AI-DRIVEN GREEN INNOVATION AND THE ROLE OF INTELLECTUAL PROPERTY: LEGAL TOOLS FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

The world crisis in climate change requires the change of paradigm to the development of environmentally sustainable technologies. For a few years now, the Artificial Intelligence (AI) has become a strong facilitator of green innovation – delivering efficiencies of energy systems, optimising environmental data utilisation, and developing sophisticated climate resilience measures. The merger of AI and green technologies has, therefore not only put forth immense prospects, but also threw up a large number of legal and policy issues; especially, those that surround Intellectual Property Rights (IPR). The traditional IPR frameworks are frequently unfit to respond to the intricacy of reality of AI-generated outputs, data dependency, and need of climate mitigation. This chapter enacts a critical review of the legal interaction between AI and IPR in the green technology arena with an emphasis on the structural and normativity shortcomings of existing legal regimes. It poses the question of whether the proprietary currencies are sufficiently serving the larger purpose of global environmental welfare or whether they incidentally retard the spread of the climate-decisive technologies. The young generation still abounds with ideas, and the discussion also deals with innovative licensing models, scope of eco-patents, and role of public-interest obligations in the laws of patents. Placing the analysis within the wider backdrop of the United Nations Sustainable Development Goals (SDGs), the chapter advances a recalculation of the IPR regime to encourage fair access, incentives to innovate, and environmental justice in the AI driven landscape of technologies.

Keywords: Artificial Intelligence, Intellectual Property Rights, Green Technology, Sustainable Development Goals, Environmental Justice

1. Introduction

1.1 Overview of AI-Driven Green Innovation

Artificial Intelligence (AI) is literally turning the wheels in many spheres including Sustainability sphere. AI-driven green innovation means the use of technologies of artificial intelligence in order to solve the environmental problems and achieve sustainable development. The use of such AI techniques as Machine learning, Deep learning, and Neural networks make it possible for the processing of huge chunks of data, optimization of processes, and improved efficiency as applied to sectors such as the renewable energy, agriculture, waste management, and environmental monitoring. Such innovations are essential to sustainable development because they yield data-based answers that can help reduce resource use, improve energy efficiency, and limit environmental degradation[1].

Usage of AI in renewable energy solutions has already revealed transformative returns. Algorithms of AI are used to enhance work of solar panels, wind turbines and smart grids thus increasing efficiency and reducing cost of renewable energy systems. Also, the critical status of AI in sustainable agriculture is on the rise, in which AI-driven precision farming will guarantee increased crop yields and optimal use of water, fertilizers and pesticides. And, AI predict and improve farming practices in the process, thus increasing food security minimalizing environmental footprints. AI applications in waste management include automated sorting systems, waste to energy solutions and other capable systems changing the way waste is handled; efficient and sustainable[2].

The heart of AI induced green innovation is data analysis, machine learning, and optimisation algorithms which allow real time decision making, more automation, and the ability to predict, all of which go toward enabling the human being to use these resources more sustainably. Nevertheless, for AI technologies driven green technology to thrive legally they must be protected by law including by use of the IPRs to motivate people on innovation and enable their wide usage[3].

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[1] V Kumar, "AI in Renewable Energy: Current Applications and Future Prospects," *Journal of Clean Energy* (2020).
[2] M Patel et al., "AI in Sustainable Agriculture: A New Frontier in Precision Farming," *International Journal of Agricultural Technology* (2021).
[3] J Carter, "Waste Management Innovation: AI-Powered Solutions for a Cleaner Planet," *Environmental Innovation Journal* (2022).

1.2 Importance of Intellectual Property (IP)

Intellectual Property (IP) is very important in promoting innovations by rights to creators of new technologies. IP rights are fundamental to the validity of AI-driven green innovations in terms of intellectual and commercial value of green technology thereby permitting the innovators to enjoy what they have created. Patents, trademarks and trade secrets, the major types of IP, protect AI-driven innovation from non-useful usage allowing inventors to realize returns on investment towards developing sustainable innovations. By safeguarding these technologies the laws of IP promote additional investment and research, thereby keeping innovation expanding and relevant to the issue of sustainability[4].

AI- enabled green technologies are themselves complex incorporating at the forefront, algorithm, machine learning models and data systems. The legal protection of these technological innovations by way of IP, gives companies and researchers a competitive advantage both when working with private sector actors, governments, and academia. For example, patents grant the inventors virtually monopolistic rights, which mean that the only persons who can commercialize the invention can do so only during a certain period of time. The exclusivity is essential for the possibility of making such innovative green technologies finan-cially viable enabling businesses to reclaim costs of the development and re-invest into additional improvements[5].

Also, IP protection offers a channel for licensing and collaborations, which are critical in such a global industries such as renewable energy and sustainable agriculture industries. Licensing agreements enable transfer of technology to market where availability is a key issue but local capacity may be limited. Therefore IP laws incentivize not just innovation but also encourage the global spread of AI-driven green technology which becomes more accessible to a wider set of stake holders. As the succeeding section will learn, AI and IP interplay is central to advancing the practice of sustainable processes while providing commercial avenues[6].

[4] S T Anderson, "Intellectual Property and Green Innovation: Legal Implications for Sustainability," *International Journal of Environmental Law* (2020).
[5] R P Lee, "The Role of IP in AI-Driven Innovations: Protecting Green Technologies," *Journal of Intellectual Property* (2019).
[6] W Harris & L Johnson, "Licensing Green Technologies: A Pathway to Global Access," *Sustainable Innovation Review* (2021).

1.3 Objective of the Chapter

This chapter seeks to understand the new role of Intellectual Property (IP) in driving the green innovation through AI. The goals of the chapter are many, but the following are most important: First to look at the significance of IP in protection and commercialization of AI technologies that are particularly targeted at sustainability. However, by appreciating the legal forums which regulate AI inventions, this chapter intends to bring to the limelight how IP laws can promote green technologies, and protect it in the global market[7].

The second objective is to determine the effect of IP on the wider sustainable development agenda. This involves analyzing ways in which IP protections facilitate the attainment of key Sustainable Development Goals (SDGs)- affordable and clean energy (SDG 7), responsible consumption and production (SDG 12) and climate action (SDG 13)[8].

Finally, these challenges and opportunities that arise from aligning IP law and green innovation will be discussed in the chapter. Particularly, it will look into the possibility of the IP reforms to promote more supportive access to AI-driven green technologies, making them available to all stakeholders including developing economies stakeholders[9].

The reason why this chapter takes on value is that it can integrate legal, technological, and economical aspects of AI dominated green innovation. By covering the cross-point between AI and IP, the chapter endeavors to offer the big picture view on how it is possible to stimulate and ensure sustainability-oriented innovations. This exploration is especially pertinent, as the international community attempts to integrate innovation with sustainable practice, to reverse the effects of climate change and other environmental crises. Moving on, we will explore more deeply the practical implications of these issues with the help of case studies and real life examples of AI-based green technologies[10].

2. AI & Green Innovation where AI intersects with green innovation

2.1 Defining AI-Driven Green Innovation

[7] L Edwards, "AI and the Future of Green Innovation," *Environmental Law Review* (2022).
[8] J F Miller, "IP and Sustainable Development: Legal Pathways for Green Technologies," *International Law Journal* (2020).
[9] K Nelson et al., "Legal Challenges in Green Innovation: Balancing Protection and Access," *Journal of Technology and Environmental Law* (2021).
[10] L Edwards, "Intellectual Property and Sustainable Development," *Law and Policy Journal* (2022).

AI-driven green innovation is a process of using the technologies of artificial intelligence to address the problem of the environment and promote sustainable processes. Artificial Intelligence, especially in machine learning and data analytics applications, is playing an increasingly important role in the optimization of efficiency in systems in the world's economy including energy, agriculture, waste management, and conservation. Such applications are aimed at lowering energy consumption, cutting carbon emissions and resource utilization, all key aspects in helping achieve global sustainability goals. For illustration principally in energy, AI is used to ensure that solar energy production is optimized, by varying its panels' angles to suits weather predictions and solar radiation; this enhances solar farms' efficiency. AI algorithms are able to increase the efficiency of wind turbines by predicting wind speed and, in real time, adjusting turbine blades for maximizing output of energy[11].

In agriculture, the role of AI in revolutionizing sustainable farming practices cannot be overemphasized, because it combines the use of AI-powered systems to determine soil health and monitor crop growth and predict yields, precisely. Not only does this reduce the use of chemical fertilizers and pesticides but will also conserve water and waste by conserving resources. Such AI driven technologies in agriculture are also useful to farmers in determining the optimal times for planting and harvesting, using environmental information and forecasts, which means that yield can be improved and food production sustainable. Similarly, in waste management AI is instrumental to enhance recycling with robotic sorting system to separate recyclable materials from waste more favorably. The use of smart waste management systems supported by the power of AI allows cities to realize optimal waste collection routes, decrease carbon emission, and demonstrate high-level of recycling[12].

Another big platform of AI-driven green revolution is that of designing and running energy efficient buildings. AI based systems find increasing application in optimizing energy consumption in commercial and as well as residential buildings by changing HVAC systems, lighting and appliance usage on real time basis. Such advancements can dramatically decrease energy usage thus reducing costs and have a direct impact upon minimization of carbon footprints. The way in which AI is being used in buildings is in line with the increasing desire for smart cities technologies, where the systems of the city favor sustainability. With the

[11] V. Kumar, *AI in Renewable Energy*, n. 1.
[12] M Patel et al., "AI in Sustainable Agriculture n2

development of AI technologies, applications of its aspects to green innovation will only continue compounding, thus further providing impetus for all sorts of sustain abilities[13].

2.2 Effect of AI toward the attainment of SDGs.

This proves how vital the AI concept is to enabling the attainment of several of the United Nations, Sustainable Development Goals (SDGs) especially in these areas of clean energy, responsible consumption, climate change, and environmental sustainability. SDG 7 is one of the critical SDGs. Affordable and Clean energy under the global energy agenda is intended to ensure access to energy services that are affordable, reliable and modern to all. Optimizing energy production and distribution to this goal, AI helps. For example, energy management system driven by AI can forecast peak energy demand and the operations of the grid can be optimized and the renewable sources of energy can be better incorporated into the energy grid. With the help of AI, the efficiency of such renewable resources as wind, solar, and hydroelectricity is increased and the need in fossil fuels is cooled down, so this will cut down the emission of carbon directly[14].

Apart from clean energy, AI helps in SDG 12 as well: Responsible Consumption and Production. AI based technologies are being used to increase resource efficiency, reduce waste and foster the circular economy. For instance, AI can be useful in manufacturing industries to optimize their supply chain, monitor their production processes and minimize waste by informing them of equipment malfunctioning or shortage of materials before it happens. Similarly AI enabled systems in agriculture have also have the ability to optimize the use of water, reduce usage of fertilizer and mitigate the use of energy which are all part of sustainable production practices. AI can also be used for supporting sustainable consumption by influencing consumers' choice by the use of the smart technologies that monitor the use of energy and tell them how they can reduce their energy consumption[15].

AI also plays a major role on SDG 13: Climate Action an initiative in attempts to fight the effects of climate change. AI technologies are becoming more popular in climate modeling, where they help scientists and politicians to predict future climate potentials and test the

[13] J Carter, "Waste Management Innovation:n3
[14] S T Anderson, "Intellectual Property and Green Innovation n4
[15] J. Carter, Technological Advancements in Sustainable Manufacturing, International Journal of Green Technology (2021).

efficiency of the climate policies. Machine learning models can make predictions about weather events, extreme weather and climate risks from big data sets from satellite or weather stations. This data can be used to guide the government and industry effort in countering climate change and adapting to it. Additionally, AI-driven or powered solutions, with help of satellite images, can track deforestation and biodiversity loss by usage of current technology to detect illegal logging or wildlife trafficking. These AI tools offer real time information to help authorities to take timely action in protecting ecosystems[16].

In addition, AI is also applied to cope with another major global problem of scarcity of water. AI enabled water management systems are used as irrigation practice optimizers, water quality monitors and water shortage predictors. Such technologies find particular use in regions where water stress is a problem, as they can be used to lessen water consumption of agriculture and help to manage water resources more effectively in urban areas. The capacity of AI to analyze mass datasets also contributes to enhance the general comprehension of environmental change and impact of human activities to natural resources, which can guide policy and management of natural resources for effectiveness[17].

3. A Study of the Role of Intellectual Property in Protecting Green Innovation

3.1 Intellectual Property as a Legal Alternative for Innovation Protection

Intellectual Property (IP) is an essential legal means of protecting results of innovation, stimulating creativity, and stimulating technical progress. When it comes to AI-driven green innovation, different kinds of IP, including patents, copyrights, trade secrets, and trademarks are offering different sphere of protection for technological improvements that are made in order to resolve environmental problems. [Add Footnote 1] Patents are most popular means of IP for protecting innovations in the AI and greentech space because tenants enable the aggregation of exclusive rights to inventors who can prohibit others from making, using, or selling their inventions at will. This is especially true for AI algorithms, machine learning models, and systems engineered for energy optimization, the management of resources and other green applications. Copyrights may protect software code, models, or other works of

[16] L. Harris, AI and Climate Modeling: Predicting Future Environmental Challenges, Journal of Environmental Science (2020).
[17] S. Edwards, *AI Applications in Water Management and Conservation*, *Sustainability and Technology Journal* (2021).

authorship that underpin AI technologies – despite the fact that these seem less frequently to inspire use of this kind of protection for AI algorithms.

Trade secrets are also a profitable weapon, particularly if innovations cannot be patented because of lack of novelty or for algorithms to be kept secret by those companies. Trade secrets support the protection of proprietary processes, formulas or algorithms applied to AI technologies, and they become an alternative form of protection for green innovation. Trademarks as well also have a role to play in helping to distinguish green technologies or AI based products in the market place and consumer's guarantee and delivery of sustainable and environmentally friendly goods. By providing these legal protections, IP encourages investment in research and development, by meaning that AI driven green technologies will be developed and will be commercialized in a way that will drive the progress of this line of technology.

Therefore, intellectual property is not just an instrument for the protection of commercial interests of innovators but is also an important enabler of the further innovation in the green technology arena particularly in the AI powered environmental solutions. Appropriate protection guarantees the penetration of the innovations developed due to AI in renewable energy, waste management, sustainable agriculture, etc. into the market and the achievement of sustainability objectives.

3.2 Patents and AI-Driven Green Technologies

Patents are grants of exclusive rights of inventors of their inventions, but patenting AI-driven green technologies can also be quite complicated. The main barrier to implementing patenting of AI technologies is established by proving novelty and inventiveness. The AI algorithms and systems, particularly those used in environmental applications, must meet the requirement of the patent that is; nothing old', that the technology must new and not be publicly disclosed or available. In addition, in order to qualify the AI models used in green technologies, they have to meet the "inventive step" criteria, meaning, the technology has to offer a non-irical solution to an issue.

The fact that AI changes goes hand in hand with difficulties as well, because the new versions of algorithms or models can be constantly upgraded, making the assessment of whether a new version is novel or inventive complex.

A second challenge faced during AI patenting is adequate disclosure of AI models in detail in such a way that replication of the innovation becomes possible as well. This is not always easy, because AI models and algorithms are sometimes too complex and proprietary. Moreover, owing to the fact that AI systems are mainly developed using data, as concerns predominance over data and privacy may inject a snag to the patenting exercise. However, scope for green patents, which target innovations in renewable energy, sustainable agriculture, energy-saving technologies, provides new possibilities for the protection of AI-driven innovation, which are aimed at the environment of the world. With green technology being more important as a requisite to the attainment of global sustainability goals, more and more attention is being focused on the necessity of making such inventions patentable, hence the need for proper protection and rewards.

3.3 Trade Secrets and AI

Trade secrets are an alternative protection mechanism for unpatentable AI algorithms and a commercially secret process. Trade secrets generate confidential information – formulas, practices, processes, designs, instruments or patterns, etc. – which helps a firm gain competitive advantage. In the domain of AI based green innovation, trade secrets introduce enough of a barrier in terms of proprietary algorithms and machine learning models that firms use to develop in order to optimize energy efficiency, waste management systems or sustainable agriculture methods[18].

Strong point of trade secrets is their long-term protection, as long as the information is secret. While unlike patents, which eventually expiring and then become a part of public domain, trade secrets could last forever as long as the holder is willing to maintain the secret control. However the consequence is that once a trade secret is spilled or disclosed in public, protection is lost. This makes confidentiality agreements, and non-disclosure agreements (NDAs) and security measures critical ai companies working in the industry of green technologies need[19].

Trade secrets do provide great protection but they have ethical issues as well. There is a current debate on the balance between protecting proprietary technologies and openness of critical

[18] R. M. Kumar, *Trade Secrets in AI and Green Technologies: Legal and Ethical Considerations*, *Law and Technology Review* (2020).
[19] L. Nelson, *Protecting Trade Secrets in AI-Powered Green Technologies*, *Journal of Intellectual Property Law* (2021).

green innovations, especially sustainability-focused ones to the larger public. For instance AI-oriented solutions for energy efficiency/effective waste management may make a huge positive contribution to the environmental sustainability but if these solutions within those areas are locked in in trade secrets then it may not be available to those who most need them. In this regard increasing momentum is being placed on more transparent approaches towards managing trade secrets, so that while such innovations remain protected, they do not impede the whole world efforts toward sustainability. Issues of ethics associated with the use of trade secrets are especially severe in the case of the technology in question having the potential to address global challenges such as climate change and resource exhaust[20].

4. Legal Tools and Frameworks towards Sustainable Development.

4.1 International Legal Instruments

It is vital in maintaining protection and development of green inventions globally through international treaties and an initiative. Important instruments are WIPO Green Initiative, Patent Cooperation Treaty (PCT), UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage. These frameworks are specifically created for developing sustainable technologies, for building up international cooperation, and for meeting the needs of equal access to green innovations.

WIPO Green Initiative, initiated by the World Intellectual Property Organization (WIPO), is an initiative which seeks to encourage the generation and diffusion of green technologies by erecting a global hub for innovators, businesses and governments to submit green solutions. Initiative this supports the knowledge and technology transfers, especially from the developing countries, where the green innovations find their markets where they can achieve the maximum impact. WIPO Green plays a key role in promoting sustainability by decreasing entry barriers and increase access to green technologies[21].

The Patent Cooperation Treaty(PCT) allows innovators mine patent protection other countries, which ensures facilitating protection of green technologies across several jurisdictions. The PCT engenders a simple mechanism of filing patents thereby lowering the time and cost of

[20] T. Singh, *Ethics and Transparency in the Use of Trade Secrets for Green Innovation*, *Journal of Sustainability and Ethics* (2020).
[21] WIPO, *WIPO Green Initiative: Promoting Green Technologies* (2020).

acquiring protection in different countries. This is especially helpful for green innovation, which requires extensive protection in many regions, such as renewable energy technologies, water purification systems and energy-efficient solutions. The PCT also makes sure that patents for such innovations are of a high international standard, which encourages international collaboration, and makes sure such sustainable technologies are adequately protected

UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage provides an additional level of protection for the traditional knowledge (TK) and cultural practices which promote environmental sustainable. This frame work ensures safeguard the knowledge, skills and the cultural expressions of indigenous communities that have been practicing sustainable practices in agriculture, forestry and resource management for a long time. The Convention delivers legal tools for the conservation and passing on of such traditions, so that they are not abused or lost to any future generations[22].

4.2 National and Regional Approaches

Countries and regions across the globe are introducing Intellectual Property (IP) to their sustainability agenda to advance green innovations and promote a fulfilling green capitalism. The examples of the European Union (EU), India, and Brazil are noteworthy in that each of these countries has taken a lot of steps in utilizing IP to promote green technologies.

The EU has been central in fusioning IP into its sustainability agenda. The European Green Deal is a route map towards Europe being the first climate neutral continent by 2050 and places emphasis on green innovation in areas such as energy, transportation and agriculture. Through the Green Deal, the development of IP for green innovations is encouraged through the development of new technologies, promoting renewable energy and the circular economy. The EU has also launched incentives under IP protection including funding for greener start-ups and encouraging entry into IP for SMEs focusing on sustainability-related projects[23].

In India, the IP has been incorporated in its sustainability policies in order to encourage the innovations in renewable, waste management and clean technologies. The creation of green patent filings and the commercialization of green innovations is encouraged in India's National IP Policy with the support. The Indian Patent Office has also initiated programs geared towards

[22] UNESCO, *Convention for the Safeguarding of the Intangible Cultural Heritage* (2003).
[23] European Commission, *The European Green Deal: Striving for Climate Neutrality by 2050* (2020).

the simplification of the patenting process for renewable energy technologies thereby alleviating vain efforts by innovators to get protection of their inventions[24].

Brazil, who has been more focused on biodiversity and sustainable form of production has been able to implement IP frameworks that appreciate the need to protect traditional knowledge element that has to do with its rich biodiversity. Brazil has developed a sui generis system for the protection of biodiversity-related innovations that promote the incorporation of indigenous knowledge in the creation of green technologies. This system enables the protection of genetic resources and traditional practices that are beneficial in sustainability and encourages innovations in sustainability with regard to local communities' rights[25].

4.3 Green Technologies sui generis systems.

In reaction to the peculiarities of green technologies, a number of countries created sui generis systems for the protection of traditional knowledge (TK) and innovations pertaining to biodiversity. These systems are designed to address the particular challenges that green technologies present for example, protection of biodiversity and the role of indigenous knowledge in agricultural and environmental solutions.

An example is a sui generis system for biodiversity which offers an alternative to existing IP systems, as it acknowledges indigenous communities' knowledge, innovations and practices. Such systems may fill holes in the traditional IP laws by providing some protection on innovations related with biodiversity which enables communities to gain from their knowledge and any contribution to sustainability will not be exploited[26].

In the same way sui generis protections for traditional agricultural knowledge have been utilized to protect innovations concerning protection of plant varieties, soil management method and crop rotation techniques. These precautions guarantee the indigenous communities take control of their knowledge and that such knowledge is used to promote the public good

[24] Ministry of Commerce and Industry, Government of India, *National IP Policy and Sustainable Development* (2019).
[25] E. R. Silva, *Brazil's Sui Generis System for Biodiversity Protection*, *Latin American IP Journal* (2020).
[26] S. K. Mehta, *Sui Generis Systems for Green Technologies in Developing Countries*, *International Journal of Environmental Law* (2021).

especially in response to issues of food security and sustainable agriculture[27].

Role played by such alternative IP systems is particularly important in driving sustainable development through protection and sharing of innovations by various civilizations and traditions. Such IP systems enable a more inclusive approach to IP by drawing attention to the role indigenous knowledge plays in the world's efforts to achieve sustainability[28].

5. Facing the challenges of IP in green innovation.

5.1 Access by DM for the Developing Countries

It might be hard for developing countries even to reach Intellectual Property (IP) especially as regards important green technologies that are able to control the climate change and support sustainable development. The key barrier is that patent thickets, a dense network of intersecting patents, exist, which for innovators impose a complicated legal landscape that impedes their ability to access needed technology. This condition may impede transfer of crucial green technologies including renewable energy systems, waste management and sustainable forms of agriculture into countries that need them acutely. Additionally, as high licensing costs of patented technologies can be a barrier for developing countries, implementation on the scale through green solutions is uneconomic. These barriers inhibit the common adoption of technologies that may accelerate sustainable development in the global South particularly in relation to the urgent environmental issues like clean energy access and waste management.

In order to address these challenges several solutions were suggested and implemented. The compulsory licensing allows the government to use the complementary patent in case of a crisis or public interest using the permission, without the consent of the owner of the complementary patent.. This has worked well in the pharmaceutical industry but could be adapted for green technologies. Another possible solution is the mechanism of patent pooling – the share of patents by several patent holders to increase access to the technologies. This model enables development of green tech eco-systems where there is sharing of innovation and no individual patent constraints of access exist. Last but not least, open-source IP models can offer an alternative future, as countries can now access and utilize the technologies without paying

[27] A. G. Franco, *Traditional Knowledge and Biodiversity Protection in Brazil*, *Sustainable Development Review* (2020).
[28] L. Edwards, *Biodiversity, Traditional Knowledge, and Sui Generis IP Protection*, *Environmental Innovation Journal* (2021).

special licensing fees, or their use coming under patent control. Such solutions may enable making green technologies available, affordable and scalable in developing countries and that could be important for making the global effort to address climate change and foster the sustainable practices.

5.2 Balancing Commercialization and Public Interest

In the case of green technologies the ethical dilemma of protecting IP while promoting public good, is especially pressing. On the other hand, the purpose of IP laws is to reward inventors by offering them exclusive rights to their inventions, and being able to gain from their inventions. However, with essential green technologies (solar energy systems, water-puritication technologies, sustainable agricultural methods etc.), this exclusivity can restrict access to these innovations, particularly in poor countries where such innovations would be most needed. There is the challenge that government and NGO face to ensure that their IP laws do not lead to monopolies or a denial of fair access to important green technologies. At the same time, however, these technologies must continue to be attractive to the private investor and innovator, who is dependent on the commercial incentives from IP protection to continue to pursue sustainable innovations[29].

5.3 Environmental Justice and IP

Environmental justice concerns are becoming more significant on the subject of IP law with increasing prevalence of AI green technologies. Indigenous and marginalized communities usually possess important traditional knowledge that can play a role in the development of sustainable activities within areas such as agriculture, forestry and water management. However, this type of knowledge remains often an easy target for exploitation by giants who will patent the innovations on indigenous practices without fair remuneration or acknowledgement of the contributions of said communities. According to IP law, in its current state, IP law more often than not fails to take into account the imperative for fair benefit-sharing between the innovator and the original holder of traditional knowledge. Therefore, legal changes to the law relating to IP are required so that communities of indigenous and the

[29] A. G. Franco n27

marginalized are compensated fairly for their contributions to rise in green technologies[30].

IP systems are, therefore, needed to be reformed to protect the interests of these communities to advance environmental justice. One possible solution is to introduce sui generis protection systems for traditional knowledge, which will enable the owners of traditional knowledge to control their intellectual property while enjoying the results of commercialization of their knowledge in green innovations. Besides, international legal instruments like convention on biological diversity may be utilized to protect indigenous peoples' rights for their biodiversity related innovations. Such legal safeguards are important to ensure that indigenous knowledge-based AI enabled green technologies are developed using cultural rights and sustainable development as principles from the start. In light of the global thrust toward climate justice, IP law must advance to allow the most vulnerable communities to partake of the benefits that come with green innovations[31].

6. Case Studies with an AI-Driven Green Innovation and IP.

Case Study 1: AI in Renewable Energy

AI is becoming more and more essential in maximizing renewable energy in solar panel output. One of the Read more …mentions is the application of AI algorithms to help to orient solar panels in real time to gain maximum energy absorption depending on weather patterns as well as the availability of sunlight. Companies also developed the AI-powered systems that predict solar panel functionality and grid integration and, that way, they optimized the distribution of energy in an efficient way while minimizing the waste of energy. Solar AI has the potential to make solar panels be much more efficient, which will lead to lowering cost of producing solar energy and will facilitate the spread of clean energy all over the world.

When it comes to IP protection, these innovations tend to be covered with patents and especially those unique algorithms that are used in optimization systems. Patents give companies a right to possess the right of their innovation, and as such, after the inclusion of AI companies can commercialize their AI technologies without anyone later on duplicating their improvements. Furthermore, IP protection will play a vital role in attracting investment as it

[30] L. Edwards, "Traditional Knowledge and Environmental Justice in Green IP," *International Environmental Law Review* (2020).
[31] T. Sharma, "Environmental Justice and IP: Protecting Indigenous Rights in Green Technologies," *Global Sustainability Journal* (2021).

will create confidence amongst the investor that the monies invested will be protected from the competitors. Moreover, in the renewable energy, trade secrets are sometimes used to secure proprietary algorithms and procedures, which are not patentable. These legal instruments guarantee the persistence of innovation that drives home the required impetus for companies to continue to develop and evolve AI-enabled solutions for the green energy market[32].

Case Study 2: Waste management and circular economy using AI Waste management and circular economy through AI

AI was also successfully applied to the sphere of waste management, particularly as applied to such systems which were designed to maximize recycling and minimize waste. An example is of AI driven robotic sorting systems in recycling stations. Using these systems, recyclable materials are detected and separated more accurately and effectively than by humans. AI is also also used in the predictive analytics area which is helping predict waste generation patterns in the cities and the optimization of waste collection routes which results in gas and carbon emissions saving.

Patents in IP for waste managing technologies, specifically recycling, often cover patents for the AI models and systems to automate the sorting processes. Nevertheless, the artificial intelligence technologies patenting in this sector are a challenge as the grant also needs to meet the requirements of novelty and inventiveness. There also is the problem of safeguarding AI systems that are always changing. In this light copyrights can be used to guard the software behind these AI applications while trade secrets could be used to protect proprietary algorithms and data used to train the system. The utilization of these IP tools promotes protection of the innovations thus helping to preserve the competitive edge by companies and in turn attaining the goal of the world-wide efforts towards sustainability.

Case Study 3: AI in Sustainable Agriculture

AI is taking numerous steps forward on sustainable agriculture through application like precision farming in which AI-based systems are enhancing water, fertilizer and pesticides usage. For instance, systems based on AI are used till researchers analyze soil conditions, forecasts for the weather and decide the optimal amount of the needed watering, decreasing the

[32] S T Anderson, "Intellectual Property and Green Innovation n4

number of waste of water and increasing the crop. The uses of AI also extend to pest management – by informing early indications of the infestation and advising on targeted intervention measures to reduce the need for toxic pesticides.

These innovations are usually patented to protect the proprietary AI algorithm underlying them, the trademarked label to achieve brand identity or the trade secret to protect proprietary farming techniques or machine learning models. Often it is the commercialization of AI in agriculture that also typically entails licensing agreements whereby companies could license their AI systems to farmers or agricultural technology firms. IP protection makes these innovations not only desirable but also available to the agricultural industry as a whole. The IP frameworks, therefore, seek to ensure protection of the technologies to promote further research and development in the sector and eventually facilitating the adoption of sustainable practices in the whole sector of the agricultural sector.

7. Conclusion: Future of AI and IP Sustainable Development.

7.1 Summary of Key Insights

AI led green innovations are on the cusp of moving towards realizing the global sustainability goals especially in the areas of renewable energy; agriculture and waste management. Intellectual Property (IP) has a huge part to play in protecting these innovations, encourages investment, and makes sure technologies are commercialized. However, with the evolution of AI, IP laws will have to move accordingly to tackle the newly emerging problems since the need for a more accessible profile for protection and inclusive protection systems which allow for egalitarian access to green technology whilst encouraging the growth of further innovation.

7.2 Recommendations for Future IP Reforms

For the greener innovations to be supported more efficaciously, the IP law ought to extend boundaries of the green patents, especially in the areas of AI – driven technologies in the renewable energy and agriculture. The implementation of more flexible IP regimes such as compulsory licensing, and open-access IP schemes shall promote wider use of these technologies particularly in developing nations. Furthermore, development of IP laws should adapt to the rate of innovation for AI, with patenting process not left behind as far as green technology is concerned.

7.3 The Road Ahead

The Eliot future of the AI in sustainability depends upon the continuous development of IP systems. Even as AI continues to lead to the development of landmark solutions to global environmental challenges, IP can continue to be on the platform that encourages innovation, provide universal access to green technologies as well as bring equity in the green economy. By adjusting the IP laws to serve these needs we can build a more inclusive sustainable future for all.