USPCAS-W
Mehran University
of Engineering & Technology
Jamshoro, Pakistan

Chemical & Pharmaceutical Sector

Brief Situation Analysis Report

Eco-Innovation for Sustainable Industrial Growth of Major Industrial Sectors in Special Economic Zones (SEZs) Under CPEC-75

(A Project funded by Higher Education Commission, HEC)

Principal Investigator: Prof. Dr. Zubair Ahmed

May 2023

Context to the study

- Status of Eco-Innovation in Chemical & Pharmaceutical Sector.
- Drivers of Eco-Innovation
- Identification of Eco-Innovation options

Summary of findings

(1) Feasible eco-innovation options were identified are also listed in this report.

(2) Many participating industries have introduced process technology eco-innovations in their organization. Over 60% of industries have adopted cleaner processes and pollution control eco-innovation.

(3) For waste management and environmental monitoring-related eco-innovation, 53% and 41% of industries respond positively, respectively.

(4) 18% of industries have responded by affirming green energy technologies. Most of the chemical and pharmaceutical industries have introduced product eco-innovations and improved their products regarding environmental pollution.

(5) 60% of industries have positively responded and adopted the organizational eco-innovation option. The remaining industries are local manufacturers.

U.S.-Pakistan Center for Advanced Studies in Water (USPCAS-W)
Mehran University of Engineering & Technology (MUET), Jamshoro
Ph. 92 22 2109145 | Email: zahmed.uspcasw@faculty.muet.edu.pk | URL: water.muet.edu.pk

Introduction

The chemical & pharmaceutical sector is critical to the economic development of any country globally. This sector has long had a global presence, providing input to other sectors such as agriculture and manufacturing industries that improve living standards around the world. Few of the products manufactured by chemical & pharmaceutical industries can be sold or used as finished products in our daily life. However, most of the products are used as raw materials for other sectors. However, this sector is comprised of two separate industries, each is a sector itself. In early 50's, Pakistan Industrial Development Corporation (PIDC) was setup by the Government, for industrialization of the country. As a result, a large chemical estate comprising Pak American Fertilizers, Maple Leaf Cement, Antibiotics (Penicillin) and Pak Dyes & Chemicals, was established at Iskanderabad (DaudKhel), district Mianwali. This estate played an important role and served as a nucleus for chemical industry in Pakistan [1]. In 1960's, another chemical complex was set up in private sector at Kala Shah Kaku, Lahore. Chemical factories also started emerging at Karachi due to the investment friendly policies which gave confidence to the investors [2]. According to Pakistan Economic Survey 2021-2022, the large-scale manufacturing (LSM) industries growth increased by 10.4% during the fiscal year 2022 as compared to the 4.2% growth in the same period last year [3]. The industry specific data shows that the chemical industry has 7.8% growth in the fiscal year 2022 [4].

Furthermore, the number of different chemical and pharmaceutical industries were also reported in Censes of Manufacturing Industries 2015-2016. These categorizations were made on type of chemical products the basic chemical industries include production of Soda Ash, Caustic Soda, Sulphuric Acid & Chlorine, and Fertilizers. Most of these industries are located in Punjab Province. Other chemical industries include industries which are involved in manufacturing of specialty chemicals. The number of sub chemical industries of Pakistan is provided in below table 1. The GIS location maps of Chemical and Pharmaceutical Industries in Pakistan are shown in figure 1.

Table 1: Provincial Wise and Sub-Sector Wise Number of Industries

Industry type	Punjab	Sindh	KPK	Baluchistan	Islamabad	Total
Basic chemicals, fertilizers etc.	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

Source: (Pakistan Bureau of Statistics, 2016)

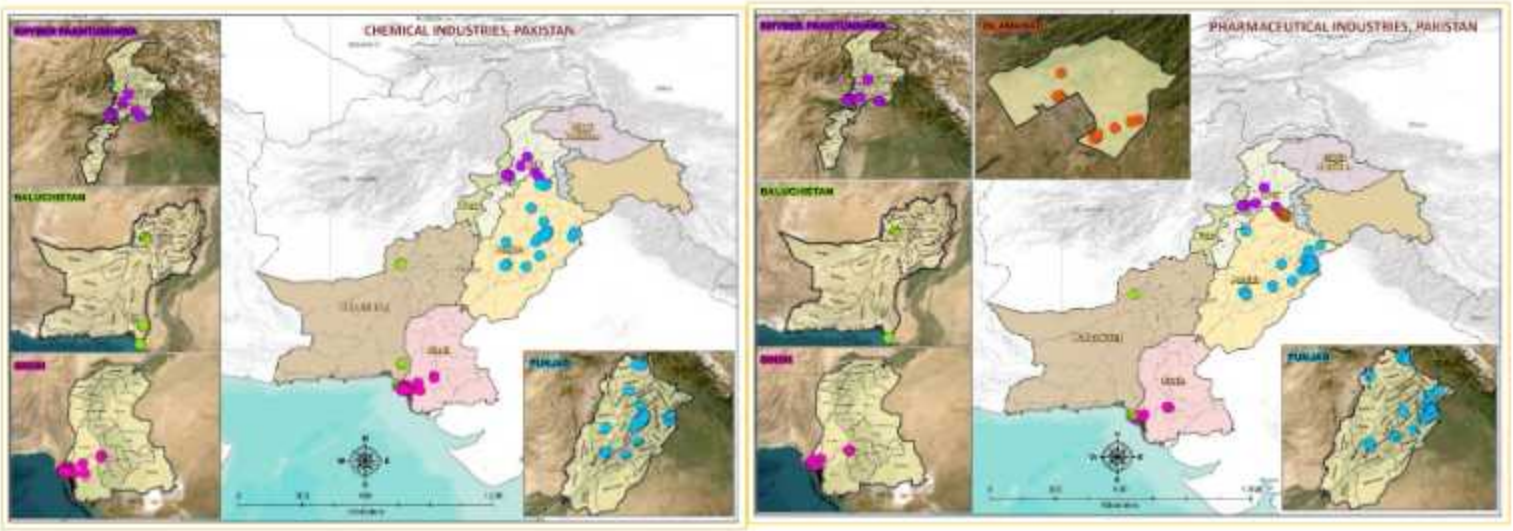


Figure 1: GIS Location Map of Chemical & Pharma Industries in Pakistan

Eco-innovation is an approach that aims to reduce environmental pollution and minimize resource consumption by encouraging reuse/recycled substitution of processes at organizational readjustment with maximization of production efficiency at output.

Approach and method

To determine the present state of the Eco-innovation approach, comprehension, and adaptation in the current textile sector, a thorough industrial survey was done in which approximately 150 industries were contacted and only 13 industries responded, 2 from large scale, 3 were of medium scale and the rest 8 from small-scale industries. A mixed data collection method was employed:

- ***Interviews*** with industries managers, environmental representatives, and owners
- Focused group meetings (***FGM***) and
- Questionnaire survey (***both online and in-person).***
- The assessment framework comprises three main elements [5] on which the questionnaire survey was designed. These key elements are given below.

i. ***Eco-Innovation related to process technology (EP)***
ii. ***Eco-Innovation related to Product (EPR)***
iii. ***Eco-Innovation related to Organization (EO)***

Research Findings

1. State of Eco-Innovation

(i) Process Technology Innovation (EP)

New addition/modification in the process for environmental damage minimization. Six questions were asked, labelled as EP1, EP2, EP3, EP4, EP5, and EP6 (Table 2).

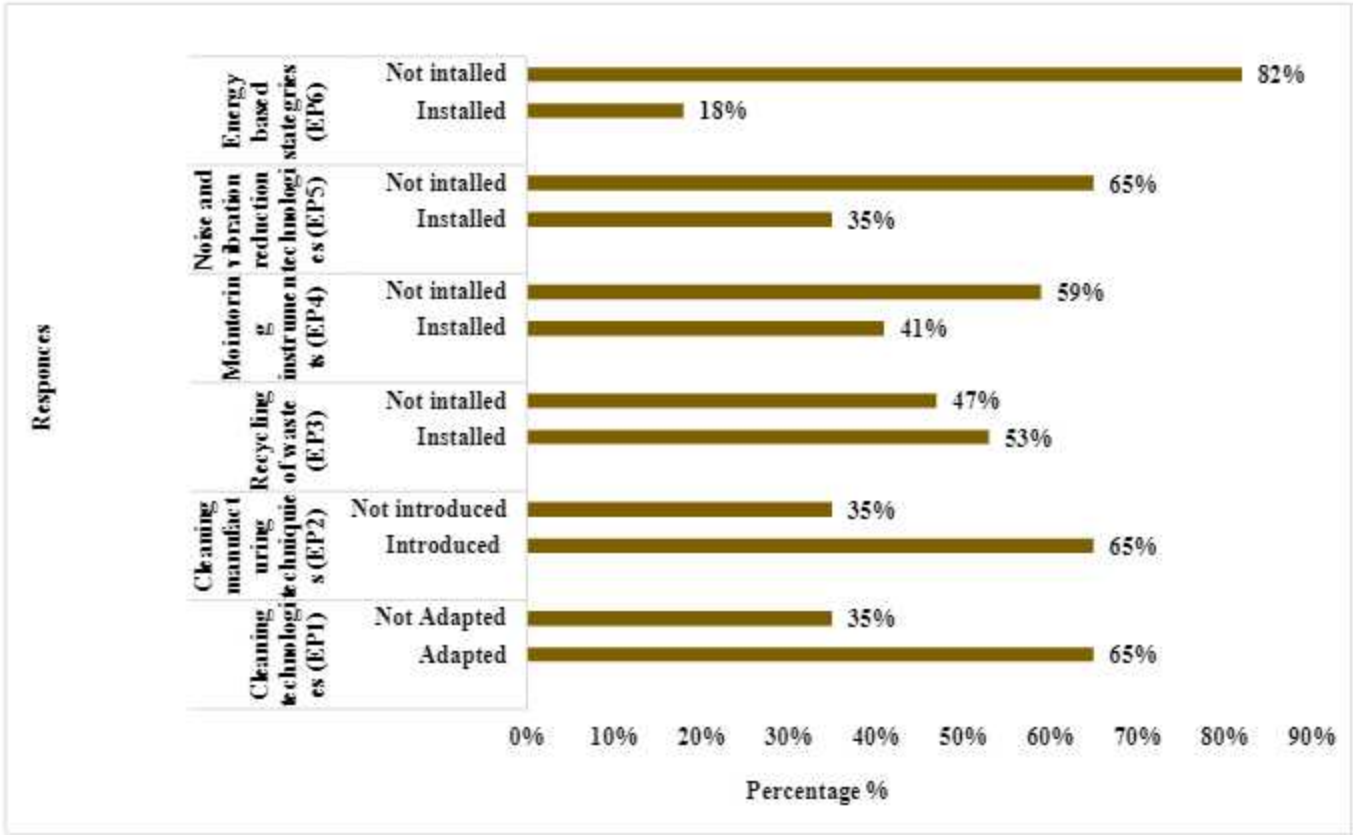
Table 2: Quarries for ranking the process technology innovation (EP).

Process technology eco-innovation	**EP1**: Technologies for cleaning the air, water, soil, and solid waste.
	EP2: Cleaner manufacturing techniques
	EP3: Final disposal of recycling/waste equipment
	EP4: Instruments used in the industry to monitor solid, liquid, and environmental contaminants.
	EP5: Technology for reducing noise and vibration.
	EP6: Energy-based strategies for renewal (solar or wind energy)

Findings

- Over 65% of industries have adopted cleaner processes and pollution control eco-innovation.
- For waste management and environmental monitoring-related eco-innovation, 53% and 41% of industries respond positively, respectively.
- However, only 18% of industries have responded by affirming green energy technologies.

Fig 2. ***State of Process technology innovation***



(ii) Product Technology Innovation (EPR)

Any modification/improvement in the product design. For environmental impact reduction during the lifecycle of the product. There were three questions EPR1, EPR2, and EPR3 (Table 3).

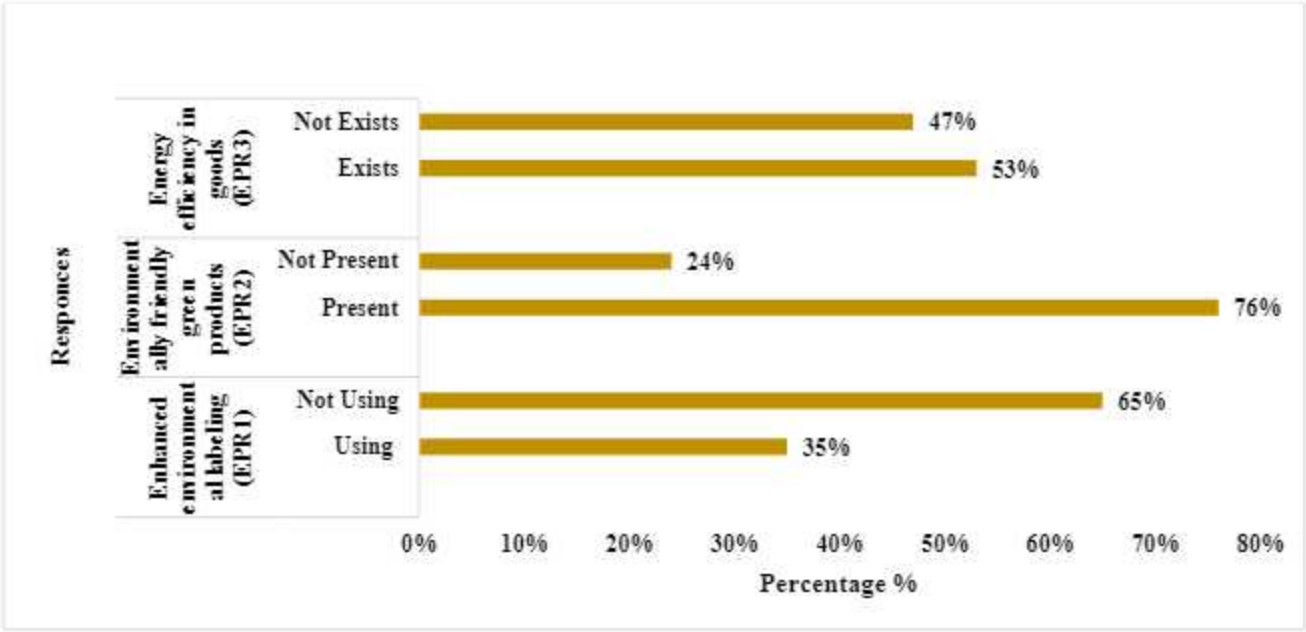
Table 3. Quarries for ranking the product technology innovation (EPR).

Product technology eco-innovation	**EPR1:** Enhanced environmental labelling
	EPR2: Green products that are environmentally friendly.
	EPR3: Greater energy efficiency in goods and services

Findings:

- The survey results reveal that in Pakistan, most of the chemical and pharmaceutical industries have introduced product eco-innovations and improved their products regarding environmental pollution.
- More than 50% of industries positively responded to the question related to product eco-innovation.

Fig 3. State of product technology innovation



(iii) Organizational Eco-Innovation (EO)

Organizational management system and coordination. Three questions were asked (i.e., EO1, EO2 & EO3). The description of questions is given in table 4.

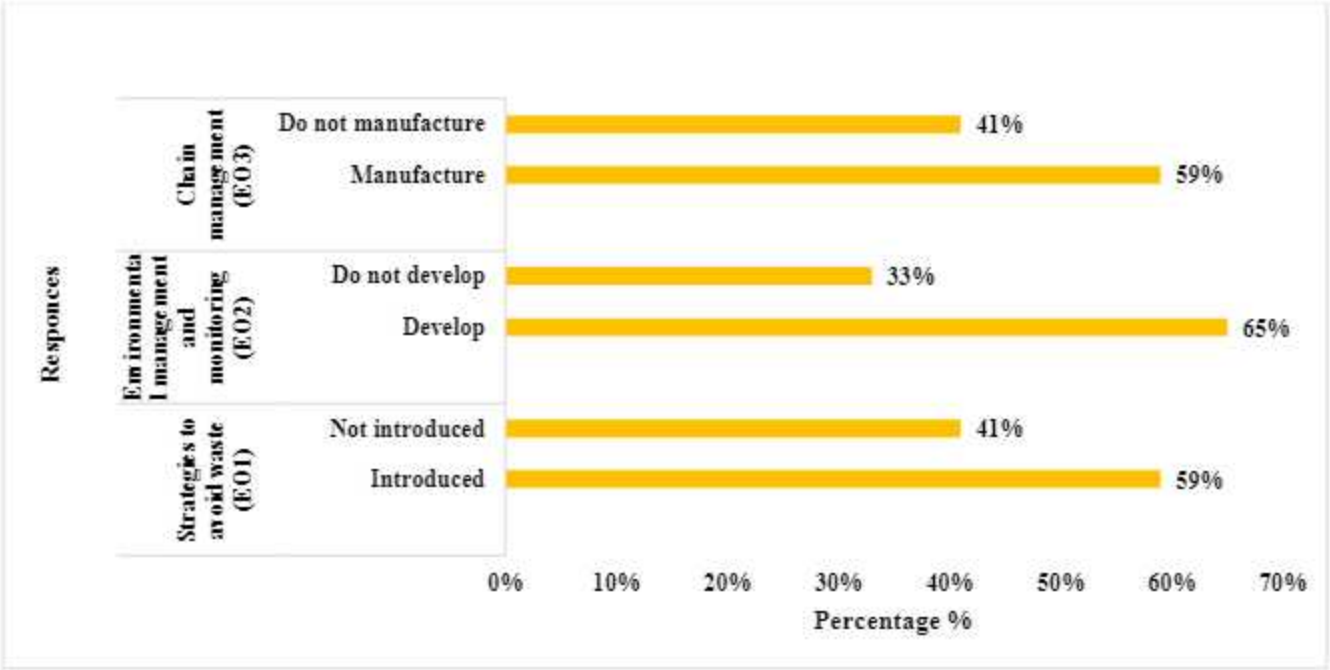
Table 4. Quarries for ranking the product technology innovation (EO)

Organizational eco-innovation	**EO1:** Avoid waste-producing management strategies.
	EO2: System for structured environmental management and monitoring (ISO 14001, EMAS, etc.)
	EO3: Chain management

Findings:

- Most of the about 60% responded chemical and pharmaceutical industries are export oriented. Thus, these industries have adopted formal environmental management systems within firms.
- 60% of industries have positively responded and adopted the organizational eco-innovation option. The remaining industries are local manufacturers.

Fig 4. State of organizational eco-innovation



2. Drivers of Eco-Innovation

The survey investigated the elements that influence eco-innovation and found both internal and external ones. These forces include the availability of resources, technological aptitude, ethical responsibility, buyer pressure, international standards, and local laws. The study covered six aspects of the factors that drive eco-innovation.

(i) Environmental regulation

By establishing criteria and objectives for decreasing environmental impact and motivating businesses to create new technologies and methods to achieve those goals, environmental regulation can operate as a catalyst for eco-innovation. The survey included numerous aspects of environmental legislation as a catalyst for eco-innovation (Table 5).

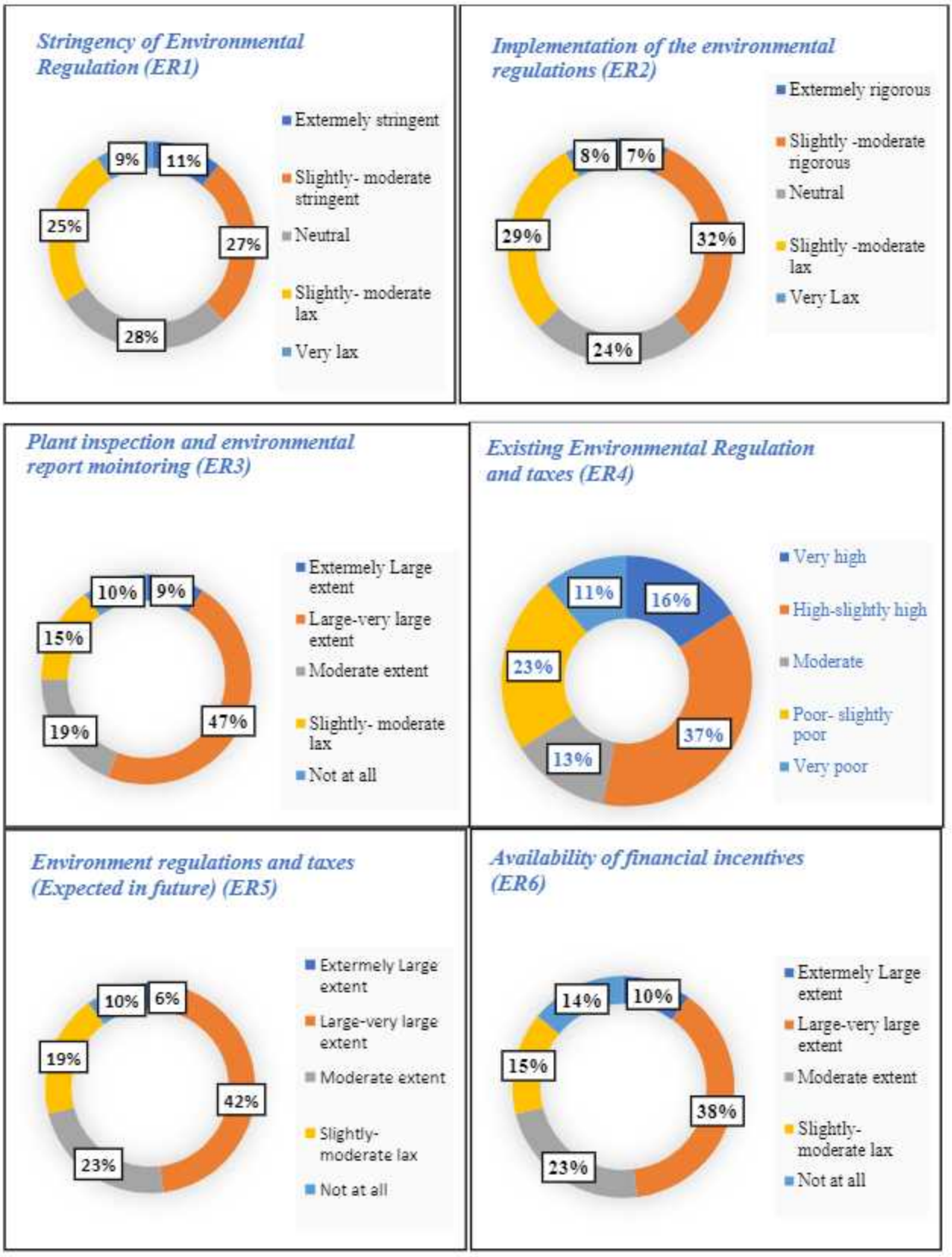
Table 5. Quarries for ranking environmental regulations in industries (ER)

Environmental Regulations (ER)	**ER1**: Stringency of the environmental regulations
	ER2: Environmental regulations implementation
	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

Findings:

- ***ER1***: About 25% responded think that environmental regulations are relaxed. 28% remain neutral. The reason of being neutral is, perhaps, reluctance due to 'unknown' fear from monitoring authority and 11% of them expressed that the environmental regulations are extremely stringent.
- ***ER2***: Majority of industries (32%) think that implementation of environmental regulations is moderate rigorous.
- ***ER3:*** About 47% industries responded that level of monitoring by the regulatory authority through audits and reporting is high.
- ***ER4:*** 37% of respondents think that organizations do innovation in response to environmental regulation and taxes are to a very large extent.
- ***ER5:*** About 23% believe that industries generate innovation to a moderate extent in response to environmental regulation expected to be introduced in the future. While 42% responded that the industry does innovation to a large extent.
- ***ER6:*** In response to the availability of government grants or any other financial incentives provided around 14% of respondents believe that industry introduces no innovation. However, 38% of respondents have an opinion to large extent.

Fig 5. Staus of environmental regulations (ER1-ER6) in industries



(ii) Organization Efforts (OE)

Through policies, procedures, and investments in the development of eco-friendly practices and products, organizations can promote eco-innovation and reduce their environmental impact by giving sustainability and environmental stewardship a high priority. Table 5, describe the questions that were asked during the survey.

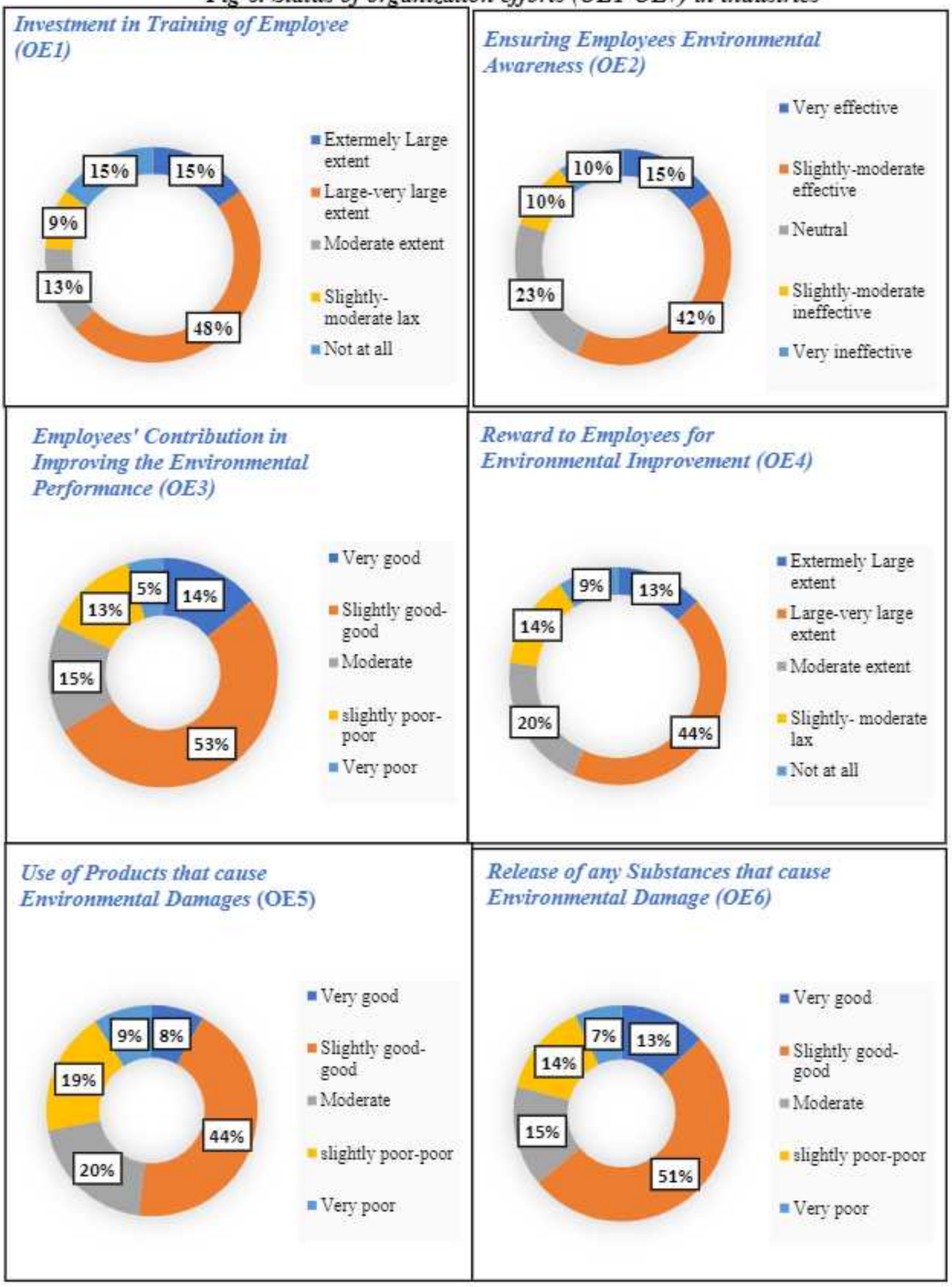
Table 6.Qurries for ranking organization efforts (OE1-OE7) in industries

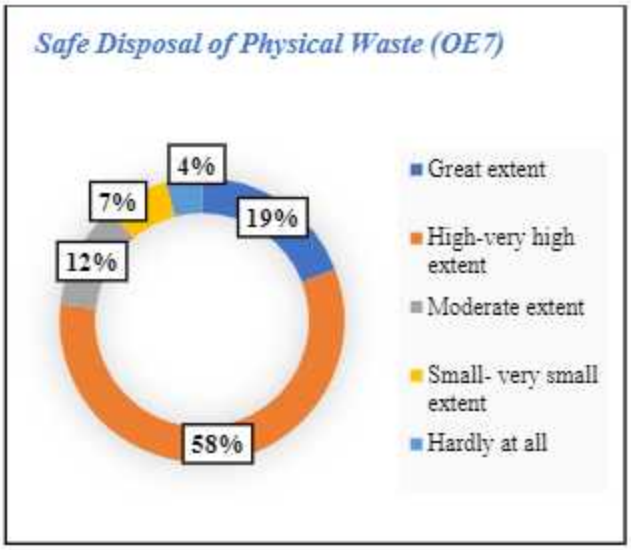
Organizational Efforts (EO)	**OE1:** Investment in environmental training and employee development.
	OE2: Efforts in ensuring employees' environmental awareness.
	OE3: Efforts to assess the role of employees in improving environmental performance.
	OE4: Reward (i.e., promotion and salary increase) to employees for environmental improvement.
	OE5: Efforts to eliminate the use of products that cause environmental damage.
	OE6: Efforts to eliminate the release of any substances that cause environmental damage.
	OE7: Efforts to dispose of physical waste through environmentally safe methods

Findings:

- ***OE1***: 48% respondents said that investment in employee training is at large extent.
- ***OE2***: About 42% respondents believe that there is effective mechanism for ensuring employee awareness and training. 23% remained neutral in response.
- ***OE3:*** About 53% believe that organizations assess their employee contribution to improving environmental performance at a large extent. About 5% responded that organizations made no efforts to access employee contributions.
- ***OE4:*** Many respondents (44%) said that there is large mechanism for ensuring employee awareness and training.
- ***OE5:*** About 44% of respondents think that efforts made by organizations to eliminate the use of products that cause environmental damages are good, while 15% believe that organizations put moderate efforts.
- ***OE6:*** Majority of industries (51%) think that efforts made by organizations to reduce emissions/substances that cause environmental Damage is good, and 15% believe that organizations put moderate efforts.
- ***OE7:*** Most respondents (about 58%) believe that organizations' efforts to dispose of the waste in an environmentally safe manner are to a great extent. While only 4% think that organization put no efforts.

Fig 6. Status of organization efforts (OE1-OE7) in industries





(iii) Organizational Collaboration (OC)

Organizational Collaboration (OC) includes partnerships between companies in the same industry to share resources and expertise and collaborations with research institutions. Table 7 briefly describes the questions related to organizational collaboration.

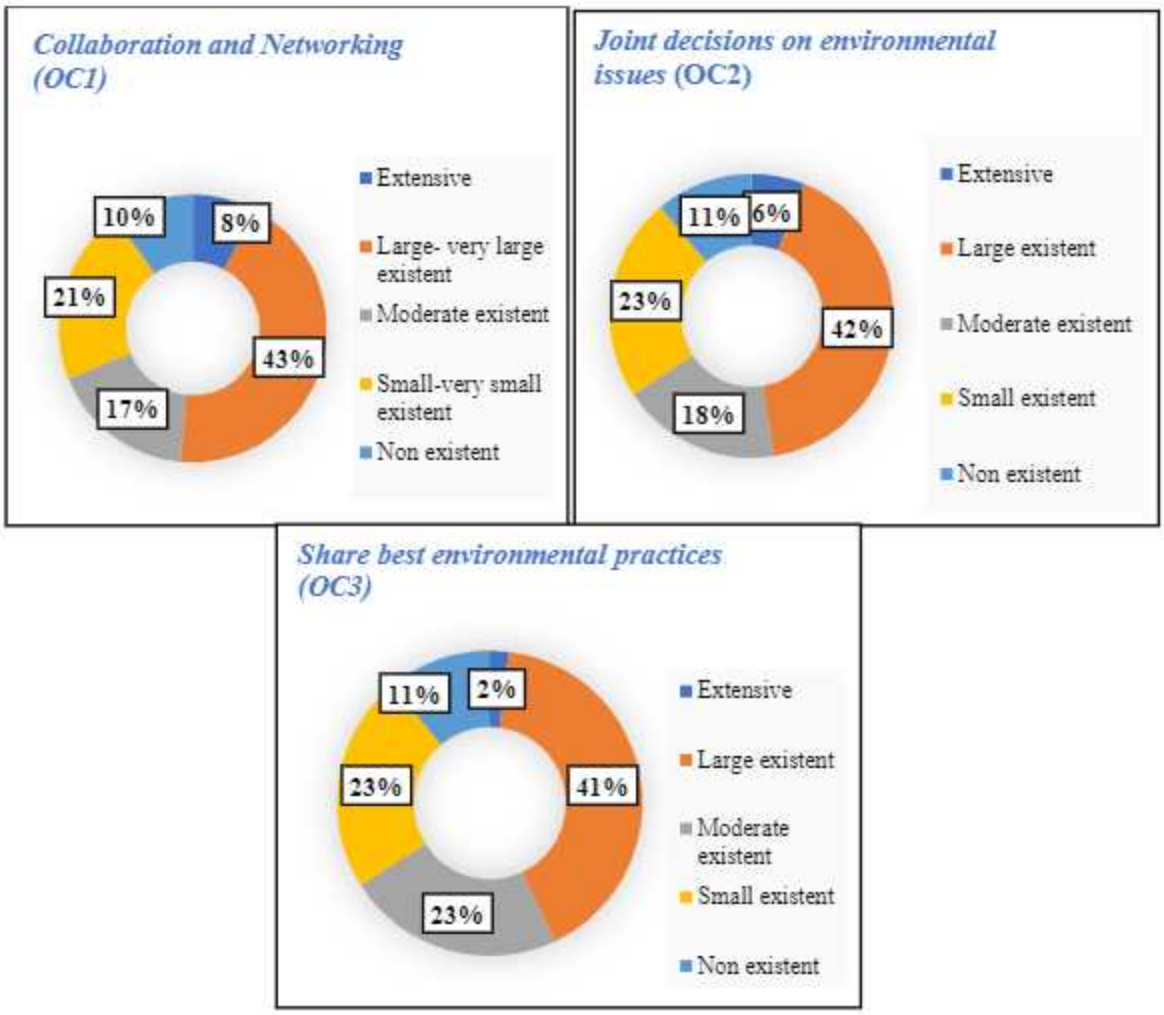
Table 7. Quarries for ranking Organizational Collaboration (OC1-OC3) in industries.

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

Findings

- ***OC1:*** 43% respondents believe that they have a high level of partnership and networking to acquire knowledge and expertise on environmental issues. While 10 % responded that there is no existence of collaboration and networking.
- ***OC2:*** 42% responded that they have a higher level of collaboration and networking between industries to make joint decisions regarding environmental issues. Whereas 18% responded that they have a moderate level of collaboration and networking.
- ***OC3:*** 41% think that in industries, sharing information about best environmentally sustainable initiatives is at large extent.

Fig 7. Status of organizational collaboration (OC1-OC3) in industries



(iv) Environmental Management System (EMS)

An Environmental Management System (EMS) provides a framework for organizations to identify and manage their environmental impacts systematically. An EMS can also help organizations monitor and measure their environmental performance, providing valuable data that can be used to identify areas where eco-innovation is needed. Table 9 briefly describes the questions related to EMS.

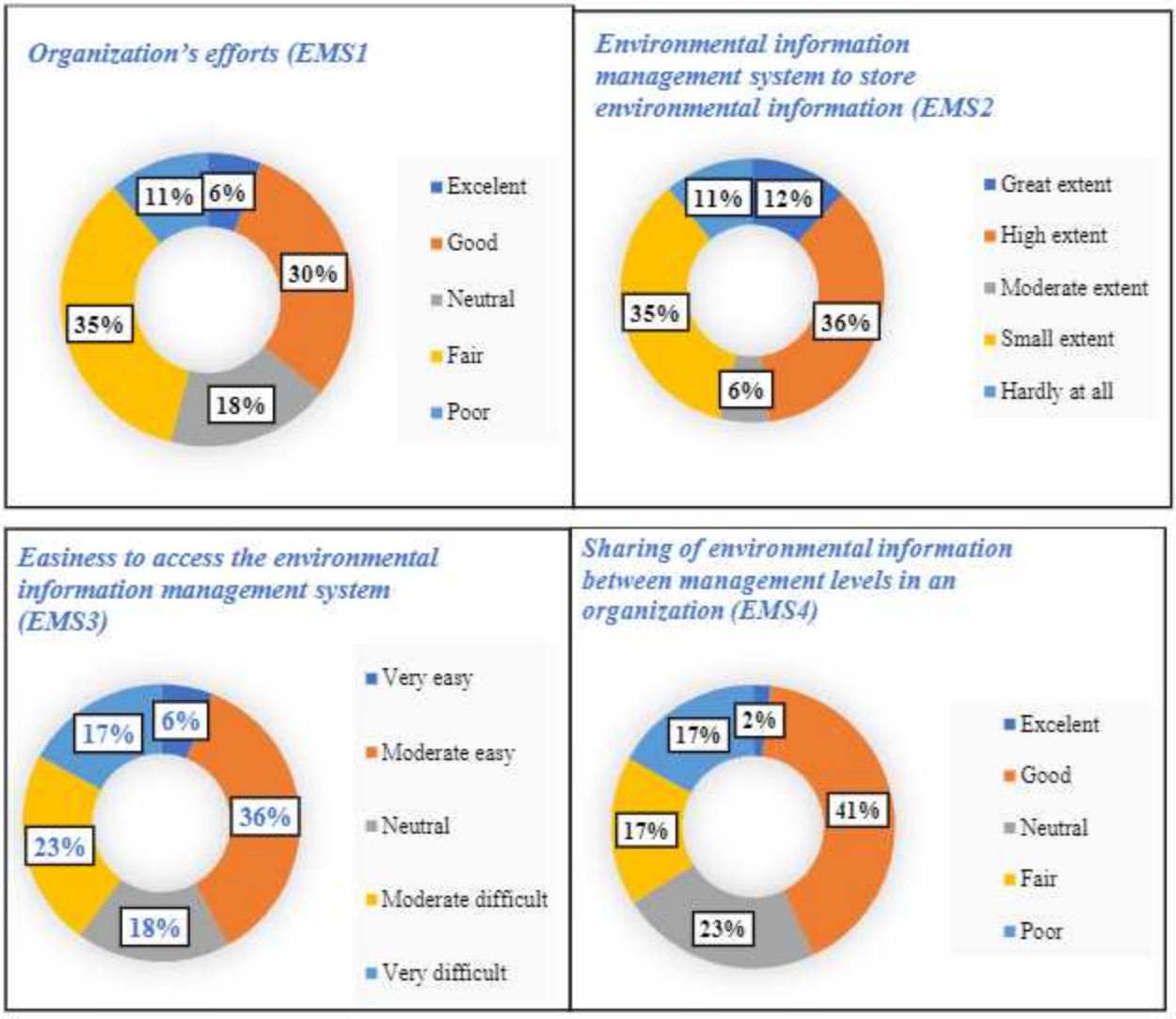
Table 9. Quarries for ranking Environmental Management System (EMS1-EMS4) in industries.

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

Findings:

- **EMS1**: About 30% responded that the EMS system existed at a higher level.
- **EMS2**: About 36% believe that organizations continuously update their environmental information at a high level. About 6% responded as neutral while answering this question.
- **EMS3**: 36% responded that access to environmental information management (MIS) is slightly easy to access environmental information in the industry.
- **EMS4**: 41% think the flow of environmental information between the managers within the industry is satisfactory (good) quality.

Fig 8. Status of environmental management system (EMS1-EMS4) in industries



(v) Customer's Pressure

With the increasing demand for sustainable products, industries may be motivated to invest in research and development to create new eco-friendly products and services. It can lead to the development of new technologies and manufacturing processes that are more sustainable. The questions regarding customer pressure are given in table 10.

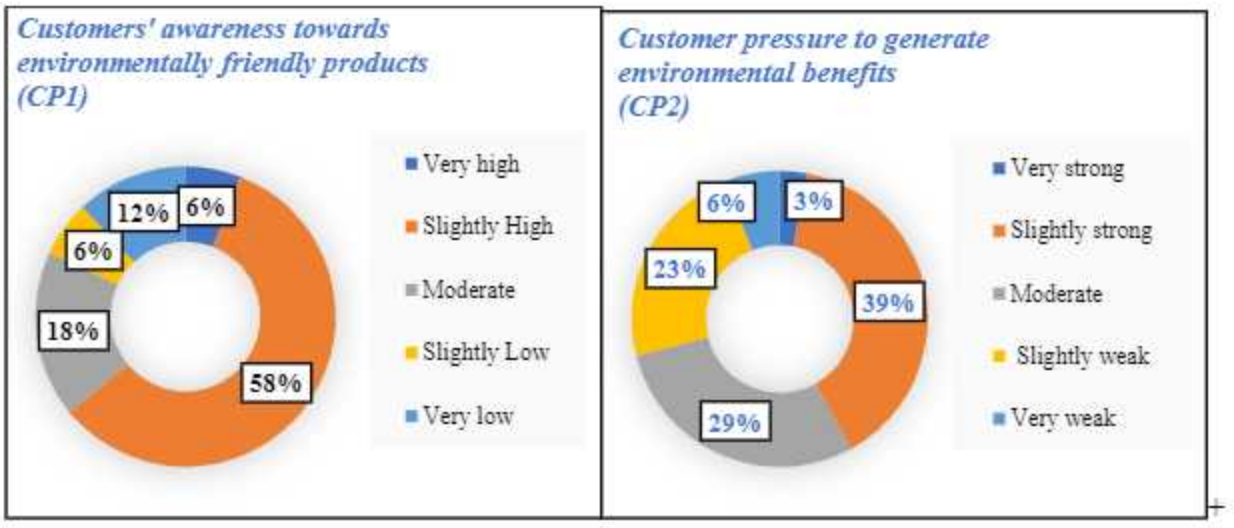
Table 10. Quarries for ranking customer pressure (CP1-CP4) in industries.

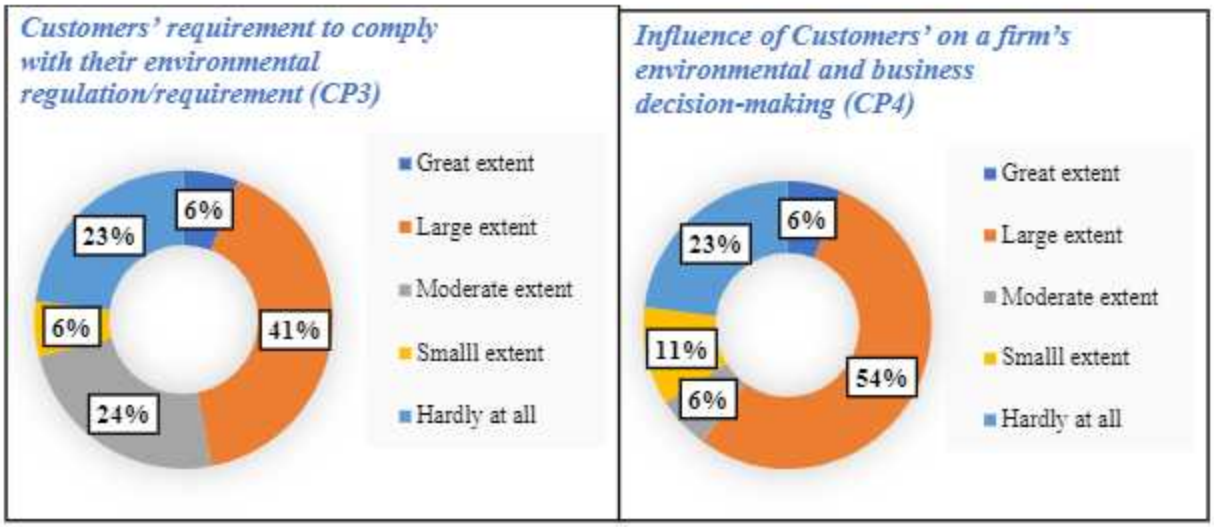
Customer's Pressure (CP)	**CP1:** Customers' awareness towards environmentally friendly products.
	CP2: Customer pressure to generate environmental benefits.
	CP3: Customers' requirement to fulfill their environmental regulations/standards (for example, ISO14001, REACH, RoHS, chemical labeling, and others).
	CP4: Influence of Customers' environmental regulations on a firm's environmental and business decision-making

Findings:

- *CP1*: About 58% responded that customers' awareness towards environmentally friendly products is at slightly high level. However, 12% of respondents rate the customers' attention about sustainable products in the organizations in the range of low to slightly low.
- *CP2*: Many responded (39%) with a view of high stemming from customers. However, 29% responded customers' pressure as a driving force for the industry to generate environmental benefits is moderate.
- *CP3*: About 41% have the opinion customer requirement to comply with their environmental regulations and procedures is, to a slightly high extent.
- *CP4*: 54%think customers' environmental regulations greatly influence industry decision-making, whereas 11% responded that customers' influence on decision-making is small.

Fig 10. Status of customer's pressure (CP1-CP4) in industries





(vi) Cost barrier

Cost can be a barrier to eco-innovation, as implementing sustainable practices and developing new eco-friendly products and services can be costly. The cost of research and development, as well as the cost of new equipment and technology, can be a significant barrier to eco-innovation. Table 11 shows the quarries related to the cost barrier.

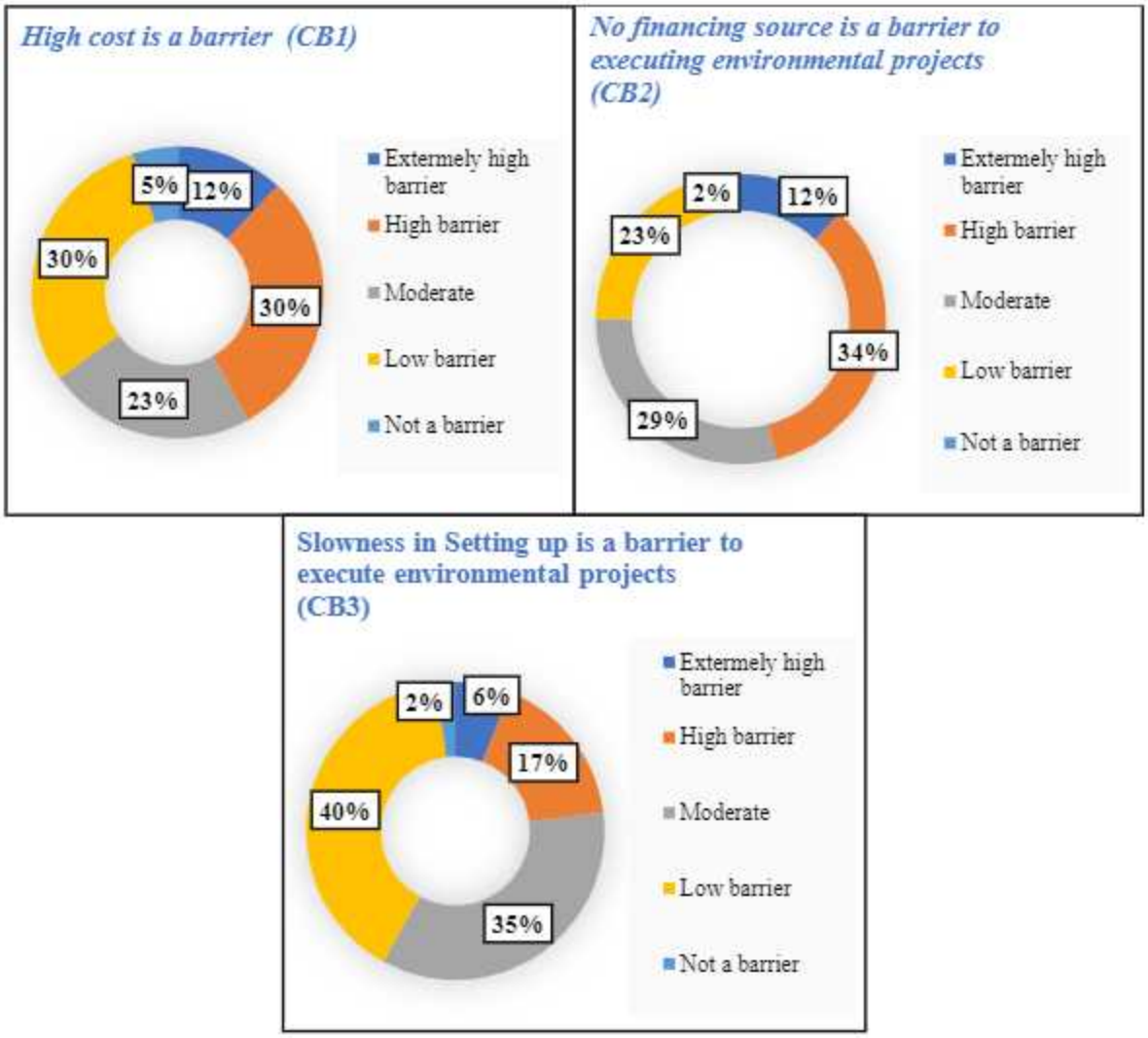
Table 11. Quarries for ranking customer barrier (CB1-CB3) in industries.

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.

Findings:

- ***CB1***: About 30% respondents believe that high cost is a barrier for industries to introduce innovations. While 5% thought the financing source was not a barrier.
- ***CB2***: 34% responded that the cost to execute environmental projects is an extremely high barrier.
- ***CB3***: 35% have similar opinions that it is a moderate barrier. Whereas 2% responded think it is a not a barrier.

Fig 11. Status of cost barrier (CB1-CB3) in industries



IDENTIFICATION OF ECO-INNOVATION OPTION

The chemical & pharmaceutical sector is one of the diverse sectors in Pakistan. The identified eco-innovation options for the chemical & pharmaceutical sector are given in table 12, as the visits and focus group meeting are planned in the upcoming month.

Table 12. 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 [6]	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 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 [7]	• Instead of a single punch, its shifts to a triple punch for a more compact and compressed tablet form. • With 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 [8]	• 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 NOx, 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 [9], Minutes of meeting, Focus group meeting, Food sector, [10]	• 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.

Conclusion

In conclusion, the survey analysis suggests that industries in Pakistan have made significant progress towards cleaner processes and pollution control eco-innovation, with over 60% adopting such practices. However, the adoption of green energy technologies remains low, with only 18% of industries using it. On the other hand, product eco-innovation has been widely adopted, with over 50% of industries responding positively. The responses suggest that industries in Pakistan are becoming more environmentally conscious and committed, although more work is required to fully transition to green energy technologies. Additionally, export-oriented industries, such as chemical and pharmaceuticals, have implemented formal environmental management systems to meet the demands of their customers. However, the majority of industries in Pakistan have a neutral attitude towards environmental regulation, and the high cost of eco-innovation choices poses a significant obstacle. Furthermore, the lack of collaboration between different organizations and research institutions hampers the feasibility of eco-innovation. Therefore, increased collaboration and coordination among different stakeholders are necessary to promote sustainable development practices in Pakistan's industries.

References

1. State Bank of Pakistan. (2016). The State of Pakistan's Economy.
2. Nadeem, A., Ali, R. U., Zayyab, M., & Tayyab, M. (2019). Chem PetroChem Pakistan: Chemical is 4th Largest and 3 rd Fastest Growing Sector in International Trade Transforming Chemical Industry. *Pakistan Chemical Menufactruing Association*, Retrieved from https://pcma.org.pk/documents/PCMA_mag_December_2019_Final.pdf
3. Ministry of Finance. (2022). Pakistan Economic Survey (2020-2021). Retrieved June 3, 2022, from https://www.finance.gov.pk/survey
4. Pakistan Bureau of Statistics. (2022). Pakistan Bureau of Statistics. Retrieved September 14, 2022, from https://www.pbs.gov.pk/
5. Keshminder, J. S., & Chandran, V. G. R. (2017). Eco-innovation in the chemical manufacturing firms: Insights for policy response. *Institutions and Economies*, *9*(1), 21–42.
6. Yaqub, G., Hamid, A., & Iqbal, S. (2012). Pollutants generated from pharmaceutical processes and microwave assisted synthesis as possible solution for their reduction - A mini review. *Nature Environment and Pollution Technology*, *11*(1), 29–36.
7. Hindiyeh, M., Altalafha, T., Al-Naerat, M., Saidan, H., Al-Salaymeh, A., Sbeinati, L., & Saidan, M. N. (2018). Process Modification of Pharmaceutical Tablet Manufacturing Operations: An Eco-Efficiency Approach. *Processes 2018, Vol. 6, Page 15*, *6*(2), 15. https://doi.org/10.3390/PR6020015
8. European Commission. (2008). *Best Available Techniques-Speciality inorganic chemicals*. https://doi.org/10.1039/9781847557841-00290
9. Thomas Jakl, & Schwager, P. (2008). *Chemical Leasing Goes Global*. *SpringerWien NewYork* (Vol. 4).
10. Ahmed, Z., Kumar, S., Ali, B., Mahar, R. B., Ahmed, N., & Asmatullah. (2022). *Minutes of meeting, Focus Group- Food Sector*

Project Team

Prof. Dr. Zubair Ahmed
Principal Investigator

Dr. Naveed Ahmed
Co-Principal Investigator

Prof. Dr. Rasool Bux Mahar
Co-Principal Investigator

Dr. Asmatullah
Policy Maker

Dr. Tanveer Ahmed Gadhi
Technical Expert

Mr. Suresh Kumar
Research Assistant

Mr. Bahadur Ali
Research Assistant

Ms. Ghazala Akber Jamali
PhD Scholar

Mr. Satesh Kumar
Research Assistant

Mr. Sajjad A. Memon
MS Scholar

Mr. Adeel Ahmed
MS Scholar

Ms. Kanwal Asandas
MS Scholar

The proposed research aims to develop a policy framework for adopting the eco-innovation approach. The objectives of the research are:

(1) To examine existing environmental measures in major industrial sectors.

(2) To develop new eco-innovation options.

(3) To develop a plan for the management of underlying factors creating challenges in the adoption of eco-innovation strategies.

Contact:

U.S.-Pakistan Centers for Advanced Studies in Water
Mehran University of Engineering and Technology, Jamshoro-76062, Sindh - Pakistan

+92 334 3833220, +92 333 3666427, +92 313 306290

http://water.muet.edu.pk/research/cpec-eco/

https://www.facebook.com/ECOINNOVATION.PK

zahmed.uspcasw@faculty.muet.edu.pk