



Intellectual Property as a Tool for Environmental Sustainability

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Abstract

The intersection of intellectual property (IP) and environmental sustainability represents one of the most dynamic and contested frontiers in contemporary international law and policy. This article examines the multifaceted role of IP rights—spanning patents, trade secrets, traditional knowledge protections, trademarks, and geographical indications—as instruments for advancing, and in some respects impeding, global environmental sustainability goals. Drawing on international treaty frameworks, comparative jurisprudence, and empirical literature, the article traces the evolution of the IP-environment discourse from early conceptual debates to present-day operational mechanisms. It analyses the systemic challenges posed by the IP-climate nexus, including technology transfer barriers, North-South tensions, and the enduring tension between private exclusivity and the global commons. Emerging issues, including artificial intelligence (AI)-driven green innovation, blockchain-enabled biodiversity tracking, and post-pandemic IP sharing models, are examined as harbingers of a transformative era. The article concludes that a recalibrated IP architecture—one that embeds environmental conditionality and equity principles into its core framework—is imperative if IP is to serve as a genuine catalyst for planetary sustainability.

Keywords: Intellectual property, Environmental sustainability, Green technology transfer, TRIPS agreement, Genetic resources and traditional knowledge.

1. Introduction

The planet stands at a critical environmental crossroads. Climate change, biodiversity loss, desertification, ocean acidification, and freshwater depletion collectively constitute what scientists have termed a "planetary emergency." In response, the international community has forged an unprecedented architecture of multilateral environmental agreements (MEAs), from the United Nations Framework Convention on Climate Change (UNFCCC) ^[1] to the Convention on Biological Diversity (CBD) ^[2] and the landmark Paris Agreement of 2015 ^[3]. At the heart of these frameworks lies a foundational question: how should innovation, technology, and knowledge be governed to advance environmental sustainability while preserving incentives for continued discovery?

Intellectual property (IP) rights occupy a paradoxical position within this debate. On the one hand, IP rights—principally patents—are widely understood to incentivise investment in research and development (R&D), including the clean technologies essential to decarbonisation, resource efficiency, and conservation ^[4]. On the other hand, IP exclusivity can impede the rapid, equitable diffusion of those same technologies, particularly to developing and least-developed countries that bear disproportionate burdens of environmental harm yet lack the economic and institutional capacity to acquire or develop green solutions indigenously ^[5].

The World Intellectual Property Organization (WIPO) has

increasingly recognised this duality, positioning itself at the interface of innovation and sustainable development through initiatives such as WIPO GREEN, the IPC Green Inventory, and its ongoing programme of capacity building for developing countries ^[6]. Simultaneously, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) ^[7], administered by the World Trade Organization (WTO), sets the baseline global standards for IP protection, including flexibilities—notably compulsory licensing—that are theoretically available to facilitate environmental technology transfer ^[8].

This article proceeds in five substantive parts. Part II surveys the progress achieved in harnessing IP for environmental goals. Part III examines the body of IP-environment law and mechanisms that sustain and institutionalise sustainability linkages. Part IV identifies persistent and structural issues and challenges that undermine the effectiveness of IP as a green tool. Part V addresses emerging issues at the cutting-edge of the IP-environment interface. Part VI offers conclusions and policy recommendations directed at scholars, practitioners, and international negotiators.

2. Progress: Intellectual Property in Service of Environmental Goals

A). The Rise of Green Patent Activity

The most visible manifestation of IP's contribution to environmental sustainability is the exponential growth of

"green" or "clean technology" patents. Data from the OECD and the European Patent Office (EPO) reveal that patent filings in climate change mitigation technologies—including renewable energy, energy efficiency, low-carbon transport, and carbon capture—have grown at rates far exceeding the broader patent universe since the early 2000s^[9]. Between 2000 and 2020, solar photovoltaic (PV) patents grew by over 2,000 percent, while wind energy patents increased by approximately 900 percent^[10]. This trajectory reflects both the commercialisation of clean energy and the maturing of innovation systems in response to climate policy signals, including carbon pricing and renewable portfolio standards.

The WIPO IPC Green Inventory, introduced in 2010 and continuously updated, provides a classification taxonomy for environmentally sound technologies (ESTs) across the International Patent Classification (IPC) system^[11]. This instrument has enhanced the ability of patent offices, researchers, policymakers, and technology transfer intermediaries to identify, track, and utilise green inventions. As of 2024, the IPC Green Inventory encompasses patent documents spanning energy production, transportation, waste management, agriculture, and administrative or regulatory frameworks, enabling systematic analysis of green innovation trends across jurisdictions.

B). WIPO GREEN and the Technology Marketplace

Launched in 2013, WIPO GREEN operates as an open marketplace and network for green technology exchange, connecting innovators, technology seekers, and investors across more than 160 countries^[12]. By facilitating matchmaking between technology holders and users—particularly those in developing countries—WIPO GREEN seeks to reduce transaction costs and information asymmetries that historically impede technology transfer. By 2022, the platform listed over 4,000 technologies and had facilitated hundreds of verified partnerships in sectors including solar energy, water purification, sustainable agriculture, and waste management^[13].

Beyond its matchmaking function, WIPO GREEN has evolved into a hub for challenge-based innovation, conducting acceleration programmes in partnership with national IP offices, development agencies, and private sector actors. These programmes leverage IP tools—including licensing, co-invention arrangements, and patent pools—to stimulate the co-creation and deployment of solutions to specific environmental challenges, from deforestation in Southeast Asia to desertification in sub-Saharan Africa.

C). Traditional Knowledge and Benefit-Sharing Frameworks

A distinct but equally significant strand of IP-environment progress concerns traditional knowledge (TK) and the equitable sharing of genetic resources. Indigenous and local communities (ILCs) worldwide have accumulated millennia of knowledge about plant varieties, ecosystems, medicinal compounds, and land management techniques that are of inestimable value for biodiversity conservation and sustainable land use^[14]. The CBD and the Nagoya Protocol on Access to Genetic Resources and Benefit-Sharing (Nagoya Protocol) together establish an international framework requiring prior informed consent (PIC) and fair and equitable benefit-sharing (ABS) as conditions for access to genetic resources and associated TK^[15].

A growing number of countries—including India, Brazil, South Africa, and the members of the Andean Community—

have enacted national ABS legislation that incorporates IP conditionalities, requiring patent applicants to disclose the origin of biological materials and evidence of PIC^[16]. These mechanisms, while imperfect, represent meaningful progress toward a more equitable and ecologically coherent IP system, one in which IP not only confers rights on formal innovators but also acknowledges and compensates the ecological stewardship of ILCs^[17].

D). The Role of Trademarks and Eco-Labeling

Beyond patents, trademarks and certification marks have emerged as important instruments for embedding environmental sustainability into consumer markets. Eco-labels such as the EU Ecolabel, Forest Stewardship Council (FSC) certification, Fairtrade International marks, and Energy Star designations function as IP-backed market signals that reward producers adhering to environmental standards and guide consumer choice toward lower-impact goods^[18]. The market for sustainably certified products has grown substantially, with studies suggesting that eco-labelled products command a price premium and generate economic rents that can be channelled into conservation and sustainable production investments^[19].

3. Sustenance: The Architecture of IP-Environment Linkages

A). The TRIPS Framework and Environmental Flexibilities

The TRIPS Agreement, as the cornerstone of global IP governance, contains several provisions relevant to environmental sustainability. Article 27.2 permits WTO Members to exclude from patentability inventions whose commercial exploitation would be "necessary to protect order public or morality, including to protect human, animal or plant life or health or to avoid serious prejudice to the environment^[20]." While this provision has rarely been invoked in practice, it signals that environmental protection is a legitimate ground for limiting IP exclusivity—a principle of growing importance as pressure mounts for differential treatment of critical environmental technologies^[21].

Article 31 of TRIPS, governing compulsory licensing, is of particular relevance for environmental technology transfer. Under this provision, a government may authorise the use of a patented invention without the patent holder's consent in cases of national emergency, extreme urgency, or public non-commercial use. Several commentators and civil society organisations have argued that the climate crisis satisfies the threshold of "national emergency," thereby justifying compulsory licensing of key clean technologies, including high-efficiency solar panels, advanced battery storage systems, and industrial carbon capture technologies. To date, however, no WTO Member has formally invoked Article 31 for environmental purposes, reflecting political sensitivities and the fear of trade retaliation by technology-exporting nations.

B). The Paris Agreement and IP for Climate Technology Transfer

Article 10 of the Paris Agreement establishes a Technology Mechanism, operationalised through the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN), with a mandate to promote the development and transfer of technologies for both mitigation and adaptation. Article 10.6 specifically calls for support to developing countries for technology development and transfer

[22]. While the Agreement does not directly regulate IP rights, it creates an architecture within which IP considerations—particularly around licensing and technology access—are central to effective implementation.

Civil society and developing country negotiators have persistently argued that the Technology Mechanism has been operationally constrained by the unwillingness of developed countries to address IP barriers directly within the UNFCCC process [23]. The result is a systemic gap: The Paris Agreement articulates ambitious technology transfer objectives but lacks enforcement mechanisms sufficient to overcome IP-based exclusivity where it operates as a barrier to the equitable diffusion of climate-critical technologies [24].

C). Geographical Indications and Agro-Biodiversity

Geographical indications (GIs), a form of IP protecting product quality and origin, have emerged as an underutilised but promising instrument for environmental sustainability. GIs incentivise the preservation of traditional agricultural practices, heirloom crop varieties, and landscape management techniques by creating premium markets for products embodying those practices. Examples such as Darjeeling tea (India), Café de Colombia, and Champagne (France) illustrate how GI protection can translate environmental and cultural stewardship into economic value, thereby sustaining the land use practices—including agroforestry, terraced cultivation, and polyculture—that underpin biodiversity conservation [25]. WIPO's Lisbon System for GI registration has been expanded through the 2015 Geneva Act to include geographical indications (in addition to appellations of origin), broadening its applicability to products from developing countries. Nonetheless, the full potential of GIs as tools for agrobiodiversity conservation remains underexplored, partly due to the high administrative costs of registration and the collective action challenges among producer communities.

D). Patent Pools and Open Licensing for Environmental Innovation

Patent pools—arrangements in which multiple patent holders collectively license their IP to users on agreed terms—have been proposed and piloted as mechanisms for reducing transaction costs and enabling broader access to green technology. In the pharmaceutical sector, the Medicines Patent Pool (MPP) has demonstrated that well-structured voluntary patent pools can expand access to essential medicines in low-income countries without eliminating innovation incentives [26]. Analogous proposals have been advanced for clean energy technologies, including a Climate Technology Patent Pool that would aggregate patents in solar, wind, battery storage, and energy efficiency and license them to LDCs on concessional or royalty-free terms [27].

4. Issues and Challenges: The Structural Fault Lines

A). The Technology Transfer Paradox

Perhaps the most persistent critique of IP's role in environmental sustainability is the "technology transfer paradox": while IP systems are designed to incentivise innovation, their exclusivity provisions may simultaneously obstruct the rapid, large-scale diffusion of green technologies necessary to achieve planetary sustainability goals within the narrow windows identified by the Intergovernmental Panel on Climate Change (IPCC) [28]. The IPCC's Sixth Assessment Report (2022) emphasises that achieving a 1.5 degrees Celsius pathway requires halving global emissions by 2030 and reaching net-zero by 2050—a timeline that presupposes

unprecedented rates of technology deployment, particularly in the Global South.

Empirical research on the relationship between patents and technology diffusion yields mixed results. Some studies find that strong IP protection attracts foreign direct investment (FDI) and associated technology transfer to developing countries, particularly at middle-income levels. Others demonstrate that patent thickets—dense webs of overlapping IP rights—impose high licensing transaction costs that fragment markets and delay deployment of composite green technologies such as smart grids, electric vehicles, and advanced biofuels [29]. For least-developed countries (LDCs) with limited industrial absorptive capacity, even notional access to patented green technologies may be commercially and technically meaningless without substantial capacity building, financial support, and adaptation assistance [30].

B). North-South Tensions and the TRIPS-Climate Nexus

The TRIPS-climate nexus crystallises longstanding North-South asymmetries in the global IP order. Developed countries—led by the United States, European Union, Japan, and South Korea—hold the overwhelming majority of patents in clean energy, water purification, advanced materials, and low-carbon transport. This concentration of green IP in a small number of jurisdictions and firms means that access to the clean technology frontier is mediated by private licensing markets in which developing country governments and firms are structurally disadvantaged [31].

Efforts within the UNFCCC to address IP barriers to technology transfer have repeatedly foundered on the resistance of technology-exporting nations, who argue that strong IP protection is a prerequisite for private sector investment in green R&D. This argument, while not without merit, tends to elide the critical distinction between incentivising future innovation (where IP has a legitimate role) and the separate question of access to already-existing technologies (where IP exclusivity may operate primarily as a barrier). The Doha Declaration on the TRIPS Agreement and Public Health (2001) [32], which affirmed the right of WTO Members to use TRIPS flexibilities to protect public health, offers a conceptual precedent for an analogous declaration affirming the right to access essential environmental technologies—a proposal advanced by a coalition of developing countries but yet to gain traction.

C). Bio piracy and the Erosion of Bio Cultural Diversity

The misappropriation of traditional knowledge and genetic resources—colloquially termed "bio piracy"—represents one of the most ethically charged challenges at the IP-environment interface [33]. Documented cases, including patents on turmeric's wound-healing properties (subsequently revoked by the USPTO following a challenge by the Indian government), patents on properties of the neem tree, and the patenting of ayahuasca, highlight the risk that formal IP systems can commodify indigenous ecological knowledge without consent or compensation. Beyond its injustice to ILCs, bio piracy is environmentally damaging because it reduces incentives for communities to maintain biodiverse habitats and the traditional agricultural systems that sustain ecosystem services.

Negotiators within WIPO's Intergovernmental Committee on Genetic Resources, Traditional Knowledge and Folklore (IGC) have laboured for more than two decades to develop a binding international instrument establishing mandatory disclosure requirements and a defensive protection registry

for TK. As of 2024^[34], the IGC has produced draft text for an international legal instrument, but significant differences remain between developed and developing country delegations on the scope of protection, relationship to existing IP frameworks, and legal effects of TK registers. The slow pace of these negotiations underscores the depth of the structural conflict between IP maximalism and the claims of bio cultural equity^[35].

D). Patent Ever greening and Environmental Technology Lifecycles

Patent ever greening—the practice of making minor modifications to existing inventions to secure successive patent terms—is a well-documented challenge that has a direct analogue in the green technology sector. In areas such as solar cell chemistry, lithium-ion battery formulations, and catalytic converters, incremental improvements may generate cascading patent portfolios that extend exclusivity well beyond the original twenty-year term, delaying generalisation and reducing price competition^[36]. For technologies where rapid cost reduction and mass deployment are environmental imperatives, patent ever greening represents a material obstacle to the achievement of sustainability goals.

A related issue is the use of trade secrets in lieu of patents for certain green technologies, particularly proprietary manufacturing processes and material formulations. Unlike patents, trade secrets are theoretically perpetual and carry no disclosure obligation. In the context of environmental technology, heavy reliance on trade secrecy reduces knowledge spill overs that would otherwise facilitate independent innovation and adaptive replication in developing country contexts.

E). Inadequate Institutional Capacity in Developing Countries

Even where legal flexibilities exist—such as Article 31 compulsory licensing under TRIPS or Article 27.2 patentability exceptions—many developing country governments lack the institutional, technical, and financial capacity to operationalise them effectively. The design and issuance of a compulsory licence requires legal expertise in patent law, economic capacity to negotiate or administer the licence, and industrial capacity to manufacture or absorb the relevant technology. For LDCs and small island developing states (SIDS), which are both the most climate-vulnerable and the least institutionally equipped, these barriers are especially acute.

5. Emerging Issues: The Frontier of IP and Environmental Sustainability

A). Artificial Intelligence, Green Innovation, and IP Ownership

Artificial intelligence (AI) is transforming the green innovation landscape, enabling the design of novel materials, accelerating environmental drug and compound discovery, optimising energy grid management, and predicting climate-system dynamics at previously impossible resolutions^[37]. AI-assisted patent filing has already accelerated the pace of green technology IP generation: between 2018 and 2023, AI-generated or AI-assisted patent applications in clean technology grew by an estimated 40 percent annually in OECD countries^[38]. This acceleration raises profound questions about IP ownership, inventor ship standards, and the adequacy of existing patent doctrine.

The question of whether an AI system can be a patent

"inventor" has been litigated in multiple jurisdictions following the DABUS case, in which applications designating an AI as inventor were rejected by the USPTO, EPO, UK IPO, and other patent offices on the ground that inventor ship requires a natural person^[39]. While legally settled in the near term, this question is likely to resurface as AI systems become more autonomously generative in ways that resist attribution to identifiable human contributors. From an environmental perspective, the critical concern is whether the current IP framework—designed for human inventors operating within market incentive structures—is adequate to govern, incentivise, and democratise the green innovations emerging from AI systems owned by a small number of dominant technology corporations.

B). Block chain, Digital Sequence Information, and Biodiversity Governance

Block chain technology and distributed ledger systems are emerging as novel instruments for governing biodiversity data, genetic resource access, and benefit-sharing under the CBD and Nagoya Protocol frameworks. Distributed ledgers offer immutable, transparent recording of genetic resource access agreements, benefit-sharing flows, and TK provenance—reducing the compliance costs of ABS frameworks and enabling real-time monitoring of resource utilisation. Several pilot projects, including block chain-based species monitoring and clearing-house mechanism exploration of digital access tracking, suggest these technologies could substantially enhance the functionality of existing IP-environment governance systems^[40].

A related and politically contested issue is the governance of "digital sequence information" (DSI) from genetic resources—that is, digital data derived from biological material that can be used in research and development without physical access to the original biological material^[41]. The Kunming-Montreal Global Biodiversity Framework (2022) and subsequent CBD negotiations have grappled with whether and how DSI should be subject to the Nagoya Protocol's ABS requirements, with developing countries arguing that DSI should generate benefit-sharing obligations and developed countries maintaining that benefit-sharing on DSI would chill scientific research^[42].

C). Open Innovation, Patent Pools, and Post-Pandemic Paradigms

The COVID-19 pandemic generated a remarkable, if contested, experiment in IP sharing. The C-TAP (COVID-19 Technology Access Pool) initiative, the Open COVID Pledge, and voluntary licensing arrangements for vaccines and treatments demonstrated that crisis conditions can catalyse IP sharing that would be deemed unthinkable in ordinary circumstances^[43]. Climate change, widely characterised by scientists and policymakers as a slow-motion emergency of equivalent or greater magnitude, has prompted analogous proposals for IP pooling in green technology sectors.

Academic commentators and developing country governments have proposed the creation of a Climate Technology Patent Pool modelled on the Medicines Patent Pool (MPP) for HIV/AIDS treatment, under which patent holders in key green technology sectors would voluntarily contribute licences on sub-commercial or no-cost terms for use in LDCs and vulnerable developing countries. Such a mechanism would need to navigate the tension between voluntary participation (politically feasible but potentially limited in scope) and mandatory contribution

(environmentally more effective but resistant to acceptance by technology-exporting nations and their domestic IP industries) [44]. The experience of the MPP suggests that a carefully negotiated voluntary architecture, backed by strong diplomatic arguments, can yield meaningful access improvements even absent compulsory measures.

D). Climate Litigation and IP as a Defensive Instrument

An emerging and under theorised dimension of the IP-environment interface is the use—or potential use—of IP rights as defensive instruments in climate litigation. As jurisdictions progressively tighten carbon regulation and climate disclosure requirements, private actors facing transition risk may seek to use trade secrets, know-how protection, and confidentiality agreements to shield carbon-intensive business practices and proprietary fossil fuel extraction technologies from regulatory scrutiny and litigation discovery [45].

Conversely, environmental litigants and regulatory agencies may seek to compel disclosure of proprietary environmental data under freedom of information laws and environmental impact assessment regulations, challenging IP-based confidentiality claims as contrary to public interest. This frontier intersection of IP law, administrative law, and climate litigation remains largely uncharted in both national and international legal systems, but is likely to grow in salience as climate litigation proliferates globally—with over 2,000 climate cases filed across more than 65 jurisdictions as of 2023.

E). Integrating IP into the Post-2030 Biodiversity and Sustainability Agendas

The adoption of the Kunming-Montreal Global Biodiversity Framework (GBF) in December 2022 represents a landmark moment in global biodiversity governance, establishing "30x30" targets—30 percent of land and ocean areas under effective conservation by 2030—alongside ambitious targets for ecosystem restoration, invasive species control, and the reduction of harmful subsidies. IP governance has a crucial, if still inadequately elaborated, role in the implementation of the GBF, particularly with respect to benefit-sharing from the use of genetic resources, the protection of TK, and the mobilisation of private investment through green technology licensing.

6. Conclusion

The analysis presented in this article reveals a complex, evolving, and fundamentally ambivalent relationship between intellectual property and environmental sustainability. IP rights have demonstrably contributed to green innovation, technology commercialisation, and the accumulation of the knowledge base necessary for the ecological transition. Instruments such as the WIPO IPC Green Inventory, the WIPO GREEN marketplace, the Nagoya Protocol's ABS framework, and the growing body of GI law for agrobiodiversity represent meaningful, if partial, progress toward an IP order more attuned to environmental imperatives.

Yet the structural challenges identified in this article—technology transfer barriers, North-South asymmetries, bio piracy, patent ever greening, and the inadequacy of existing TRIPS flexibilities for environmental purposes—remain stubbornly unresolved. The emerging challenges posed by AI-generated green inventions, block chain-mediated biodiversity governance, DSI regulation, and post-pandemic open innovation paradigms represent both risks and opportunities:

risks of further concentrating the green technology frontier in the hands of a few actors, and opportunities for a more inclusive, adaptive, and ecologically rational IP architecture. The path forward requires a multidimensional reform agenda. At the international level, the adoption of a declaratory instrument affirming the right to access essential environmental technologies—analogue in structure and purpose to the Doha Declaration on TRIPS and Public Health—would provide a normative foundation for the broader use of TRIPS flexibilities for environmental purposes. The expedited conclusion of the WIPO IGC negotiations, the establishment of a Climate Technology Patent Pool, and the integration of mandatory environmental conditionalities into international patent norms are all necessary steps.

At the national level, IP offices should systematically incorporate environmental impact considerations into patent examination procedures, develop fast-track examination pathways for verified green technologies, and build capacity in developing countries to utilise IP instruments—including defensive publication, patent opposition, and compulsory licensing—more effectively. Development finance institutions and multilateral climate funds should be empowered to directly support the acquisition and deployment of green technology licences by LDCs and SIDS, as part of an integrated climate finance architecture.

Ultimately, IP reform alone cannot deliver environmental sustainability. It must be embedded within a broader policy architecture encompassing carbon pricing, public R&D investment, development finance for green technology deployment, and the recognition of the rights of indigenous and local communities as stewards of the planet's biological heritage. The intellectual property system, recalibrated for the Anthropocene, holds the potential to be a powerful tool for planetary sustainability—but only if it is repositioned as an instrument in service of the global commons, rather than an end in itself.

Footnotes

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