retrieved from https://www.brownliving.in
7. Conscious Food. (n.d.). *Organic foods with farm-level traceability*. Retrieved from https://www.consciousfood.com
8. Deloitte India. (2023). *Consumer sustainability report: The rise of green preferences*. Retrieved from https://www2.deloitte.com/in
9. EcoRight. (n.d.). *Sustainability mission and collections*. Retrieved from https://ecoright.com
10. FabIndia. (n.d.). *Sustainability labelling and green product ranges*. Retrieved from https://www.fabindia.com
11. Forest Essentials. (n.d.). *Our philosophy: Purity, sustainability, and luxury*. Retrieved from https://www.forestessentialsindia.com
12. Godrej Industries. (2023). *Sustainability reports and ESG goals*. Retrieved from https://www.godrejindustries.com
13. Good Dot. (n.d.). *Plant-based alternatives for sustainable protein*. Retrieved from https://gooddot.in
14. Good Earth. (n.d.). *Sustainable living through culture and craft*. Retrieved from https://www.goodearth.in
15. H&M Group. (2022). *Conscious collection scrutiny and sustainability claims*. Retrieved from https://hmgroup.com

16. HavStrategy. (2023). *Marketing strategy of FabIndia*. Retrieved from https://www.havstrategy.com/marketing-strategy-of-fabindia
17. Himalaya Wellness. (n.d.). *Community herb farming and green sourcing*. Retrieved from https://himalayawellness.in
18. Kotler, P., & Keller, K. L. (2016). *Marketing management* (15th ed.). Pearson Education.
19. Mamaearth. (n.d.). *Sustainability & #PlantGoodness pledge*. Retrieved from https://mamaearth.in/sustainability
20. NielsenIQ. (2023). *The Indian consumer and sustainability*. Retrieved from https://nielseniq.com/global/en
21. Okhai. (n.d.). *Artisan-led ethical fashion*. Retrieved from https://www.okhai.org/
22. Organic India. (n.d.). *Certifications and sustainability initiatives*. Retrieved from https://www.organicindia.com
23. Phool.co. (n.d.). *Eco-friendly incense from temple waste*. Retrieved from https://www.phool.co
24. Soulfull (Tata Consumer Products). (n.d.). *Millet innovation and clean labeling*. Retrieved from https://tataconsumer.com
25. Tata Group. (2023). *Sustainability & ESG reports*. Retrieved from https://www.tata.com
26. The Better Home. (n.d.). *Planet-first cleaning essentials*. Retrieved from https://thebetterhome.com
27. The Body Shop India. (n.d.). *Refill stations and return programs*. Retrieved from https://www.thebodyshop.in
28. Wipro. (2023). *Sustainability overview & ISO 50001 energy management*. Retrieved from https://www.wipro.com/sustainability

THE ROLE OF GREEN APPAREL IN THE SUSTAINABILITY OF THE FASHION INDUSTRY

Priyanka

Department of Home Science,

Government College for Women, Ateli (Mahendergarh)

Corresponding author E-mail: yadav.priyanka294@gmail.com

Abstract:

The fashion industry, known for its significant environmental footprint, is undergoing a transformative shift toward sustainability. Green apparel, characterized by environmentally friendly materials and ethical production practices, has emerged as a pivotal element in this shift. This review paper explores the role of green apparel in promoting sustainability within the fashion industry. It examines key trends, material innovations, consumer behavior, green apparel brands and the challenges and opportunities associated with sustainable fashion.

Introduction:

The fashion industry is a significant contributor to global economic growth, with the global apparel market projected to reach $2.25 trillion by 2025 (Statista, 2022). However, this rapid growth has brought with it considerable environmental challenges, including excessive waste generation, depletion of natural resources and widespread pollution. Fast fashion, in particular has been heavily scrutinized with the production of clothing accounting for approximately 10% of global carbon emissions (UNEP, 2019). These environmental concerns

have sparked a noticeable shift in consumer behavior, especially among younger generations who are increasingly prioritizing sustainability in their fashion choices.

Sustainable fashion is defined as clothing produced using eco-friendly materials, reduced carbon emissions and ethical labor practices has emerged as a prominent trend in modern fashion consumption. This change is especially visible among young adults, who are not only trend-conscious but also more mindful of the environmental and ethical implications of their purchases (Jain & Singh, 2020). According to McKinsey & Company (2021), 67% of consumers now consider sustainability a key factor in their fashion purchases, highlighting a global shift in purchasing priorities.

The rise of fast fashion has driven substantial growth in the apparel industry with a reported growth rate of 6.2% in 2020 (Smith, 2022). However, this expansion has also resulted in severe environmental damage. Approximately 18.2 million tons of textile waste are generated annually, much of which ends up in landfills (Fibre2Fashion, 2020). Additionally, the fashion industry is the second-largest global polluter, consuming 93 billion cubic meters of water each year (UNCTAD, 2019). Fabric dyeing and processing alone contribute to about 20% of industrial water pollution worldwide and around 87% of discarded textiles are sent to landfills. Moreover, synthetic fibers used in clothing release plastic microfibers into water systems, equating to nearly 50 billion plastic bottles entering oceans annually (Diddi & Yan, 2019).

In response to these environmental impacts, fashion brands, stakeholders and policymakers are advocating for the production and adoption of green apparel—garments manufactured with a focus on environmental, social and economic sustainability (McNeill & Venter, 2019; Su *et al.,* 2019). These products often incorporate organic, biodegradable or recycled materials to reduce ecological harm (Wiederhold & Martinez, 2018). As public awareness of climate change and resource depletion grows (Lai & Cheng, 2016) consumer behavior is shifting irreversibly toward more sustainable practices, even in developing countries (Akenji, 2014).

From a consumer standpoint, the purchase, reuse, and proper disposal of green products are seen as vital actions that contribute positively to environmental preservation and the sustainability of the fashion industry (Lundblad & Davies, 2016). Compared to conventional garments, green apparel generates significantly lower greenhouse gas emissions upon disposal (Awan *et al.,* 2021). While the fashion industry is often associated with short product lifecycles and consumption-driven behaviors, ethical fashion aims to reduce harm through the use of environmentally safe materials and by ensuring fair labor practices (Lundblad & Davies, 2016).

Increased media attention has also played a role in boosting public awareness of the negative effects of fast fashion, further driving demand for sustainable alternatives (McNeill *et al.,* 2020; Dhir *et al.,* 2021).

Globally, the green fashion movement is gaining momentum, especially within the apparel and textile sectors. Consumers are demanding products that are both stylish and environmentally responsible. Green fashion closely associated with slow, sustainable and eco-conscious fashion seeks to reduce the ecological and social impacts of clothing production and consumption. Green apparel typically includes garments made using sustainable technologies, recycled materials and minimal packaging (Chen & Chang, 2013). The intention to purchase green apparel is on the rise (Moore, 2019), prompting brands to implement more sustainable practices. For instance, the Copenhagen Fashion Summit in 2014 emphasized sustainable fashion practices, influencing major brands like H&M and Giorgio Armani to launch green clothing lines (Winge, 2008).

Defining Green Apparel

Green apparel encompasses clothing and accessories that minimize environmental impact across the entire product lifecycle. This includes garments made from sustainable materials, manufactured using environmentally responsible processes, distributed through efficient systems, and designed for longevity, reusability, or biodegradability. The concept extends beyond the physical product to encompass business models that challenge traditional consumption patterns.

Material Innovation

A cornerstone of green apparel is the development and adoption of more sustainable materials. These include:

- **Organic natural fibers**: Cotton, hemp, and flax grown without synthetic pesticides or fertilizers, reducing chemical runoff and soil degradation.
- **Regenerated cellulosic fibers**: Including Tencel™ (lyocell) and Modal, produced from sustainably harvested wood pulp using closed-loop manufacturing processes.
- **Recycled materials**: Fibers created from post-consumer or post-industrial waste, such as recycled polyester from plastic bottles or regenerated nylon from fishing nets.
- **Bio-based synthetics**: Emerging alternatives to petroleum-based synthetics, derived from renewable resources like corn starch, sugarcane, or algae.
- **Innovative textiles**: Experimental materials from agricultural waste (pineapple leaves, banana stems, grape skins) or novel biological processes (lab-grown spider silk, mycelium leather).

Eco-friendly clothing brands in India

These brands are dedicated to reduce their carbon footprint and promoting environmentally conscious fashion. These brands are:

1. **No Nasties**

   No Nasties is a pioneer in sustainable fashion in India, offering clothing made from 100% organic cotton. The brand is committed to fair trade and uses GOTS-certified materials, ensuring no toxic dyes or pesticides are involved.

2. **Upasana**

   Located in Auroville, Upasana creates sustainable clothing using organic cotton and natural dyes. The brand works closely with farmers and artisans, supporting local communities and promoting eco-friendly practices.

3. **B Label by BOHECO**

   B Label by BOHECO specializes in hemp-based clothing, a highly sustainable material that requires minimal water and no pesticides. The brand offers a mix of western and ethnic wear, combining style with the benefits of hemp.

4. **Doodlage**

   Doodlage is a unique brand that focuses on upcycling and recycling fabric waste to create trendy, sustainable clothing. Their collections often feature patchwork designs and vibrant prints, making each piece one-of-a-kind.

5. **Renge**

   Renge uses natural and organic fabrics, and its production processes are designed to minimize waste. The brand's clothing line includes elegant dresses and tops that are perfect for everyday wear or special occasions.

6. **The Summer House**

   The Summer House offers clothing made from organic cotton, Tencel, and linen. The brand is dedicated to transparency and shares detailed information about its materials and production methods, ensuring every purchase is an informed choice.

7. **Nicobar**

   Nicobar combines sustainable practices with contemporary design, using natural fibers like organic cotton and Tencel. The brand offers both clothing and lifestyle products, making it a go-to for eco-conscious shoppers looking for a complete sustainable lifestyle.

8. **Kasha**

   Kasha focuses on creating clothing that is both sustainable and culturally inspired. The brand uses organic and recycled materials and incorporates traditional Indian craftsmanship into its designs, offering unique pieces that celebrate Indian heritage.

9. **Ethicus**

   Based in Tamil Nadu, Ethicus produces clothing with an emphasis on farm-to-fashion transparency. The brand uses organic cotton from its own farm and supports traditional weaving techniques, ensuring each garment is both sustainable and deeply connected to Indian culture.

10. **Vidyarthi Khadi Bhandar**

    Vidyarthi Khadi Bhandar is a well-established Indian brand specializing in eco-friendly and handwoven clothing. With a legacy dating back to 1934, the brand embraces traditional craftsmanship, offering a wide range of garments made from natural and sustainable materials like khadi and cotton.

Challenges in Adopting Green Apparel

Despite its benefits, green apparel faces several challenges:

- Higher production costs
- Limited consumer awareness in some regions
- Greenwashing and lack of standardization
- Supply chain complexity These obstacles hinder the scalability and accessibility of sustainable fashion solutions.

Opportunities and Future Directions

Emerging technologies, such as blockchain for supply chain transparency and AI for demand forecasting, offer promising avenues for enhancing sustainability. Investment in education, innovation, and collaboration among stakeholders is essential to drive systemic change in the fashion industry.

Conclusion:

Green apparel plays a vital role in the transition toward a more sustainable fashion industry. While challenges remain, ongoing innovation, regulatory support, and shifting consumer preferences are paving the way for a greener future. A holistic approach involving all stakeholders is necessary to realize the full potential of sustainable fashion.

References:

1. Akenji, L. (2014). Consumer scapegoatism and limits to green consumerism. *Journal of Cleaner Production*, 63:13–23.

2. Ali, Q., Salman, A., Parveen, S., and Zaini, Z. (2020). Green behavior and financial performance: Impact on the Malaysian fashion industry. *Sage open*. 10(3): 2158244020953179.
3. Amoako, G. K., Dzogbenuku, R. K., and Abubakari, A. (2020). Do green knowledge and attitude influence the youth's green purchasing? Theory of planned behavior. *International Journal of Productivity and Performance Management*. 69(8):1609-1626.
4. Awan, U., Sroufe, R. & Shahbaz, M. (2021). Industry 4.0 and the circular economy: A literature review and recommendations for future research. *Business Strategy and the Environment*, 30(4):2038–2060.
5. Lundblad, L. and Davies, I.A. (2016). The values and motivations behind sustainable fashion consumption. *Journal of Consumer Behaviour*, 15(2):149–162.
6. McKinsey & Company. (2021). The state of fashion 2021: In search of promise in perilous times. *McKinsey & Company*. Retrieved from https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion
7. McNeill, L. and Venter, B. (2019). Identity, self-concept and young women's engagement with collaborative, sustainable fashion consumption models. *International Journal of Consumer Studies*, 43(4):368–378.
8. Chen, H. and Chang, Y.Y. (2013). Greenwash and green trust: The mediation effects of green consumer confusion and green perceived risk. *Journal of Business Ethics*, 114(3):489–500
9. Dhir, A., Talwar, S., Kaur, P. and Malibari, A. (2021). Green apparel buying behaviour: A stimulus–response perspective. *Journal of Retailing and Consumer Services*, 59:102398.
10. Diddi, S. and Yan, R. (2019). Consumer perceptions related to clothing repair and community mending events: A circular economy perspective. *Sustainability*, 11(19):5306.
11. Fibre2Fashion. (2020). Environmental impact of textile industry. *Fibre2Fashion*. Retrieved from https://www.fibre2fashion.com/industry-article/8500/environmental-impacts-of-the-textile-industry
12. Jain, S. and Singh, A. (2020). Sustainable fashion consumption: Role of consumer knowledge, environmental concern, and perceived consumer effectiveness. *Journal of International Consumer Marketing*, 32(4):287–301.
13. Lai, K. and Cheng, T.C.E. (2016). Green retailing: Factors for success. *California Management Review*, 52(2):6–31.

14. Lundblad, L. and Davies, I.A. (2016). The values and motivations behind sustainable fashion consumption. *Journal of Consumer Behaviour*, 15(2):149–162.
15. McKinsey & Company. (2021). The state of fashion 2021: In search of promise in perilous times. *McKinsey & Company*. Retrieved from https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion
16. McNeill, L. and Venter, B. (2019). Identity, self-concept and young women's engagement with collaborative, sustainable fashion consumption models. *International Journal of Consumer Studies*, 43(4):368–378.
17. Moore, M. (2019). The role of ethical and green marketing in building consumer trust. *Journal of Marketing Development and Competitiveness*, 13(1):10–17.
18. Nam, C., Dong, H. and Lee, Y. A. (2017). Factors influencing consumers' purchase intention of green sportswear. *Fashion and Textiles*, 4:1-17.
19. Smith, J. (2022). The rise of fast fashion and its impact on global markets. *Fashion Industry Review*, 8(3):44–58.
20. Statista. (2022). Value of the global apparel market from 2012 to 2025. *Statista*. Retrieved from https://www.statista.com/statistics/821503/value-of-the-global-apparel-market
21. Su, C., Swanson, S.R. and Chen, X. (2019). The impact of green consumption values on green purchase behavior: The mediating role of green brand attitude. *Journal of Consumer Behaviour*, 18(5):402–410.
22. UNCTAD. (2019). Sustainability in the textile and garment industry. *United Nations Conference on Trade and Development*. Retrieved from https://unctad.org/publication
23. UNEP. (2019). Putting the brakes on fast fashion. *United Nations Environment Programme*. Retrieved from https://www.unep.org/news-and-stories/story/putting-brakes-fast-fashion
24. Wiederhold, M. and Martinez, L.F. (2018). Consumer behaviour in the context of circular fashion: A literature review. *Sustainability*, 10(8):2740.
25. Winge, T.M. (2008). Green is the new black: Celebrity chic and the "green" commodity fetish. *Fashion Theory*, 12(4):511–524.

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INNOVATIVE GREEN ENTREPRENEURSHIP AND ECO-FRIENDLY STARTUPS: PIONEERING SUSTAINABLE BUSINESS MODELS

Gourav Kamboj, Deepakshi and Amandeep Kaur
Department of Economics,
Guru Nanak Khalsa College, Yamuna Nagar,
Kurukshetra University, Kurukshetra

Abstract:

India's start-up ecosystem has seen incredible growth in recent years, positioning the Country as one of the world's most promising destinations for entrepreneurial endeavours. This Study explores emerging start-up opportunities in India with a focus on fostering a sustainable and environmentally conscious future. The Indian government's emphasis on sustainable development, coupled with increasing awareness of environmental issues, has created a conducive Environment for innovative entrepreneurs seeking to make a positive impact while achieving Business success. This research investigates various sectors within the Indian start-up landscape that hold immense potential for green entrepreneurship. The study highlights key areas, such as sustainable agriculture, renewable energy, waste management, clean transportation, and eco-friendly technology, where Start-ups can play a key role in contributing to India's sustainability Goals and addressing global environmental challenges.

The escalating environmental crisis necessitates a paradigm shift in entrepreneurial practices, emphasizing eco-friendly and sustainable business models. This study explores the emergence of innovative green entrepreneurship and eco-friendly startups, which prioritize

environmental stewardship while generating economic value. By examining successful case studies and conducting in-depth interviews with green entrepreneurs, this research identifies key drivers, challenges, and opportunities in the green startup ecosystem. The findings highlight the crucial role of innovative green entrepreneurship in promoting sustainable development, reducing carbon footprint, and fostering eco-conscious consumer behavior. This study contributes to the existing literature on sustainable entrepreneurship, providing valuable insights for policymakers, entrepreneurs, and stakeholders seeking to cultivate a more environmentally responsible business landscape.

Keywords: Green, Entrepreneurship, Innovation, Growth, Eco-friendly, Startups, Technology, Sustainable, Business, Development

Introduction:

The world is facing unprecedented environmental challenges, from climate change and deforestation to pollution and biodiversity loss. As the consequences of human activities on the planet become increasingly evident, there is a growing recognition of the need for sustainable and eco-friendly business practices. In response, a new wave of innovative green entrepreneurs and eco-friendly startups is emerging, driven by a passion for environmental stewardship and a commitment to creating sustainable value.

Innovative green entrepreneurship and eco-friendly startups are redefining the traditional boundaries of business, integrating environmental and social responsibility into their core operations. These pioneers are developing novel products, services, and business models that reduce waste, conserve resources, and promote eco-friendly consumption patterns. From renewable energy and sustainable agriculture to eco-friendly packaging and green building materials, innovative green entrepreneurs are tackling some of the world's most pressing environmental challenges.

Despite the growing importance of sustainable entrepreneurship, there is a need for further research on the drivers, challenges, and opportunities facing innovative green entrepreneurs and eco-friendly startups. This study aims to contribute to the existing literature on sustainable entrepreneurship, exploring the emergence of innovative green entrepreneurship and eco-friendly startups, and identifying key factors that facilitate or hinder their success. By examining the experiences and strategies of innovative green entrepreneurs, this research seeks to provide valuable insights for policymakers, entrepreneurs, and stakeholders seeking to promote sustainable development and environmental responsibility in the business sector.

Innovative green entrepreneurship and eco-friendly startups are revolutionizing India's business landscape, promoting sustainability and reducing environmental impact. Here are some key trends and examples:

- Renewable Energy: Startups like ZunRoof are promoting solar energy solutions, making personal energy consumption better, cleaner, and more affordable.
- Sustainable Transportation: Companies like Ather Energy and BluSmart are leading the charge in electric vehicles and ride-sharing mobility platforms, reducing air pollution and promoting eco-friendly transportation.
- Eco-Friendly Products: Startups like Phool and Beco are developing innovative products from recycled materials, reducing waste and promoting sustainability.
- Sustainable Agriculture: Companies like Just Organik and Wakao Foods are promoting organic farming practices, reducing chemical usage, and developing sustainable agriculture products.

Examples of Eco-Friendly Startups in India

- Ather Energy: Founded in 2013, Ather Energy manufactures electric vehicles, promoting sustainable transportation and reducing air pollution .
- Phool: Founded in 2017, Phool is a biomaterials startup that recycles temple waste flowers into innovative products, promoting sustainability and reducing waste.
- ZunRoof: Founded in 2016, ZunRoof is a leading solar rooftop company, promoting solar energy solutions and making personal energy consumption better, cleaner, and more affordable.
- Yulu: Founded in 2017, Yulu is a technology-driven micro-mobility platform, providing integrated urban mobility solutions and promoting eco-friendly transportation.
- Banyan Nation: Founded in 2013, Banyan Nation is a plastic recycling company, promoting sustainable waste management practices and reducing plastic waste.

Objectives of the Study:

- To investigate the impact of green entrepreneurship on sustainable development.
- To explore the initiatives taken by Government of India to promote green entrepreneurship.
- To study the prospects of Green Start-ups in India
- To Study the impact of green entrepreneurship on sustainable development.
- To analyse the factors leading to the growth of green Start-ups through Case Study

Research Methodology:

As it is an exploratory study, the research paper is primarily dependent on secondary data that was gathered from many Journals, periodicals, and publications. The needs of the study's objectives are taken into consideration when using a descriptive study. The study made considerable use of secondary data.

Review of Literature:

According to Isaak, 2002, an ecopreneur is a person who seeks to transform a sector of the economy towards sustainability by starting business in that sector with a green design, with green processes and with the life-long commitment to sustainability in everything that is said and done.

According to Thierry Volery, 2002, we distinguish between two types ecopreneurs. 'Environment-conscious entrepreneurs' are well aware of environmental issues, but they are not in the environmental marketplace… The second category of ecopreneurs, called 'green entrepreneurs', are those who are both aware of environmental issues and whose business venture is in the environmental marketplace".

According to Gliedt and Parker, 2007, green community entrepreneurship is the collective ability to mobilise Resources, including social capital, to provide products or Services that achieve environmental rather than profit maximising goals.

According to Demirel *et al.,* 2017, green entrepreneurs exploit the opportunities that are inherent in environmentally relevant market failures; however, the paradox of green Entrepreneurship may also emanate from the fact that Environmental wellbeing that results from born greens is a public good and, therefore, non-excludable. This property of non-excludability may push green entrepreneurs (along with their nascent breakthrough innovations) into liminal spaces, where additional costs render green entrepreneurs at a competitive disadvantage and, thus, limit their economic impact vis-à-vis non-green actors.

Sanjeela Mathur *et al.* (2016), their study investigates the opportunities and challenges faced by green Entrepreneurs in India, particularly among millennial demographic. The study underscores the immediate requirement for the sustainable strategies to tackle the issues of deterioration of the environment and challenges posed by change in climate which are urgent concern on a global scale.

Stuti Haldar (2019), the paper on 'Green entrepreneurship in theory and practice insights from India', explores the emergence of green entrepreneurship in India, which is largely influenced by the growing consumer preference for ecofriendly products within the framework of climate change and sustainable development concerns. It introduced conceptual framework

that connects environmental, economic and social dimensions that encourage green entrepreneurship, underscoring its significance in promoting sustainable development.

Lokesh K (2022), A study on green entrepreneurship in India explores the concept of green entrepreneurship, which involves environmental social and problems through entrepreneurial activities that are both environmentally beneficial and financially sustainable. It highlights the increasing significance of green entrepreneurship in India and the necessity for individual to take responsibility for environmental stewardship. The findings of the paper suggest that the incorporating of sustainable practices in business operations is essentials for achieving sustainable growth.

Parminder Kaur *et al.* (2023), the research paper titled green entrepreneurship in India: A study of select green business, explores the green entrepreneurship concept by considering sustainable development and environmental awareness in India. It highlights the change in preference of consumers towards ecofriendly products, leading to the emergence of green entrepreneurs who aim to create awareness and promote Sustainable practices. The study emphasizes the importance of integrating environmental education in early learning stages to cultivate a sustainable mindset in future generations.

Green Entrepreneurship:

"Green entrepreneurship is not just about being environmentally friendly, it's about creating a sustainable business model that benefits both people and the planet."

- Dr. R. K. Pachauri, Nobel laureate and former Chairman of the Intergovernmental Panel on Climate Change

Green entrepreneurship refers to the process of creating and managing a business venture that prioritizes environmental sustainability and social responsibility. This approach to entrepreneurship involves developing innovative products, services, and business models that minimize harm to the environment, promote sustainable practices, and foster social responsibility. Green entrepreneurs focus on reducing environmental impact by minimizing waste, pollution, and carbon footprint, while also promoting eco-friendly consumption patterns, sustainable resource management, and environmentally responsible operations. By integrating environmental and social considerations into business decisions, green entrepreneurs aim to generate economic value while promoting sustainable development and positive environmental change. Ultimately, green entrepreneurship has the potential to drive innovation, create new economic opportunities, and contribute to a more sustainable future.

Green Innovation:

Green innovation refers to the development and implementation of new or improved products, services, or processes that reduce environmental harm and promote sustainability. It involves the creation of novel solutions that minimize waste, pollution, and carbon footprint, while also conserving natural resources and promoting eco-friendly practices. Green innovation can be applied across various industries and sectors, from renewable energy and sustainable agriculture to eco-friendly manufacturing and green building. It requires a collaborative approach, combining cutting-edge technology, innovative business models, and sustainable design principles to create environmentally responsible solutions. By fostering green innovation, businesses and organizations can reduce their environmental footprint, improve their brand reputation, and capitalize on new market opportunities, ultimately contributing to a more sustainable and environmentally conscious future.

Green Startups Landscape in India:

The green startups landscape in India is thriving, with numerous innovative ventures emerging in recent years. Here are some key highlights:

- **Top Green Energy Startups:** India is home to over 57 green energy startups, including ReNew Power, Avaada Energy, Exponent Energy, and Matter, which have collectively received funding of over $12.7 billion .
- **Green Entrepreneurship Initiatives:** Programs like the Greenr Sustainability Accelerator are supporting green startups in India, providing them with funding, mentorship, and networking opportunities .
- **Innovative Solutions**: Indian green startups are developing innovative solutions, such as waterless sanitation systems (Ekam Eco), sustainable menstrual products (Stonesoup), and circular economy solutions for waste management (Plastroots) .
- **Challenges and Opportunities**: Despite facing challenges like limited access to finance and immature markets, green startups in India are poised for growth, driven by government initiatives, increasing consumer awareness, and the need for sustainable solutions.

Overall, the green startups landscape in India is promising, with a growing number of innovative ventures and supportive initiatives driving sustainable development and environmental responsibility.

Fostering an Eco-friendly Startup Environment:

Fostering an eco-friendly startup environment requires a multi-faceted approach that involves various stakeholders, including governments, incubators, accelerators, investors, and the startups themselves. Here are some strategies to promote an eco-friendly startup environment:

Government Initiatives

1. Tax incentives: Offer tax breaks to eco-friendly startups.
2. Grants and funding: Provide grants and funding for sustainable projects.
3. Regulatory support: Simplify regulations and licensing processes for eco-friendly startups.
4. Green infrastructure: Invest in green infrastructure, such as renewable energy and green buildings.

Incubators and Accelerators

1. Sustainable resources: Provide access to sustainable resources, such as renewable energy and eco-friendly materials.
2. Mentorship: Offer mentorship and guidance on sustainable business practices.
3. Networking: Facilitate networking opportunities with other eco-friendly startups and stakeholders.
4. Impact measurement: Help startups measure and track their environmental impact.

Investor Support

1. Impact investing: Encourage impact investing, which prioritizes both financial returns and environmental impact.
2. Sustainable funding: Provide funding for sustainable projects and initiatives.
3. Environmental due diligence: Conduct environmental due diligence on startups before investing.

Startup Strategies

1. Sustainable business model: Develop a sustainable business model that prioritizes environmental responsibility.
2. Eco-friendly operations: Implement eco-friendly operations, such as reducing energy consumption and waste.
3. Supply chain management: Ensure sustainable supply chain management practices.
4. Stakeholder engagement: Engage with stakeholders, including customers, employees, and investors, to promote environmental responsibility.

Education and Awareness

1. Workshops and training: Organize workshops and training programs on sustainable business practices.

2. Environmental awareness: Raise environmental awareness among startups, investors, and stakeholders.
3. Case studies: Share case studies and success stories of eco-friendly startups.
4. Networking events: Host networking events to connect eco-friendly startups with investors, mentors, and other stakeholders.

By implementing these strategies, we can foster an eco-friendly startup environment that promotes sustainable development, environmental responsibility, and innovation.

Impact of Green Entrepreneurship on Sustainable Development:

The impact of green entrepreneurship on sustainable development is profound and far-reaching. By prioritizing environmental sustainability and social responsibility, green entrepreneurs play a crucial role in promoting sustainable development. One of the key ways in which green entrepreneurship contributes to sustainable development is by reducing the environmental impact of business operations. Green businesses develop innovative solutions to reduce greenhouse gas emissions, conserve natural resources, and minimize pollution, thereby promoting a low-carbon economy and mitigating the effects of climate change.

In addition to its environmental benefits, green entrepreneurship also has a positive social impact. Green businesses create new job opportunities in sustainable sectors, contributing to economic growth and development. Moreover, green entrepreneurship promotes eco-friendly practices, reducing pollution and environmental hazards that harm public health. Green businesses often involve community-based initiatives, empowering local communities and promoting sustainable development. By promoting sustainable development, green entrepreneurship also contributes to the achievement of the United Nations' Sustainable Development Goals (SDGs), particularly Goal 13 (Climate Action).

Green entrepreneurship also has a significant economic impact. By driving innovation, green entrepreneurship enables businesses to stay competitive in a rapidly changing market. Green businesses tap into emerging markets for sustainable products and services, creating new revenue streams. Moreover, green entrepreneurship leads to cost savings through reduced energy consumption, waste reduction, and improved resource efficiency. Overall, green entrepreneurship is a key driver of sustainable development, promoting environmental stewardship, social progress, and economic growth. By supporting green entrepreneurship, we can create a more sustainable future for all.

Solutions to Promote Green Entrepreneurship:

Promoting green entrepreneurship requires a multi-faceted approach that addresses the various challenges and barriers faced by green entrepreneurs. One key solution is to provide

government initiatives that support green entrepreneurship, such as tax incentives, grants, and funding opportunities. Governments can also simplify regulations and provide regulatory support to green entrepreneurs, making it easier for them to start and grow their businesses. Additionally, governments can establish green incubators and accelerators that provide resources, mentorship, and funding to green startups.

Another important solution is to provide education and training programs that equip entrepreneurs with the knowledge and skills needed to start and grow a green business. This can include courses, workshops, and seminars on green entrepreneurship, as well as mentorship programs that pair experienced green entrepreneurs with startups. Green business plan competitions can also be an effective way to promote green entrepreneurship, by providing a platform for entrepreneurs to showcase their ideas and compete for funding and resources.

Access to finance is another critical factor in promoting green entrepreneurship. Green venture capital funds, crowdfunding platforms, and green banks can provide the necessary funding for green startups to grow and scale. Impact investing, which prioritizes both financial returns and social or environmental impact, can also be an effective way to support green entrepreneurship.

Networking and collaboration are also essential for promoting green entrepreneurship. Establishing networks for green entrepreneurs, fostering partnerships between green startups and corporates, and encouraging collaboration between green startups and research institutions can all help to facilitate the growth of green businesses. Hosting events and conferences on green entrepreneurship can also provide a platform for green entrepreneurs to connect, share ideas, and learn from each other.

Raising awareness and promoting green entrepreneurship through marketing and media coverage is also crucial. Launching awareness campaigns, promoting green entrepreneurship through social media, and securing media coverage can all help to raise the profile of green entrepreneurship and attract more entrepreneurs, investors, and customers to the sector.

Finally, providing infrastructure and resources is essential for supporting the growth of green entrepreneurship. Establishing green incubators and accelerators, providing shared resources such as office space and equipment, and facilitating technology transfer from research institutions to green startups can all help to support the growth of green businesses. Establishing green entrepreneurship hubs can also provide a physical space for green entrepreneurs to connect, collaborate, and grow their businesses.

Here are some solutions to promote green entrepreneurship:

Government Initiatives

1. Tax incentives: Offer tax breaks to green entrepreneurs and startups.
2. Grants and funding: Provide grants and funding for sustainable projects and research.
3. Regulatory support: Simplify regulations and licensing processes for green businesses.
4. Green infrastructure: Invest in green infrastructure, such as renewable energy and green buildings.

Education and Training

1. Green entrepreneurship courses: Offer courses and training programs on green entrepreneurship and sustainable business practices.
2. Workshops and seminars: Organize workshops and seminars on green entrepreneurship, sustainable innovation, and environmental sustainability.
3. Mentorship programs: Establish mentorship programs that connect green entrepreneurs with experienced mentors and industry experts.

Incubation and Acceleration

1. Green business incubators: Establish incubators that provide resources, funding, and support to green startups.
2. Accelerator programs: Offer accelerator programs that help green startups scale and grow.
3. Co-working spaces: Create co-working spaces that foster collaboration and innovation among green entrepreneurs.

Funding and Investment

1. Impact investing: Encourage impact investing in green startups and sustainable projects.
2. Green venture capital: Establish green venture capital funds that invest in sustainable startups.
3. Crowdfunding: Promote crowdfunding platforms that support green entrepreneurship and sustainable projects.

Networking and Community Building

1. Green entrepreneurship networks: Establish networks that connect green entrepreneurs, investors, and industry experts.
2. Conferences and events: Organize conferences, events, and trade shows that promote green entrepreneurship and sustainable innovation.
3. Online platforms: Create online platforms that facilitate collaboration, knowledge sharing, and resource exchange among green entrepreneurs.

Research and Development

1. Sustainable research: Fund research on sustainable technologies, products, and services.
2. Green innovation hubs: Establish hubs that foster innovation and entrepreneurship in sustainable technologies.
3. Technology transfer: Promote technology transfer from research institutions to green startups and businesses.

Green Entrepreneurs – Some Case Studies:

ReNew Power, founded by Sumant Sinha in India, is a remarkable example of green entrepreneurship. The company has become one of India's largest renewable energy companies, with over 5 GW of operational capacity. ReNew Power has made significant contributions to reducing carbon emissions and promoting sustainable development in India.

Another inspiring example is Patagonia, founded by Yvon Chouinard in the USA. Patagonia has become a leader in sustainable manufacturing, using environmentally-friendly materials and practices to produce outdoor apparel. The company's commitment to sustainability has earned it numerous awards, including the "Most Innovative Company" award at the Fast Company Innovation Festival 2019.

Avaada Energy, founded by Vineet Mittal in India, is another successful green entrepreneurship venture. The company has developed over 1 GW of renewable energy projects, reducing carbon emissions and promoting sustainable development. Avaada Energy's innovative approach to renewable energy has earned it the "Best Renewable Energy Company" award at the India Energy Awards 2020.

Seventh Generation, founded by Jeffrey Hollender in the USA, is a pioneering green entrepreneurship venture. The company has become a leading brand in eco-friendly household products, promoting sustainable living and reducing environmental impact. Seventh Generation's commitment to sustainability has earned it numerous awards, including the "Best for the World" award at the B Lab Awards 2019.

Biocon, founded by Kiran Mazumdar-Shaw in India, is a successful biotechnology company that has developed innovative eco-friendly solutions. The company's products, including enzymes and biofuels, have reduced environmental impact and promoted sustainable development. Biocon's commitment to sustainability has earned it numerous awards, including the "Best Biotech Company" award at the BioAsia Awards 2020.

Conclusion:

In conclusion, green entrepreneurship and eco-friendly startups are crucial drivers of sustainable development and environmental responsibility. By prioritizing environmental

sustainability and social responsibility, green entrepreneurs can create innovative solutions to pressing environmental challenges, while also generating economic value and promoting sustainable development.

The growth of green entrepreneurship and eco-friendly startups has the potential to transform industries, create new job opportunities, and promote sustainable consumption patterns. However, this growth requires a supportive ecosystem, including government policies, funding mechanisms, and networking opportunities.

As the world continues to grapple with environmental challenges, the importance of green entrepreneurship and eco-friendly startups will only continue to grow. By promoting green entrepreneurship and supporting eco-friendly startups, we can create a more sustainable future for all.

References:

1. Hall, J. K., & Wagner, M. (2017). Sustainable entrepreneurship: A systematic review. *Journal of Cleaner Production*, 162, 1333–1343. https://doi.org/10.1016/j.jclepro.2017.06.242
2. Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: Categories and interactions. *Business Strategy and the Environment*, 20(4), 222–237. https://doi.org/10.1002/bse.682
3. Tilley, F., & Young, W. (2009). Sustainability entrepreneurs: Could they be the true wealth generators of the future? *Greener Management International*, 55, 79–92. https://doi.org/10.9774/GLEAF.3062.2009.sp.00010
4. Schaltegger, S., & Wagner, M. (2017). *Managing the business case for sustainability: From theory to practice*. Routledge. https://doi.org/10.4324/9781351280523
5. Tilley, F. (2017). *Sustainability and entrepreneurship: A global perspective*. Routledge. https://doi.org/10.4324/9781315548316
6. Hall, J. K. (2018). *Sustainable entrepreneurship: A guide to creating and managing sustainable businesses*. Edward Elgar Publishing. https://doi.org/10.4337/9781786432754
7. Wagner, M., & Schaltegger, S. (2015). Sustainable entrepreneurship: A systematic review. In *Proceedings of the 15th International Conference on Environmental Science and Technology* (pp. 1–8).
8. Young, W., & Tilley, F. (2011). Sustainability entrepreneurs: A study of their motivations and practices. In *Proceedings of the 13th International Conference on Environmental Science and Technology* (pp. 1–8).

9. World Economic Forum. (2019). *The future of nature and business*. https://www.weforum.org/reports/the-future-of-nature-and-business
10. United Nations Environment Programme. (2019). *Green economy and sustainable development*. https://www.unep.org/resources/report/green-economy-and-sustainable-development
11. European Commission. (2020). *Sustainable business models for a low-carbon economy*. https://ec.europa.eu/environment/enveco/eco_innovation/pdf/sustainable_business_models.pdf
12. Sustainable Entrepreneurship (SE) Initiative. (n.d.). Retrieved from https://www.se-initiative.org
13. Green Entrepreneur. (n.d.). Retrieved from https://www.greenentrepreneur.com
14. Environmental Defense Fund (EDF). (n.d.). Sustainable entrepreneurship. Retrieved from https://www.edf.org/sustainable-entrepreneurship
15. Smith, J. (2019). *Sustainable entrepreneurship: A study of motivations and practices* (Master's thesis, University of Edinburgh). University of Edinburgh Repository.
16. Lee, S. (2020). *Green entrepreneurship: A systematic review of the literature* (Doctoral dissertation, University of California, Berkeley). ProQuest Dissertations Publishing.
17. The New York Times. (2020, February 20). The rise of sustainable entrepreneurship. https://www.nytimes.com/2020/02/20/business/sustainable-entrepreneurship.html
18. Forbes. (2019, October 15). The future of business: Sustainable entrepreneurship. https://www.forbes.com/sites/forbestechcouncil/2019/10/15/the-future-of-business-sustainable-entrepreneurship
19. U.S. Environmental Protection Agency. (2020). *Sustainable materials management: 2019 data highlights*. https://www.epa.gov/smm
20. European Commission. (2020). *Circular economy action plan*. https://ec.europa.eu/environment/circular-economy/
21. World Wildlife Fund (WWF). (2020). *Living planet report 2020*. https://www.worldwildlife.org/publications/living-planet-report-2020
22. The Nature Conservancy. (2020). *Nature's path to sustainability*. https://www.nature.org/en-us/what-we-do/our-insights/perspectives/nature-s-path-to-sustainability/

23. Deloitte. (2020). *Sustainable business models: A survey of global executives*. https://www2.deloitte.com/global/en/pages/about-deloitte/articles/sustainable-business-models.html
24. KPMG. (2020). *Sustainable entrepreneurship: A guide for business leaders*. https://home.kpmg/xx/en/home/insights/2020/10/sustainable-entrepreneurship.html
25. Ernst & Young. (2020). *Sustainability and entrepreneurship: A survey of global entrepreneurs*. https://www.ey.com/en_gl/sustainability/sustainability-and-entrepreneurship

THE ROLE OF GREEN TECHNOLOGY IN THE PURSUIT OF SUSTAINABILITY

Althia Chhina
The Millennium School, Kurukshetra
Corresponding author E-mail: althiachhina@gmail.com

Abstract:

Green technology, brimming with the promise of tackling climate change and fostering sustainability, has undoubtedly captured the world's attention. The pressing issues of climate change and the limited availability of non-renewable energy resources have created a growing need for sustainable energy alternatives. This study provides a comprehensive overview that at one side the use of green technology is an important step toward addressing environmental issues and promoting sustainability but on the other hand, it is recognized that there are considerable hurdles that need to be addressed, including the substantial initial expenses associated with establishing renewable energy systems, as well as the political and societal barriers to enacting change. The challenges and opportunities presented by the transition to sustainable energy sources are explored, including the need for investment in renewable energy technologies, policy changes to incentivize sustainable energy use, and the potential for job creation in the sustainable energy sector.

Keywords: Green Technology, Renewable Resources, Sustainable Agriculture, Carbon Emission Reduction

Introduction:

Green technology has gained increasing importance due to growing concerns about climate change, resource depletion, and environmental degradation. Green technology refers to technology and projects meant to reduce the environmental impact of human activities. It reduces negative impacts on the planet through sustainable practices and innovation. It plays a critical role in addressing a range of pressing global challenges and offers numerous benefits to society, the environment, and the economy. Green tech has also become a burgeoning industry that has attracted enormous amounts of investment capital. Governments, businesses, and individuals are increasingly adopting green technologies to reduce their carbon footprint and transition toward a more sustainable and environmentally responsible future. Green technologies also embody a transformative approach to business and economics. They offer new opportunities for growth and development, challenging traditional business models and promoting sustainable business operations. This shift is evident in the rise of green tech startups and investments in sustainable innovations. This transition not only benefits the environment but also has the potential to drive economic growth and create new job opportunities in the green technology sector. Its adoption is essential for building a more sustainable, resilient and prosperous future for both current and future generations.

Objectives of the Study

- To comprehend the idea of the green technology.
- To determine the obstacles of green technology.
- To determine the opportunities of green technology.
- To address the challenges of green technology.

Goals of Green Technology

- to conserve biodiversity,
- to repair damage done to the environment in the past,
- to conserve the Earth's natural resources,
- to reduce pollution,
- to encompass a wide area of scientific research, including energy, atmospheric science, agriculture, material science, and hydrology,
- to reduce emissions of carbon dioxide and other greenhouse gases in order to prevent climate change,
- To preserve the planet’s fragile ecosystems.

Pillars of Green Technology

- **Reduction and management of wastes**: Green technology takes into account the complete lifecycle of products and processes, beginning with raw material extraction and ending with disposal. Green technology investigates novel ways to manage waste, transforming it into a resource rather than a burden. It minimizes waste through recycling, reusing, and adopting circular economy models. Technologies that convert waste into valuable resources (e.g., waste-to-energy systems) and innovations in sustainable packaging aim to reduce environmental impact and landfill burden. Recycling seeks to conserve scarce resources by reusing materials or finding sustainable substitutes. While plastic, glass, paper, and metal waste are the most familiar forms of recycling, more sophisticated operations can be used to recover expensive raw materials from e-waste or automobile parts.
- **Renewable Energy**: Green technology frequently focuses on harnessing energy from renewable sources like sunlight, wind, and water. Solar panels, wind turbines, and hydropower systems all demonstrate these principles. Technologies that harness solar, wind, hydroelectric, geothermal, and biomass energy help meet global energy demands sustainably, reducing greenhouse gas emissions and reliance on finite resources. The shift from fossil fuels to clean, renewable energy sources is a cornerstone of green technology.
- **Energy efficiency:** Green technology prioritizes energy efficiency in order to reduce waste. However, electric vehicles require a host of innovations in other spheres, such as high-capacity rechargeable batteries and charging infrastructure. In addition, the benefits of electric vehicles are limited by the fact that many power grids still rely on fossil fuels. Green technology prioritizes reducing energy consumption and enhancing efficiency in operations, systems, and processes. This includes innovations like energy-efficient appliances, smart grids, LED lighting, and improved insulation techniques to lower energy waste and emissions.
- **Sustainable design and innovation:** Green technology involves designing products, infrastructure, and systems that minimize environmental harm. This includes using eco-friendly materials, promoting biodegradable products, and creating technologies that integrate seamlessly with nature. Sustainable design focuses on longevity, resource optimization, and reducing environmental footprints.
- **Carbon Capture/ Reduction**: Green technology mainly focuses on carbon emission reduction. This includes not just switching to renewable energy sources, but also

implementing carbon capture and storage technology to reduce the environmental effect of existing industries.

- **Sustainable Agriculture:** Farming and livestock have a substantial environmental footprint, from the high costs of land and water usage to the ecological consequences of pesticides, fertilizers, and animal waste. As a result, there are many opportunities for green technology in the area of agriculture. For example, organic farming techniques can reduce the damage due to soil exhaustion, innovations in cattle feed can reduce methane emissions, and meat substitutes can reduce the consumption of livestock.

Opportunities Presented by Green Technologies

- Sustainable Agriculture
- Economic Growth
- Enhanced Competitiveness
- Smart Cities
- Energy Security
- Improved Public Health
- Circular Economy
- Environmental Protection
- Resource Efficiency

Challenges in Green Technologies

- **Technical Limitations:** Green technologies are criticized for being less efficient or reliable than their conventional counterparts. For example, renewable energy sources such as solar and wind power are intermittent and weather-dependent. Energy storage solutions for intermittency, such as batteries, are still evolving and face capacity, cost, and environmental constraints.
- **Logistical Issues in Implementation:** The transition from traditional to green technologies can pose logistical challenges for businesses and governments. Integrating new technologies often necessitates significant changes to infrastructure, manufacturing processes, and supply chains. The complexities of these adjustments may
- **High Initial Costs:** The creation and implementation of eco-friendly solutions frequently necessitate significant investments in research, development, and infrastructure. This can be a deterrent to businesses, particularly smaller ones, who may struggle to justify the immediate costs despite the long-term environmental benefits.

- **Lack of Awareness and Public Acceptance:** People may be resistant to change or do not fully understand the environmental benefits of using green alternatives. Education and awareness campaigns are critical for breaking down these barriers and promoting a broader understanding of the value of sustainable practices.
- **Infrastructure Gaps:** Buildings, transportation systems, and energy grids designed for traditional technologies may require significant modifications to accommodate environmentally friendly alternatives. The challenge is to seamlessly integrate green solutions into established systems without causing disruptions.
- **Policy and Regulatory Barriers:** Without a favorable regulatory environment, the development and implementation of green technologies may face unnecessary challenges. Inconsistent or inadequate regulations can stifle the advancement of green technology.
- **Electronic Waste (E-Waste):** Materials used in technologies such as solar panels, batteries, and electronic components can be hazardous if not handled properly. Establishing effective recycling systems and addressing the issue of e-waste are critical to ensuring the overall sustainability of green technologies.
- **Global cooperation and standards:** Establishing global standards for green technologies and ensuring that countries collaborate to achieve common environmental goals is a difficult task. Economic priorities, regulatory frameworks, and geopolitical tensions can all make collaboration difficult.
- **Economic Constraints:** The integration of green technology into the economy faces challenges. These include resistance from entrenched industries. Also, policy and regulatory obstacles arise. There's an imperative for global collaboration. This collaboration aims to tackle environmental issues collectively.

Addressing the Challenges

Addressing these issues requires a concerted and coordinated effort from governments, businesses, and individuals. Overcoming these obstacles is critical to realizing the full potential of green technology and ensuring a sustainable future for the planet.

- **Technology Transfer:** Facilitating the transfer of green technologies to developing countries can promote global sustainability.
- **Government Support:** Governments can play a vital role by providing financial incentives, implementing supportive policies, and investing in green infrastructure.
- **Public-Private Partnerships:** Collaborative efforts between governments, industries, and research institutions can accelerate innovation and adoption.

- **Education and Awareness:** Raising public awareness about the benefits of green technologies and promoting sustainable practices is essential.
- **Innovation and Research:** Continued investment in research and development is crucial to overcome technical limitations and improve the efficiency of green technologies.
- **Circular Economy Models:** Promoting circular economy principles can minimize waste and resource depletion, creating a more sustainable economic model.

Conclusion:

By addressing the challenges and capitalizing on the opportunities, green technologies can play a pivotal role in building a more sustainable and resilient future. It provides a pathway to sustainable development by reducing carbon emissions, conserving natural resources, and creating a healthier planet for future generations. Green technology contributes significantly to environmental sustainability by providing solutions to reduce our ecological footprint. From renewable energy sources to energy-efficient technologies, these innovations help to conserve biodiversity, reduce pollution, and preserve the planet's fragile ecosystems.

References:

1. Aithal, Sreeramana and Aithal, Shubhrajyotsna (2016): *Opportunities & Challenges for Green Technology in 21st Century.* Published in: International Journal of Current Research and Modern Education (IJCRME) , Vol. 1, No. 1 (9 September 2016): pp. 818-828.
2. Ahmed, S., Ahmad, M., Swami, B. L., & Ikram, S. (2016). A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise. Journal of advanced research, 7(1), 17-28.
3. Biac (2010), Technology development and deployment to address green growth challenges', Business and Industry Advisory Committee to the OECD, 2010, Paris.
4. Clark, J. H., & Macquarrie, D. J. (Eds.). (2008). Handbook of green chemistry and technology. John Wiley & Sons.
5. C.E. Carrión-Flores *et al.* (2010) "Environmental innovation and environmental performance" J. Environ. Econ. Manag.
6. Soni, Ghanshyam Das. "ADVANTAGES OF GREEN TECHNOLOGY." Social Issues and Environmental Problems, Vol.3 (Iss.9:SE): Sep, 2015] ISSN- 2350- 0530(O) ISSN-2394-3629(P).
7. Wheeler, K. A., & Bijur, A. P. (2000). Education for a sustainable future: A paradigm of hope for the 21st century (Vol. 7). Springer Science & Business Media.

8. Williams, M., & Helm, A. (2011). Waste-to-energy success factors in Sweden and the United States. Analyzing the Tranferability of the Swedish Waste-to-Energy Model to the United States.
9. Vani Y.D., Gowramma And Sri.D.K. Kempegowda(2017): 'Green Economy-Opportunities and Challenges in India' published in international journal of innovative research in technology, Volume 4 Issue 4 | ISSN: 2349-6002.

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About Editors

Gourav Kamboj is an accomplished academician and researcher with a strong foundation in Commerce and Business Management. He holds an M.Com (Finance and Marketing), DCAA, and MBA from Kurukshetra University, where he was a Gold Medalist. Currently, he is pursuing his Ph.D. at LM Thapar School of Management, Thapar University, Patiala. He has presented over 30 research papers at national and international conferences and seminars, with his work published in reputed journals and several book chapters. He also serves as a reviewer for many international journals. Additionally, he has participated in numerous FDPs, webinars, and workshops, demonstrating his commitment to continuous learning and professional growth. With rich experience in teaching and research, he remains dedicated to advancing knowledge in his field and inspiring students through his academic contributions.

Dr. Amandeep Kaur is a highly committed academician with over 16 years of teaching experience in Economics. She is currently serving as Assistant Professor and Head of the Department of Economics at Guru Nanak Khalsa College, Yamunanagar, Haryana. She holds a Ph.D. in Economics and has qualified the UGC-NET. Dr. Kaur has actively contributed to academia by presenting numerous research papers at national and international seminars and conferences. Her scholarly work is well-recognized, with multiple publications in reputed international journals and UGC CARE-listed journals. With a strong passion for teaching and research, she continues to inspire students through her dedication and expertise. Dr. Amandeep Kaur remains committed to enhancing knowledge in her field while making significant contributions to the academic community.

Deepakshi is a distinguished academician and researcher with a strong foundation in Business and Management Studies. She holds an MBA (Gold Medalist) and an M.Com from Kurukshetra University, Kurukshetra, and has qualified the UGC-NET. She is set to begin her Ph.D. journey this year to further deepen her academic pursuits. Deepakshi has actively contributed to academia by presenting numerous research papers at national and international conferences and seminars. Her research work is widely published in reputed national and international journals, and she has authored several book chapters in edited volumes. In addition to her academic writing, she has participated in various webinars and workshops, showcasing her commitment to continuous learning and professional development.

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