Driving Sustainable Growth: Eco-Innovation in Pakistan's Chemical and Pharmaceutical Sector

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Citation | Qambrani. N. A, Kumar. S, Ali. B, Jamali. G. A, Saeed. Z, Qureshi. R.A, Li. J, Ahmed. Z "Driving Sustainable Growth: Eco-Innovation in Pakistan's Chemical and Pharmaceutical Sector", IJIST, Special Issue pp 550-564, June 2024

Received | June 17, 2024 **Revised |** June 22, 2024 **Accepted |** June 27, 2024 **Published |** June 30, 2024.

This paper explores the state of eco-innovation in Pakistan's chemical and pharmaceutical industries, focusing on advancements in process technology, product technology, and organizational eco-innovation. By analyzing survey data, the study evaluates the adoption of eco-friendly practices and identifies key drivers of eco-innovation, including environmental regulations, organizational initiatives, collaboration, environmental management systems, customer pressure, and cost barriers. The results show notable progress in adopting cleaner processes and pollution control measures, with over 65% of companies implementing these techniques. However, green energy technology adoption remains low, with only 18% of industries utilizing it. Product eco-innovation is more widely accepted, with more than 50% of industries responding positively. The study also highlights that around 60% of Pakistan's chemical and pharmaceutical industries are export-oriented and have formal environmental management systems in place. These industries are committed to improving environmental performance and sustainability throughout their supply chains. While there is generally a neutral stance towards environmental regulations, the high cost of eco-innovation and the lack of collaboration between organizations and research institutions pose significant barriers. Overall, the findings indicate a growing environmental awareness among industries in Pakistan, but more efforts are needed to fully adopt green technologies and practices. Enhanced collaboration and coordination among stakeholders are essential for advancing sustainable development in the country's industries.

Keywords: Eco-Innovation, Eco-Innovation Drivers, Eco-Innovation Options, Chemical and Pharmaceutical Industry.

Introduction:

The concept of sustainability gained prominence as the negative impacts of the Industrial Revolution on the socio-ecological environment became increasingly apparent. Scholars began to focus on environmental policies and practices aimed at addressing growing environmental concerns. Eco-innovation emerged as a solution to these challenges, offering not only environmental protection but also driving green economic growth. By enabling businesses to enhance their operations and gain a competitive edge, eco-innovation helps mitigate the costs associated with environmental regulations. Pakistan's chemical and pharmaceutical industries, significant contributors to the country's GDP and employment, have been linked to environmental pollution and degradation, particularly in air and water quality. Recently, these industries have been exploring innovative approaches to improve their sustainability performance. One key strategy gaining attention is eco-innovation, which involves developing and implementing new technologies, products, and processes to reduce environmental impacts.

From 2015 to 2016, the census of product manufacturing industries categorized chemical products into basic chemicals and fertilizers, pharmaceutical products, and other chemical products. In Punjab, of the 846 chemical and pharmaceutical companies, 237 are involved in basic chemicals and fertilizers, 252 in pharmaceutical products, and 357 in other chemical products. Pakistan primarily exports these products to the Middle East, Africa, and Southeast Asia, while major import markets include China, India, and the United States. The Eco-Innovation Observatory of the European Union defines eco-innovation (EI) as the introduction of new or significantly improved products, processes, organizational changes, or marketing solutions that reduce resource use and the release of harmful substances throughout their life cycle. At the company level, EI encompasses three dimensions: process EI, which involves adopting new technologies and modifying manufacturing processes for better environmental performance; product EI, focusing on creating products with sustainable life cycles, such as those designed for disassembly and recycling; and organizational EI, which involves structural or procedural changes within the company to facilitate process and product EI.

Table 1: Statistics for Chemical and Pharmaceutical Industries in Punjab

Industry Type	Number of Industries
Basic chemicals, fertilizers	237
Pharmaceutical Products	252
Other chemical products	357
Total	**846**

Table 2: Number of Companies in Different Categories

Industry Type	Punjab	Sindh	KPK	Balochistan	Islamabad	Total
Basic chemicals, fertilizers	237	110	26	4	2	379
Pharmaceutical Products	252	211	63	16	66	608
Other chemical products	357	155	44	4	8	568
Total	**846**	**476**	**133**	**24**	**75**	**1,555**

These tables offer a clear and organized overview of statistics related to the chemical and pharmaceutical industries in Punjab, detailing the distribution of companies across various categories in different provinces.

Objectives:

- To Analyze the Current State of Eco-Innovation in Pakistan's Chemical and Pharmaceutical Industries
- To Assess the Environmental and Economic Impacts of Eco-Innovation
- To Develop Recommendations for Enhancing Eco-Innovation Practices

Novelty Statement:

This study delivers the first comprehensive analysis of eco-innovation practices in Pakistan's chemical and pharmaceutical industries. It uniquely integrates the process, product, and organizational dimensions of eco-innovation to provide practical recommendations for sustainable growth.

Methodology and Framework:

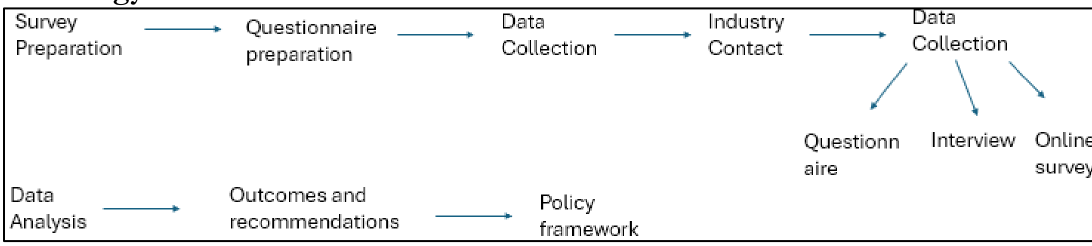

Figure 1: Methodology and framework flow chart

Method and Approaches:

A comprehensive industrial survey was conducted to assess the current status of eco-innovation in Pakistan's chemical sector. A mixed data collection method, including both online and in-person questionnaires, was employed. Approximately 150 industries were contacted, with 17 from the chemical and pharmaceutical sectors participating. These participants were categorized by size: small (0-80 employees), medium (81-250 employees), and large (more than 250 employees). Of the 17 participating industries, 6 were small, 6 were medium, and 5 were large, with 52% of them exporting products internationally.

Additionally, a survey was conducted to understand the environmental status of the textile sector. This survey, adapted and refined from previous studies, was administered both online and in person. The focus was on four key dimensions of eco-innovation: novel or improved systems, practices, processes, and products that promote environmental sustainability. These dimensions, as identified by [1], formed the basis of the questionnaire. The survey aimed to evaluate the extent of adoption of these eco-innovations within the textile sector, including specific techniques, approaches, and products used to enhance environmental performance. The results are intended to identify strengths and weaknesses within the sector and guide strategies for improving environmental performance.

Framework of Questionnaire Assessment:

The assessment framework comprises three primary elements: Eco-Innovation related to Process Technology (EP), Eco-Innovation related to Product (EPR), and Eco-Innovation related to Organization (EO) [2].

- EP involves implementing cleaner technologies, waste management, and environmental monitoring to minimize damage. It includes six questions (EP1-EP6 – Table 3) focused on new or modified processes for environmental damage reduction.
- EPR deals with product design modifications for low emissions, energy efficiency, and sustainable products. It includes three questions (EPR1-EPR3 – Table 3) related to minimizing environmental impact throughout the product lifecycle.
- EO pertains to organizational management systems, including environmental management systems and certifications/standards. It consists of three questions (EO1-EO3 – Table 3) addressing the organization's approach to eco-innovation.

Eco-Innovation Drivers:

The survey examined the drivers of eco-innovation, categorizing them into internal factors (such as available resources, technical capabilities, willingness, and ethical responsibility) and external factors (including pressure from buyers, adherence to international standards, and compliance with local regulations). These drivers are essential for guiding industrial units in their environmental planning and implementation of eco-innovation actions. To evaluate industries' perspectives on these drivers, the questionnaire survey included questions on six major eco-innovation drivers: Environmental Regulations (ER), Organizational Efforts (EO), Organizational Collaborations (OC), Environmental Management System (EMS), Buyer Pressure (BP), and Cost Barriers (CB). Each driver was assessed through multiple questions, with responses recorded using a seven-point Likert scale. Details of each eco-innovation driver are provided in Table 4.

Table 3: Assessment framework for analyzing the state of eco-innovation

	Eco-Innovation related to Process Technology (EP)
EP1	Cleaning technology before the release of pollutants into the environment: air, water & soil treatment within the industry (air/water/wastewater/solid waste treatment)
EP2	Cleaner production processes: less polluting manufacturing processes or resource conserving than contemporary manufacturing processes.
EP3	Ultimate disposal of waste/recycling equipment (Incinerators/recycling devices)
EP4	Tools for water/air/solid pollutants monitoring within the industry
EP5	Noise and vibration control technologies
EP6	Renewal energy-based techniques (alternative to fossil fuels such as solar/wind/bioenergy)
	Eco-Innovation related to Product (EPR)
EO1	Pollutant elimination/reduction/prevention manufacturing strategy aims to reduce resource use/reuse and recycling/energy consumption: screening out management practices that increase wastes
EO2	Structured environmental management/monitoring system with appropriate documentation such as ISO 14001, EMAS, etc.
EO3	Chain management: external partnerships to implement "close material loops," considering life cycle assessment across the value chain
	Eco-Innovation related to Organization (EO)
EPR 1	Products/services for end-users with improved environmental status/labels
EPR 2	Environmentally friendly products (green products) that will have low pollutants at user-end
EPR3	Products/Services that are more energy efficient

Table 4: Drivers of eco-innovation and their description

Drivers of Eco-Innovation	Description
Environmental Regulations (ER)	**ER1**: Stringency of the environmental regulations in Pakistan. **ER2**: Environmental regulations implementation in Pakistan. **ER3**: Level of monitoring by the regulatory authority through audits and reporting. **ER4**: Environmental benefits in response to existing environmental regulations or taxes on pollution. **ER5**: Environmental benefits in response to the environmental laws or taxes to be imposed in the future. **ER6**: Availability of government grants, subsidies, or other financial incentives.
	EO1: Investment in environmental training and employee development. **EO2**: Efforts in ensuring employees' environmental awareness. **EO3**: Efforts to assess the role of employees in improving environmental performance.

Organizational Efforts (EO)	**EO4**: Reward (i.e., promotion and salary increase) to employees for environmental improvement. **EO5**: Efforts to eliminate the use of products that cause environmental damage. **EO6**: Efforts to eliminate the release of any substances that cause environmental damage. **EO7**: Efforts to dispose of physical waste through environmentally safe methods
Organizational Collaboration (OC)	**OC1**: Knowledge/ information/ expertise related to environmental issues acquired through collaboration and networking (among groups, firms, suppliers, partners, and associations). **OC2**: Collaboration and networking to make joint decisions on environmental issues. **OC3**: Collaboration and networking to share best environmental practices
Environmental Management System (EMS)	**EMS1**: Organization's efforts to routinely update its environmental information. **EMS2**: Environmental information management system to store environmental information. **EMS3**: Easiness to access the environmental information management system. **EMS4**: Sharing of environmental information between management levels in an organization.
Buyer's Pressure (BP)	**BP1**: Customers' awareness towards environmentally friendly products. **BP2**: Customer pressure to generate environmental benefits. **BP3**: Customers' requirement to fulfill their environmental regulations/standards (for example, ISO14001, REACH, RoHS, chemical labeling, and others). **BP4**: Influence of Customers' environmental regulations on a firm's environmental and business decision-making
Cost Barrier (CB)	**CB1**: High cost is a barrier to executing environmental projects/activities /innovations. **CB2**: No financing source is a barrier to executing environmental projects/activities/ innovations. **CB3**: Slowness in creating funds is a barrier to initiating environmental projects/activities/innovations.

Results:

State of Eco-Innovation in Chemical and Pharmaceutical Industries:

Eco-Innovation Process Technology (EP):

Eco-innovation has made notable strides across sectors, with over 65% of companies adopting cleaner methods. Approximately 53% of industries reported positive feedback on waste management, reflecting an increasing awareness and commitment to reducing waste and its environmental impacts. Similarly, 41% of industries recognized the importance of environmental monitoring, which helps ensure regulatory compliance and identify potential risks. However, only 18% of industries have embraced green energy technology, highlighting a significant gap in adoption. This disparity indicates a need for enhanced initiatives and financial incentives to promote widespread use of sustainable energy solutions, supporting a more comprehensive approach to addressing environmental challenges and advancing a greener future (Figure 2. A).

Product Technology Innovation (EPR):

The survey results indicate a positive trend in Pakistan's chemical and pharmaceutical industries, with a majority adopting environmentally friendly product developments and reducing pollution. Over 50% of industries responded positively to questions about product eco-innovation, showing their commitment to minimizing ecological impacts and integrating sustainable practices into their operations. These industries are working to create and offer more sustainable and environmentally sensitive products, reflecting corporate responsibility and a dedication to reducing environmental pollution. Their focus on sustainable practices contributes to building a greener and more sustainable Pakistan (Figure 2. B).

Eco-Innovation Related to Organization (EO):

The survey found that approximately 60% of Pakistan's chemical and pharmaceutical industries are export-oriented and have implemented formal environmental management systems to adhere to global environmental standards. This proactive approach highlights their commitment to enhancing environmental performance and sustainability throughout their supply chains. Additionally, 60% of industries have adopted organizational eco-innovation, indicating their pursuit of innovative methods to address environmental challenges. Although some industries are still focused on domestic production, there is potential for broader implementation of eco-innovation to further improve environmental performance. Overall, these results reflect a promising trend towards sustainability and responsible business practices in Pakistan's chemical and pharmaceutical sectors (Figure 2. C).

Status of Drivers of Eco-Innovation:

This study analyzed various drivers of eco-innovation, including environmental regulation, organizational efforts, organizational collaboration, environmental management systems, customer pressure, and cost barriers (Figure 3). The survey explored how these drivers influence the status of eco-innovation, with responses scored on a Likert scale.

Environmental Regulation:

Survey results on the impact of environmental regulation as a catalyst for eco-innovation showed diverse industry perspectives. While most respondents had no opinion, a significant portion considered regulations either lenient (25%) or moderately strict (32%). The neutral stance of 28% of participants may be influenced by concerns about oversight authorities. Almost half of the industries reported high levels of oversight through audits and reporting. Regarding innovation, 37% observed extensive organizational innovation, while 23% anticipated moderate industry innovation in response to regulations. Additionally, 42% expected significant innovation. As for government incentives, 14% believed industries exhibited no innovation, while 38% perceived a substantial influence. These findings highlight the complex attitudes towards compliance and innovation driven by environmental policies (Figure 3. A).

Organization Efforts (OE):

Organizational efforts are vital for driving eco-innovation, encompassing the implementation of sustainability-focused policies, setting goals to reduce environmental impact, and investing in the research and development of eco-friendly products and practices. Survey responses on organizational efforts (OE1-OE7) reveal significant progress in promoting eco-innovation and environmental stewardship. Nearly half of the respondents (48%) reported substantial investment in employee training, while 42% believe that effective mechanisms are in place to ensure employee awareness and training. Over half (53%) perceive that organizations evaluate employee contributions to improving environmental performance. A majority of respondents (44% and 51%) view efforts to eliminate environmentally damaging products and reduce emissions as positive. Additionally, 58% believe organizations make extensive efforts to dispose of waste in an environmentally safe manner. These findings highlight organizations' commitment to sustainability, emphasizing the importance of employee training, awareness, waste management, and reducing environmental harm.

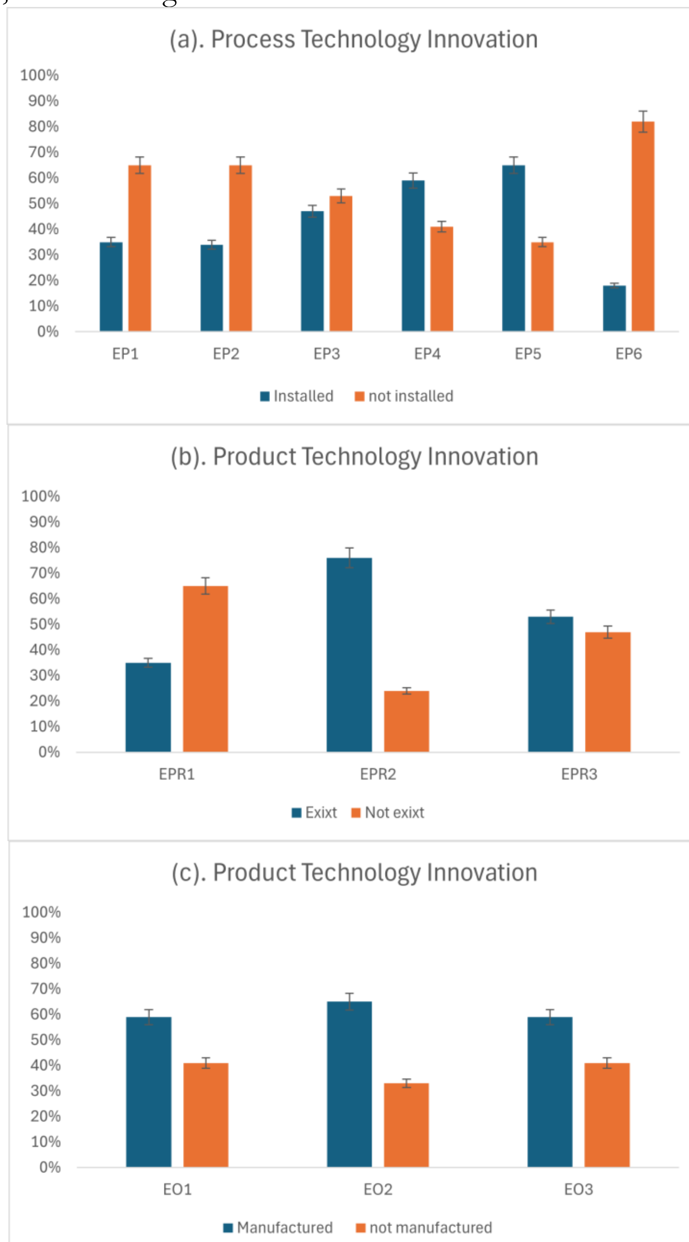

Figure 2: Status of: **(a)**. Process technology innovation, **(b)**. Product Technology Innovation, **(c)**. Organizational innovation

Organizational Collaboration (OC):

The study highlights the role of organizational collaboration (OC) in driving eco-innovation through alliances for resource and knowledge sharing, as well as partnerships with research institutions. Results indicate a strong focus on industry networking and collaboration to address environmental challenges. While 43% of respondents feel they have strong partnerships for developing environmental expertise, 10% perceive a lack of networking opportunities, suggesting a need for initiatives to enhance collaboration. Additionally, 42% of respondents note improved collaboration between industries on environmental concerns, underscoring the importance of collective action. Eighteen percent report moderate levels of collaboration, indicating potential for further improvement. Regarding information sharing, 41% believe it occurs frequently within industries, reflecting a willingness to exchange best practices. These findings emphasize the importance of partnerships, cooperation, and information exchange in addressing environmental challenges and highlight the need for further initiatives to bolster industry networking and collaboration (Figure 2. C).

Environmental Management System (EMS):

The study underscores the importance of Environmental Management Systems (EMS) in identifying and managing an organization's environmental impacts. EMS helps track and measure environmental performance, identifying areas in need of eco-innovation and promoting continuous improvement. Results show widespread EMS implementation, with approximately 30% of respondents indicating high-level implementation. About 36% believe businesses consistently update their environmental data at a high level, reflecting a commitment to staying current with environmental information. Additionally, 36% find access to environmental information management (MIS) somewhat easy. Finally, 41% believe the quality of environmental information shared among managers is satisfactory. These findings suggest a positive perception of EMS adoption, regular updates to environmental information, and effective industry-wide exchange of environmental data (Figure 3. D).

Customer's Pressure:

The study explores the impact of rising consumer demand for sustainable products on industries' investments in eco-friendly R&D and environmentally friendly manufacturing techniques. Results show that consumer pressure significantly influences eco-innovation, with 58% of respondents noting high consumer awareness of environmentally friendly products. However, 12% rated customer attention toward sustainable products as low to slightly low, suggesting room for increased awareness. Thirty-nine percent view customer pressure as high, while 29% consider it moderate, indicating a significant role for consumers in encouraging environmental initiatives. Additionally, 41% believe customer requirements to comply with environmental regulations are slightly high, underscoring customer influence on industry practices. Fifty-four percent perceive that customer-driven environmental regulations greatly impact industry decision-making, while 11% report minimal customer influence. These findings highlight the importance of customer awareness, pressure, and requirements in driving industries toward environmental sustainability (Figure 3. E).

Cost Barrier:

The survey reveals significant challenges industries face in adopting environmental technologies. Approximately 30% of respondents identify financial limitations as a major obstacle, indicating that high costs are a substantial barrier to innovation. Additionally, 34% view the expense of environmental projects as extremely high, highlighting the financial strain associated with these initiatives. Another 35% perceive cost as a moderate barrier, underscoring its continued relevance. A small percentage (2%) of respondents indicate that cost is not a barrier, suggesting that these industries might have sufficient financial resources or alternative funding sources. These findings emphasize the need to address cost-related issues and develop innovative solutions to overcome financial obstacles for environmental initiatives (Figure 3. F).

Identification of Eco-Innovation Option:

The study team engaged in detailed discussions with experts to examine environmental policies implemented globally, focusing on the chemical and pharmaceutical sectors. They proposed eco-innovation options (Table 5) related to industrial activities, including the adoption of best management practices to reduce resource consumption, promote recycling and reuse, conserve resources, and minimize pollutant emissions to achieve zero discharge. The team stressed the importance of conducting a comprehensive cost-benefit analysis, including payback periods, to evaluate the feasibility of these eco-innovation measures. Financial viability was a key consideration, taking into account factors such as initial capital expenses, ongoing costs, and anticipated payback periods for implementation.

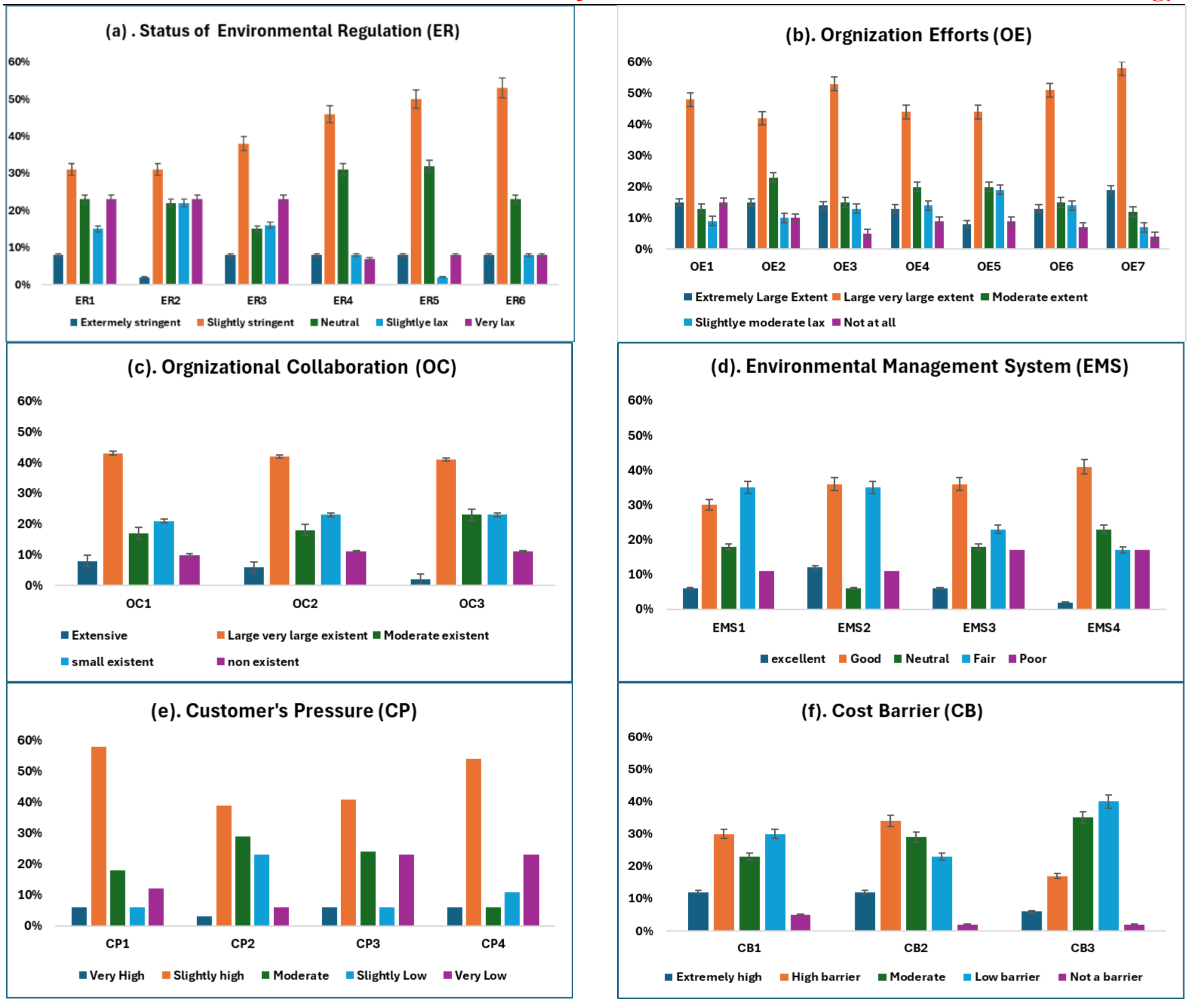

Figure 3: Status of Eco-drivers **(a)** environmental regulation **(b)** organization efforts **(c)** organizational collaboration **(d)** environmental management system **(e)** customer's pressure **(f)** cost barrier

Table 5: Eco-Innovation Options for the Chemical & Pharmaceutical Sector

Pharmaceutical Industry	
Eco-Innovation options	**Description**
Environmental Issues: Water/Air	
Microwave-assisted technology methods of manufacturing pharmaceuticals. [3]	Microwave-assisted synthesis of pharmaceuticals. • No heat is lost to the surroundings. • In a microwave, superheating boosts a solvent's boiling point by up to 5°C because the surface cooling of the microwave causes the center to be 5°C hotter than the outside. • Both the substance and the reaction experience uniform heating. • Desirable chemical and physical effects are produced due to the quenching of undesired side reactions. • Electromagnetic waves generate heat. • No environmental or health risks from the SO solvent-free method. • No air emissions. • No creation of waste or use of water as a coolant.

	• Specific components can be heated separately in a microwave, increasing efficiency and lowering operating costs. • High reaction speeds produce effective results. • Limited space is required. • No physical contact with and purity in the product is achieved.
Environmental Issues: Technological Advancement	
Tablet manufacturing by process modification [4]	• Instead of a single punch, it shifts to a triple punch for a more compact and compressed tablet form. • With a triple punch, processes became faster and more efficient. • Tableting, oscillation, blender units, and sifter units reduce production time by 70%and time from 70 hours to 50 hours. • Energy consumption per batch might be cut by 73.2%, from 5600 kWh to 1499 kWh. • Instead of 3855 kg CO_2 eq per batch, 1032 kg CO_2 eq. of emissions were anticipated.
Less use of chemicals instead of the full amount. Source: Discussion with an expert	• A slightly less amount of chemicals (for example, sweeteners) is added instead of the full amount given in a recipe. It must be carried out carefully without compromising the taste and quality of the product. A considerable amount of chemicals can be saved annually, resulting in significant financial savings.
Chemical Industries	
Environmental Issues: Energy	
Low air emissions from industrial waste [5]	• Two-stage, dry flue gas treatment system, an existing boiler, and a private combustion system. • High swirl, sub-stoichiometric combustion chambers make up the combustor. • 0.3 seconds of residence time and a temperature of 1200 °C are guaranteed with the addition of secondary air. • Low NO_X, CO, and dioxin production rates. • Recirculation of flue gas to reduce its temperature by 1100-1150 °C • Lime powder and steam are applied to eliminate HCl after heat recovery. • Using bag filters, flue gas is cleansed. • No detectable levels of phosgene BTEX-aromatics about 50 % of the targeted energy savings.
Chemical leasing suggests using the chemicals as services instead of consumables. Source:[6], Minutes of meeting, Focus group meeting, Food sector, [7]	• Services are outsourced instead of using chemicals (for example, in washing, chemicals are used). Instead of using chemicals, the process is outsourced to a chemical supplier. The chemical supplier then optimizes the usage of chemicals to increase profit. Consequently, the consumption of chemicals is reduced, and so is the environmental burden. Economically, both the company and the chemical supplier get mutual benefits.

Discussion:

The findings of this study on eco-innovation in Pakistan's chemical and pharmaceutical industries reveal notable progress in several areas, with some gaps remaining. Over 65% of companies adopting pollution prevention and cleaner methods is a positive indicator of the industry's commitment to reducing environmental impact. This aligns closely with [8], which reported a similar trend globally in the chemical sector, with an adoption rate of approximately 70%. This suggests that Pakistan's industry is on par with global trends in pollution prevention.

Moreover, the positive feedback on waste management from 53% of industries reflects growing awareness and efforts toward minimizing waste [8]. This finding aligns with [9], which reported that 55% of chemical industries in developed countries had implemented effective waste management practices. The slight difference in percentages may result from varying levels of regulatory enforcement and industrial maturity between regions [10]. Environmental monitoring, favored by 41% of industries, underscores a proactive approach to ecological preservation [11]. This is consistent with [12], which highlighted that 45% of pharmaceutical companies in Southeast Asia had established robust environmental monitoring systems. The alignment of these figures indicates a regional trend toward increased environmental accountability [13].

However, the adoption of green energy technology by only 18% of industries reveals a significant gap, corroborated by [14], which noted a low uptake of green energy solutions in the South Asian chemical sector, at around 20%. Both studies highlight the need for enhanced initiatives and financial incentives to promote sustainable energy technologies. Addressing this gap is crucial for achieving broader environmental goals and fostering a sustainable industrial future [15]. Overall, the findings validate existing research on eco-innovation practices within the chemical and pharmaceutical industries but highlight the need for targeted policies to support green energy adoption [16].

The positive response from over 50% of industries regarding product eco-innovation aligns with [17], which found that approximately 55% of firms in the Asian chemical sector had integrated eco-friendly product developments. This indicates a regional trend towards sustainable practices in product design, reflecting growing corporate responsibility. The efforts by these industries to develop more sustainable products are essential for reducing environmental pollution and enhancing corporate responsibility [18]. The survey revealed that about 60% of industries have adopted organizational eco-innovation and formal environmental management systems, similar to [19], which reported that 62% of South Korean chemical industries had established formal EMS frameworks. This proactive approach demonstrates a commitment to enhancing environmental performance and sustainability, crucial for maintaining global environmental standards, particularly for export-oriented industries [20].

In terms of eco-innovation drivers, mixed responses on environmental regulation as a catalyst, with 25% viewing regulations as lenient and 32% as moderately strict, are consistent with [21], which observed similar perceptions in the Chinese manufacturing sector. They noted that 30% of respondents viewed regulations as moderate, highlighting the need for stricter enforcement and incentives to drive eco-innovation. The substantial investment in employee training reported by nearly 48% of respondent's mirrors [11], which found that 50% of European chemical industries had significant training programs to enhance environmental performance, indicating that organizational efforts in training and awareness are crucial drivers of eco-innovation.

The strong emphasis on industry networking and collaboration, noted by 43% of respondents, aligns with [22], which found that 45% of industries in North America had robust partnerships to address environmental challenges. This underscores the importance of collaboration in driving eco-innovation and sharing best practices. The widespread implementation of EMS, with about 30% indicating high-level implementation, is consistent with [12], which reported a 33% high-level implementation rate in Southeast Asian industries. Regular updates to environmental data and easy access to environmental information management further validate the positive perception of EMS adoption [23].

The significant influence of customer pressure on eco-innovation, with 58% noting high awareness, aligns with [24], which found that 60% of consumers in the Asian market were highly aware of environmentally friendly products. This indicates that customer demand is a critical driver of sustainable practices. Financial limitations cited by approximately 30% of respondents as a significant obstacle to innovation are similar to [25], which reported that 32% of industries in the Chinese manufacturing sector faced high costs as a barrier to eco-innovation. Addressing cost-related issues is essential for promoting sustainable initiatives.

Overall, the findings of this study closely align with global research, validating trends in eco-innovation practices within the chemical and pharmaceutical industries. The data highlight the importance of regulatory frameworks, organizational efforts, collaboration, customer pressure, and cost management in driving eco-innovation. However, the lower adoption rates of green energy technologies emphasize the need for targeted policies and support mechanisms to foster a more sustainable industrial landscape.

Conclusion:

In conclusion, the survey analysis indicates that industries in Pakistan have made significant strides in adopting cleaner processes and pollution control eco-innovation, with over 60% implementing such practices. However, the adoption of green energy technologies remains notably low, with only 18% of industries utilizing them. In contrast, product eco-innovation is more widely embraced, with over 50% of industries reporting positive adoption. These responses suggest a growing environmental consciousness among Pakistani industries, though more effort is needed to fully integrate green energy technologies. Additionally, export-oriented sectors like chemicals and pharmaceuticals have established formal environmental management systems to satisfy customer demands. Nonetheless, many industries display a neutral stance towards environmental regulations, and the high costs associated with eco-innovation present a significant challenge. The lack of collaboration among organizations and research institutions further hampers the feasibility of eco-innovation. Therefore, enhanced collaboration and coordination among stakeholders are essential to advancing sustainable development practices in Pakistan's industries. Authors are encouraged to include concluding remarks on these findings and propose recommendations for future work.

Acknowledgement:

We extend our heartfelt appreciation to everyone who contributed to the completion of this research. First and foremost, we express our sincere gratitude to Professor Dr. Zubair Ahmed, our adviser, for his invaluable support and guidance throughout the study. His expertise and insights have significantly shaped this work. We also thank USPCAS-W, MUET, and Jamshoro Pakistan for providing the essential resources and a supportive environment for conducting this research. Special thanks are due to the CPEC project team for their active involvement, which greatly enhanced the quality of our study. Lastly, we are deeply grateful to all the respondents and participants who generously shared their time and knowledge, making this study possible.

Author's Contribution:

Professor Dr. Zubair Ahmed contributed as a Principal Investigator and guided and programmed the research work. Mr. Suresh Kumar and Mr. Bahadur Ali did all the fieldwork surveys and report writing. Ms. Zulaikha Saeed and Mr. Rehan Ali Qureshi contributed to the paper writing. Ms. Ghazala Akbar Jamali Contributed to Data collection from various organizations. Finally, Dr. Naveed Ahmed Qambrani supervised this research work.

Conflict of Interest:

Regarding the publishing of this work in the International Journal of Information Science and Technology (IJIST), the authors declare that there is no conflict of interest. There have been no financial or personal ties that have impacted the research, analysis, or findings provided in this work. All authors have contributed in a way that complies with the ethical guidelines of the journal.

Project Details:

This research was conducted as a result of a Project titled "Eco-innovation for sustainable industrial growth of major industrial sectors in Special Economic Zones (ECZs) under CPEC-75". The project number is CPEC-75 and the completion date of the project is February 2025. The approximate cost of the project is 25.256 million PKR.

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