GREEN INNOVATION AND PATENT LAW: BALANCING INTELLECTUAL PROPERTY RIGHTS WITH THE GLOBAL CLIMATE CRISIS

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ABSTRACT

The growing threat of climate change has made technological innovation an essential component of global environmental governance. The development and dissemination of renewable energy systems, energy-efficient technologies, sustainable transportation, carbon capture mechanisms and other climate-related innovations are necessary for achieving meaningful decarbonisation. Patent law plays an important role in this process by granting inventors exclusive rights that may encourage investment in research, development and commercialisation. However, the same exclusivity may also restrict access to essential technologies, increase licensing costs and create obstacles to the wider distribution of environmentally beneficial inventions, particularly in developing countries. This article examines the relationship between green innovation and patent protection, focusing on the tension between encouraging technological development and ensuring equitable access to climate-related technologies. It analyses the double externality problem associated with green innovation and considers the limitations of relying exclusively on patent protection to address environmental challenges. The article further evaluates India's patent framework under the Patents Act, 1970, including its public-interest safeguards, compulsory licensing provisions and working requirements. A comparative examination of the United States and the European Union is undertaken to identify institutional approaches that connect patent administration with technological development and climate objectives. The article also considers international technology-transfer mechanisms, patent pools and voluntary licensing arrangements. It argues that the effective use of patent law for climate action requires a balanced framework combining appropriate intellectual property protection, public-interest safeguards, financial support, institutional coordination and accessible technology-transfer mechanisms. It concludes that patents should operate as part of a broader climate innovation strategy rather than as isolated instruments of

technological development.

Keywords: Green Innovation, Patent Law, Climate Change, Intellectual Property Rights, Technology Transfer, Compulsory Licensing.

I. Introduction

Climate change has transformed technological innovation from a matter of economic and industrial advancement into an essential component of global environmental policy. The increasing need to reduce greenhouse gas emissions has placed considerable importance on the development of technologies capable of supporting a transition towards sustainable production, energy generation and transportation. Renewable energy systems, energy-efficient industrial processes, electric mobility, carbon capture technologies and other environmentally beneficial inventions are increasingly recognised as important instruments for addressing the climate crisis. The effectiveness of international climate commitments, including those undertaken under the Paris Agreement, depends considerably upon the development, availability and practical application of such technologies.[1] Within this context, patent law occupies an important position. A patent grants an inventor an exclusive right over a qualifying invention for a limited period, subject to the requirements prescribed by law. This exclusivity is intended to encourage innovation by enabling inventors and businesses to obtain commercial benefits from their research and development activities. In technologically demanding sectors, where research involves substantial expenditure, uncertainty and lengthy commercialisation periods, patent protection may provide the legal security required to attract investment.[2] Green technologies frequently involve such conditions because their development may require specialised equipment, advanced research facilities, technical expertise and significant financial resources.

India provides an important context for examining this relationship. Its patent framework has historically sought to balance the protection of intellectual property with public interest, technological self-reliance and access to essential products. The Patents Act, 1970 reflects this developmental orientation through provisions dealing with patentability, the working of patents, compulsory licensing and the prevention of abuse of exclusive rights. Subsequent amendments, particularly those introduced to bring Indian patent law into conformity with the

[1] Paris Agreement art. 10, Dec. 12, 2015, T.I.A.S. No. 16-1104.
[2] David Popp, Patents, Citations, and Innovations in the Energy Sector, 35 J. Env't Econ. & Mgmt. 455, 455-76 (2006).

Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), have further shaped the country's patent framework. However, the existing framework does not establish a comprehensive climate-specific patent policy. Consequently, the relationship between patent administration and the country's environmental and industrial objectives requires closer examination. This article analyses the role of patent law in encouraging green innovation while safeguarding access to environmentally significant technologies. It examines the theoretical foundations of green innovation, the relationship between intellectual property protection and technological diffusion, India's access-oriented patent framework, and selected comparative approaches adopted in the United States and the European Union. It also considers the relevance of compulsory licensing, patent pools, open licensing and international technology transfer. The central argument is that neither the unrestricted expansion of patent rights nor the general weakening of patent protection offers a complete solution. A more effective approach requires patent law to operate alongside environmental regulation, public funding, procurement policies, institutional cooperation and technology-transfer arrangements.

II. Green Innovation and the Theoretical Foundations of Patent Protection

2.1 Understanding Green Innovation

Green innovation refers to the development and application of products, processes and technologies that contribute to environmental protection, resource efficiency and the reduction of environmental harm. It includes innovations that improve the generation and distribution of renewable energy, reduce industrial emissions, promote energy conservation, improve transportation systems and support more sustainable methods of production. Unlike conventional commercial innovations, green technologies have a broader social significance because their benefits are not confined to the individuals or enterprises that develop or use them. The development of environmentally beneficial technologies is influenced by several factors. Research institutions, universities, private enterprises, government agencies, financial institutions and industrial organisations all contribute to the innovation process. An invention may begin as a research project, develop into a technically workable product, undergo testing and demonstration, and eventually reach commercial production. Its successful adoption may then depend upon infrastructure, financing, regulatory approvals, manufacturing capacity and market demand.

2.2 The Double Externality Problem

The traditional economic justification for patent protection is closely connected with the problem of knowledge spillovers. Technological information can be used by more than one person and may be reproduced or applied by others without necessarily depriving the original inventor of its use. As a result, inventors may be unable to obtain the full economic benefit of the knowledge they create. This possibility can discourage private investment in research and development because the financial returns may not adequately reflect the resources invested in producing the invention. Kenneth Arrow's analysis of the economics of invention explains the difficulty of securing adequate private investment in the creation of knowledge when information is difficult to appropriate. Patent law attempts to address this problem by granting temporary exclusive rights to qualifying inventions. A reduction in emissions, for instance, may improve air quality, reduce environmental damage and contribute to the mitigation of climate change. These benefits are not necessarily reflected in the price paid to the inventor or manufacturer. The social value of the technology may therefore be significantly greater than the private financial return available to the enterprise that develops it.[3] An effective framework must therefore combine intellectual property protection with measures such as emissions standards, carbon pricing, renewable energy requirements, public procurement and research subsidies. Patent law can encourage the supply of new technologies, while environmental regulation and economic policy can create the conditions necessary for their adoption.[4]

2.3 The Debate Between Patent Protection and Wider Access

The role of patents in green innovation has generated two broad perspectives. One perspective question whether exclusive rights are appropriate for technologies whose environmental benefits are of general public importance. According to this view, patent monopolies may delay the dissemination of important inventions, increase licensing costs and prevent smaller enterprises from entering the market. Where a particular technology depends upon several complementary inventions, different patent owners may control separate components of the same technological system. Negotiating licences with multiple owners can increase transaction costs and create uncertainty for businesses seeking to develop or manufacture products. This

[3] William D. Nordhaus, To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming, 1 Rev. Env't Econ. & Pol'y 26 (2007).
[4] Id.; see also Mariana Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* 15-20 (2013).

problem is commonly associated with patent thickets. When overlapping patents cover different elements of a technological field, an enterprise may need to obtain several permissions before it can commercialise a product. Such arrangements may be particularly difficult for new innovators and smaller enterprises that lack the financial resources and negotiating capacity of large corporations. In the context of climate change, delays in technological adoption may have consequences beyond ordinary commercial competition because they can affect the speed at which emissions-reducing technologies become available.

2.4 The Innovation Pipeline: From Research to Commercial Application

The limitations of treating patent protection as an independent innovation incentive become clearer when the entire process of technological development is considered. Green technologies generally move through several stages, beginning with basic research and applied development, followed by demonstration, commercial scaling, infrastructure integration and wider diffusion. Each stage involves different financial and institutional requirements. Initial research may depend upon universities, public research institutions and government-funded scientific programmes. As the invention develops, private investors and specialised enterprises may become involved. Commercial production may then require manufacturing facilities, supply-chain arrangements, regulatory permissions and long-term purchasing commitments. Finally, the adoption of the technology may depend upon supporting infrastructure, including electricity grids, charging facilities, storage systems and distribution networks. Patent protection may support the earlier stages by providing a basis for securing investment and establishing licensing arrangements. However, it cannot independently provide the infrastructure or market demand necessary for large-scale implementation.

III. India's Patent Framework and Its Public-Interest Orientation

3.1 Historical Development of Patent Law in India

India's patent system has developed in response to the country's historical experience, economic priorities and international obligations. During the post-independence period, patent policy was closely associated with technological self-reliance and the need to prevent excessive dependence upon foreign patent holders. The Patents and Designs Act, 1911, inherited from the colonial period, was considered inadequate for addressing the developmental needs of an independent economy. The recommendations of the Ayyangar Committee played an important

role in shaping the Patents Act, 1970.[5] The 1970 Act adopted a framework that sought to encourage domestic industrial development and ensure that patent protection did not operate against public welfare. Its approach to pharmaceutical and agricultural chemical inventions was particularly significant. By permitting process protection while excluding certain product patents in these sectors, the legislation sought to encourage domestic manufacturing capabilities and improve access to essential products. This approach reflected the economic and social priorities of the period. India's international obligations subsequently influenced the structure of its patent regime. The TRIPS Agreement established minimum standards for intellectual property protection among World Trade Organization members. India introduced amendments to the Patents Act to bring its domestic law into conformity with these obligations, including the introduction of pharmaceutical product patent protection. The amendments did not, however, remove all public-interest safeguards. The Indian framework continues to contain provisions intended to prevent the abuse of patent rights and ensure that the patent system contributes to technological development and public welfare.[6] This historical development is important when considering green technologies. India's patent system was not designed specifically to address climate change. Nevertheless, its emphasis on public interest, domestic technological capacity and the prevention of abusive monopolies provides a legal foundation upon which climate-responsive policies may be developed.

3.2 Patentability of Green Technologies

Green technologies are not automatically entitled to patent protection merely because they contribute to environmental sustainability. Like other inventions, they must satisfy the statutory requirements under the Patents Act, 1970. Section 2(1)(j) defines an invention by reference to a new product or process involving an inventive step and capable of industrial application. Section 2(1)(ja) explains the meaning of an inventive step.[7] Accordingly, an environmentally beneficial invention must satisfy the ordinary requirements of novelty, inventive step and industrial applicability. Its environmental value may provide a strong policy reason for encouraging its development, but it does not replace the legal requirements for obtaining a patent. This distinction is important because a climate-related label should not become an alternative route for granting patents to inventions that do not satisfy the statutory standards.

[5] Justice N. Rajagopala Ayyangar, *Report on the Revision of the Patents Law* (1959).
[6] The Patents Act, 1970, No. 39 of 1970, INDIA CODE (1970), as amended by the Patents (Amendment) Act, 2005.
[7] Id. S.2(1)(j), 2(1)(ja).

The exclusions under Section 3 must also be considered where relevant. These exclusions identify subject matter that is not regarded as patentable under Indian law. Their application depends upon the nature of the claimed invention and the relevant statutory provisions. A green technology application must therefore be examined according to the same legal standards applicable to other inventions, while administrative policies may separately recognise its environmental significance for purposes such as classification, information management or procedural prioritisation.

3.3 The Relevance of Section 3(d) and the Novartis Decision

Section 3(d) of the Patents Act, 1970 is an important example of India's attempt to prevent the extension of patent protection through certain forms of incremental innovation that do not satisfy the statutory requirement of enhanced efficacy. Although the provision is principally associated with pharmaceutical patent disputes, it reflects a broader legislative concern that patent rights should be granted in accordance with substantive standards rather than merely on the basis of minor modifications to existing inventions. The Supreme Court's decision in *Novartis AG v. Union of India*[8] provides an important illustration of this approach. The dispute concerned the patentability of a modified form of a known pharmaceutical substance and the application of Section 3(d). The Court examined the statutory requirement relating to enhanced efficacy and rejected the patent claim because the necessary standard had not been established. The decision is relevant to the broader discussion of green innovation because it demonstrates that the Indian patent system seeks to maintain a distinction between genuine technological advancement and modifications that do not satisfy the prescribed legal requirements. However, the pharmaceutical context should not be transferred mechanically to climate technologies. Green technologies frequently involve complex systems, complementary components, manufacturing processes and infrastructure requirements. The legal and economic circumstances of these technologies may differ considerably from those involved in the pharmaceutical sector. The significance of *Novartis* therefore lies in its illustration of India's public-interest-oriented approach to patentability, rather than in establishing a specific legal test for green inventions. Climate-related patent policy must preserve the statutory standards of patentability while recognising the distinct characteristics of environmental innovation.

[8] (2013) 6 SCC 1 (India).

3.4 Section 83 and the Objectives of the Patent System

Section 83 of the Patents Act, 1970 sets out general principles governing the working of patented inventions. It recognises that patents are granted to encourage inventions and ensure that inventions are worked in India on a commercial scale, without undue delay. It also states that patents should not be granted merely to enable patentees to enjoy a monopoly for importing the patented article.[9] The provision further recognises that patent rights should not impede the protection of public health and nutrition or operate against the public interest. It emphasises that patents should not be abused and that they should contribute to technological innovation and the transfer and dissemination of technology. These principles are relevant to green innovation because they connect patent protection with domestic technological development and the broader interests of society. Although Section 83 does not expressly identify climate change or decarbonisation as a separate statutory objective, its language provides a foundation for considering how patent rights contribute to technological development and public welfare. The policy challenge is to interpret and implement these principles in a manner that recognises the environmental significance of green technologies without departing from the statutory framework.

3.5 Compulsory Licensing under Section 84

Compulsory licensing is one of the principal safeguards through which Indian patent law seeks to balance exclusive rights with public interest. Section 84 permits an interested person to apply for a compulsory licence after the expiry of the prescribed period from the grant of a patent, subject to the statutory conditions. These include circumstances in which the reasonable requirements of the public have not been satisfied, the patented invention is not available at a reasonably affordable price, or the invention is not worked in the territory of India. The provision recognises that patent protection should not result in the indefinite exclusion of the public from access to patented inventions. It provides a legal mechanism through which a licence may be granted without the consent of the patent holder when the statutory requirements are fulfilled. The decision in *Natco Pharma Ltd. v. Bayer Corporation*[10] is an important illustration of the operation of compulsory licensing in India. The Controller of Patents granted a compulsory licence in relation to a patented pharmaceutical product after considering the statutory grounds under Section 84. The decision demonstrates the role of

[9] The Patents Act, 1970, No. 39 of 1970, S.83, INDIA CODE (1970).
[10] Compulsory License Application No. 1 of 2011 (Controller of Patents, Mar. 9, 2012)

compulsory licensing in addressing concerns relating to public requirements, affordability and the working of patented inventions. The relevance of this mechanism to green technologies requires careful consideration. Environmental technologies may be essential to climate mitigation, but their development and deployment often depend upon large investments, specialised manufacturing and supporting infrastructure. The assessment of reasonable public requirements and affordability may therefore involve considerations different from those arising in pharmaceutical disputes. A policy framework dealing with green technology licensing should take account of these sector-specific characteristics while preserving the statutory safeguards available under the Act.

3.6 Working Requirements and Section 146

The requirement that patented inventions be worked in India is another important element of the Indian patent framework. Section 146 empowers the Controller to require patentees and licensees to furnish information regarding the extent to which a patented invention has been commercially worked in India.[11] The provision supports transparency and enables the authorities to examine whether patent protection is contributing to domestic technological and industrial development. In the context of green technologies, however, the concept of working may raise complex practical questions. Some inventions require local manufacturing, while others may be implemented through licensing, technical collaboration, component supply or integration into larger infrastructure systems. The commercial application of a green invention may therefore involve several enterprises and locations rather than a single manufacturing facility. An excessively narrow understanding of working may fail to recognise legitimate forms of technological deployment. At the same time, treating mere importation as sufficient in every situation may weaken the broader statutory objective of encouraging domestic technological capacity. Clearer administrative guidance may help address these difficulties by recognising the different commercial structures through which green technologies are developed, licensed and deployed.

IV. International Patent Law and the Transfer of Green Technology

4.1 The TRIPS Agreement and the Balance Between Rights and Public Interest

The TRIPS Agreement establishes minimum standards for the protection and enforcement of intellectual property rights among World Trade Organization members. Its provisions have a

[11] The Patents Act, 1970, No. 39 of 1970, S. 146, INDIA CODE (1970).

significant influence on the regulation of patents, including those relating to environmentally beneficial technologies.[12] Article 7 identifies the objectives of intellectual property protection, including the promotion of technological innovation, the transfer and dissemination of technology, and the mutual advantage of producers and users of technological knowledge in a manner conducive to social and economic welfare. Article 8 recognises that members may adopt measures necessary to protect public health and nutrition and to promote the public interest in sectors of vital importance to their socioeconomic and technological development, subject to the requirements of the Agreement.[26] These provisions are important because they demonstrate that the international patent framework is not concerned exclusively with the protection of private rights. It also recognises the relationship between intellectual property, technological development and public welfare. Article 31 of TRIPS provides the conditions under which a member may permit the use of a patented invention without the authorisation of the right holder. Compulsory licensing under this provision is subject to procedural and substantive requirements, including conditions relating to remuneration and the circumstances in which such use may be authorised. Although the compulsory licensing mechanism has been widely discussed in connection with public health, its legal framework may also be relevant to discussions concerning access to environmentally important technologies. Its application must, however, comply with the conditions prescribed by TRIPS and the relevant domestic law. The existence of Article 31 does not mean that every climate-related invention may automatically be subjected to compulsory licensing. The statutory grounds and procedural requirements must be satisfied in each case.

4.2 The Patent Cooperation Treaty

The Patent Cooperation Treaty (PCT) establishes an international framework that enables applicants to seek patent protection in multiple jurisdictions through a coordinated filing procedure.[13] It facilitates the international patent application process and provides mechanisms for international search and preliminary examination. However, the PCT does not grant a single worldwide patent. The decision to grant patent protection remains with the national or regional patent offices in accordance with their applicable laws. The Treaty is therefore relevant to green innovation because it facilitates international filing and information exchange, but it does not independently ensure the transfer or affordability of patented environmental technologies. A

[12] TRIPS Agreement, supra note 5.
[13] Patent Cooperation Treaty, June 19, 1970, 28 U.S.T. 7645, 1160 U.N.T.S. 231.

more effective international approach requires coordination between patent filing mechanisms, technology-transfer programmes, research partnerships and financial support for developing countries.

4.3 WIPO Green and Technology Exchange

The World Intellectual Property Organization has developed WIPO Green as a platform intended to facilitate the exchange of sustainable technologies and connect technology providers with potential users.[14] The initiative supports the identification of environmentally beneficial technologies and provides a mechanism through which organisations may explore possible partnerships. WIPO Green is significant because it recognises that technological transfer involves more than the legal availability of a patent. Potential users may need access to technical information, business partners, licensing opportunities and institutional support before a technology can be adopted successfully. Nevertheless, a voluntary marketplace cannot by itself guarantee technology transfer. The participation of patent holders depends upon their willingness to make technologies available on mutually acceptable terms. Developing countries may also face financial and institutional barriers that prevent them from taking advantage of the opportunities offered through such platforms. Accordingly, WIPO Green should be viewed as a facilitating mechanism rather than a substitute for binding legal obligations, financial assistance or domestic capacity-building measures.

V. Challenges in the Protection and Dissemination of Green Technologies

5.1 Financial Barriers to Patent Protection

One of the major challenges facing green technology innovators is the cost associated with obtaining and maintaining patent protection. Patent applications may involve drafting expenses, professional fees, examination costs and maintenance fees. Where protection is sought in multiple jurisdictions, the overall financial burden may increase substantially. These costs can be particularly difficult for individual inventors, start-ups, universities and small enterprises. Large corporations may possess the resources necessary to maintain extensive patent portfolios, whereas smaller innovators may struggle to protect their inventions beyond their domestic markets. As a result, the distribution of patent ownership may become concentrated among enterprises that already possess significant financial and technological

[14] World Intellectual Property Organization, *WIPO Green: The Marketplace for Sustainable Technology* (2022).

advantages. Reducing unnecessary financial barriers and providing targeted support to smaller innovators may help create a more inclusive environment for green innovation. Government assistance could include subsidised filing fees, research grants and support for the commercial development of environmentally beneficial inventions.

5.2 Patent Thickets and Fragmented Ownership

The development of modern green technologies may involve several interdependent inventions. Different enterprises may hold patents over separate components, processes or improvements within the same technological field. Where these rights overlap, businesses seeking to commercialise a product may need to negotiate multiple licences. Such arrangements may increase transaction costs, create uncertainty and expose enterprises to the risk of patent infringement disputes. The problem may be especially difficult for new entrants that do not possess the legal and financial resources required to negotiate with several patent owners. Patent pools and standardised licensing arrangements may reduce some of these difficulties. However, their effectiveness depends upon the participation of relevant patent holders and the existence of fair and transparent licensing conditions.

5.3 Absence of a Uniform Definition of Green Patents

There is no universally accepted legal definition of a green patent that operates uniformly across all jurisdictions. Different patent offices and institutions may use different classification methods to identify environmentally relevant inventions. Some systems rely on patent classification codes, while others use administrative identification or applicant-based declarations. This lack of uniformity creates difficulties in comparing patenting trends and designing coordinated international policies. It may also create uncertainty for innovators seeking to access special administrative procedures or financial incentives connected with green technologies. The development of a consistent classification framework would assist patent offices, policymakers and research institutions in identifying inventions relevant to climate mitigation. Such a framework should, however, function as an administrative and information-management tool rather than as a substitute for the substantive requirements of patentability.

5.4 The North-South Divide in Green Technology Ownership

The concentration of technological research and patent ownership in technologically advanced

economies creates an important challenge for developing countries. Countries with limited research infrastructure and financial resources may find it difficult to participate meaningfully in the development of advanced green technologies. This disparity can result in a situation in which developing countries depend heavily on foreign technology providers. Access may then be influenced by licensing costs, commercial conditions, availability of technical expertise and the ability to establish international partnerships. The problem is particularly significant because developing countries may face substantial climate-related vulnerabilities while possessing comparatively limited capacity to develop and manufacture the technologies required for mitigation. The unequal distribution of technological capability therefore raises questions of environmental justice as well as economic development. Addressing this imbalance requires more than changes to patent law. International financial assistance, research cooperation, technical education, manufacturing partnerships and technology-transfer arrangements are also necessary to strengthen the capacity of developing countries.

5.5 Institutional Fragmentation in India

India's green innovation policy involves several government departments, regulatory institutions, research organisations and industrial programmes. Patent administration, environmental regulation, renewable energy development and industrial incentives may be administered through different institutional structures. Where these institutions operate without effective coordination, patent information may not adequately inform climate planning, and environmental priorities may not be reflected in patent administration. This fragmentation can create difficulties in moving inventions from public research institutions into commercial production. A more coordinated system would enable patent authorities, research institutions, climate agencies and industrial departments to share information and identify areas where technological development requires additional support. Such coordination would also help ensure that public research and industrial incentives contribute to a common climate innovation strategy.

VI. Reforming India's Patent Framework for Climate-Responsive Innovation

6.1 Developing a Green Patent Classification Framework

India could consider developing a structured classification mechanism for identifying patent applications relating to climate mitigation technologies. The classification should cover

relevant areas such as renewable energy, energy storage, energy efficiency, low-emission transportation and carbon capture. The purpose of such a mechanism would be to improve the identification and analysis of environmentally significant inventions. It could assist policymakers in understanding the distribution of green technology patents, identifying areas of domestic research strength and recognising sectors in which technological dependence remains high. The European Patent Office's Y02 and Y04S classification schemes provide a useful institutional reference. India may consider a comparable approach adapted to its domestic technological and industrial priorities. Such classification should not lower the statutory requirements of novelty, inventive step or industrial applicability. Its purpose should be to improve patent administration and policy planning.

6.2 Introducing Climate-Responsive Procedural Facilitation

A further reform would involve examining the possibility of providing procedural prioritisation for qualifying green technology applications. Climate-related inventions may be particularly important where their commercial application can contribute to the reduction of emissions or the development of essential environmental infrastructure. A carefully designed expedited examination mechanism may reduce procedural delays and provide innovators with greater certainty. Such a system should identify eligible technologies through transparent criteria and ensure that procedural priority does not compromise the quality of patent examination.

6.3 Linking Public Research with Commercialisation

India's universities, public laboratories and research institutions play an important role in developing technologies relevant to environmental sustainability. However, the transition from publicly funded research to commercial deployment may require clearer arrangements concerning ownership, licensing and collaboration with private enterprises. The Bayh-Dole framework in the United States offers a comparative reference for examining how publicly funded inventions may be transferred into commercial use. India could consider strengthening its institutional arrangements for the management and licensing of publicly funded green technology inventions. Such arrangements should preserve appropriate public-interest safeguards. Publicly funded research should not become inaccessible merely because it has been converted into patent-protected commercial property. Licensing conditions may therefore take account of public funding, environmental objectives, reasonable access and the need to encourage domestic manufacturing capabilities.

6.4 Strengthening Compulsory Licensing and Public-Interest Safeguards

Compulsory licensing should remain an important safeguard within the Indian patent framework. Where the statutory grounds are satisfied, it may provide a mechanism for addressing circumstances in which patented technologies are not made available in a manner consistent with public requirements, reasonable affordability or the working of the invention. However, the application of compulsory licensing to green technologies requires sector-sensitive assessment. The capital-intensive and infrastructure-dependent nature of many environmental technologies should be considered when evaluating whether a patented invention is being adequately worked or whether public requirements have been met.

6.5 Encouraging Patent Pools and Voluntary Licensing

The Government may encourage patent holders, research institutions and industrial enterprises to participate in voluntary licensing arrangements for environmentally significant technologies. Patent pools could be supported in sectors where the integration of multiple complementary inventions is necessary for commercial application. Government incentives may encourage participation by reducing certain financial or administrative barriers. Public research institutions may also contribute relevant patents to licensing arrangements where doing so is consistent with their institutional responsibilities and the terms of public funding. International institutions, including WIPO, may assist in developing standardised approaches to the governance of green technology patent pools. Such arrangements should ensure transparency, fair licensing conditions and appropriate safeguards against anti-competitive practices.

6.6 Providing Financial Support to Green Innovators

Financial assistance is necessary to enable a wider range of innovators to participate in green technology development. Government schemes may provide research grants, subsidised patent filing support and assistance with the commercialisation of inventions. Particular attention should be given to start-ups, small enterprises, individual inventors and public research institutions. These entities may possess valuable technological ideas but lack the financial resources required to protect and commercialise them.

6.7 Integrating Patent Policy with Climate and Industrial Policy

Patent administration should operate in coordination with India's environmental and industrial

objectives. The development of green technologies requires cooperation between patent authorities, climate-related departments, energy regulators, research institutions and industrial bodies. A coordinated framework could facilitate the exchange of information concerning patent applications, public research projects, technological requirements and commercialisation opportunities. It could also help identify areas in which domestic technological development requires additional investment. The broader objective should be to ensure that intellectual property policy contributes to the development of domestic technological capacity while supporting India's environmental commitments. Patent protection should not function independently of the policies that create demand for cleaner technologies and provide the infrastructure necessary for their adoption.

6.8 Strengthening International Technology Transfer and Capacity Building

India and other developing countries require effective participation in international arrangements for technology transfer. Such participation should include access to technical knowledge, research collaboration, manufacturing expertise and institutional training. International organisations may support capacity-building programmes for patent officials, researchers, legal practitioners and technology developers. These programmes could improve understanding of international patent procedures, licensing arrangements and the flexibilities available under TRIPS. Developed countries and major technology holders should also be encouraged to support meaningful technology-transfer arrangements. Such cooperation should move beyond general commitments and seek to establish practical mechanisms through which developing countries can acquire the technical and institutional capabilities necessary to implement green technologies.

VII. Conclusion

The relationship between green innovation and patent law presents one of the important challenges in contemporary intellectual property policy. The global climate crisis requires the development and widespread adoption of technologies capable of reducing emissions, improving energy efficiency and supporting sustainable industrial activity. Patent protection can contribute to this objective by encouraging research, attracting investment and facilitating the commercialisation of technological inventions. At the same time, exclusive rights may restrict access where licensing conditions, patent fragmentation and financial barriers prevent wider adoption. The double externality problem explains why conventional justifications for

patent protection are insufficient when applied to environmental innovation. Patents may help address the difficulty of securing returns from knowledge creation, but they cannot independently ensure that the environmental benefits of an invention are realised. Effective climate innovation therefore requires a combination of intellectual property protection, environmental regulation, financial incentives, public procurement and institutional coordination. India's patent framework provides an important foundation for maintaining a balance between private rights and public interest. The Patents Act, 1970 contains provisions dealing with patentability, working requirements and compulsory licensing that may contribute to the responsible use of patent rights. Decisions such as *Novartis AG v. Union of India* and the compulsory licensing proceedings in *Natco Pharma Ltd. v. Bayer Corporation* illustrate the importance of statutory standards and public-interest safeguards. However, these pharmaceutical decisions should not be mechanically applied to green technologies because the commercial and infrastructural characteristics of environmental inventions may be substantially different.

The future development of India's green patent framework should therefore focus on improving classification, procedural efficiency, research commercialisation, financial support and coordination between patent administration and climate policy. Compulsory licensing and other public-interest safeguards should remain available in accordance with the applicable statutory requirements. At the same time, policies should recognise the investment and infrastructure requirements associated with the development and deployment of climate technologies. Ultimately, patent law cannot resolve the climate crisis independently. Its contribution depends upon the manner in which exclusive rights are balanced with public welfare and integrated into wider environmental and industrial policies. A patent system that rewards genuine innovation while facilitating responsible access and technology transfer can become a meaningful instrument of sustainable development. The central objective should be to ensure that intellectual property protection supports not only the creation of green technologies but also their practical availability and effective use across countries and communities.