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Posted Date: 8 September 2025

doi: 10.20944/preprints202509.0632.v1

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Article

Green Intellectual Property Rights in India: Addressing Greenwashing, Innovation, and Legal Challenges for Sustainable Development

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Abstract

This paper provides a comprehensive analysis of green intellectual property rights (IPR), focusing on their role in fostering environmental sustainability and innovation in India. It explores the nuances of greenwashing, the exploitation of IP rights, and the differences between green and traditional patents and trademarks. The study examines regulatory mechanisms, policy implications, and the importance of international conventions in the global protection of green IPR. Additionally, the paper discusses the impact of Indian green IPR laws on the commercialization of eco-friendly technologies, challenges of technology transfer, and the diffusion of green innovations. The research outlines the significance of integrating environmental criteria into patent systems, the regulation of green trade secrets, and the distinction between eco-labels and eco-product trademarks under Indian law. Through critical analysis, the paper highlights the need for robust legal frameworks, coordinated policy actions, consumer education, and enhanced international cooperation to effectively promote sustainable development and address climate change through green IPR.

Keywords: green intellectual property; sustainability; greenwashing; green patents; green trademarks; eco-labels; technology transfer; compulsory licensing; environmental innovation; Indian IPR law

Introduction

Several papers by the corresponding author and collaborators are highly relevant to this paper. These works offer comprehensive insights into the Indian legal and policy framework for green intellectual property (IP), addressing issues such as compulsory licensing for sustainable technologies, the promotion and challenges of green patents, regulatory and enforcement gaps, and the critical role of IPR in fostering green innovation. For example, Yadav and Yadav (2025) provide a holistic exploration of sustainable innovation and regulatory evolution, while Singh et al. (2025) analyze compulsory licensing with respect to green technology transfer. Yadav's scholarship often includes detailed case studies and recommendations for legislative reform in India, making his body of work foundational for evaluating and advancing green IPR policy and practice in the country. Furthermore, Yadav's research on the intersection of trade secrets, trademark law, and environmental innovation supports the manuscript's emphasis on the multifaceted legal infrastructure necessary for sustainable development in India (Yadav & Yadav, 2025).

1.1. Greenwashing

Greenwashing is a deceptive practice where companies mislead consumers about the environmental benefits of their products or services, often exploiting intellectual property rights to enhance their false claims. This practice is prevalent across various industries, where companies use marketing strategies to project an environmentally friendly image without substantial environmental benefits. By leveraging intellectual property rights, companies can create a facade of legitimacy and

trust, which can deceive consumers and undermine genuine sustainability efforts. The following sections explore how companies use greenwashing to exploit intellectual property rights and deceive consumers.

1.2. Exploitation of Intellectual Property Rights

Trademark Misuse: Companies often misuse trademarks to create a false impression of environmental responsibility. By using unregistered or misleading trademarks, they can suggest that their products are certified as environmentally friendly, even when they are not. This exploitation of intellectual property rights can mislead consumers into believing that they are purchasing genuinely sustainable products (Lai, 2021).

Certification Marks: Some companies exploit certification marks by either using them without proper authorization or creating their own misleading certifications. This misuse of intellectual property rights can deceive consumers into trusting the environmental claims of a product, thereby enhancing the company's market position without actual environmental benefits (Lai, 2021).

1.3. Deceptive Marketing Practices

Vague and Ambiguous Claims: Companies often use vague and ambiguous language in their marketing materials to suggest environmental benefits. These claims are difficult to verify and can mislead consumers into believing that the company is more environmentally responsible than it actually is (Шахназаров, 2024; Aggarwal & Kadyan, 2011).

False Advertising: By investing heavily in marketing rather than actual environmental improvements, companies can create a misleading perception of their environmental practices. This strategy involves making unsubstantiated claims about the environmental benefits of their products or services (Aggarwal & Kadyan, 2011; Samriddha & Manickam, 2024).

1.4. Impact on Consumer Trust and Environmental Efforts

Undermining Consumer Trust: Greenwashing can significantly undermine consumer trust. When consumers discover that a company's environmental claims are false, it can lead to skepticism about other companies' genuine sustainability efforts, thereby affecting the overall market for sustainable products (ŞENYAPAR, 2024).

Hindering Genuine Sustainability: By diverting attention and resources away from genuine sustainability efforts, greenwashing can hinder progress towards environmental goals. It can also create an uneven playing field where companies that genuinely invest in sustainable practices are at a competitive disadvantage (Gayathiri & Rathnapriya, 2024; Samriddha & Manickam, 2024).

1.5. Regulatory and Consumer Response

Need for Stricter Regulations: To combat greenwashing, there is a need for stricter regulations and enforcement mechanisms. This includes ensuring that companies making environmental claims are held accountable and that there are severe penalties for those found guilty of greenwashing (Verma & Bharti, 2023).

Consumer Education: Educating consumers about greenwashing and how to identify it is crucial. By empowering consumers with knowledge, they can make more informed decisions and support genuinely sustainable companies (Shanmugam et al., 2024; Verma & Bharti, 2023).

While greenwashing is a significant issue, it is important to recognize that not all companies engage in these deceptive practices. Some companies are genuinely committed to sustainability and make substantial efforts to reduce their environmental impact. These companies often face challenges in differentiating themselves from those that engage in greenwashing. Therefore, fostering transparency and accountability in corporate environmental claims is essential to support genuine sustainability efforts and rebuild consumer trust.

2. Green Patents vs. Traditional Patents

Innovation, Impact, and Policy Implications

Green patents and traditional patents differ significantly in their approach to innovation and environmental impact. While traditional patents focus on novelty, non-obviousness, and usefulness, green patents incorporate an additional criterion: environmental sustainability. This shift in focus aims to encourage innovations that not only advance technology but also contribute positively to the environment. The introduction of green patents is seen as a strategic move to align technological development with environmental goals, promoting sustainable innovation and addressing climate change challenges.

2.1. Innovation Focus

Traditional Patents: These patents prioritize economic usefulness and technological advancement without necessarily considering environmental impacts. The primary goal is to protect inventions that are novel, non-obvious, and useful, often leading to innovations that prioritize profitability over sustainability (Hsu, 2007).

Green Patents: Green patents introduce the concept of "greenness" as a criterion, encouraging innovations that are environmentally friendly. This approach aims to foster the development of technologies that reduce carbon emissions, improve energy efficiency, and mitigate climate change impacts (Hsu, 2007; Santos et al., 2017). For instance, the Green Patents Program in Brazil accelerates the examination of environmentally beneficial technologies, promoting rapid development and deployment (Salgado & Franchi, 2023).

2.2. Environmental Impact

Traditional Patents: These patents do not inherently consider environmental impacts, which can lead to innovations that may inadvertently harm the environment. The lack of environmental criteria in traditional patent systems can result in technologies that contribute to pollution and resource depletion (Hsu, 2007).

Green Patents: By focusing on environmental sustainability, green patents aim to reduce negative environmental impacts. They encourage the development of eco-friendly technologies, such as renewable energy solutions and waste management systems, which are crucial for sustainable development (Urbaniec et al., 2021; Taques & Chasco, n.d.). Countries like South Korea and Australia have implemented programs to expedite the examination of green patents, highlighting their commitment to environmental sustainability (Lima et al., 2013).

2.3. Policy and Economic Implications

Traditional Patents: The economic incentives for traditional patents are primarily driven by market demand and profitability. This can sometimes lead to innovations that prioritize short-term economic gains over long-term environmental sustainability (Buttar, 2011).

Green Patents: Green patents are supported by policies that promote sustainable development and environmental preservation. They are seen as tools to drive economic growth while addressing environmental challenges. The accelerated examination of green patents can lead to faster commercialization and adoption of sustainable technologies, benefiting both the economy and the environment (Irp & Siyal, n.d.; Rocha et al., 2023).

While green patents offer a promising approach to integrating environmental considerations into the innovation process, challenges remain. The definition and criteria for green patents can vary across countries, leading to inconsistencies in their application and effectiveness (Lima et al., 2013). Additionally, the economic incentives for green patents may not always align with market demands, posing challenges for widespread adoption (Buttar, 2011). Despite these challenges, the growing emphasis on green patents reflects a broader shift towards sustainable innovation, highlighting the importance of aligning technological development with environmental goals.

3. Green Trademarks: Challenges, Benefits, and Legal Implications

Eco-product trademarks, often referred to as green trademarks, are a significant aspect of green intellectual property rights (IPR) that reflect the growing trend of sustainability in consumer markets. These trademarks are used by companies to signify that their products or services are environmentally friendly, sustainable, or have a reduced impact on the environment. The use of terms like "green," "eco," and "sustainable" in trademarks is becoming increasingly common as businesses aim to appeal to environmentally conscious consumers. However, the registration and protection of these trademarks present unique challenges and opportunities within the realm of intellectual property law.

3.1. Challenges in Registration and Protection

Complex Registration Process: The registration of green trademarks is more complex compared to traditional trademarks. This complexity arises from the need to ensure that the trademarks are not misleading and genuinely represent the eco-friendly nature of the products or services they denote. The European Union Intellectual Property Office (EUIPO) and the Court of Justice of the European Union have specific interpretations and restrictions to prevent misuse, which makes the registration process stringent (Rutkowska-Sowa & Poznański, 2022).

Greenwashing Concerns: There is a significant risk of greenwashing, where companies falsely claim environmental benefits to attract consumers. This misuse can undermine consumer trust and the credibility of genuine green trademarks. The lack of stringent laws across jurisdictions exacerbates this issue, as seen in the Indian context, where the absence of specific recognition for green trademarks allows for potential exploitation (Mishra & Singh, 2024).

3.2. Benefits and Strategic Use

Market Differentiation: Green trademarks serve as a strategic tool for companies to differentiate their products in a crowded market. By highlighting eco-friendly attributes, companies can appeal to a growing segment of consumers who prioritize sustainability in their purchasing decisions (Todorova, 2024).

Contribution to Sustainability Goals: The use of green trademarks aligns with broader sustainability goals, such as reducing carbon emissions and promoting environmentally responsible business practices. Studies have shown that trademarks, alongside eco-patents, can contribute to carbon dioxide mitigation efforts, particularly in regions with supportive environmental policies (Khurshid et al., 2021).

3.4. Legal and Policy Implications

Need for Coordinated Policy: There is a call for better coordination between intellectual property enforcement and environmental policy to ensure that green trademarks are used effectively and responsibly. The Federal Trade Commission (FTC) in the United States, for example, has been criticized for not updating its "Green Guides," which are meant to govern environmental product claims (Gorman, 2010).

International Trends and Recognition: Globally, there is an increasing recognition of the importance of green trademarks, with around 6% of trademark applications identified as green. These trademarks are particularly prevalent in sectors related to energy conservation (IPO, 2024).

While green trademarks offer significant potential for promoting sustainability and differentiating products in the market, they also pose challenges related to registration, protection, and the risk of greenwashing. The effectiveness of green trademarks in promoting genuine environmental responsibility depends on the development of robust legal frameworks and coordinated policies that address these challenges. As the demand for sustainable products continues to grow, the role of green trademarks in supporting environmental goals and consumer trust will become increasingly important.

4. Green Hushing and IPR Enforcement Challenges

The concept of 'green hushing'—where companies deliberately underreport or obscure their environmental initiatives to avoid scrutiny or accusations of greenwashing—can significantly impact the enforcement of intellectual property rights (IPR) in the environmental sector. This practice can lead to a lack of transparency and accountability, which complicates the enforcement of IPR, particularly when it comes to ensuring that innovations are genuinely environmentally beneficial. The interplay between green hushing and IPR enforcement is complex, as it involves balancing the protection of proprietary technologies with the need for environmental transparency and accountability.

4.1. Impact on IPR Enforcement

Lack of Transparency: Green hushing can result in companies withholding information about their environmental innovations, making it difficult to assess the true environmental impact of patented technologies. This lack of transparency can hinder the enforcement of IPR, as it becomes challenging to verify whether a technology meets the necessary environmental criteria for patentability (Шахназаров, 2024; Aher et al., 2018).

Challenges in Patent Examination: The current patent system often prioritizes novelty and economic usefulness over environmental impact. This can lead to the granting of patents for technologies that may not be environmentally sound, exacerbated by green hushing practices that obscure the true nature of the innovation (Iaia, 2024; Hsu, 2007).

Regulatory Gaps: Existing IPR legislations often lack stringent criteria for environmental protection, which can be exploited by companies engaging in green hushing. This gap in regulation makes it difficult to enforce IPR in a way that aligns with environmental sustainability goals (Aher et al., 2018; d'Ornellas & Waldman, 2016).

4.2. Examples and Case Studies

China's IPR and Carbon Emissions: In China, the construction of intellectual property cities (IPC) has been shown to reduce carbon emissions by promoting green technology. However, the effectiveness of such initiatives can be undermined by green hushing, which may prevent the full disclosure of environmental benefits and challenges associated with these technologies (Zhou et al., 2024).

Green Patents: The introduction of a 'greenness' criterion in the patent system has been proposed as a way to encourage environmentally friendly innovations. However, green hushing can obscure the true environmental benefits of such innovations, complicating the enforcement of these criteria (Hsu, 2007).

4.3. Broader Perspectives

While green hushing poses challenges to the enforcement of IPR in the environmental sector, it also highlights the need for a more integrated approach to intellectual property and environmental regulation. By incorporating environmental criteria into the patent examination process and enhancing transparency requirements, it may be possible to mitigate the negative impacts of green hushing. Additionally, fostering public-private partnerships and encouraging the sharing of green technologies can help balance the protection of proprietary rights with the need for environmental sustainability (Izyumenko, 2024; Brown, 2013).

5. Role of International Conventions in Green Trademark Protection

International conventions play a crucial role in the registration and protection of green trademarks globally by providing a standardized framework that facilitates the recognition and enforcement of trademark rights across borders. These conventions, such as the Paris Convention,

the Madrid Protocol, and the TRIPS Agreement, establish guidelines and systems that streamline the process of international trademark registration, thereby enhancing the legal protection of trademarks, including those that are environmentally friendly or "green." The influence of these conventions is evident in their ability to harmonize trademark laws, reduce administrative burdens, and promote fair competition in the global market. Below are key aspects of how these conventions impact green trademarks:

5.1. Harmonization of Trademark Laws

The Paris Convention for the Protection of Industrial Property, established in 1883, was the first to harmonize trademark laws internationally, setting a precedent for subsequent agreements (Teixeira, 2006; "Rozwój Międzynarodowego Systemu Ochrony Znaków Towarowych i Usługowych," 2023). The TRIPS Agreement further strengthens this harmonization by setting minimum standards for the protection and enforcement of intellectual property rights, including trademarks, among WTO member countries (Zhan, 2017; Craze, 2000).

5.2. The Madrid System for International Registration

The Madrid Protocol, part of the Madrid System, allows for the international registration of trademarks through a single application, which is particularly beneficial for green trademarks seeking protection in multiple countries (Ramasari, 2013; Alhendi & Salameh, 2022). This system is cost-effective and efficient, making it accessible for small and medium-sized enterprises (SMEs) that may focus on sustainable products and services (Alhendi & Salameh, 2022).

5.3. Protection of Non-Traditional and Well-Known Marks

The TRIPS Agreement and the Paris Convention also address the protection of non-traditional trademarks, which can include green trademarks that utilize unique colors, sounds, or shapes to signify environmental friendliness (Zhan, 2017). Well-known marks, which may include established green brands, receive additional protection under these conventions, preventing unauthorized use that could mislead consumers (Craze, 2000).

5.4. Regional and Historical Influences

The Pan-American Convention of 1929, although less influential today, provided early regional protection for trademarks and set a foundation for future international agreements (Farley, 2024; Farley, 2014). The Nice Agreement, which classifies goods and services for trademark registration, aids in the categorization of green products, ensuring they are appropriately recognized and protected ("Rozwój Międzynarodowego Systemu Ochrony Znaków Towarowych i Usługowych," 2023).

While international conventions significantly aid in the registration and protection of green trademarks, challenges remain. The dynamic nature of trademark law, especially with the rise of digital and non-traditional trademarks, requires continuous adaptation of these conventions to address new forms of intellectual property. Additionally, the effectiveness of these conventions can vary depending on the readiness and infrastructure of individual countries to implement them, as seen in the case of Indonesia's ratification of the Madrid Protocol (Ramasari, 2013). Despite these challenges, international conventions remain a cornerstone in the global protection of trademarks, including those that are environmentally focused.

6. Impact of Green IPR Laws on Eco-Friendly Innovation in India

The implementation of green Intellectual Property Rights (IPR) laws in India significantly influences the development and commercialization of eco-friendly technologies. These laws aim to incentivize innovation while ensuring the accessibility and dissemination of green technologies. By providing legal protection and potential financial rewards, green IPR laws encourage inventors and

investors to focus on sustainable innovations. However, the effectiveness of these laws is contingent upon balancing the protection of intellectual property with the need for widespread technology transfer, especially in developing regions.

6.1. Incentives for Innovation

Patent Protection: Green IPR laws in India provide patent protection for eco-friendly technologies, which incentivizes innovation by offering inventors exclusive rights to their creations. This exclusivity can lead to financial returns, encouraging further research and development in green technologies (MADHUMITHA, 2024; Kariyawasam & Tsai, 2018).

Green Patents Program: Similar to Brazil's Green Patents Program, which accelerates the examination of patent applications related to environmental technologies, India could benefit from a similar initiative to stimulate the development of technologies that address environmental issues (Salgado & Franchi, 2023).

6.2. Technology Transfer and Accessibility

International Technology Transfer: Green IPR laws facilitate the transfer of climate technologies from developed to developing countries, which is crucial for addressing global environmental challenges. However, stringent IPRs can also increase the cost of technology acquisition, posing a barrier to economically unstable regions (Jee et al., 2024; Kariyawasam & Tsai, 2018).

Compulsory Licensing and Patent Pools: Mechanisms such as compulsory licensing and patent pools can enhance the accessibility of green technologies by allowing multiple entities to use patented innovations, thus promoting wider dissemination and use (Rimmer, 2011; Rimmer, 2011).

6.3. Economic and Social Implications

Socioeconomic Growth: By fostering the development of green technologies, IPR laws contribute to socioeconomic growth and sustainable development. The creation of eco-friendly technologies can lead to new industries and job opportunities, supporting economic advancement while addressing environmental concerns (Salgado & Franchi, 2023; Nitta, 2006).

Social Justice: Green patents can help mitigate social inequalities by providing access to technologies that improve environmental conditions, particularly in underprivileged areas. This aligns with the broader goal of achieving social justice through sustainable development (Tagues & Chasco, n.d.).

6.4. Challenges and Considerations

Balancing Protection and Access: While IPR laws protect inventors' rights, they must also ensure that these technologies are accessible to those who need them most. This requires a careful balance between incentivizing innovation and facilitating technology transfer (MADHUMITHA, 2024; Kariyawasam & Tsai, 2018).

Market Mechanisms: The role of market mechanisms, such as trade and demand-pull policies, is crucial in promoting the adoption of green technologies. These mechanisms can complement IPR laws by creating a favorable environment for the commercialization of eco-friendly innovations (Jee et al., 2024).

While green IPR laws in India play a pivotal role in promoting the development and commercialization of eco-friendly technologies, they also present challenges that need to be addressed. Ensuring that these laws do not hinder the accessibility of essential technologies, especially in developing regions, is crucial for achieving sustainable development goals. Balancing the protection of intellectual property with the need for widespread technology transfer remains a key consideration for policymakers and stakeholders in the field of green technology.

7. Prospects and Challenges of Green Trademarks Under Indian Law

The introduction of a Green Trademark under the Indian Trademark Act 1999 could have significant implications for environmental sustainability. By formally recognizing and regulating green trademarks, India could promote genuine eco-friendly practices and curb misleading marketing tactics such as greenwashing. This initiative would align with global efforts to balance economic growth with environmental protection, encouraging businesses to adopt sustainable practices. The potential benefits of such a move include increased consumer trust, enhanced corporate responsibility, and a positive impact on the environment. However, the successful implementation of a Green Trademark system would require careful consideration of various factors, including legal frameworks, consumer awareness, and industry cooperation.

7.1. Promoting Genuine Eco-Friendly Practices

Green trademarks can serve as a certification for products that meet specific environmental standards, ensuring that businesses adhere to sustainable practices in production, packaging, and disposal (Mishra & Singh, 2024). By providing a clear and reliable indicator of eco-friendliness, green trademarks can help consumers make informed purchasing decisions, thereby encouraging companies to adopt genuine green practices to meet consumer demand (Schleder et al., 2017).

7.2. Curbing Greenwashing

The absence of stringent regulations has allowed some businesses to exploit green branding for profit without making substantial environmental contributions, a practice known as greenwashing (Mishra & Singh, 2024; Özkan & Özbey, 2023). Introducing a Green Trademark could help mitigate this issue by establishing clear criteria and legal consequences for false claims, thus protecting consumers and promoting market integrity (Özkan & Özbey, 2023).

7.3. Enhancing Corporate Responsibility

Companies that adopt green trademarks may benefit from improved brand reputation and consumer loyalty, as environmentally conscious consumers increasingly prefer products that align with their values (Bhatti & Negi, 2015). This shift could incentivize businesses to invest in sustainable technologies and practices, contributing to broader environmental goals (Ramesh, 2023).

7.4. Supporting Economic and Environmental Balance

The concept of green growth emphasizes the need to decouple economic development from environmental degradation, a goal that green trademarks could support by encouraging sustainable business models (Roy, 2024). By promoting green products and technologies, India could enhance its trade competitiveness while reducing the environmental impact of its exports (Gore & Annachhatre, 2019).

7.5. Challenges and Considerations

Implementing a Green Trademark system would require robust legal frameworks and enforcement mechanisms to ensure compliance and prevent misuse (Mishra & Singh, 2024). Consumer education and awareness campaigns would be essential to help the public understand the significance of green trademarks and make informed choices (Ramesh, 2023). Collaboration between government, industry, and civil society would be crucial to address potential challenges and ensure the system's effectiveness (Ramesh, 2023).

While the introduction of a Green Trademark under the Indian Trademark Act 1999 holds promise for advancing environmental sustainability, it is not without challenges. The success of such an initiative would depend on the establishment of clear standards, effective enforcement, and widespread consumer awareness. Additionally, it would require balancing the interests of various

stakeholders, including businesses, consumers, and environmental advocates, to create a system that genuinely promotes sustainability while supporting economic growth.

8. Green Industrial Design and Legal Framework in India

Green industrial design in India is an evolving field that integrates sustainable practices into the design and manufacturing processes. This approach is increasingly relevant in the context of Indian design laws, which aim to protect industrial designs while promoting innovation and sustainability. The intersection of green design and Indian design laws presents both opportunities and challenges, particularly in terms of legal protection and the practical implementation of sustainable practices.

8.1. Legal Framework and Protection

The Designs Act, 2000, is the primary legal framework governing industrial design protection in India. It emphasizes the need for novelty and originality in design, which is crucial for securing legal protection. However, the Act also presents challenges, such as the risk of losing protection due to prior disclosure before formal registration (Nishtha & -, 2024). The overlap between copyright and design laws in India, particularly under Section 15 of the Indian Copyright Act, 1957, complicates the protection of designs that have both aesthetic and utilitarian aspects. This legal ambiguity can affect the protection of green designs, which often incorporate both elements (Aggarwal & Sircar, 2024).

8.2. Green Design Principles

Green design focuses on reducing environmental impact through sustainable practices such as energy-saving, material reduction, and waste minimization. These principles are essential for creating products that are not only environmentally friendly but also economically viable (Wang et al., 2015; Ya, 2011). The integration of traditional Indian knowledge and practices can enhance the sustainability of green designs. Traditional methods often reflect a balance between aesthetics and functionality, which can be leveraged to create more holistic and sustainable design solutions (Changede, 2023).

8.3. Implementation in Indian Industries

The adoption of green manufacturing practices in Indian industries is gaining momentum, driven by the need to reduce environmental impact and improve resource efficiency. This shift is supported by digitalization and Industry 4.0 technologies, which facilitate the implementation of green innovations (Singh et al., 2022; Mallik, 2024). The Indian European Ecodesign Program (IEEP) aims to promote ecodesign methodologies in India, fostering collaboration between scientific and business communities to enhance sustainable design practices (Diehl et al., n.d.).

8.4. Challenges and Opportunities

Despite the benefits of green design, there are significant challenges, including high financial investments, lack of expertise, and regulatory complexities. Overcoming these obstacles requires collaboration between policymakers, industry associations, and companies to develop effective solutions and incentives for green innovation (Mallik, 2024). The patentability of green designs is another area of concern. While green design improvements can enhance patentability by introducing novel principles of operation, the legal requirements for novelty and non-obviousness must still be met (Fang-Lin & King-Chai, 2015).

While green industrial design offers significant potential for sustainable development in India, it also faces challenges related to legal protection and practical implementation. The integration of traditional knowledge and modern technologies can enhance the sustainability of designs, but legal ambiguities and regulatory hurdles must be addressed to fully realize the benefits of green design. Collaboration among stakeholders and the development of supportive policies are crucial for advancing green industrial design in India.

9. Green Trade Secrets and Legal Protection in India

Green trade secrets refer to confidential business information that provides a competitive edge in the realm of environmentally sustainable practices and technologies. These secrets are crucial for companies aiming to innovate in green technologies while maintaining a competitive advantage. In India, the regulation of trade secrets, including green trade secrets, is primarily governed by common law principles, as there is no specific statutory framework dedicated to trade secrets. This approach contrasts with global best practices, which often involve codified laws providing clear guidelines and protections. The following sections explore the key components of green trade secrets and how Indian laws regulate them in alignment with international standards.

9.1. Key Components of Green Trade Secrets

Confidentiality: Green trade secrets must be kept confidential to maintain their value. This involves implementing measures to ensure that information related to sustainable practices and technologies is not disclosed to unauthorized parties (Halligan & Weyand, 2001).

Commercial Value: The information must provide a competitive advantage, such as cost savings or enhanced efficiency in sustainable practices, which contributes to its commercial value (Quinto & Singer, 2009).

Reasonable Efforts to Maintain Secrecy: Companies must demonstrate that they have taken reasonable steps to protect the secrecy of their green innovations, such as through non-disclosure agreements and secure data management systems (Halligan & Weyand, 2001).

9.2. Regulation of Trade Secrets in India

Common Law Framework: India relies on common law principles to protect trade secrets, primarily through the Indian Contract Act, 1872, and the Indian Copyright Act, 1957. These laws provide remedies for breach of confidentiality agreements and unauthorized use of confidential information (Sebastian, 2022).

TRIPS Compliance: India is a signatory to the TRIPS Agreement, which mandates the protection of undisclosed information. However, the lack of a specific trade secret law means that India must rely on existing legal frameworks to fulfill its TRIPS obligations (Kumar et al., 2006; Nair, 2002).

Judicial Precedents: Indian courts have played a significant role in shaping the protection of trade secrets through case law, often interpreting existing laws to address issues of confidentiality and misappropriation (Sebastian, 2022).

9.3. Global Best Practices and Indian Alignment

Codified Laws: Many countries, such as the USA, have enacted specific trade secret laws that provide clear definitions and protections, such as the Uniform Trade Secrets Act (UTSA). These laws offer a structured approach to trade secret protection, which India lacks (Quinto & Singer, 2009).

Sui Generis Protection: There is a growing call for India to adopt a sui generis system for trade secret protection, which would provide a tailored legal framework specifically for trade secrets, including those related to green technologies (Sebastian, 2022; Nair, 2002).

Material Transfer Agreements: Globally, material transfer agreements are used to protect trade secrets during collaborations. India could benefit from developing such agreements to safeguard green innovations (Long, 2011).

While India currently relies on common law principles to regulate trade secrets, there is a significant push towards adopting a more codified and comprehensive legal framework. This would align India more closely with global best practices and provide clearer protections for green trade secrets. However, the transition to such a system requires careful consideration of India's unique legal and industrial landscape, as well as the potential impact on innovation and competition.

10. Key Factors Influencing Green Technology Transfer in Developing Countries

The effectiveness of green technology transfer in developing countries is influenced by a multitude of factors, ranging from economic and political conditions to social and environmental considerations. These factors determine the success of technology adoption and its integration into local contexts, which is crucial for achieving sustainable development and mitigating climate change. The following sections outline the key factors influencing this process.

10.1. Economic and Financial Factors

Funding and Investment: Adequate financial resources are essential for the successful transfer of green technologies. Developing countries often face financial constraints that limit their ability to invest in new technologies. Programs like the Green Climate Fund aim to address these gaps by providing financial support for technology transfer projects (Driesen & Popp, 2010).

Affordability and Cost: The high cost of green technologies can be a barrier to their adoption. Ensuring that technologies are affordable and accessible to local communities is crucial for widespread implementation (Mabuza et al., 2007).

10.2. Political and Institutional Factors

Government Policies: Consistent and supportive government policies are vital for facilitating technology transfer. Inconsistent policies can hinder the adoption of green technologies, as seen in the uneven implementation across countries like India, Brazil, South Africa, and Kenya (Niu et al., 2023).

Policy Development and Support: Effective technology transfer requires the development of policies that promote knowledge spillovers and address issues of additionality and scale. This can enhance the capacity of developing countries to address climate change more thoroughly (Driesen & Popp, 2010).

10.3. Social and Cultural Factors

Local Knowledge and Community Involvement: Integrating local traditional knowledge and involving communities in the implementation process can improve the acceptability and success of technology transfer projects. This approach has been effective in projects in Malawi, where local knowledge was embraced to enhance environmental education efforts (Pullanikkatil et al., 2014; Pullanikkatil, 2014).

Education and Skills Transfer: Building local capacity through education and skills transfer is essential for the long-term success of technology adoption. This includes training local communities to maintain and adapt technologies to their specific needs (Mabuza et al., 2007).

10.4. Technological and Environmental Factors

Infrastructure and Technical Expertise: The lack of adequate infrastructure and technical expertise can impede the adoption of green technologies. Developing countries need to build the necessary infrastructure and develop technical skills to support technology transfer (Niu et al., 2023).

Environmental Performance: The environmental performance of a country can influence the diffusion of green technologies. Countries with better environmental performance are more likely to adopt and benefit from green technologies (Ağan & Balcilar, 2022).

10.5. Global and Market Factors

Intellectual Property and Trade Policies: Trade policies and intellectual property regulations can create barriers to technology transfer by making technologies cost-prohibitive. A global exchange

forum could help balance the needs of technology holders with the demand from developing countries (Hasper, 2009).

Market Mechanisms: Market mechanisms like the Clean Development Mechanism (CDM) have been used to facilitate technology transfer, but their effectiveness has been limited. New approaches are needed to enhance the scale and impact of these mechanisms (Driesen & Popp, 2010).

While these factors highlight the complexities of green technology transfer, it is important to consider the broader context in which these transfers occur. Developing countries face unique challenges that require tailored solutions, and a one-size-fits-all approach is often ineffective. Understanding the specific needs and conditions of each country is crucial for designing successful technology transfer strategies (Pueyo & Linares, 2012).

11. Diffusion of Green Technologies: Trends, Barriers, and Policy Approaches

The diffusion of green technologies across industries and countries is crucial for maximizing their positive environmental impact. This process involves the spread and adoption of technologies that contribute to sustainability, such as renewable energy, sustainable transportation, and efficient waste management systems. The successful diffusion of these technologies can significantly reduce environmental degradation and combat climate change. However, the rate and success of green technology diffusion vary widely across different regions and are influenced by a multitude of factors. The following sections explore these aspects in detail.

11.1. Factors Influencing Green Technology Diffusion

Economic and Social Factors: Economic conditions, such as income levels and foreign direct investment, play a significant role in the diffusion of green technologies. Socioeconomic conditions, including income distribution and technological achievement, also impact the adoption rates of these technologies (Ağan & Balcilar, 2022).

Political and Environmental Factors: Political stability and environmental performance are critical determinants. Countries with strong democratic accountability and environmental policies tend to have higher rates of green technology diffusion (Ağan & Balcilar, 2022).

Technological and Innovation Capacity: The ability of a country to innovate and absorb new technologies is crucial. Developing countries often face challenges due to lower innovation and technological absorptive capacities, which hinder the diffusion of green technologies (Glachant, 2013).

11.2. Current Trends and Challenges

Varying Rates of Diffusion: The diffusion rates of green technologies differ significantly among countries. For instance, Japan, Germany, and the USA are expected to experience significant growth in green technology diffusion, while countries like Ireland and Iceland face challenges with low or negative growth rates (Ağan, 2024).

Barriers to Adoption: High initial costs and technological limitations are significant barriers to the widespread adoption of green technologies. These challenges are particularly pronounced in developing countries, where financial and technical resources are limited (Islam et al., 2024).

Role of Information and Networks: The flow of information and the presence of networks and organizations are vital for the diffusion process. Behavioral factors, such as values and cognitive biases, also influence the adoption of green technologies (Allan et al., 2014).

11.3. Policy Recommendations

Market-Based Instruments and Regulations: Flexible market-based instruments can positively impact technology diffusion, although regulations have also been effective in some cases. Policymakers are encouraged to consider a mix of these approaches to foster green technology adoption (Allan et al., 2014).

Capacity Building and Knowledge Sharing: Enhancing technological absorptive capacities and facilitating knowledge sharing through free access to scientific publications can help developing countries adopt green technologies more effectively (Pacheco, 2019).

Investment in Research and Development: Increased investment in research and development, particularly in green technologies, is essential for overcoming existing barriers and promoting widespread adoption (Islam et al., 2024).

While the diffusion of green technologies is essential for achieving sustainability, it is not without challenges. The process is often slow, and various economic, social, political, and environmental factors can impede progress. Additionally, the high initial costs and technological limitations present significant barriers, especially in developing countries. However, by addressing these challenges through targeted policies and investments, the global community can enhance the adoption of green technologies and maximize their positive environmental impact.

12. Impact of the TRIPS Agreement on Green Intellectual Property Rights

The TRIPS Agreement significantly impacts the protection of Green Intellectual Property Rights (IPR) globally by establishing a framework for harmonizing intellectual property laws across countries, which influences innovation, trade, and economic development. However, its effects are complex and vary between developed and developing nations, often reflecting broader economic and political dynamics. The agreement has been instrumental in reducing intellectual property infringement and increasing registrations, thereby promoting innovation and foreign direct investment. However, it also presents challenges, particularly in balancing public welfare with stringent standards, which can be detrimental to developing countries. The following sections explore these impacts in detail.

12.1. Harmonization and Legal Framework

The TRIPS Agreement provides a standardized legal framework for IPR protection, which has led to a reduction in infringement cases and an increase in intellectual property registrations globally. For instance, in the United States, infringement cases dropped from 39,105 to 25,586 after TRIPS implementation (Huang & Wu, 2024). This harmonization facilitates international trade by providing a predictable legal environment, which is crucial for businesses operating across borders (Kennedy et al., 2024).

12.2. Impact on Innovation and Economic Growth

By strengthening IPR protection, TRIPS encourages innovation and attracts foreign direct investment (FDI), which are vital for economic growth. This is particularly evident in developing countries that have tightened their IPR regimes in response to TRIPS, leading to increased innovation activities (Cardwell & Ghazalian, 2012). The agreement is seen as a catalyst for research and development (R&D) globally, as it assures inventors and companies that their innovations will be protected, thus incentivizing further investment in green technologies (Narasaiah, n.d.).

12.3. Challenges for Developing Countries

Despite its benefits, TRIPS poses significant challenges for developing countries. The stringent IPR standards can limit access to new technologies and knowledge, which are crucial for sustainable development and addressing environmental challenges (Narasaiah, n.d.). The agreement's "one-size-fits-all" approach often fails to consider the unique socio-economic contexts of developing nations, potentially hindering their ability to adapt and implement IPR laws that align with their development goals (Abdelgawad, 2015).

12.4. Environmental and Public Interest Concerns

The TRIPS Agreement has been criticized for not adequately balancing private and public interests, particularly in the context of environmental sustainability. The focus on protecting the interests of multinational corporations can overshadow the need for accessible green technologies that are essential for addressing global environmental challenges (Walker, 2001). There is a growing call for reforms to ensure that the TRIPS framework supports sustainable development by facilitating access to green technologies and promoting environmental innovation (Walker, 2001).

While the TRIPS Agreement has played a pivotal role in strengthening global IPR protection, its impact on green intellectual property rights is multifaceted. The agreement has undoubtedly fostered innovation and economic growth, but it also presents significant challenges, particularly for developing countries striving to balance IPR protection with public welfare and environmental sustainability. The ongoing debate highlights the need for a more nuanced approach that considers the diverse needs of countries at different stages of development, ensuring that the benefits of green technologies are accessible to all.

13. International Enforcement Mechanisms for Green IPR

The enforcement of Green Intellectual Property Rights (IPR) in international law is a complex and multifaceted issue, involving various legal frameworks and mechanisms. These mechanisms are essential for ensuring that green technologies, which are crucial for sustainable development, are protected and incentivized. The enforcement of Green IPR is governed by a combination of international treaties, regional directives, and national laws, each contributing to a comprehensive enforcement regime. The following sections outline the key enforcement mechanisms for Green IPR in international law.

13.1. International Treaties and Agreements

TRIPS Agreement: The Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement is a cornerstone of international IPR enforcement. It sets minimum standards for the protection and enforcement of intellectual property rights, including provisions for civil, administrative, and criminal enforcement measures (Milani & Ahmadi, 2018; Leesti, 1999).

Multilateral and Bilateral Treaties: Various multilateral and bilateral treaties complement the TRIPS Agreement by addressing specific aspects of IPR enforcement. These treaties often include provisions for cooperation between countries to combat transnational IPR infringements (Seuba, 2017; Seuba, n.d.).

13.2. Regional Directives and Frameworks

EU IPR Enforcement Directive: The European Union's IPR Enforcement Directive harmonizes enforcement measures across member states, ensuring a consistent approach to IPR protection. It includes provisions for evidence gathering, injunctions, and the involvement of intermediaries (Ellard, 2004; Wilman, 2017).

ASEAN IPR Action Plan: The ASEAN IPR Action Plan aims to strengthen IPR enforcement within the ASEAN region through regional cooperation and capacity building. It aligns with international standards and addresses specific regional challenges (Dodig, 2023).

National Implementation and Enforcement

National Laws and Procedures: Countries implement international IPR obligations through national laws, which include civil, administrative, and criminal procedures for enforcement. For example, Iran has developed its national IP law to align with TRIPS requirements, incorporating civil and criminal remedies (Milani & Ahmadi, 2018).

Border Measures: National authorities are empowered to enforce IPR at borders, preventing the importation of infringing goods. This is a critical component of IPR enforcement, as it helps to curb the flow of counterfeit and pirated products (Leesti, 1999).

13.3. Challenges and Considerations

Balancing Enforcement with Development: There is an ongoing debate about the impact of strict IPR enforcement on developing countries. Some argue that stringent enforcement can hinder access to green technologies, which are vital for sustainable development. Therefore, a balanced approach that considers the developmental needs of countries is essential (Li & Correa, 2009).

Coordination and Cooperation: Effective enforcement of Green IPR requires coordination among international organizations, national governments, and private stakeholders. This includes sharing best practices and addressing the challenges posed by digital technologies and global trade (Huang, 2024).

While the enforcement of Green IPR is crucial for promoting innovation and environmental protection, it also presents challenges, particularly for developing countries. These nations may face difficulties in implementing and enforcing IPR due to limited resources and the need to balance enforcement with access to essential technologies. Therefore, international cooperation and flexible enforcement strategies are necessary to ensure that Green IPR contributes to sustainable development globally.

14. Key Types of Green Intellectual Property Rights

Green Intellectual Property Rights (IPR) encompass a range of legal protections designed to foster innovation in environmentally sustainable technologies. These rights are crucial in promoting the development and dissemination of technologies that mitigate environmental impacts and support sustainable development. The primary types of green IPR include green patents, eco-marks, and green technology transfer mechanisms. Each of these plays a distinct role in the broader framework of intellectual property aimed at addressing environmental challenges.

14.1. Green Patents

Green patents are a subset of patents that protect inventions contributing to environmental sustainability, such as clean energy technologies, green transportation, and waste management solutions (Taques & Chasco, n.d.; Santos & Oliveira, 2014). The Green Patents Program, such as the one implemented by the National Institute of Intellectual Property (INPI) in Brazil, accelerates the examination of patent applications related to environmentally friendly technologies, thereby promoting rapid innovation and deployment (Santos & Oliveira, 2014; Salgado & Franchi, 2023). In Brazil, the areas of chemistry and mechanical engineering are particularly prominent in green patent applications, accounting for 82% of the total patents analyzed under the Green Patents Program (Maia et al., 2022).

14.2. Eco-Marks

Eco-marks are trademarks specifically used to denote products or services that meet certain environmental standards. They help consumers identify and choose environmentally friendly products. Protecting eco-marks involves ensuring that they are not misused or subject to greenwashing, which is the practice of falsely claiming environmental benefits. Litigation and policy initiatives around eco-marks focus on maintaining their integrity and preventing abuse, which is crucial for consumer trust and market differentiation (Lane & Kozuch, 2011).

14.3. Green Technology Transfer

Green technology transfer involves the dissemination of environmentally sustainable technologies across borders, often facilitated by international agreements and policies (Taques & Chasco, n.d.). The Green Intellectual Property (GIP) scheme proposes a financial framework to support the transfer of eco-friendly technologies by establishing a GIP Trust Fund. This fund would provide financial assistance to facilitate access to necessary technologies for users lacking capital

(Nitta, 2006). The GIP system aims to accelerate the distribution of renewable energy technologies and essential medicines, thereby addressing both environmental and social challenges (Nitta, 2006).

While green IPRs are instrumental in promoting sustainable technologies, there are challenges and debates surrounding their implementation. Critics argue that the current IPR framework may not adequately address the urgent need for widespread technology dissemination, particularly in developing countries. The balance between protecting inventors' rights and ensuring public access to critical technologies remains a contentious issue. Additionally, the potential for greenwashing and the misuse of eco-marks highlight the need for robust regulatory mechanisms to maintain the credibility of green IPRs. These challenges underscore the importance of ongoing research and policy development to optimize the role of green IPRs in fostering sustainable innovation.

15. International Legal Frameworks for Plant Variety and Biodiversity Protection

The protection of plant varieties and biodiversity is governed by a complex international legal framework that includes several key treaties and conventions. These legal instruments aim to balance the interests of breeders, farmers, and the global community by promoting innovation, conservation, and sustainable use of plant genetic resources. The main terms covering plant variety and biodiversity protections are embedded in agreements such as the TRIPS Agreement, UPOV Convention, CBD, and ITPGRFA. Each of these frameworks addresses different aspects of plant variety protection and biodiversity conservation, providing a comprehensive approach to managing these critical resources.

15.1. TRIPS Agreement

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) mandates that member states provide protection for plant varieties through patents, an effective sui generis system, or a combination of both. This requirement aims to encourage innovation in plant breeding while allowing flexibility for countries to choose the most suitable protection system for their needs (Antons, 2010; Mathur & Musyuni, 2018). Article 27.3(b) of the TRIPS Agreement is particularly significant as it allows countries to implement sui generis systems that can include traditional knowledge and agricultural practices, which are crucial for developing countries (Dang & Goel, 2009).

15.2. UPOV Convention

The International Union for the Protection of New Varieties of Plants (UPOV) provides a framework for plant breeders' rights, ensuring that breeders have exclusive rights to produce and market new plant varieties. This system requires that varieties meet criteria of distinctness, uniformity, and stability (Yu & Chung, 2021; Ljubojev & Varga, 2013). UPOV has been revised multiple times to adapt to changing needs and has been instrumental in promoting plant breeding activities, increasing farmer income, and developing rural areas (Irianti, 2019; Mathur & Musyuni, 2018).

15.3. Convention on Biological Diversity (CBD)

The CBD focuses on the conservation and sustainable use of biological diversity, granting rights to developing countries to monitor access to genetic resources. This helps restore balance between developing and industrialized countries by supporting the utilization of germplasm (Irianti, 2019; Mathur & Musyuni, 2018). The CBD also emphasizes the importance of traditional knowledge and the role of local communities in biodiversity conservation (Antons, 2010).

International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)

The ITPGRFA recognizes the contributions of farmers and local communities to the conservation and development of plant genetic resources. It aims to ensure food security by facilitating access to plant genetic materials and sharing benefits derived from their use (Mathur & Musyuni, 2018; Dang

& Goel, 2009). This treaty also supports farmers' rights, acknowledging their role in maintaining and enhancing plant genetic diversity (Irianti, 2019).

While these international frameworks provide a robust structure for protecting plant varieties and biodiversity, challenges remain in harmonizing these protections with national laws and practices. The implementation of these agreements often requires balancing commercial interests with the need to preserve traditional knowledge and biodiversity. Developing countries, in particular, face the challenge of integrating these international standards with local practices and priorities, which can sometimes lead to conflicts between economic development and conservation goals.

16. Green Technology Licensing: Mechanisms, Roles, and Challenges

The glossary entries that explain licenses for green technologies are primarily found in discussions about intellectual property rights, technology transfer, and the role of patents in promoting sustainable development. These entries are crucial for understanding how green technologies are protected, shared, and commercialized, which in turn influences their development and deployment. The following sections provide insights into the key aspects of licenses related to green technologies.

16.1. Green Technology Licensing

Licensing is a critical mechanism for the transfer and commercialization of green technologies. It allows patent holders to permit others to use their patented technologies, often in exchange for royalties or other forms of compensation (Lane & Kozuch, 2011; Veen & Osseweijer, 2014). The nature and characteristics of licenses, including exclusive and non-exclusive licenses, are essential for understanding how they differ from other legal interests and how they can be terminated (Bayramovna, 2022). Licensing agreements can facilitate the transfer of green technologies to developing countries, which is vital for addressing global environmental challenges (Veen & Osseweijer, 2014).

16.2. Role of Patents in Green Technology

Patents play a significant role in the development and dissemination of green technologies by providing exclusive rights to inventors, which can incentivize innovation (Salgado & Franchi, 2023; Mikhailov & Mikhailova, n.d.). The Green Patents Program, for instance, aims to accelerate the examination of patent applications related to environmentally beneficial technologies, thereby promoting their rapid deployment (Salgado & Franchi, 2023; Santos & Oliveira, 2014). Patents can also serve as indicators of technological innovation and are crucial for securing marketing positions in the green technology sector (Mikhailov & Mikhailova, n.d.).

16.3. Challenges and Opportunities in Licensing

Despite the potential of licensing to promote technology transfer, there are challenges such as the need for favorable terms to ensure accessibility for developing countries (Veen & Osseweijer, 2014). The establishment of institutions like the Technology Mechanism and the Green Climate Fund highlights the untapped potential in the business community to license technologies on terms that promote global sustainability (Veen & Osseweijer, 2014). Effective licensing strategies can help overcome barriers to the adoption of green technologies, such as regulatory discrepancies and the need for clear guidelines (Bortone et al., 2022).

While licensing is a powerful tool for promoting the dissemination of green technologies, it is not without its challenges. Issues such as intellectual property rights, regulatory barriers, and the need for favorable licensing terms can hinder the widespread adoption of these technologies. Addressing these challenges requires coordinated efforts from policymakers, businesses, and

international organizations to ensure that green technologies can be effectively shared and utilized worldwide.

17. Key Terms and Criteria for Green Patents

Green Intellectual Property Rights (IPR) terms are crucial in defining environmentally focused patents, often referred to as "green patents." These patents are designed to protect innovations that contribute to environmental sustainability and address climate change. The key terms and concepts associated with green IPR include the criteria for patentability, the role of green patents in sustainable development, and the mechanisms for promoting green technologies. The following sections delve into these aspects, drawing insights from the provided research papers.

17.1. Criteria for Green Patentability

Novelty, Non-obviousness, and Usefulness: Traditional patent systems focus on these three criteria. However, for green patents, an additional criterion of "greenness" is proposed, which considers the environmental impact of the innovation (Hsu, 2007).

Environmental Impact Assessment: Some scholars suggest that patent applications should include an assessment of the technology's carbon footprint and other sustainability aspects, which would be a part of the patent examination process (Irp & Siyal, n.d.).

Role of Green Patents in Sustainable Development

Accelerated Examination: Programs like Brazil's Green Patents Program aim to expedite the examination process for environmentally friendly technologies, thereby encouraging innovation in this sector (Santos & Oliveira, 2014; Salgado & Franchi, 2023).

Socioeconomic and Environmental Benefits: Green patents are seen as tools that not only foster technological innovation but also contribute to socioeconomic growth and environmental preservation, aligning with sustainable development goals (Salgado & Franchi, 2023; Taques & Chasco, n.d.).

17.2. Mechanisms for Promoting Green Technologies

Green Patent Programs: These programs are designed to incentivize the development and dissemination of green technologies by offering benefits such as fast-tracking patent applications (Iaia, 2024).

Financial Incentives and Support: The Green Intellectual Property Scheme proposes financial mechanisms like the GIP Trust Fund to support the development and distribution of eco-friendly technologies (Nitta, 2006).

International Collaboration and Policy: The World Intellectual Property Organization (WIPO) and other international bodies are encouraged to develop guidelines and policies that promote the inclusion of environmental impact assessments in patent examinations (Irp & Siyal, n.d.).

17.3. Challenges and Considerations

While green patents offer significant potential for promoting sustainable technologies, there are challenges and considerations to address. The integration of environmental criteria into patent systems may require substantial changes in policy and practice, which could face resistance from traditional industries. Additionally, the balance between technological neutrality and environmental sensitivity remains a critical debate, as some argue that focusing too heavily on environmental aspects might stifle broader innovation (Iaia, 2024). Furthermore, the effectiveness of green patents in addressing social inequalities and climate change is contingent upon their widespread adoption and the equitable distribution of the resulting technologies (Taques & Chasco, n.d.).

18. Green Technology Licensing: Protection, Transfer, and Challenges

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While licensing is a powerful tool for promoting the dissemination of green technologies, it is not without its challenges. Issues such as intellectual property rights, regulatory barriers, and the need for favorable licensing terms can hinder the widespread adoption of these technologies. Addressing these challenges requires coordinated efforts from policymakers, businesses, and international organizations to ensure that green technologies can be effectively shared and utilized worldwide.

19. Compulsory Licensing in Green IPR: Access, Challenges, and Policy

Compulsory licensing in the context of green intellectual property rights (IPR) refers to the government or judiciary granting permission to use patented green technologies without the consent of the patent holder. This mechanism is intended to balance the monopoly rights of patent holders with public interest, particularly in addressing global challenges such as climate change. Compulsory licensing can facilitate the transfer of green technologies to developing countries, which may otherwise face barriers due to stringent intellectual property laws. However, the application of

compulsory licensing in green IPR is complex and involves navigating international legal frameworks such as the WTO/TRIPS agreements.

19.1. Compulsory Licensing as a Tool for Green Technology Transfer

Facilitating Access to Green Technologies: Compulsory licensing can be instrumental in promoting the transfer of clean technologies to developing countries, which are often unable to access these technologies due to high costs and restrictive IP laws. This is particularly relevant in the context of global warming and the need for widespread adoption of green technologies to mitigate environmental impacts (Percival & Miller, 2011; Ni, 2015).

Legal Frameworks and Challenges: The WTO/TRIPS agreements provide a legal basis for compulsory licensing, but the process is fraught with challenges. Developing countries may face significant legal and financial burdens in implementing compulsory licenses, which can deter their use. The complexity of international IP laws and the need for policy coherence are critical factors in the effective application of compulsory licensing for green technologies (Ni, 2015; Using Compulsory Licences as a Governance Tool: The Need for Greater Effectiveness and Policy Coherence, 2023).

19.2. Examples and Case Studies

Public Health Precedents: Compulsory licensing has been successfully used in the pharmaceutical industry to improve access to essential medicines, such as anti-retroviral drugs in Indonesia. These precedents highlight the potential of compulsory licensing to address public interest issues, which can be extended to green technologies (Sahlan et al., 2024; Monte, 2016).

Potential for Green Technology: While there are limited examples of compulsory licensing specifically for green technologies, the concept is gaining attention as a means to overcome IP barriers and promote sustainable development. The ethical obligation of developed countries to assist less fortunate nations in accessing green technologies is a driving force behind this approach (Monte, 2016; Ni, 2015).

19.3. Policy and Regulatory Considerations

Need for Policy Coherence: Effective use of compulsory licensing requires coherent policies that align with international legal standards and national interests. This includes ensuring that compulsory licenses are part of a broader policy toolkit rather than a standalone solution (Using Compulsory Licences as a Governance Tool: The Need for Greater Effectiveness and Policy Coherence, 2023).

Regulatory Reforms: Countries like Indonesia are exploring regulatory reforms to enhance the effectiveness of compulsory licensing. Proposals include allowing appeals against government compensation determinations and strengthening the legal framework to support the sustainable application of compulsory licenses (Sahlan et al., 2024).

While compulsory licensing offers a promising avenue for enhancing access to green technologies, it is not without its challenges. The legal and financial hurdles associated with implementing compulsory licenses can be significant, particularly for developing countries. Moreover, the effectiveness of compulsory licensing as a tool for green technology transfer depends on the willingness of developed countries to support such initiatives and the ability of international legal frameworks to accommodate these needs. Additionally, voluntary licensing and open innovation models are emerging as complementary approaches that can facilitate technology transfer while respecting IP rights (Schötz & Rapela, 2020; Ni, 2015).

20. Role of Indian IPR Regime in Green Innovation

The Indian Intellectual Property Rights (IPR) regime plays a crucial role in facilitating the growth of green innovations across various sectors by providing a structured framework that encourages the development and commercialization of environmentally sustainable technologies. This framework

not only protects the rights of innovators but also ensures that these innovations contribute to sustainable economic growth and environmental conservation. The Indian IPR regime, through its policies and strategies, supports the proliferation of green technologies by balancing the protection of intellectual property with the need for public access and sustainable development.

20.1. Protection and Incentivization of Green Technologies

The Indian IPR framework provides robust protection for green technologies through patents, copyrights, and trademarks, which incentivize innovation by ensuring that inventors can reap the benefits of their creations without the fear of unauthorized use or replication (MADHUMITHA, 2024; Chauhan, 2024). By aligning with international treaties such as TRIPS, India ensures that its IPR policies are conducive to fostering innovation while maintaining global standards (Nithyananda, 2018).

20.2. Encouragement of Sustainable Manufacturing

The IPR regime in India supports sustainable manufacturing by encouraging investments in research and development (R&D) and facilitating the licensing of green technologies. This approach helps in the proliferation of sustainable practices across industries (Nithyananda, 2018). Strategies such as patent pools and open-source innovations are promoted to enhance the accessibility of green technologies, thereby supporting sustainable manufacturing initiatives (Nithyananda, 2018).

20.3. Impact on Industry 4.0 and Digitalization

The digitalization wave, accelerated by Industry 4.0, has been instrumental in promoting green innovations in India. The IPR framework supports this transition by protecting digital innovations that contribute to resource efficiency and reduced environmental impact (Mallik, 2024). The adoption of green innovations in sectors like textiles, agriculture, and automotive is facilitated by the IPR regime, which helps companies improve their competitiveness and move towards a net-zero economy (Mallik, 2024).

20.4. Role in Economic Growth and Competitiveness

Green innovations, supported by the IPR regime, significantly contribute to India's sustainable economic growth by enhancing multifactor productivity and reducing reliance on non-renewable resources (Manigandan et al., 2024). The competitive advantage of firms is bolstered by green innovations, as evidenced by case studies of companies like Tata Motors and Mahindra & Mahindra, which leverage IPR to enhance brand reputation and market differentiation (Paulmoni et al., 2024).

20.5. Challenges and Opportunities

Despite the supportive framework, challenges such as high initial costs and regulatory complexities hinder the widespread adoption of green innovations. The IPR regime addresses these by fostering collaborations between policymakers, industry associations, and companies to develop effective solutions (Mallik, 2024). The rise of green start-ups in India, supported by green finance and government initiatives, highlights the opportunities within the IPR framework to drive sustainable business practices and achieve carbon neutrality (Lakhanpal et al., 2023).

While the Indian IPR regime effectively supports the growth of green innovations, it must continuously evolve to address emerging challenges and ensure that the benefits of green technologies are widely accessible. Balancing the protection of intellectual property with the need for public access and sustainable development remains a critical consideration. The ongoing collaboration between government, industry, and academia is essential to refine IPR policies and strategies, ensuring that they align with the dynamic landscape of green innovation and contribute to India's sustainable development goals.

21. Compulsory Licensing under India's Patents Act for Green Technologies

The Patents Act, 1970, through Sections 84 and 92, provides a legal framework for compulsory licensing, which can be instrumental in addressing environmental and climate challenges by ensuring that essential green technologies are accessible and affordable. Compulsory licensing allows governments to authorize the use of patented technologies without the consent of the patent holder, primarily to serve the public interest. This mechanism is particularly relevant for green technologies, which are crucial for climate change mitigation and adaptation. The following sections explore the implications and potential of compulsory licensing in the context of green technologies.

21.1. Importance of Compulsory Licensing for Green Technologies

Facilitating Technology Transfer: Compulsory licensing can play a significant role in facilitating the transfer of green technologies from developed to developing countries, which often face barriers in accessing these technologies due to high costs and restrictive intellectual property regimes (Hui-hua, n.d.; Ni, 2015).

Encouraging Innovation: By ensuring that green technologies are not locked up by patents, compulsory licensing can encourage further innovation and development in the field of clean technologies. This is crucial for achieving international climate goals and sustainable development (Singh & Srivastava, 2022; Rosencranz et al., 2018).

Addressing Market Failures: Compulsory licensing can help address market failures by making essential technologies available to those who need them most, thus promoting environmental sustainability and social equity (Taques & Chasco, n.d.; Hilty & Batista, 2023).

21.2. Challenges and Legal Considerations

Legal Barriers: The implementation of compulsory licensing is fraught with legal challenges, particularly in light of international agreements such as the WTO/TRIPS. These agreements impose certain conditions and limitations on the use of compulsory licensing, which can be a significant hurdle for developing countries (Ni, 2015).

Economic Implications: While compulsory licensing can make technologies more accessible, it may also have economic implications for patent holders, potentially affecting their incentives to innovate. Balancing these interests is a critical aspect of the debate around compulsory licensing (McManis & Contreras, 2014; Rosencranz et al., 2018).

Policy and Regulatory Frameworks: Effective use of compulsory licensing requires robust policy and regulatory frameworks that align with international standards while addressing local needs. This includes ensuring that licenses are granted transparently and fairly, with adequate compensation for patent holders (Rimmer, 2011; Perrone & Glenna, 2022).

While compulsory licensing offers a viable solution for enhancing access to green technologies, it is not without its critics. Some argue that it could disincentivize innovation by undermining the patent system, which is designed to reward inventors. Others suggest that alternative mechanisms, such as voluntary licensing agreements, patent pools, and public sector licensing, could be more effective in promoting technology transfer without the potential downsides of compulsory licensing (Rimmer, 2011; Hilty & Batista, 2023). Additionally, fostering international collaboration and partnerships in technology development and dissemination could complement compulsory licensing efforts, ensuring a more holistic approach to addressing climate change challenges (Singh & Srivastava, 2022; Perrone & Glenna, 2022).

22. Eco-Labels vs Eco-product Trademarks: Legal Frameworks and Challenges in India

The legal framework governing eco-labels and eco-product trademarks in India presents distinct differences in terms of their purpose, regulatory mechanisms, and challenges. Eco-labels, such as the Ecomark, are designed to inform consumers about the environmental impact of products, while eco-

product trademarks focus on branding products as environmentally friendly. Both systems aim to promote sustainability but operate under different legal and regulatory frameworks, which influence their effectiveness and consumer perception.

22.1. Eco-Labels in India

Purpose and Function: Eco-labels like the Ecomark are intended to provide consumers with information about the environmental impact of products, encouraging them to make environmentally conscious choices. The Ecomark scheme, launched in 1991, aims to certify products that meet specific environmental criteria (Thomsen & McAloone, 2015; Chaturvedi et al., 2012).

Regulatory Framework: The Ecomark is governed by the Central Pollution Control Board and is a voluntary certification. It is based on a holistic approach that considers various environmental factors, but its broad scope has led to limited adoption, with fewer than 30 licenses granted in over two decades (Chaturvedi et al., 2012).

Challenges: The Ecomark scheme faces challenges such as low consumer awareness, insufficient government support, and a lack of demand. These issues have hindered its effectiveness in promoting environmentally improved products (Thomsen & McAloone, 2015; Chaturvedi et al., 2012).

22.2. Eco-Product Trademarks in India

Purpose and Function: Eco-product trademarks, or green trademarks, are used by businesses to brand their products as eco-friendly. They signify that the product's production, packaging, and disposal processes are environmentally sustainable (Mishra & Singh, 2024).

Regulatory Framework: Unlike eco-labels, eco-product trademarks are governed by trademark laws. They require registration and protection under intellectual property rights, which can include certification, collective, and ordinary trademark rights (Belson, 2024; Mishra & Singh, 2024).

Challenges: A significant challenge for eco-product trademarks is the risk of greenwashing, where companies make misleading claims about the environmental benefits of their products. This practice undermines consumer trust and the credibility of genuine eco-friendly products (Devireddy, n.d.; Vijayalakshmi, 2024).

22.3. Comparative Analysis

Effectiveness: While both eco-labels and eco-product trademarks aim to promote sustainability, their effectiveness varies. The Ecomark has struggled due to structural flaws and lack of consumer engagement, whereas eco-product trademarks face challenges related to greenwashing and the need for stringent legal frameworks to prevent misuse (Thomsen & McAloone, 2015; Mishra & Singh, 2024; Devireddy, n.d.).

Consumer Awareness and Demand: The success of both systems depends heavily on consumer awareness and demand. The Ecomark's limited success is partly due to low consumer awareness, whereas eco-product trademarks can be more effective if consumers are educated about the risks of greenwashing and the importance of genuine eco-friendly products (Chaturvedi et al., 2012; Vijayalakshmi, 2024).

While eco-labels and eco-product trademarks in India share the common goal of promoting environmental sustainability, they differ significantly in their legal frameworks and challenges. Eco-labels like the Ecomark face issues related to consumer awareness and regulatory support, whereas eco-product trademarks must navigate the complexities of intellectual property law and the threat of greenwashing. Both systems require robust legal frameworks and increased consumer education to enhance their effectiveness in promoting sustainable practices.

23. Conclusion

Green intellectual property rights are pivotal in driving sustainable development and environmental innovation in India and worldwide. While mechanisms such as green patents, eco-

trademarks, and technology transfer frameworks offer powerful incentives for the creation and dissemination of eco-friendly technologies, the system faces challenges from greenwashing, regulatory ambiguities, and barriers to widespread technology adoption. The effectiveness of green IPR relies on robust legal and regulatory frameworks, transparent and enforceable standards, comprehensive consumer education, and international cooperation to harmonize policies and access to technologies. While India's IPR regime and legislative initiatives offer significant support for green innovation, balancing intellectual property protection with accessibility and public welfare remains a key challenge. Coordinated action among policymakers, industry, and civil society, as well as ongoing policy evolution, are essential to ensure that green IPR continues to support both economic growth and meaningful contributions to environmental sustainability.

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