

GREEN INNOVATION IN CHAINS: RECONCILING INTELLECTUAL PROPERTY WITH ENVIRONMENTAL IMPERATIVES

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BEST CITATION – SPINITA PRIYADARSINI, GREEN INNOVATION IN CHAINS: RECONCILING INTELLECTUAL PROPERTY WITH ENVIRONMENTAL IMPERATIVES, *INDIAN JOURNAL OF LEGAL REVIEW (IJLR)*, 6 (9) OF 2026, PG. 817-824, APIS – 3920 – 0001 & ISSN – 2583-2344. <https://doi.org/10.65393/IJLRV6I985>

Abstract

The prevailing intellectual property rights regime, while intended to stimulate innovation, can paradoxically impede the widespread diffusion of green technologies, which is vital for addressing persistent environmental challenge. The patent system, a cornerstone of intellectual property rights, is frequently invoked as a key incentive for the development of climate change technologies; however, its efficacy in promoting environmental innovation is questionable due to the significant role of market demand in directing innovation. There is a growing need to integrate modern IPR systems with customary laws and international frameworks to safeguard traditional knowledge from exploitation and misappropriation. The rush to patent climate change technologies, driven by private funding and market incentives, may create substantial tensions within the patent system, particularly concerning equitable access to these technologies. These tensions could also lead to increased patent litigation, which could further hinder the dissemination of green technologies.

This article examines the inherent tension between IPRs and environmental imperatives, analyzing the impacts of the current system and proposing policy recommendations aimed at fostering a more balanced and effective approach to green innovation. It argues that reforms are needed to ensure that IPRs serve as enablers, rather than barriers, to a sustainable future.

Keywords: Environment, IPR, Biopiracy, Patent, WIPO.

1. Introduction: The Double-Edged Sword of Intellectual Property

The Earth is facing unprecedented environmental crises. Climate change is causing rising sea levels and extreme weather events. Biodiversity is declining at an alarming rate, and pollution is threatening human health and ecosystems. Technological innovation is crucial to addressing these challenges, offering solutions ranging from renewable energy and sustainable agriculture to carbon capture and waste reduction. Intellectual property rights, including patents, copyrights, and trademarks, are designed to incentivize innovation by granting creators exclusive rights over their

inventions and creations. This exclusivity fosters an environment where investment in research and development can yield tangible returns, encouraging further innovation. However, the application of IPRs to green technologies presents a complex paradox: while they can stimulate innovation, they can also hinder the widespread adoption and deployment of environmentally beneficial solutions. Digital tools can enhance the diffusion of sustainable technologies by simplifying access to innovation protection and ensuring transparent, efficient

processes¹⁵⁸⁴. These digital platforms can lower costs and entry barriers, especially for small and medium-sized enterprises in developing countries, encouraging broad participation in green innovation and technology transfer. Technology transfer plays a key role in global efforts to reduce greenhouse gas emissions, yet lax intellectual property rights can have a strong and negative impact on the international diffusion of patented knowledge. Restrictions on international trade and foreign direct investment can also hinder the diffusion of climate-friendly technologies¹⁵⁸⁵. This article argues that the current IPR regime, particularly patents, can paradoxically hinder the widespread adoption of green technologies and exacerbate environmental problems. It will examine this paradox through case studies, analyze the role of patents in both promoting and hindering green innovation, propose alternative models for incentivizing sustainability, and offer policy recommendations for creating a more balanced and effective approach to green innovation.

2. The Paradox of Patents and Environmental Harm

Patents, by design, grant inventors a limited monopoly over their inventions. This exclusivity allows inventors to recoup their investments in research and development and profit from their creations. While this can incentivize innovation, it can also restrict access to crucial technologies, slowing down their deployment. This is particularly problematic in the context of green technologies, where rapid and widespread adoption is essential for addressing urgent environmental challenges. The implications for developing nations, which may lack the financial capacity to license patented green technologies, are significant. These nations often bear the brunt of environmental degradation and are

most in need of affordable access to climate-friendly solutions. The incentive for private innovation through patents conflicts with the urgent global need for broad accessibility of environmental technologies. Over-protection of biotechnology may hinder the fulfillment of sustainable development goals, while the lack of exclusive rights would hold back innovation, which is also harmful to these goals.

The complexities surrounding intellectual property rights in biotechnology highlight the balance between promoting innovation and ensuring accessibility. Option deals have become more prevalent, where large pharmaceutical companies outsource their R&D costs by obtaining exclusive licensing rights from smaller, innovative biotech companies. Such arrangements can accelerate the development of new treatments but also raise concerns about potential monopolies and restricted access. Complex technical backgrounds and market disputes increasingly encourage licensees to include alternative enforcement clauses, which may drastically reduce payments by aggrieved parties while maintaining the contract in case of a breach. A balanced approach is required to handle biotech patents, especially as such inventions can significantly contribute to sustainable development goals related to health, agriculture, and environmental sustainability¹⁵⁸⁶.

The academic research landscape faces increasing competition for limited funding, making the protection of intellectual property crucial for securing financial support and maintaining institutional reputation¹⁵⁸⁷. The rise in intellectual property within biotechnology has sparked controversies, reflecting the intense development phase of this technology and the ongoing efforts to demonstrate its importance

¹⁵⁸⁴ George Mihail Man and others, "The Role of Digital Technologies and Intellectual Property Management in Driving Sustainable Innovation" (2025) 17 Sustainability 3135 <<https://doi.org/10.3390/su17073135>> accessed June 2025.

¹⁵⁸⁵ Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière, "What Drives the International Transfer of Climate Change Mitigation Technologies? Empirical Evidence from Patent Data" (2012) 54 Environmental and Resource

Economics 161 <<https://doi.org/10.1007/s10640-012-9592-0>> accessed February 2025.

¹⁵⁸⁶ Barna Arnold Keserű and Máté Frank, "The Holy Trinity of Patents, Biotechnology and Sustainability. Review of Biotech Patents in the Scope of US Patent Case Law."

¹⁵⁸⁷ Sue Ross and others, "Protecting Intellectual Property Associated with Canadian Academic Clinical Trials - Approaches and Impact" (2012) 13 Trials <<https://doi.org/10.1186/1745-6215-13-243>> accessed June 2025.

and sustainability. The convergence of new technologies presents significant benefits to society but also raises complex issues concerning the protection of intellectual property¹⁵⁸⁸. Strong intellectual property protection is essential to attract investment and drive innovation, but it must be balanced with the need to promote public access to these progressions.

Biotechnology patents have raised delicate issues, debated extensively by legal and medical scholars, during patent procedures and disputes in Europe and the US. Some argue that ethical exclusions from granting patents may not be appropriate, while others point out that ethical concerns are not entirely justified, which does not justify delaying efficient treatments for diseases such as cancer, which causes high mortality rates across countries¹⁵⁸⁹. The evolution of biotechnology patentability since the 1970s demonstrates the increasing importance of this field, particularly in the United States. The patenting of biotechnology inventions involves various procedures that must be followed to ensure exclusive patent rights. These include patentability requirements such as novelty, non-obviousness, and enablement, all of which are subject to scrutiny and legal precedent¹⁵⁹⁰.

3. Case Studies: When Patents Go Wrong

Biopiracy and Traditional Knowledge:

The cases of the Neem tree and turmeric are classic examples of biopiracy, where indigenous environmental practices are exploited without consent or benefit-sharing. In the case of Neem, the pesticidal properties of the Neem tree have been known and used in India for centuries. However, foreign companies sought and obtained patents on various Neem-based products, effectively privatizing this traditional knowledge. Similarly, in the case of turmeric, the wound-healing properties of turmeric have been

known in India for generations. However, a patent was granted in the United States for the use of turmeric in wound healing, sparking outrage and ultimately leading to the patent being revoked. The patent system struggles to protect traditional knowledge because it is often collectively held and passed down through generations, rather than being the product of a single inventor. This collective and intergenerational nature of traditional knowledge does not fit neatly into the Western model of individual intellectual property rights. These examples illustrate how the patent system can be used to exploit traditional knowledge, undermine local communities, and hinder the broader adoption of sustainable practices. To address these issues, some countries have implemented sui generis systems to protect traditional knowledge, while others advocate for greater recognition of collective rights and benefit-sharing mechanisms.

India's Balancing Act:

India's legislative measures, including amendments to its patent law and acts related to the Convention on Biological Diversity, demonstrate a positive approach to safeguarding indigenous knowledge. It has also established the Traditional Knowledge Digital Library, a database that documents traditional knowledge to prevent misappropriation by helping to prevent the granting of unauthorized patents on traditional knowledge. Indian patent law balances intellectual property rights with public health needs, incorporating compulsory licensing and the Bolar exception, thus addressing access to medicines and stimulating domestic innovation. Section 3 of India's Patent Act restricts the patenting of plants, animals, and biological processes, reflecting concerns about protecting traditional rights. It also prevents evergreening by disallowing patents for new forms of known substances without significantly

¹⁵⁸⁸ KK Tripathi, "Biotechnology and IPR Regime: In the Context of India and Developing Countries."

¹⁵⁸⁹ Angad Singh, Sharanabasava Hallihosur and Latha Rangan, "Changing Landscape in Biotechnology Patenting" (2009) 31 World Patent Information 219 <<https://doi.org/10.1016/j.wpi.2009.03.004>> accessed April 2025.

¹⁵⁹⁰ Drishti Arora, "BIOTECHNOLOGY PATENTING: COMPARISON BETWEEN USA AND INDIA."

enhanced efficacy. India strategically interprets the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights to benefit its national and industrial interests, standing in contrast to other countries that strictly adhere to the developed world's intellectual property agenda¹⁵⁹¹.

Restricting Access to Green Technologies:

Patents on key green technologies have, in some cases, limited their diffusion, particularly in developing countries. For example, patents on solar panels and wind turbines have been cited as barriers to the widespread adoption of renewable energy in some regions. Similarly, patents on water purification technologies have been criticized for limiting access to clean water in developing countries. These restrictions can have a significant impact on efforts to mitigate climate change and promote biodiversity conservation. The Agreement on Trade-Related Aspects of Intellectual Property Rights has been criticized for prioritizing the rights of patent holders over the needs of developing countries.

Developing nations often favor reforms to the TRIPS agreement, while developed nations are more inclined to support the existing framework¹⁵⁹². Some scholars argue that the current global intellectual property regime favors developed countries and hinders technology transfer to developing countries¹⁵⁹³. To address these challenges, some advocate for the use of compulsory licensing, patent pools, and other mechanisms to promote access to essential technologies. The importance to developed and developing countries of genetic resources and traditional knowledge requires that issues concerning their allocations and

protection be brought into the WTO for resolution in the context of a Millennium Round¹⁵⁹⁴.

4. The Role of Patents in Green Innovation: A Nuanced Perspective

It is important to acknowledge the positive role of patents in incentivizing green innovation. Patents can drive competition and lead to the development of more efficient and effective environmental technologies. For example, companies that hold patents on green technologies may be more likely to invest in research and development to improve those technologies, leading to further innovation. However, it is crucial to strike a balance between incentivizing innovation and ensuring broad access to these technologies. Intellectual properties are the lifeline of the research based pharmaceutical industry. Without the protection of the patent, the research based pharmaceutical industry would not be able to invest in the development of new drugs. The protection of intellectual property is essential to the discovery of new, life-saving drugs¹⁵⁹⁵. The patent system is designed to encourage and protect technological innovations across numerous countries, marking a significant global shift. Effective intellectual property protection and enforcement contribute to the growth, development, and success of human invention involving biotechnology. IP is now essential for organizations in both industrial and academic sectors, reflecting a growing need for sophisticated, integrated IP strategies.

5. Rethinking Patent Incentives for Sustainability

Alternative models for incentivizing green innovation should balance proprietary interests with the need for widespread access. Open-

¹⁵⁹¹ Shamnad Basheer, "Trumping TRIPS: Indian Patent Proficiency and the Evolution of an Evergreening Enigma" (2018) 18 Oxford University Commonwealth Law Journal 16 <<https://doi.org/10.1080/14729342.2018.1455479>> accessed February 2025.

¹⁵⁹² Kenneth J Armour and Peter S Harrison, "Poisons and Politics – Indigenous Rights and IP Protection" (2007) 29 World Patent Information 255 <<https://doi.org/10.1016/j.wpi.2007.02.001>> accessed March 2025.

¹⁵⁹³ Krishna Ravi Srinivas, "Climate Change, Technology Transfer and Intellectual Property Rights" [2009] SSRN Electronic Journal <<https://doi.org/10.2139/ssrn.1440742>> accessed January 2025.

¹⁵⁹⁴ Thomas Cottier, "The Protection of Genetic Resources and Traditional Knowledge: Towards More Specific Rights and Obligations in World Trade Law" (1998) 1 Journal of International Economic Law 555 <<https://doi.org/10.1093/jiel/1.4.555>> accessed February 2025.

¹⁵⁹⁵ ProfKD Raju, "The Debacle of Novartis Patent Case in India: Strict Interpretation of Patentability Criteria Under Article 27 of the Trips Agreement" [2007] SSRN Electronic Journal <<https://doi.org/10.2139/ssrn.1030963>> accessed June 2025.

source innovation, patent pools, and collaborative research models have emerged as potential solutions. Open-source innovation allows for the free sharing of knowledge and technologies, potentially accelerating the pace of innovation and ensuring broad access to solutions. Patent pools allow multiple patent holders to license their technologies collectively, reducing transaction costs and promoting the diffusion of innovation. Collaborative research models involve partnerships between universities, businesses, and government agencies, fostering the sharing of knowledge and resources. Government subsidies and tax incentives can also play a role in promoting green technology development and diffusion. The TRIPS agreement struggles to accommodate the collective nature of traditional and indigenous knowledge. There are also arguments for prize-based innovation systems, where innovators are rewarded for achieving specific environmental goals, rather than obtaining exclusive rights to their inventions. Such approaches could stimulate innovation while ensuring that the benefits of green technologies are widely shared¹⁵⁹⁶.

The traditional, internally focused closed innovation paradigm is increasingly giving way to firms opening up their innovation processes, making intellectual property of substantial relevance for both firms and societies¹⁵⁹⁷. Open innovation encompasses various strategies, including selling intellectual property, sourcing ideas, and co-developing new products or

services with external partners. Intellectual property rights encourage innovation in diverse fields and safeguard innovations with commercial value by granting innovators the exclusive right to prevent others from using their innovation without permission¹⁵⁹⁸. Patents grant a temporary monopoly right over inventions as a social recognition and compensation for efforts, including the “right to sue”¹⁵⁹⁹. This encourages further innovation and technological advancements. Open innovation acknowledges that valuable innovation can originate from outside the boundaries of a company and that internally generated innovation may not always be successfully commercialized within the company itself¹⁶⁰⁰.

The effectiveness of environmental policy in driving innovation depends on several factors, including policy stringency, predictability, and flexibility. Stringent environmental regulations can create a strong incentive for firms to develop and adopt cleaner technologies. However, regulations must be designed carefully to avoid creating unnecessary burdens on businesses and stifling innovation¹⁶⁰¹. Predictable and stable environmental policies provide firms with the certainty they need to invest in long-term research and development¹⁶⁰². Flexibility in environmental regulations can allow firms to find the most cost-effective ways to reduce pollution, encouraging innovation and efficiency. Eco-innovation is increasingly important amidst rising global temperatures and natural disasters¹⁶⁰³. Eco-innovation helps businesses

¹⁵⁹⁶ Matthew Clancy and GianCarlo Moschini, “Incentives for Innovation: Patents, Prizes, and Research Contracts” (2013) 35 Applied Economic Perspectives and Policy 206 <<https://doi.org/10.1093/aep/ppt012>> accessed June 2025.

¹⁵⁹⁷ Jan Sternkopf and others, “Open IP Strategies for Enabling Sustainability Transitions” <<http://publications.eng.cam.ac.uk/879021/>> accessed February 2025.

¹⁵⁹⁸ Sarita Tiwari and others, “Intellectual Property Rights in Plant Biotechnology: Relevance, Present Status, and Future Prospects,” BENTHAM SCIENCE PUBLISHERS eBooks (2013) <<http://neeri.csircentral.net/468/>> accessed April 2025.

¹⁵⁹⁹ Daphne Esquivel-Sada, “Responsible Intellectual Property Rights? Untangling Open-Source Biotech Adherence to Intellectual Property Rights through DIYbio” (2022) 70 Technology in Society 102005 <<https://doi.org/10.1016/j.techsoc.2022.102005>> accessed March 2025.

¹⁶⁰⁰ Andy Wai Kan Yeung and others, “Open Innovation in Medical and Pharmaceutical Research: A Literature Landscape Analysis” (2021) 11

Frontiers in Pharmacology <<https://doi.org/10.3389/fphar.2020.587526>> accessed June 2025.

¹⁶⁰¹ Nick Johnstone, Ivan Haščić and Margarita Kalamova, “Environmental Policy Design Characteristics and Innovation,” OECD studies on environmental innovation (Organization for Economic Cooperation and Development 2011) <<https://doi.org/10.1787/9789264115620-3-en>> accessed February 2025.

¹⁶⁰² Kristina ML Acri née Lybecker, “Innovation and Technology Dissemination and Transfer in Low-Carbon Technology Markets: The Role of Intellectual Property Rights, Trade, and Other Enabling Factors” [2014] SSRN Electronic Journal <<https://doi.org/10.2139/ssrn.2517438>> accessed January 2025.

¹⁶⁰³ Daniel Kammerer, “The Effects of Customer Benefit and Regulation on Environmental Product Innovation.” (2009) 68 Ecological Economics 2285 <<https://doi.org/10.1016/j.ecolecon.2009.02.016>> accessed February 2025.

expand markets, increase productivity, attract investment, improve value chains, and maintain a competitive edge by adhering to environmental regulations.

Patents are vital indicators of technological innovation, representing protected inventions that can enter the market or society and generate wealth. Radical innovation may lead to the creation of entirely new industries or disrupt existing ones, while incremental innovation involves making improvements to existing products or processes¹⁶⁰⁴. Sustainable innovation is pivotal in addressing the intricate balance between environmental preservation, social equity, and economic progress, thereby fostering competitiveness, enhancing environmental performance, and driving social responsibility¹⁶⁰⁵. Eco-innovation addresses environmental challenges like climate change, pollution, and waste disposal by developing new or significantly improved services, processes, and products that support a sustainable environment¹⁶⁰⁶. Innovation includes a range of scientific, technological, organizational, financial, and commercial activities that collectively lead to new developments. Innovation can take various forms, including product innovation, process innovation, organizational innovation, and marketing innovation. Eco-innovation emphasizes reducing environmental costs, enhancing social acceptance, and promoting sustainable development through innovative products, processes, or organizational innovations¹⁶⁰⁷. Environmental innovation integrates economic strategies with environmental aspects, serving

as a continuous process of learning and improvement¹⁶⁰⁸.

6. Policy Recommendations: A Path Forward

Reform Patent Laws:

Patent laws should be reformed to promote the diffusion of green technologies. This could include measures such as compulsory licensing, which allows governments to authorize the use of patented technologies without the patent holder's consent in certain circumstances. It could also include patent buy-outs, where governments purchase patents and make them available for public use. Measures should also be implemented to protect traditional knowledge from biopiracy, such as requiring prior informed consent and benefit-sharing agreements. Patent laws and regulations must strike a delicate balance between incentivizing innovation and ensuring access to new technologies¹⁶⁰⁹. The duration and scope of patent protection should be carefully calibrated to ensure that they are not overly broad or long-lasting, which could smother follow-on innovation.

Investment in Green Technologies:

Governments should invest in basic research and development of green technologies. This can create new pathways to sustainable development. This could include funding for research institutions, universities, and private companies. Governments should also support the commercialization of green technologies, such as through grants, loans, and tax incentives. This financial support is crucial for enabling organizations and researchers to turn innovative ideas into practical solutions that tackle pressing

¹⁶⁰⁴ Luke A Stewart, "The Impact of Regulation on Innovation in the United States: A Cross-Industry Literature Review" <<https://itif.org/publications/2011/11/14/impact-regulation-innovation-united-states-cross-industry-literature-review>> accessed February 2025.

¹⁶⁰⁵ Praveen Kumar Saxena, A Seetharaman and Girija Shawarika, "Factors That Influence Sustainable Innovation in Organizations: A Systematic Literature Review" (2024) 16 Sustainability 4978 <<https://doi.org/10.3390/su16124978>> accessed June 2025.

¹⁶⁰⁶ Phaninee Naruetharadhol, A ConwayLenihan and Helen McGuirk, "Assessing the Role of Public Policy in Fostering Global Eco-Innovation" (2024) 10 Journal of Open Innovation Technology Market and Complexity 100294 <<https://doi.org/10.1016/j.joitmc.2024.100294>> accessed June 2025.

¹⁶⁰⁷ Patrycja Sieg, Iwona Posadzińska and Marek Józwiak, "Academic Entrepreneurship as a Source of Innovation for Sustainable Development" (2023) 194 Technological Forecasting and Social Change 122695 <<https://doi.org/10.1016/j.techfore.2023.122695>> accessed June 2025.

¹⁶⁰⁸ Mariia Ermilova and others, "Improvement of Innovation Systems in Sustainable Economic Development" (2019) 135 E3S Web of Conferences 4027 <<https://doi.org/10.1051/e3sconf/201913504027>> accessed February 2025.

¹⁶⁰⁹ Nicola Lucchi, "A New Era for Biotech Patents? Empirical and Theoretical Considerations on the Current Patent Dilemma" (2021) 21 289 <<http://rivista.biodiritto.org/ojs/index.php?journal=biolaw&page=article&op=download&path%5B%5D=787&path%5B%5D=656>> accessed April 2025.

environmental issues. Such support helps bridge the gap between groundbreaking research and real-world applications, ensuring that innovative solutions have the resources they need for successful deployment and widespread adoption¹⁶¹⁰.

Promote International Cooperation:

International agreements should be promoted to facilitate the transfer of green technologies to developing countries. This could include mechanisms for technology transfer, capacity building, and financial assistance. Collaboration should be encouraged between governments, businesses, and research institutions to develop and disseminate sustainable solutions. Open innovation extends beyond merely using external sources for innovation like customers, competitors, and academic institutions¹⁶¹¹. It seeks to actively involve external partners, including suppliers, customers, and even competitors, in the innovation process¹⁶¹². Open innovation is thus a powerful approach to complement the internal resources of a firm with external sources of knowledge, and can involve different actors in collaborative arrangements¹⁶¹³. This strategy involves organizations opening their boundaries to enable innovations from the combination of internal and external resources¹⁶¹⁴.

Support Research and Development:

Increased funding for research and development in green technologies should be provided, focusing on areas with high potential for sustainability impact. Government funding for R&D is less than private sector funding;

therefore, the profit motive becomes a priority. This may delay the implementation of environmentally sustainable projects, especially for projects with a high up-front capital investment. In order to encourage innovation and invention by domestic companies, the government could offer financial support to these companies at various stages of product invention and development¹⁶¹⁵. This support can take the form of tax credits or subsidies to lower the cost of new technology research and development. These programs could focus on developing advanced materials, renewable energy sources, and waste reduction technologies. Directing research funds towards environmentally friendly technologies will stimulate advancements. Small- and medium-sized enterprises and new biotechnology firms can be supported through state funding programs.

Invest in Public Research:

Increased public funding should be allocated for research and development of green technologies. This could include funding for basic research, applied research, and demonstration projects. Open-source innovation and collaborative research models should be supported. Government intervention in innovation, such as funding programs for smaller research-oriented firms, can support innovation organized in research firms¹⁶¹⁶. Collaboration and network expansion through collaborative data sharing among academic communities should be encouraged, particularly in developed countries, to provide opportunities for researchers in developing countries¹⁶¹⁷.

¹⁶¹⁰ José Alberto Solís-Navarrete, "Innovations in Response to the COVID-19 Pandemic: The Role of Non-Profit and Public Institutions" (2025) 80 World Patent Information 102340 <<https://doi.org/10.1016/j.wpi.2025.102340>> accessed April 2025.

¹⁶¹¹ Open Innovation (Oxford University Press 2006) <<https://doi.org/10.1093/oso/9780199290727.001.0001>> accessed February 2025.

¹⁶¹² Anita M McGahan and others, "Tackling Societal Challenges with Open Innovation" (2020) 63 California Management Review 49 <<https://doi.org/10.1177/0008125620973713>> accessed June 2025.

¹⁶¹³ Romana Rauter and others, "Open Innovation and Its Effects on Economic and Sustainability Innovation Performance" (2018) 4 Journal of Innovation & Knowledge 226 <<https://doi.org/10.1016/j.jik.2018.03.004>> accessed February 2025.

¹⁶¹⁴ Cristiano Gonçalves Pereira and others, "Technological Cooperation Network in Biotechnology Analysis of Patents with Brazil as the Priority Country."

¹⁶¹⁵ Vijaypriya Lalgudi Ramachandran, "A Critical Study of Access to Medicines in Light of Indian Patent (Amendment) Act, 2005" [2020] SSRN Electronic Journal <<https://doi.org/10.2139/ssrn.3554639>> accessed January 2025.

¹⁶¹⁶ Swagata Bhattacharjee, "Dynamic Contracting for Innovation under Ambiguity" (2022) 132 Games and Economic Behavior 534 <<https://doi.org/10.1016/j.geb.2022.01.015>> accessed March 2025.

¹⁶¹⁷ Ademola A Adenle and others, "Analysis of Open Source Biotechnology in Developing Countries: An Emerging Framework for Sustainable Agriculture" (2012) 34 Technology in Society 256 <<https://doi.org/10.1016/j.techsoc.2012.07.004>> accessed April 2025.

Governmental programs support scientific research, and funding is provided by non-governmental organizations and private companies. Public support such as R&D grants, subsidies, and tax credits could encourage SMEs to undertake more essential innovations. Moreover, funding research and development projects and grants helps facilitate new product innovation for private sectors and may stimulate innovative culture in government agencies¹⁶¹⁸.

7. Conclusion: Towards a Sustainable Innovation Ecosystem

Green innovation has been identified as a critical factor in mitigating environmental degradation and promoting sustainable development. The strategic management of technological innovation is essential for achieving sustainable development by incorporating green practices into production methods. Green innovations not only aid businesses in adhering to environmental regulations but also lead to the creation of innovative, high-quality products with a reduced environmental impact. Focusing on green innovation and the adoption of eco-friendly technologies is fundamental in breaking the traditional link between economic growth and environmental degradation, thereby creating a pathway towards a more sustainable future. Reconciling intellectual property with environmental imperatives is essential for building a sustainable future. Policymakers, businesses, and researchers must work together to create a more sustainable innovation ecosystem that fosters both innovation and broad access to green technologies. This requires a fundamental shift in mindset, from viewing IPRs as solely mechanisms for protecting private interests to recognizing their potential as tools for promoting the common good. By reforming patent laws, promoting international cooperation, and investing in public research, we can create a future where innovation drives environmental sustainability, rather than undermining it.

¹⁶¹⁸ Nurazwa Ahmad and others, “A LITERATURE REVIEW ON HOW TAX INCENTIVES COULD ASSIST INNOVATION AND SME

RESEARCH ECOSYSTEM” 228 <<https://doi.org/10.35631/aijbes.39016>> accessed June 2025.