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Article

Advancing Sustainable Development Through Green Intellectual Property Rights: Opportunities and Challenges

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Abstract

Green Intellectual Property Rights (IPR) are pivotal in promoting sustainable development by incentivizing innovation in environmentally friendly technologies, facilitating technology transfer, and reducing carbon emissions. This paper explores the multifaceted role of green IPR in fostering a transition from a brown to a green economy, emphasizing its impact on renewable energy technologies, such as solar and wind, and its integration with global sustainability goals through public-private partnerships (PPPs). Drawing on empirical evidence and case studies, the study highlights how green IPR encourages research and development (R&D), enhances economic and environmental sustainability, and supports technology dissemination, particularly in developing nations. However, challenges such as monopolistic control, regional disparities, and accessibility issues persist, necessitating flexible IPR frameworks, international cooperation, and innovative financing mechanisms. The paper proposes policy recommendations to strengthen global IPR systems, promote collaborative innovation, and balance protection with equitable access to green technologies, ensuring alignment with the United Nations Sustainable Development Goals (SDGs).

Keywords: Green IPR; sustainable development; renewable energy; technology transfer; public-private partnerships; green patents; eco-marks; carbon emissions; innovation

Introduction

Green Intellectual Property Rights (IPR) play a crucial role in fostering sustainable development by incentivizing innovation in environmentally friendly technologies. These rights serve as a strategic resource for organizations aiming to balance economic, social, and environmental goals, thereby promoting a transition from a brown to a green economy. The protection and promotion of green IPR are essential for encouraging research and development (R&D) in green technologies, facilitating technology transfer, and ultimately reducing carbon emissions. The following sections delve into the importance of green IPR, supported by empirical evidence and theoretical insights from the provided papers.

Incentivizing Green Innovation

Green IPR provides a legal framework that protects the rights of innovators, thereby encouraging investment in green technologies. This protection is vital for fostering innovation in green products and processes, as it assures innovators that their efforts will be rewarded and safeguarded against infringement (Huang, 2024) (MADHUMITHA, 2024). Empirical studies, such as those conducted in China, demonstrate that IPR policies significantly promote firm green innovation (FGI) by increasing R&D investment and easing financing constraints. These policies have a more substantial impact on green product innovation compared to process innovation (Xia & Zhang, 2023) (Liu et al., n.d.).

Strategic Resource for Sustainable Development

Organizations that integrate green IPR into their strategies can achieve a balance between economic growth and environmental sustainability. By focusing on green technologies, these organizations not only enhance their competitive edge but also contribute to broader environmental goals (Dereń & Skonieczny, 2022). Green IPR serves as a strategic asset that enables organizations to manage resources creatively and develop innovative solutions that align with sustainable development objectives (Dereń & Skonieczny, 2022).

Facilitating Technology Transfer

Green IPR plays a pivotal role in the transfer of technology necessary for the green economy. The private sector, through foreign investment, licensing, and export, is a key driver of this transfer. However, the international investment legal regime presents challenges that need to be addressed to facilitate smooth technology transfer (Ma, 2022). The protection of green IPR ensures that technology transfer occurs in a manner that respects the rights of innovators while promoting widespread access to green technologies (MADHUMITHA, 2024).

Reducing Carbon Emissions

The protection of green IPR has been shown to reduce carbon emissions by promoting the development and adoption of green technologies. In China, the construction of intellectual property cities (IPC) has led to a significant reduction in carbon emissions, highlighting the environmental benefits of robust IPR protection (Zhou et al., 2024). By curbing energy consumption and promoting green technology, green IPR contributes to achieving carbon neutrality and addressing climate change challenges (Zhou et al., 2024).

Challenges and Considerations

While green IPR is instrumental in promoting sustainable development, it also faces challenges such as the rigidity of international rules and the imbalance in the distribution of benefits. These issues necessitate international cooperation and the establishment of fair and reasonable patent protection mechanisms for green technology (Huang, 2024). Additionally, the effectiveness of green IPR in reducing carbon emissions varies across regions, indicating the need for tailored approaches to IPR protection (Zhou et al., 2024). Addressing these challenges is crucial for maximizing the potential of green IPR in driving global sustainability efforts.

Global Energy Crisis

Sustainable Solutions and IPR Challenges

The global energy crisis is a multifaceted challenge that encompasses environmental, economic, and geopolitical dimensions. The transition from fossil fuels to renewable energy sources is critical to addressing these challenges, but it is fraught with obstacles such as technological limitations, policy inconsistencies, and intellectual property rights (IPR) issues. Sustainable energy solutions are pivotal in mitigating the adverse impacts of the energy crisis, but their implementation requires a coordinated global effort. The role of intellectual property rights in this transition is complex, as they can both hinder and facilitate the development and dissemination of renewable energy technologies.

Current Energy Challenges

- **Fossil Fuel Dependency:** The world remains heavily reliant on fossil fuels, which are finite and contribute significantly to global warming. The depletion of these resources and the environmental damage they cause are central to the energy crisis (Newton, 2012) (Heinberg, 2017).
- **Geopolitical and Economic Factors:** Energy supply is often subject to geopolitical tensions, which can lead to conflicts and economic instability. The rising cost of fossil fuels further exacerbates these issues, making energy security a pressing concern (Newton, 2012) (Legget, 2006).
- **Technological and Policy Barriers:** The transition to renewable energy is hindered by technological challenges, such as the need for improved energy storage solutions, and inconsistent policy frameworks across different jurisdictions (Closson, 2008) (Rajashekar et al., 2024).

Environmental and Economic Impacts

- **Climate Change:** The combustion of fossil fuels is a major contributor to climate change, leading to severe environmental consequences. Transitioning to renewable energy sources is essential to reduce carbon emissions and mitigate climate change impacts (Rajashekar et al., 2024) (Pathak, 2014).
- **Economic Growth and Sustainability:** Renewable energy can drive sustainable economic growth by reducing dependency on imported fuels and creating new industries and jobs. However, the initial investment and technological development required can be significant (Rajashekar et al., 2024) (Zissler, 2022).

Role of Sustainable Energy Solutions

- **Renewable Energy Technologies:** Technologies such as solar, wind, and bioenergy are crucial for reducing carbon footprints and achieving energy sustainability. These technologies are becoming more economically viable and are essential for a sustainable energy future (Muneer, 2010) (Pathak, 2014).
- **Policy and Innovation:** Effective policy frameworks and innovation are necessary to accelerate the adoption of renewable energy. This includes government interventions, patent pools, and open-source development to facilitate technology transfer and deployment (Closson, 2008) (Tee et al., 2021).

Intellectual Property Rights and Green IPR

- **Facilitating Innovation:** Intellectual property rights can incentivize innovation by protecting investments in renewable energy technologies. Strong IPR protection can drive renewable energy production by encouraging firms to invest in new technologies (Tee et al., 2021).
- **Barriers to Technology Transfer:** Conversely, IPR can also act as a barrier to the widespread adoption of renewable technologies, particularly in developing countries. A balance must be struck between protecting innovations and ensuring equitable access to technology (Deane & Bodimeade, 2024) (Closson, 2008).

While the transition to renewable energy is critical for addressing the global energy crisis, it is not without its challenges. Intellectual property rights, while essential for fostering innovation, can

also impede the dissemination of technology if not managed carefully. A coherent global policy that harmonizes IPR with the need for sustainable energy solutions is crucial. This requires international cooperation and a commitment to balancing economic growth with environmental sustainability.

Green IPR Meaning

Green Intellectual Property Rights (IPR) are a specialized subset of intellectual property rights that focus on innovations contributing to environmental sustainability. These rights are crucial for promoting green technologies, which are essential in addressing climate change and fostering sustainable development. Green IPR encompasses various types of intellectual property, including patents, trademarks, and designs, specifically aimed at environmental protection. The legal frameworks and international agreements governing green IPR are designed to facilitate the development and dissemination of eco-friendly technologies while balancing the interests of innovators and the public. The following sections delve into the definition, scope, types, and legal frameworks of Green IPR.

Definition and Scope of Green IPR

Green IPR refers to intellectual property rights that protect innovations aimed at environmental sustainability, such as clean energy, green transportation, and waste management technologies (Taques & Chasco, n.d.). These rights are integral to promoting scientific and technological progress, economic growth, and environmental protection, serving as a cornerstone for sustainable development (Huang, 2024). The scope of Green IPR includes not only patents but also eco-marks and other forms of intellectual property that support green innovation and technology transfer (Lane & Kozuch, 2011).

Types of Green Intellectual Property

- **Green Patents:** These protect inventions that contribute to environmental sustainability, such as renewable energy technologies and energy-efficient products (Taques & Chasco, n.d.) (Salgado & Franchi, 2023).
- **Eco-Marks:** Trademarks that signify environmentally friendly products or services, helping consumers identify and choose sustainable options (Lane & Kozuch, 2011).
- **Green Technology Transfer:** Mechanisms that facilitate the sharing of green technologies across borders, often supported by international agreements and initiatives (Rimmer, 2011).

Legal Frameworks and International Agreements

- **International Treaties:** Key agreements like the TRIPS Agreement and the Paris Agreement provide a framework for the protection and transfer of green technologies (Ilardi & Blakeney, 2004) (Salokannel, 2006).
- **National Programs:** Countries like Brazil have implemented programs to expedite the examination of green patents, encouraging the development and dissemination of eco-friendly technologies (Salgado & Franchi, 2023).
- **Eco-Patent Commons:** An initiative that allows companies to share patents for green technologies, promoting innovation and technology transfer without the barriers of traditional patent systems (Xia, n.d.).

While Green IPR plays a pivotal role in promoting environmental sustainability, it also faces challenges such as the rigidity of international rules and the imbalance in the distribution of benefits. These issues highlight the need for a more equitable and flexible intellectual property system that can adapt to the diverse needs of different countries and promote global cooperation in addressing climate change (Huang, 2024) (Salokannel, 2006).

Fostering Sustainable Energy Innovation and Access Through Green IPR

Green Intellectual Property Rights (IPR) play a crucial role in promoting sustainable energy by incentivizing innovation, facilitating technology transfer, and balancing protection with public access. These rights are designed to protect and encourage the development of technologies that contribute to environmental sustainability, such as renewable energy sources. However, the effectiveness of IPR in achieving these goals is subject to debate, with various perspectives on how best to implement and manage these rights to support global sustainable energy infrastructure.

Incentivizing Innovation in Renewable Energy

Green IPRs provide a framework for protecting innovations in renewable energy, thereby encouraging investment in research and development. By securing exclusive rights, inventors and companies are motivated to invest in new technologies, knowing they can potentially reap financial rewards from their innovations (MADHUMITHA, 2024) (Salgado & Franchi, 2023). Programs like Brazil's Green Patents Program expedite the patent process for environmentally beneficial technologies, further incentivizing innovation by reducing the time and cost associated with obtaining patent protection (Salgado & Franchi, 2023).

Facilitating Technology Transfer

While IPRs can be seen as barriers to technology transfer, they also play a role in facilitating it by providing a structured system for licensing and collaboration. This is particularly important for transferring clean energy technologies to developing countries, which are crucial for global climate change mitigation efforts (Deane & Bodimeade, 2024) (Zhuang, 2011). Legal solutions, such as compulsory licensing and patent pools, have been proposed to overcome barriers and enhance technology transfer, ensuring that developing nations can access necessary technologies without infringing on IPRs (Rimmer, 2011).

Balancing IPR Protection and Public Access

The challenge lies in balancing the protection of intellectual property with the need for public access to green technologies. This balance is essential to ensure that innovations contribute to broader societal goals, such as reducing carbon emissions and promoting sustainable development (MADHUMITHA, 2024) (Rimmer, 2018). Initiatives like the Eco-Patent Commons and Climate Innovation Centres aim to promote open innovation and public sector licensing, allowing for wider dissemination of green technologies while still respecting the rights of inventors (Rimmer, 2011).

Broader Perspectives

While green IPRs are instrumental in promoting sustainable energy, there are concerns about their potential to exacerbate inequalities between developed and developing nations. The economic nature of patents often aligns with the interests of developed countries, potentially hindering access to renewable energy technologies in less affluent regions. This has led to calls for more flexible IPR policies that prioritize cooperation and solidarity over competition, ensuring that all nations can benefit from advancements in green technology (Boff & Cioatto, 2015). Additionally, the establishment of a Green Intellectual Property Scheme, which includes financial assistance mechanisms, could further support the equitable distribution of eco-friendly technologies (Nitta, 2006).

Green IPR in Solar and Wind

Strategies and Challenges

The development and application of green intellectual property rights (IPR) in solar and wind energy technologies are crucial for advancing renewable energy solutions and addressing climate change. Successful case studies in these areas highlight the importance of strategic patenting and the challenges faced in emerging technologies. This response explores successful green IPR applications, innovative patent strategies, and the challenges encountered in the field of renewable energy technologies.

Successful Green IPR Applications in Solar and Wind Energy

- **Solar Energy Innovations:** In India, solar energy innovations have been significantly influenced by government policies and auction mechanisms, which have driven down costs and increased adoption. Case studies show that decentralized solar projects and rooftop solar sectors have benefited from strategic patenting and government incentives, leading to successful implementation and cost reductions (Thapar, 2024).
- **Wind Energy Innovations:** The growth of wind power in India has been facilitated by factors such as favorable government policies, technological advancements, and strategic patenting. These elements have contributed to the successful deployment of wind energy projects, demonstrating the importance of aligning patent strategies with policy frameworks (Thapar, 2024).

Patent Strategies in Green Technologies

- **Green Patent Fast Track Programs:** Many countries have implemented fast-track programs for green patents to expedite the examination process. These programs, such as the UK's Green Channel, have seen increasing popularity, with over 4,000 applications, indicating their effectiveness in promoting green innovation (IPO, 2024). Harmonizing these programs internationally could further enhance their impact by reducing costs and complexity for applicants (Lane, 2012).
- **Patent Pools and Licensing:** Patent pools and licensing agreements are strategic tools used to manage intellectual property in green technologies. They facilitate technology transfer and standardization, balancing the protection of proprietary rights with the public interest in addressing climate change (Mocanu, 2024).

Challenges in Green IPR for Emerging Technologies

- **Legislative and Policy Barriers:** The legislative framework for intellectual property in renewable energy can vary significantly across regions, creating challenges for innovators. In the EU, for example, differences in IP policies between developed and developing countries can impact the diffusion of green technologies (Miron & Gabor, 2012).
- **Cost and Complexity of Patent Processes:** The disparity in fast-track program requirements across different jurisdictions can lead to increased costs and complexity for patent applicants. This can be a barrier to the widespread adoption of green technologies, highlighting the need for international harmonization of patent processes (Lane, 2012).
- **Balancing IP Rights and Technology Transfer:** There is an ongoing tension between protecting intellectual property rights and facilitating the global transfer of green technologies. This balance

is crucial for ensuring that innovations can be effectively deployed to combat climate change while respecting the rights of inventors (Mocanu, 2024).

While the strategic use of patents and fast-track programs has facilitated the growth of green technologies, challenges remain in harmonizing international patent processes and balancing IP rights with technology transfer needs. Addressing these challenges is essential for fostering innovation and ensuring the widespread adoption of renewable energy solutions.

Green IPR Challenges

Intellectual property rights (IPR) play a crucial role in fostering innovation and economic growth, but they also present significant challenges, particularly in the context of green technologies and sustainable development. These challenges are multifaceted, involving conflicts over intellectual property, issues of accessibility and affordability, and regional disparities in the implementation of green IPR. Addressing these challenges requires a nuanced understanding of the barriers and potential solutions.

Challenges and Barriers in Intellectual Property Conflicts

- **Monopolistic Control:** Developed countries often hold monopolistic control over IPR, which can lead to economic dependency for developing nations and limit the sharing of knowledge necessary for addressing global challenges like climate change (Kumar & Jawed, 2024).
- **Conflicts in Green Growth:** In the context of green growth, intellectual property conflicts arise from the need to balance sustainable development with economic growth. For instance, in China, the exploitation of natural resources for green growth is complicated by IPR issues, which can hinder the development and deployment of environmentally friendly technologies (Liu & Zhong, 2024).
- **Ownership Conflicts in Academia:** In higher education, conflicts over the ownership of intellectual property can arise, particularly when discoveries are commercialized. This can lead to litigation and complicate the process of technology transfer (Dusen, 2013).

Accessibility and Affordability Issues

- **Access to Essential Technologies:** IPR can hinder access to essential goods and technologies, such as medications and agricultural innovations, which are crucial for sustainable development in developing countries (Kumar & Jawed, 2024).
- **Financial Barriers:** The Green Intellectual Property (GIP) scheme proposes a system to alleviate financial barriers by establishing a trust fund to support the dissemination of eco-friendly technologies. This system aims to make technologies more accessible to those lacking capital (Nitta, 2006).

Regional Disparities in Green IPR Implementation

- **North-South Divide:** There is a significant divide between developed and developing countries regarding the role of IPR in the transfer of clean technologies. This divide can impede international negotiations and the effective deployment of low-carbon technologies (Bollyky, 2009).
- **Disparities in Agricultural Research:** International agricultural research centers face challenges in managing IPR, which can affect technology access and partnerships. These disparities can hinder the implementation of green technologies in agriculture, particularly in developing regions (Binenbaum, 2004).

While intellectual property rights are essential for incentivizing innovation, they can also create barriers to the equitable distribution of green technologies. The current IPR framework often favors developed countries, leading to regional disparities and accessibility issues. To address these challenges, a multifaceted approach is needed, including reforming the IPR regime to promote equitable access and benefit-sharing, fostering international cooperation, and implementing financial mechanisms like the GIP scheme to support technology dissemination. Such measures could help bridge the gap between innovation and accessibility, ensuring that green technologies contribute to sustainable development globally.

Fostering Innovation: Global IPR, Collaboration, and Incentives

Strengthening global intellectual property rights (IPR) frameworks, promoting collaborative innovation models, and implementing financial and regulatory incentives are crucial for fostering innovation and economic development. The intersection of these elements can create a robust environment for technological advancement and equitable growth. This response synthesizes insights from various academic papers to provide policy recommendations in these areas.

Strengthening Global IPR Frameworks

- **Balanced IPR Regimes:** A uniform global IPR system can be unjust, particularly for developing countries. A more flexible framework that allows countries to adapt IPRs to their economic and technological levels is recommended (Salokannel, 2006).
- **Institutional Reforms:** Reforms such as the Bayh-Dole Act have been implemented to enhance innovation and commercialization. These reforms should be tailored to local contexts to avoid unintended negative impacts (Edler et al., 2015).
- **Capacity Building:** Strengthening the capacity of SMEs and public institutions in IPR management and legal issues is essential. This includes using IPR databases for technology searches and understanding the role of IPR in public procurement (Edler et al., 2015).

Promoting Collaborative Innovation Models

- **Open Licensing Models:** Encouraging open licensing and collaborative models can leverage IPRs to foster innovation. This approach supports the public domain and facilitates knowledge sharing (Beer et al., 2011).
- **Cross-Border Collaboration:** Effective collaboration across borders requires well-defined IPRs and appropriate governance structures. This is crucial for generating positive development outcomes and overcoming challenges such as resource constraints and knowledge leakage (IPRs, Cross-Border (Collaborative) Innovation and Development Challenges: A Commentary, 2022) (Zhang, 2025).
- **Government Support:** Policies that provide financial assistance and foster an innovation ecosystem are vital. This includes promoting a collaborative culture within enterprises and supporting talent development (Zhang, 2025).

Financial and Regulatory Incentives

- **Regulatory Sandboxes:** Establishing regulatory sandboxes can foster innovation by allowing fintech and other sectors to experiment with new technologies in a controlled environment. This approach balances consumer protection with technological advancement (Igbinenikaro & Adewusi, 2024).

- **Incentives for R&D:** Financial incentives such as tax breaks and grants for research and development can stimulate innovation. These incentives should be designed to encourage both financial and non-financial returns on investments (Beer et al., 2011).
- **Avoiding Technology Mandates:** Governments should avoid technology mandates that stifle innovation. Instead, they should promote technological neutrality and choice in procurement decisions (Tsilas, 2007).

While strengthening IPR frameworks and promoting collaborative innovation are essential, it is also important to recognize the potential downsides. For instance, overly stringent IPRs can impede innovation by creating barriers to entry and limiting access to knowledge, particularly in developing countries. Additionally, the focus on bilateral agreements by powerful states like the US and EU can lead to regulatory competition and redundancy, which may not always align with the interests of less powerful nations (Morin & Cartwright, 2020). Therefore, a balanced approach that considers the diverse needs of stakeholders and promotes equitable access to innovation is crucial.

Green IPR and PPPs

The integration of green intellectual property rights (IPR) with global sustainability goals is increasingly being facilitated by public-private partnerships (PPPs). These partnerships are emerging as crucial mechanisms for advancing sustainable development, particularly in the realm of green technologies. By leveraging the strengths of both public and private sectors, PPPs can accelerate the diffusion of green technologies and innovation, thereby contributing to the achievement of the United Nations Sustainable Development Goals (SDGs). The role of PPPs in this context is multifaceted, involving governance, stakeholder engagement, and innovative business models. Below, the key aspects of this integration are explored.

Role of Public-Private Partnerships in Green IPR

- **Facilitating Technology Diffusion:** PPPs are instrumental in overcoming the stalemate in multilateral debates on IPRs by adopting pragmatic approaches to intellectual property matters. Initiatives like WIPO GREEN and bilateral partnerships such as the US–China Clean Energy Research Center exemplify how PPPs can enhance technology diffusion in green technologies (Abdel-Latif, 2018).
- **Enhancing Governance and Stakeholder Engagement:** Effective PPPs require good governance and active participation from all stakeholders. This ensures that partnerships are not only collaborative but also adhere to ethical standards, which is crucial for their success in promoting sustainable development (Herath et al., 2024).
- **Innovative Business Models:** The development of relational business models within PPPs, which integrate diverse stakeholders and utilities, is essential for addressing the complex challenges of the SDGs. These models facilitate the creation of innovation ecosystems that are crucial for sustainable development (Ricart, 2024).

Integration with Global Sustainability Goals

- **Alignment with SDGs:** PPPs are increasingly recognized as vital tools for achieving the SDGs, particularly in areas like energy infrastructure and the built environment. They provide a framework for integrating the interests of various stakeholders along the triple bottom line of sustainable development: people, planet, and profit (Badi & Alhosani, 2024).
- **Networked Governance:** The World Intellectual Property Organization (WIPO) is exploring how PPPs can be structured to support sustainable development through networked

governance. This approach emphasizes the need for higher standards in PPP governance to align with the SDGs (Bannerman, 2018).

- **Cross-Sector Collaboration:** In emerging markets, new models of PPPs are being developed to address energy infrastructure needs. These models emphasize adaptive governance, risk-sharing, and the integration of local communities, which are crucial for sustainable development (Owoola et al., 2024).

Challenges and Future Directions

- **Overcoming Bottlenecks:** Despite their potential, PPPs face challenges such as governance issues and the need for better integration of private sector capabilities. Addressing these challenges is essential for maximizing the impact of PPPs on sustainable development (Budnyk et al., 2024).
- **Innovative Financing Mechanisms:** Green PPPs require innovative financial support mechanisms to be effective. This includes leveraging green financing and digital technologies to facilitate sustainable projects (Vassileva, 2022).
- **Long-term Impact and Scalability:** Future research should focus on understanding the long-term impacts and scalability of innovative PPP models, particularly in the context of energy infrastructure and green technology development (Owoola et al., 2024).

While PPPs offer significant potential for advancing green IPR and sustainability goals, they are not without challenges. Issues such as governance, stakeholder engagement, and financial mechanisms need to be addressed to fully realize their potential. Moreover, the integration of PPPs with global sustainability goals requires a nuanced understanding of local contexts and a commitment to capacity building. As these partnerships evolve, they will play an increasingly critical role in shaping sustainable development strategies worldwide.

Conclusions

Green Intellectual Property Rights serve as a cornerstone for advancing sustainable development by incentivizing innovation and facilitating the global dissemination of green technologies. They play a critical role in transitioning to a green economy, particularly through the development and adoption of renewable energy solutions like solar and wind. However, the effectiveness of green IPR is hindered by challenges such as monopolistic control by developed nations, regional disparities, and barriers to accessibility and affordability. To overcome these, a balanced and flexible global IPR framework is essential, supported by collaborative innovation models and public-private partnerships. Initiatives like green patent fast-track programs, patent pools, and the Eco-Patent Commons demonstrate the potential to enhance technology transfer while respecting innovators' rights. Furthermore, integrating green IPR with the SDGs through innovative financing and governance mechanisms can ensure equitable access to eco-friendly technologies, fostering sustainable economic growth and environmental preservation worldwide. Addressing these challenges through international cooperation and tailored policy reforms will be crucial for maximizing the impact of green IPR on global sustainability efforts.

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