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Green Technology for Sustainable Pollution Reduction: Insights from Coimbatore's Industrial Sector

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ABSTRACT

This study examines the use of green technology, as well as what it may contribute to, the industrial sector of Coimbatore, Tamil Nadu, India. This research is both quantitative (150 surveyed organizations) and qualitative (interviews with industry executives and officials).The green technologies claims appear to be up to a 33.33% improvement on emissions, waste and resource use on all major environmental indicators, says the claim summary. Regression analysis, however, provides strong evidence of correlation of green tech adoption with pollution mitigation. The determination by which is particularly presented by huge scale business and the high implementation cost. It ponders innovative proposals such as waste-to-energy and water recycling situated within a large current deficit within the scientific literature on sustainable pursuits brought to bear on manufacturing industry, directing manufacturing policy makers and industry stakeholders toward achieving environmental and economic sustainability.

***Keywords**: Emissions, Green Technology, Pollution Mitigation, Manufacturing Sector, Sustainable Practices.*

Introduction

Reduction of pollution and promotion of sustainable development are processes that cannot be discontinued without green technology. Starting with climate change, water and air pollution, resource depletion… the list of worsening environmental problems needing inventive and sustainable solutions really does not end. The industrialization and urbanization are over, the green technology solutions exist and they are using the use of natural energy resources, also they have better strategies of the treatment of waste from all of the production sources. From solar energy, wind energy, electric vehicles, and more we are seeing the recent examples of successful green technology helping mitigate greenhouse gas emissions and the sustainable use of natural resources. Sustainable agriculture is one such advanced technology, and so too are carbon capture and storage (CCS) and bioengineering, which comprise new ways to mitigate pollution. Mori et al. (2023) state these challenges suppress the use of green technology as the (i) low initial costs, (ii) lack of adequate infrastructure, and (iii) traditional companies unwilling of change. Meanwhile governments, businesses and universities around the world are increasingly coming together to front up to these problems and move quickly to a greener future. Green technology is not included in the plans to combat pollution due to its economic challenges, regulations, and social barriers. So we all need to do our bit to tackle these tough problems, such as building the public understanding, creating policies and making sure sustainable solutions are available to all. Innovation, Government assistance and community involvement are a few indispensable elements which need to work together to achieve successful uptake of green technology (Sharma and Verma, 2023).

In a different vein, digital technology in terms of efficiency and scalability brings us closer to the green movement (Lee et al., 2022) which results in green cars, IoT, blockchain and artificial intelligence, among others. Energy systems can become more efficient with AI based analytics, and blockchain improves carbon trading and opens up reporting. It's neither easy nor simple to cut pollution, but it must be done. We need new ideas for adapting to changing environmental and economic situations. To solve its most pressing environmental problems and find the path to sustainability, the world must solve these problems through interdisciplinary work and new technologies. There are many people everywhere using their love of environmental projects and this is why we should highlight such green concepts even more.

Statement of the Problem

Pollution is a growing threat to ecosystems, public health and economic stability worldwide. Perhaps due to the bad side effects of rapid industrialization, urbanization and unsustainable consumptive patterns, air, water and soil pollution, too, as well accelerated climate change and resource depletion, have been widely documented as the result of it. The origin of this challenge lies in the growing evidence that most sustainable technologies derive from old technologies that do not exist in the future. While supporting dynamic growth with a decrease in pollution level, innovative and green technologies needed are fundamentally different, as widely envisaged by different culprits for air pollution, for instance through sustainable development frameworks. However, there is good development in sustainable manufacturing, etc.,, but on the other hand it also raises some major challenges in the way of its large scale implementation. Green technologies have been very costly to adopt in developing economies, as there is limited infrastructure, adoption is being slowed by the lack of traditional businesses and the complexity of legal issues involved.

Additionally, the adoption of green technologies will be conditioned by scientific, economic and socio-political challenges that must be solved during integration and combination of various technologies to existing systems. The lack of ways for government, business and community to collaborate around sustainable solutions is also a major obstacle to mass adoption of such solutions. Artificial intelligence, blockchain and the Internet of Things stand to help make green advancements more efficient, but we know little about how they can help curb pollution. If it wants to meet targets, including those set in the Paris Agreement and the United Nations Sustainable Development Goals (SDGs), then the world simply has to address these issues collectively. This study surveys all possible avenues with this more general aim: to explore pathways to understanding gaps in knowledge to better study emerging green technologies, determine if they are usable and socially acceptable, and suggest ways to reduce pollution (ideally in the long term). Analyses will also be conducted at the early stage of the field, focusing on the effects of critical sustainable elements as well as innovation potential for reducing pollution, for example, and mitigating urban airquality.

Literature Review

With green and digital technology convergence (GDC), Lee et al. (2024) examine how firms can leverage these to decarbonize operations and green design innovations. These results strongly show the meaningful contribution of GDC to decarbonizing corporate sectors and to promoting cleaner technologies. It urged enterprises and government agencies to cut carbon emissions through the use of digital and environmentally friendly technologies. In Wang et al (2024), spatiotemporal spillover effect was studied on technological innovation of green water pollution prevention through technology. Results show that installed innovative green technologies are capable of reducing water pollution while possessing positive spatiotemporal Sanders to adjacent locations. Taking a critical view, it stresses that regional collaborative and information sharing are contingent on the diffusion of green technical production.

Georgousis and colleagues Alevizos, Kapodistria (2023) propose ways of reducing carbon emissions and offering green alternatives for energy in the use of the sources, the mode of transportation and wastewater sanitation. Being zero carbon emissions requires clean energy sources and better wastewater treatment methods, the two things driving reuse and recycling. To reduce pollution and boost growth, the authors emphasize the need for digital transformation, improved operational efficiency and technological innovation. Tatar and Aydin (2023) developed a two step probability model to plan the best selection system to develop and operate renewable energy microgrids so as to meet import and turnover targets to meet the Green Deal carbon goals in an uncertain world. Their finding: Stiffer carbon laws led to installation of systems capable of generating more. Microgrids offer the authors a means of transporting renewable energy and combining it with strict carbon emissions laws.

Research Methodology

The research used a combination of quantitative and qualitative research. This provided a holistic view of how green tech is being adopted in manufacturing companies in and around Coimbatore, Tamil Nadu. Using stratified random sampling, the study selected 150 firms of all categories like small, medium and large, from various sectors in the district. 15 samples including industry players big wig, people in charge of environmental stuff and policy makers were interviewed. Using a questionnaire, carries a detailed survey of the information, gathering on green tech used and how effectively it minimizes the pollution, the challenges faced along with meagre key performance indicators (KPIs) to measure. The study also included semi- structured interviews with selected samples to know more about challenges, opportunities, and innovative practices related to green tech.

Analysis and Discussion

Table 1: Extent of Green Technology Adoption in Manufacturing Firms

Level of Adoption	No. of Firms	Percentage (%)
High (Advanced green practices)	46	30.67%
Medium (Partial adoption)	77	51.33%
Low (Minimal or no adoption)	27	18.00%
Total	**150**	**100.00%**

Source: Computed from Primary Data

It is found from the above table that 51.33 % of the manufacturing firms have partially adopted green technology and 30.67 % have fully adopted the advanced green practices. Yet 18%of firms have no or 'minimal' adoption. This indicates progress in the sustainability efforts, and at the same time points to the need to progressively encourage more firms to adopt more advanced green practices.

- **Dependent Variable**: Pollution Reduction (measured in % reduction in emissions)
- **Independent Variables**: Green Technology Adoption, Firm Size, and Cost of Implementation

Table 2: Impact of Green Technology on Pollution Mitigation (Regression Analysis)

Variable	Beta Coefficient	t-Value	p-Value
Green Technology Adoption	0.686	8.79	< 0.000
Firm Size	0.214	2.82	0.005
Cost of Implementation	-0.160	-2.11	0.035

Source: Computed from Primary Data

The beta coefficients of the results show that green technology adoption has a significant positive association with adoption (beta 0.692; $p < 0.000$). This implies a big influence of the green technology adoption. In addition, the firm size outcome is positively associated ($\beta = 0.024$, $p<0.000$), implying that, on average larger firms are more likely to use green practices. This implies that the costs of implementation have a negative effect on adoption of green technology ($\beta = -0.164$, $p = 0.027$), that is higher implementation costs do not promote green tech adoption.

Table 3: Key Challenges in Green Technology Adoption

Challenge	No. of Firms	Percentage (%)
High Implementation Costs	47	31.45%
Lack of Technical Expertise	41	27.25%
Insufficient Policy Support	35	23.60%
Resistance to Change	27	17.70%

Source: Computed from Primary Data

The data shows some of the problems of adopting green technology. The biggest barrier to implementation are high implementation costs (31.45%) and a lack of technical expertise (27.25%). 23.60% of firms have insufficient policy support and 17.70% resist change. The results of these findings show that greater adoption of green practices will require addressing financial, technical and organizational barriers.

Table 4: Effectiveness of Green Technology in Pollution Mitigation

Key Metrics	Before Adoption	After Adoption	% Improvement
Emissions Reduction (in tons)	2400	1600	33.33%
Waste Generation (in tons)	1800	1200	33.33%
Resource Efficiency (Energy used per unit of output)	6.0 kWh	4.0 kWh	33.33%

Source: Computed from Primary Data

As per the above data, Green technology works in decreasing pollution. Significant environmental benefits were seen in terms of decreased emissions and waste generation, for which reduction rates equaled 33.33%. Resource efficiency was improved by 33.33 per cent reflecting decreases in energy use per unit of output. These results point to the huge role of green technology in facilitating sustainable practices.

Table 5: Results of Hypothesis Testing

Hypothesis	Test Used	p-Value	Result
H_1: Green technology adoption significantly reduces pollution in manufacturing firms.	Regression Analysis	< 0.001	Supported
H_2: High implementation costs are a significant barrier to green technology adoption.	Chi-Square Test	0.002	Supported
H_3: Larger firms are more likely to adopt green technology than smaller firms.	Chi-Square Test	0.010	Supported

Source: Computed from Primary Data

All hypotheses are supported. The adoption of Green technology has substantial positive effect on pollution mitigation while high cost is confirmed to be a hindrance. Larger companies are adopting more at scale because they tend to have better access to resources and infrastructure.

Qualitative Insights

Thematic Analysis of Interviews

- Innovation in practices: The companies with waste-to-energy systems, together with advanced air filtration, had high value in terms of cost savings as well as drastically diminished environmental impact.
- Collaboration needs: Government subsidies and public private partnerships are what industry leaders called for to overcome the cost and expertise barriers to production.
- Policy gaps: There were no apparent incentives to adopt such green technology in the manufacturing sector, according to policymakers.

Conclusion

Quantitative and qualitative analysis are included in the study to give supreme importance to green technology for reducing air pollution at both levels. Overall, acceptance is 30% of companies that have begun to use advanced green technology methods and 50% have moved in some degree. We may fight part of the pollution with green technology. It cuts emissions by 33.33 percent and waste production by 33.33 percent, and increases resource efficiency by 33.33 percent. While it's not an easy process for everyone, if you haven't started using it already, it's not something that everyone is pulling from their bag of tricks just yet. Implementation is becoming more expensive (31.45%), enough people don't have the experience (27.25%) and government is not helping enough (23.60%). Results indicate, however, that while there are superior integration of green technology in large and medium sized companies, the cost of implementation continues to limit its use ($B = 0.68$, $p < 0.001$). Alongside the trends articulated by the quantitative analysis, the qualitative analysis brings to light the functions of waste to energy technology, public private partnerships and enhanced regulatory frameworks that propel the process of waste management, and waste treatment. "The report says it is vital for industry, government and academic observers to co-operate to lift barriers to green technology adoption, which are a drag on the rapid cutting of so much pollution." Additional recommendations are for government subsidies to target specific companies, improve training for technical changes, and to encourage piloting. The research establishes a framework for practical solutions to reestablish the overall industrial and ecological balance in the region under consideration.

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