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

Steel 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 Steel Sector.
- Drivers of Eco-Innovation
- Identification of Eco-Innovation options

Summary of findings

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

(2) It is observed from the survey data that most of the industries adopted process technology eco-innovation, especially cleaning technologies for pollution reduction.

(3) More than 80% of the responded industries said they had improved their production process to reduce pollution and effectively utilize resources.

(4) Above 70% of industries introduced green energy options, such as solar power plants.

(5) More than 65% of industries have responded positively to product emissions and energy efficiency questions.

(6) More than 65% of industries responded that they had adopted organization eco-innovations within their industries.

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 steel industry is essential for economic growth and development in many nations, including Pakistan, as it provides raw materials to a number of industries, including transportation, machinery, energy, and home appliances. It also creates jobs and generates income for the government through taxes and exports. The full value chain of the sector includes pig iron furnaces and end-user industries. Despite this, Pakistan's steel sector is mostly made up of tiny facilities that use antiquated technology, which results in low productivity and efficiency when compared to nations that export steel. In addition, using outdated technology leads to excessive manufacturing costs, subpar output, and inconsistent output standards. To increase productivity and competitiveness, the sector must thus modernize and improve its technologies.

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.

Major clusters of steel industry

There are about 2,718 steel industries in Pakistan deals with various steel products. The below table 1 provide total number of iron & steel industries in Pakistan. Most of the Pakistan's steel industries (2,356 units) are located in Punjab province, while there are 179 steel industries in Sindh province. Most of the steel industries in Pakistan are manufacturing basic iron and steel products.

Table 1. Provincial Breakdown of Steel Industries in Pakistan

Industry Type	Number of Industries					
	Punjab	Sindh	KPK	Baluchistan	Islamabad	Total
Basic iron & steel Products	454	109	40	30	29	662
Basic precious & non-ferrous metals	92	13	1	0	2	108
Casting industries	168	4	0	0	1	173
Fabricated metal products	1,642	53	60	6	14	1,775
Total	**2,356**	**179**	**101**	**36**	**46**	**2,718**

Source: (Pakistan Bureau of Statistics, 2016)

Furthermore, steel sector of Pakistan (consisting of top 20 players) makes up 80% of the total market [1]. Pakistan Steel Mills is the largest steel producer in the country, and it plays a significant role in the industry. Other major players include Amreli, Agha, Mughal, Frontier Foundry Steel, Razzaque, Bilal, and Aitmad Steels. These companies are involved in various aspects of the steel production process, including iron and steel making, melting, re-rolling, and fabricating. The GPS Location of major steel industries in Pakistan are shown in fig 1.

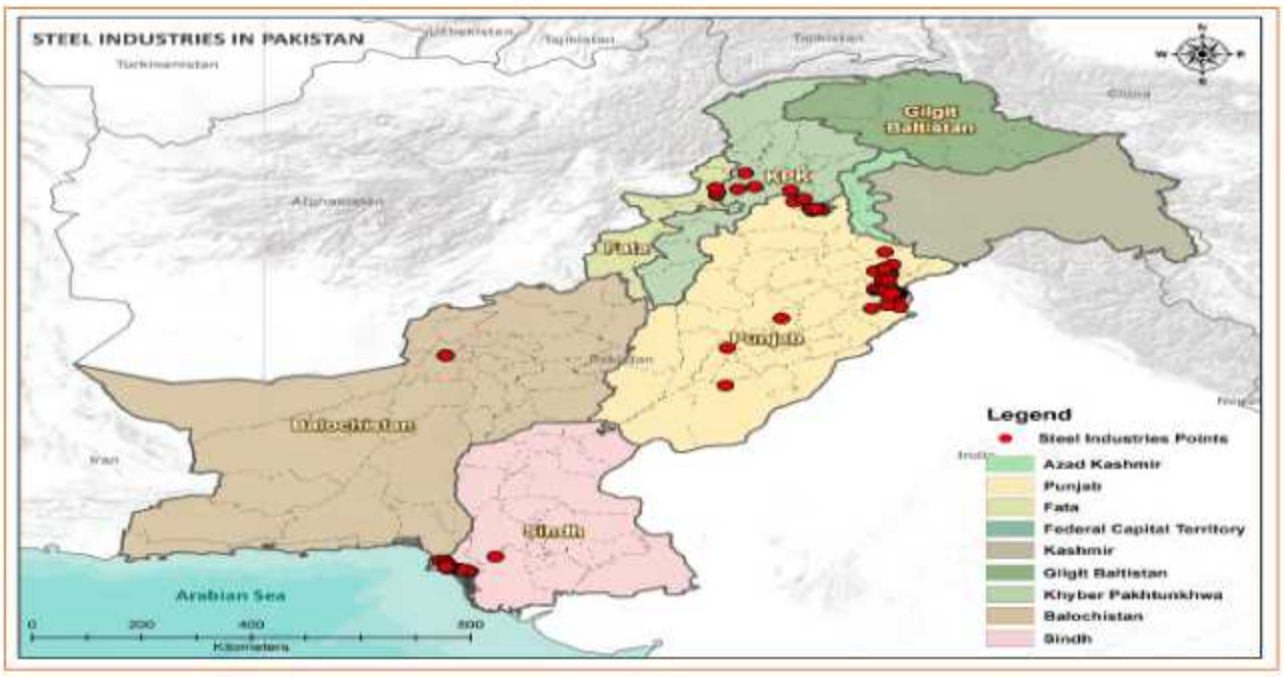


Fig 1. GIS Location Map of Steel Industries Pakistan

Approach and method

A thorough industrial survey was conducted to determine the present state of the Eco-innovation approach, comprehension, and adaptation in the current textile sector. A total of 150 industries were contacted, and 13 industries responded. Among them 5 were from large scale, 7 from medium scale, and 1 from small-scale industries.

A mixed data collection method was employed:

- ***Interviews*** with industries managers, environmental representatives, and owners (fig 2,3)
- Focused group meetings (***FGM***) and
- Questionnaire survey (***both online and in-person).***
- The assessment framework comprises three main elements [2] 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)***

Fig 2. Interview with Agha Steel Industry

Fig 3. Interview with Amreli Steel Industry

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).

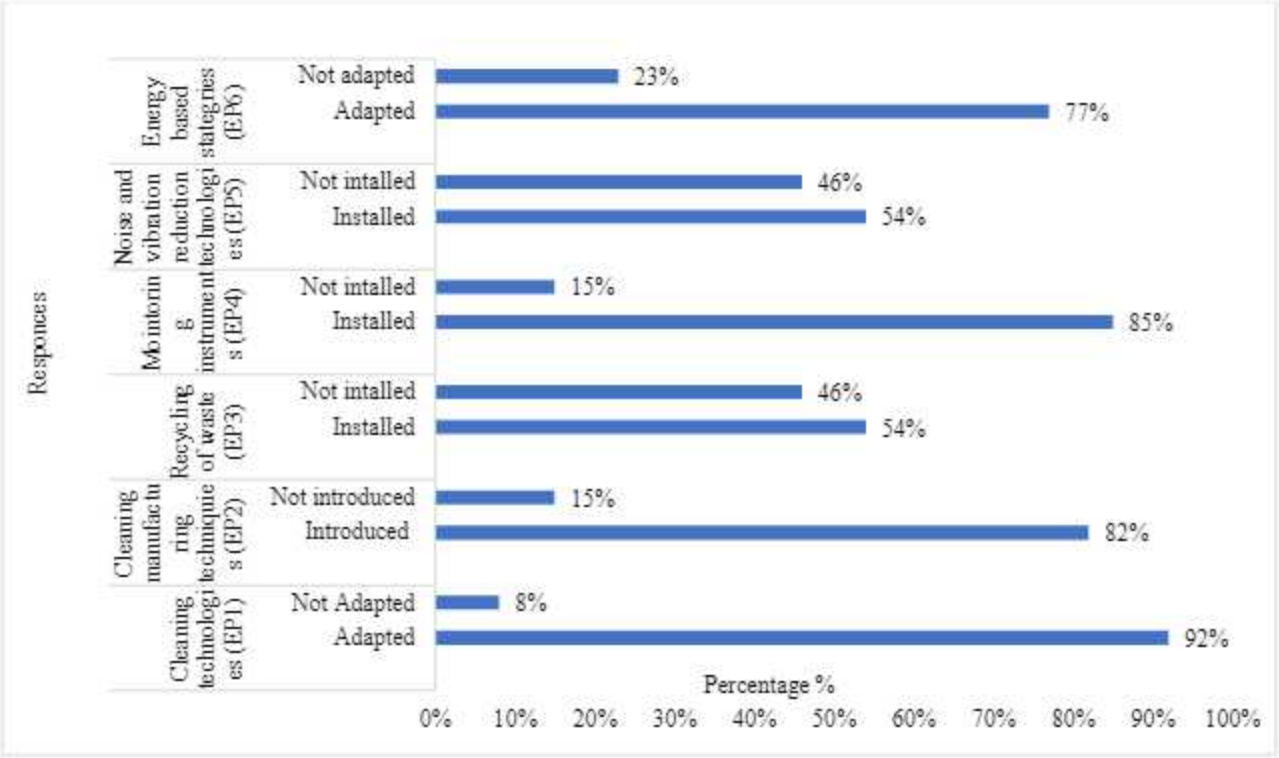
Table 2: Quarries for ranking the process technology innovation (EP).

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

- It is observed from the survey data that most of the steel industries have adopted process technology eco-innovation, especially cleaning technologies for pollution reduction.
- More than 80% of the responded industries said they had improved their production process to reduce pollution and effectively utilize resources.
- Moreover, above 70% of industries introduced green energy options, such as solar power plants.

Fig 4. State of Process technology innovation (EP1-EP6) in industries



(ii) Product technology innovation

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).

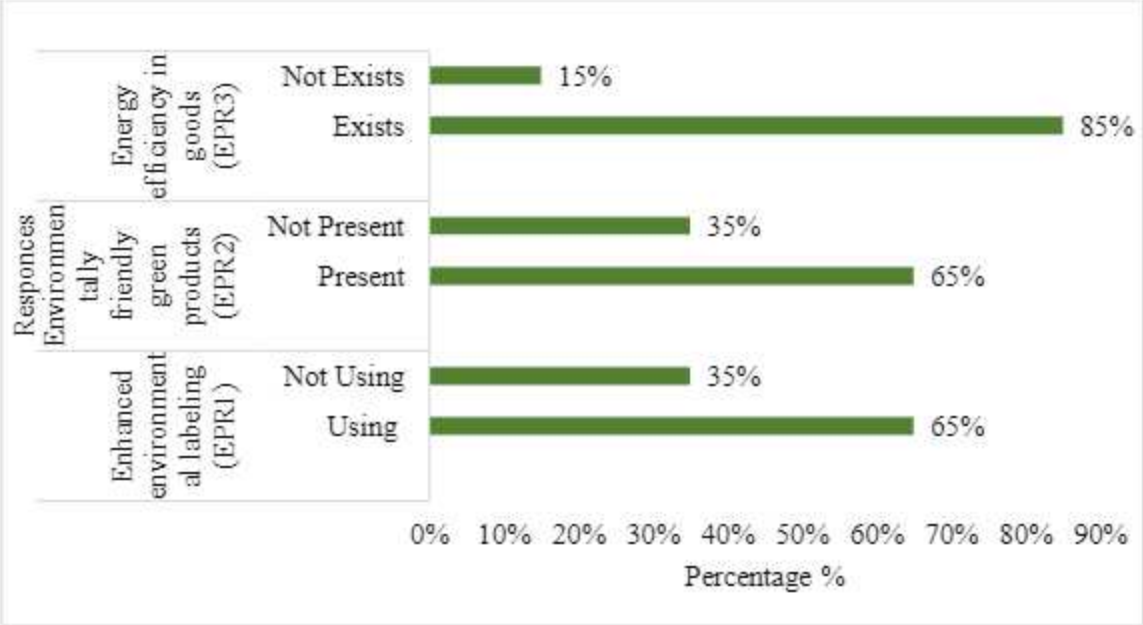
Table 3. Quarries for ranking the product technology innovation (EPR).

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

Findings:

- Steel industries' product quality, emission levels, and energy consumption widely depend on the raw material and production process.
- The survey results (fig 5) show that more than 65% of industries have responded positively to product emissions and energy efficiency questions.

Fig 5. State of product eco-innovation (EPR1-EPR3) in industries



(iii) Organizational Eco-innovation

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

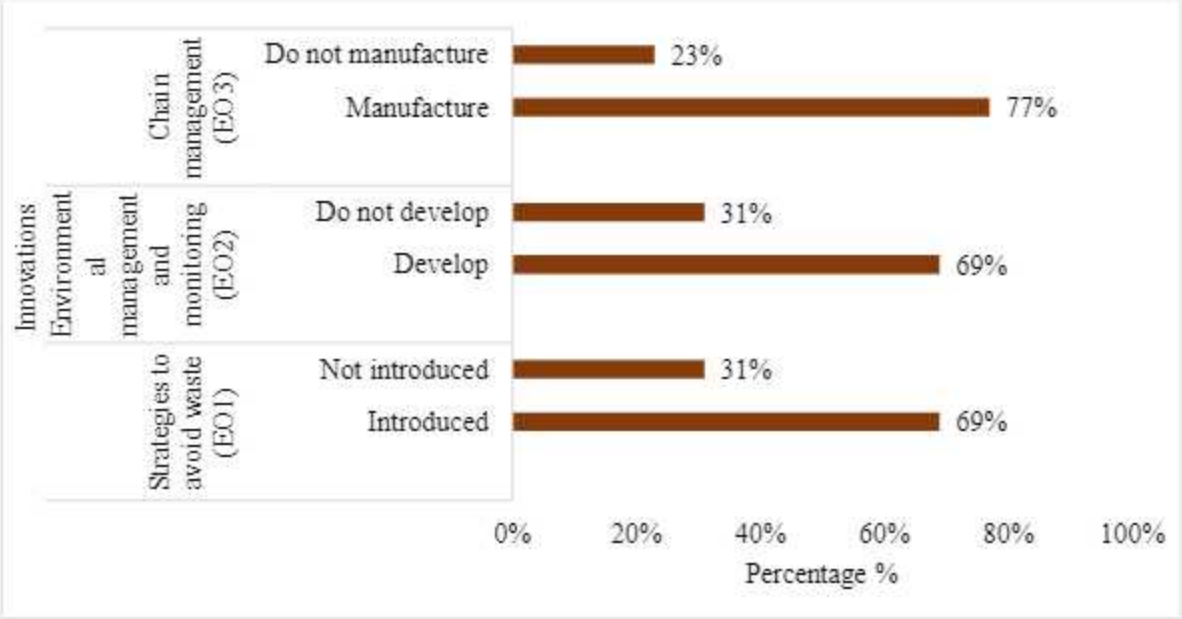
Table 4. Quarries for ranking the product technology innovation (EO)

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:

- According to their industries, organizational innovation is essential to improving environmental performance.
- Environmental management and pollution prevention systems let industries combine all their efforts, assets, and skills to address environmental issues.
- More than 65% of industries responded that they had adopted organization eco-innovations within their industries.

Fig 6. State of organizational eco-innovation (EO1-EO3) in industries



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).

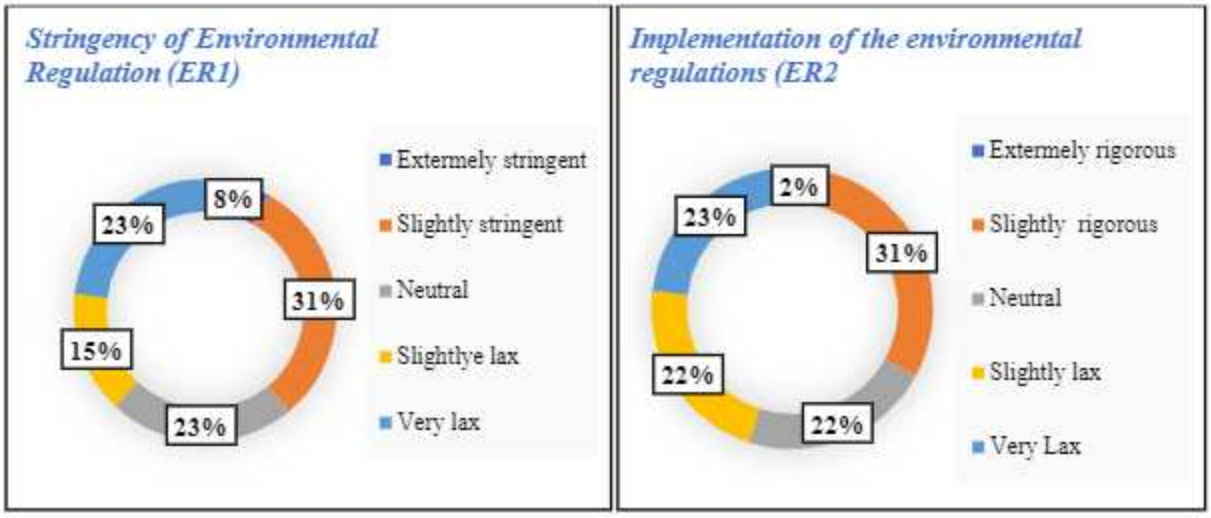
Table 5. Quarries for ranking environmental regulations in industries (ER)

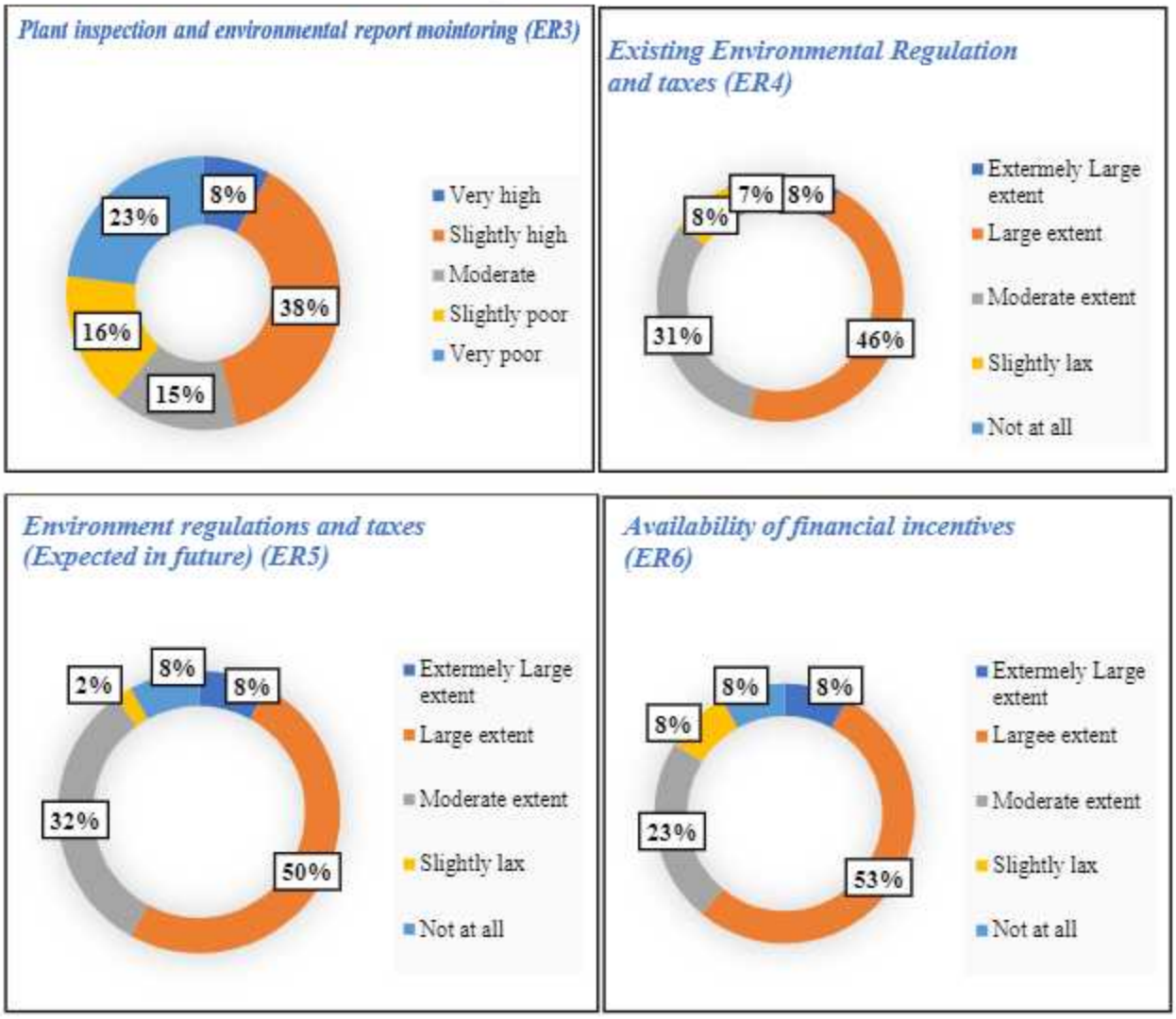
Environmental Regulations (ER)	**ER1**: Stringency of the environmental regulations
	ER2: Environmental regulations implementation
	ER3: Level of monitoring by the regulatory authority through audits and reporting
	ER4: Environmental benefits in response to existing environmental regulations or taxes 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 23% responded think that environmental regulations are relaxed. 23% remain neutral. The reason of being neutral is, perhaps, reluctance due to 'unknown' fear from monitoring authority and 31% of them expressed that the environmental regulations are slightly stringent.
- ***ER2***: Majority of industries (31%) think that implementation of environmental regulations is slightly rigorous.
- ***ER3:*** About 38% industries responded that level of monitoring by the regulatory authority through audits and reporting is high.
- ***ER4:*** 46% of respondents think that organizations do innovation in response to environmental regulation and taxes are to a very large extent.
- ***ER5:*** About 50% believe that industries generate innovation to a large extent in response to environmental regulation expected to be introduced in the future. While 32% responded that the industry does innovation to a moderate extent.
- ***ER6:*** In response to the availability of government grants or any other financial incentives provided around 8% of respondents believe that industry introduces no innovation. However, 53% of respondents have an opinion to a large extent.

Fig 7. Staus of environmental regulations (ER1-ER6) in industries





(ii) Organization Efforts

Through policies, procedures, and investments in the development of eco-friendly practises and products, organisations can promote eco-innovation and reduce their environmental impact by giving sustainability and environmental stewardship a high priority. Table 6, describes the questions that were asked during the survey.

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

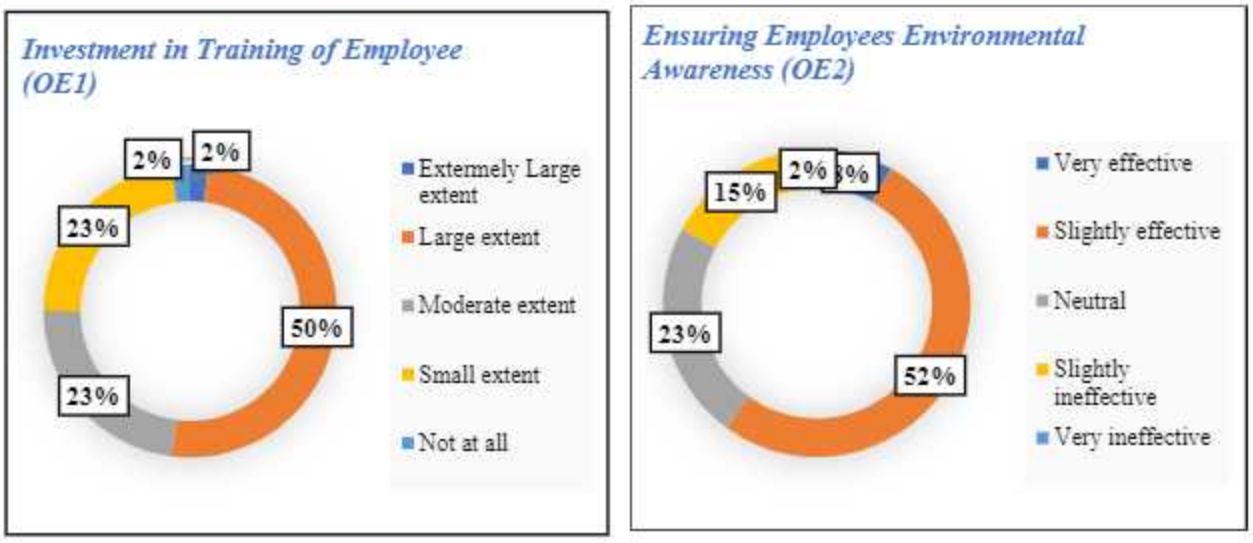
Organizational Efforts (EO)	**OE1:** Investment in environmental training and employee development.
	OE2: Efforts in ensuring employees' environmental awareness.
	OE3: Efforts to assess the role of employees in improving environmental performance.
	OE4: Reward (i.e., promotion and salary increase) to 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

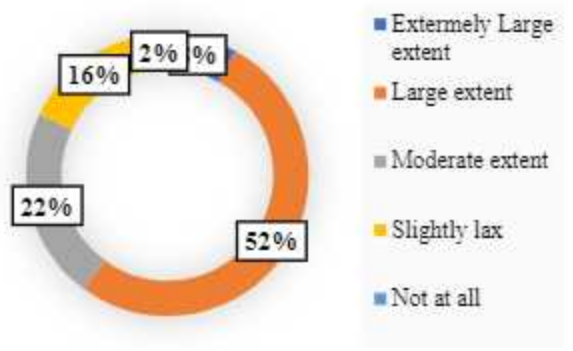
Findings:

- ***OE1***: 50% respondents said that investment in employee training is at large extent.
- ***OE2***: About 52% respondents believe that there is slightly effective mechanism for ensuring employee awareness and training. 23% remained neutral in response.
- ***OE3:*** About 52% believe that organizations assess their employee contribution to improving environmental performance at an extremely large extent. Only 2% responded that organizations made no efforts to access employee contributions.
- ***OE4:*** Many respondents (53%) said that there is large mechanism for ensuring employee awareness and training.
- ***OE5:*** About 79% of respondents think that efforts made by organizations to eliminate the use of products that cause environmental damages are good, while 8% believe that organizations put small efforts.
- ***OE6:*** Majority of industries (72%) think that efforts made by organizations to reduce emissions/substances that cause environmental Damage is slightly good, and 9% believe that organizations put moderate efforts.
- ***OE7:*** Most respondents (about 72%) believe that organizations' efforts to dispose of the waste in an environmentally safe manner are to a high extent. While only 2% think that organization put no efforts.

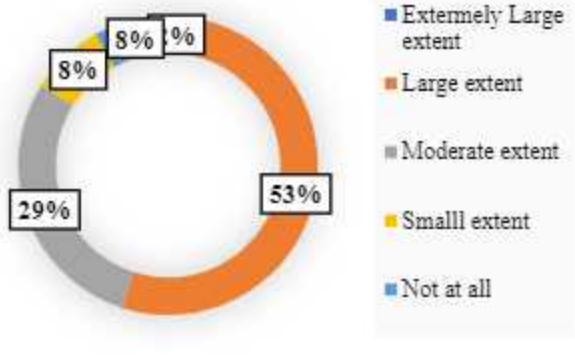
Fig 8. Status of organization efforts (OE1-OE7) in industries



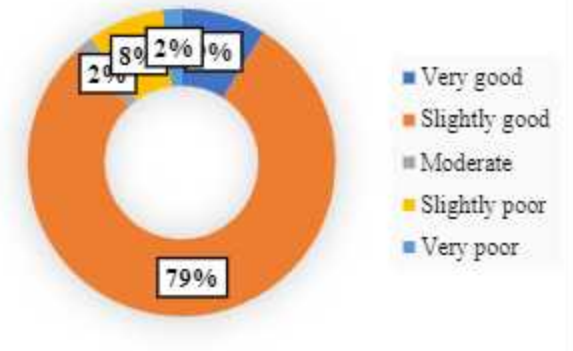
Employees' Contribution in Improving the Environmental Performance (OE3)



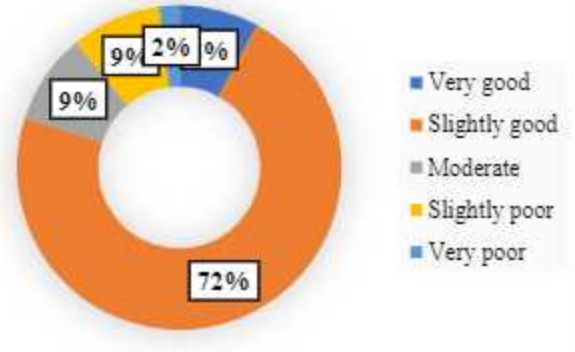
Reward to Employees for Environmental Improvement (OE4)



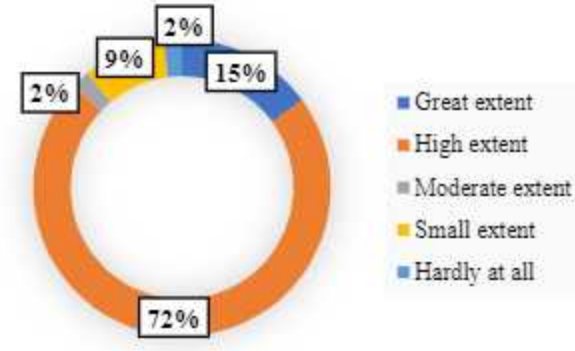
Use of Products that cause Environmental Damages (OE5)



Release of any Substances that cause Environmental Damage (OE6)



Safe Disposal of Physical Waste (OE7)



(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 describe the questions related to organizational collaboration.

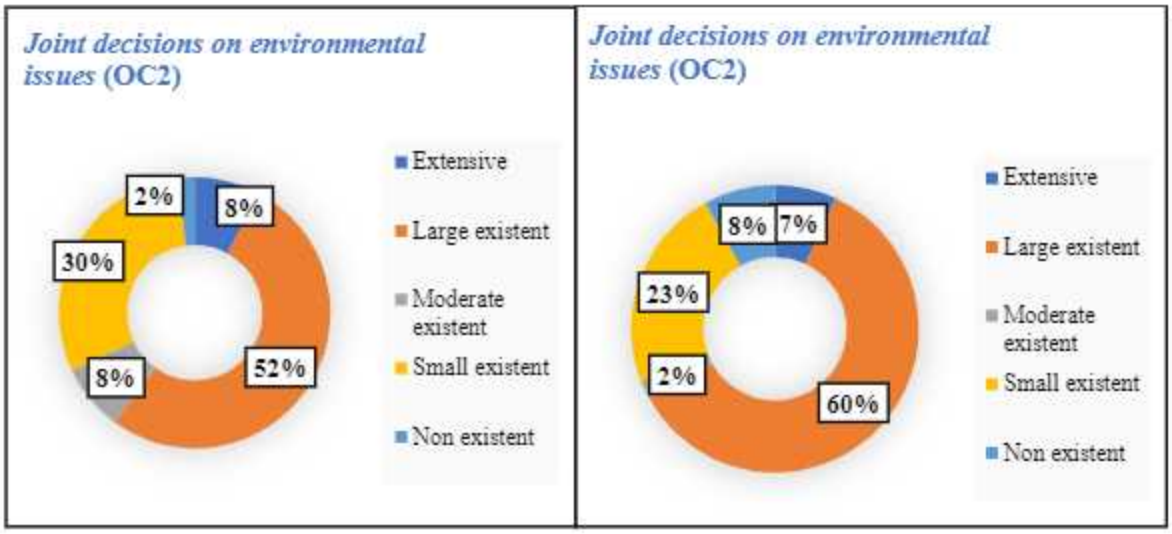
Table 7. Quarries for ranking Organizational Collaboration (OC1-OC3) in industries.

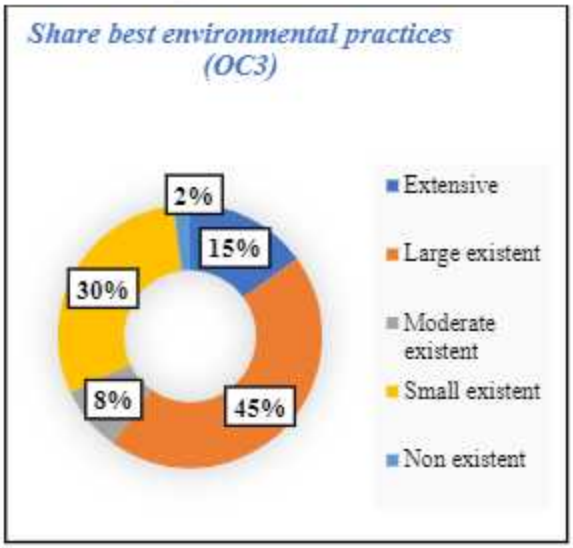
Organizational Collaboration (OC)	**OC1**: Knowledge/ information/ expertise related to environmental issues acquired through collaboration and networking (among groups, firms, suppliers, partners, and associations).
	OC2: Collaboration and networking to make joint decisions on environmental issues.
	OC3: Collaboration and networking to share best environmental practices

Findings

- ***OC1:*** 52% respondents believe that they have a high level of partnership and networking to acquire knowledge and expertise on environmental issues. While only 2% responded that there is no existence of collaboration and networking.
- ***OC2:*** 60% responded that they have a higher level of collaboration and networking between industries to make joint decisions regarding environmental issues. Whereas 23% responded that they have a small level of collaboration and networking.
- ***OC3:*** 45% think that in industries, sharing information about best environmentally sustainable initiatives is at large extent.

Fig 9. 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 8 briefly describe the questions related EMS.

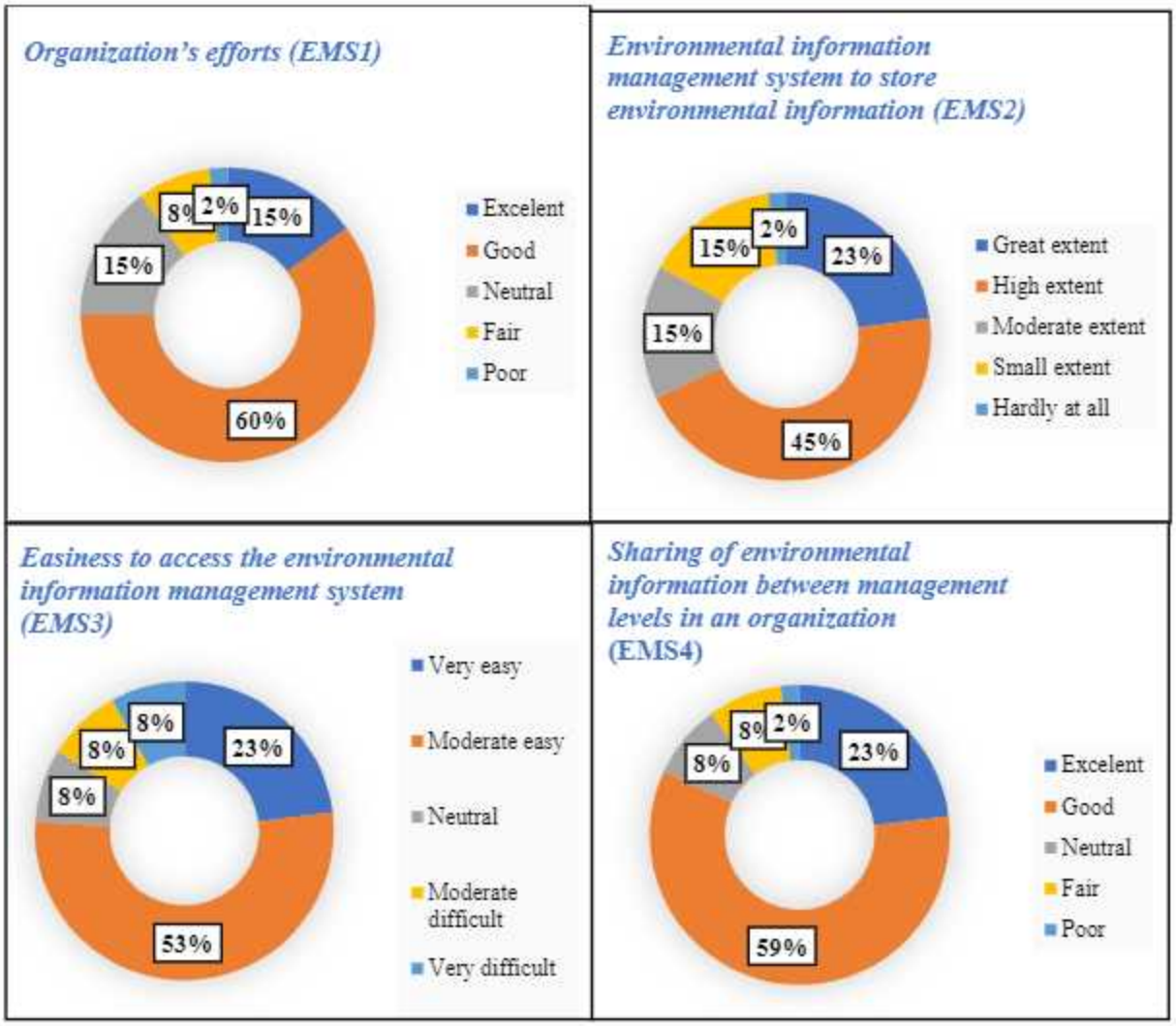
Table 8. Quarries for ranking Environmental Management System (EMS1-EMS4) in industries.

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 60% responded that the EMS system existed at a higher level.
- **EMS2**: About 45% believe that organizations continuously update their environmental information at a high level. About 15% responded as neutral while answering this question.
- **EMS3**: 53% responded that access to environmental information management (MIS) is moderate easy to access environmental information in the industry.
- **EMS4**: 59% think the flow of environmental information between the managers within the industry is satisfactory (good to excellent) quality.

Fig 10. 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 9.

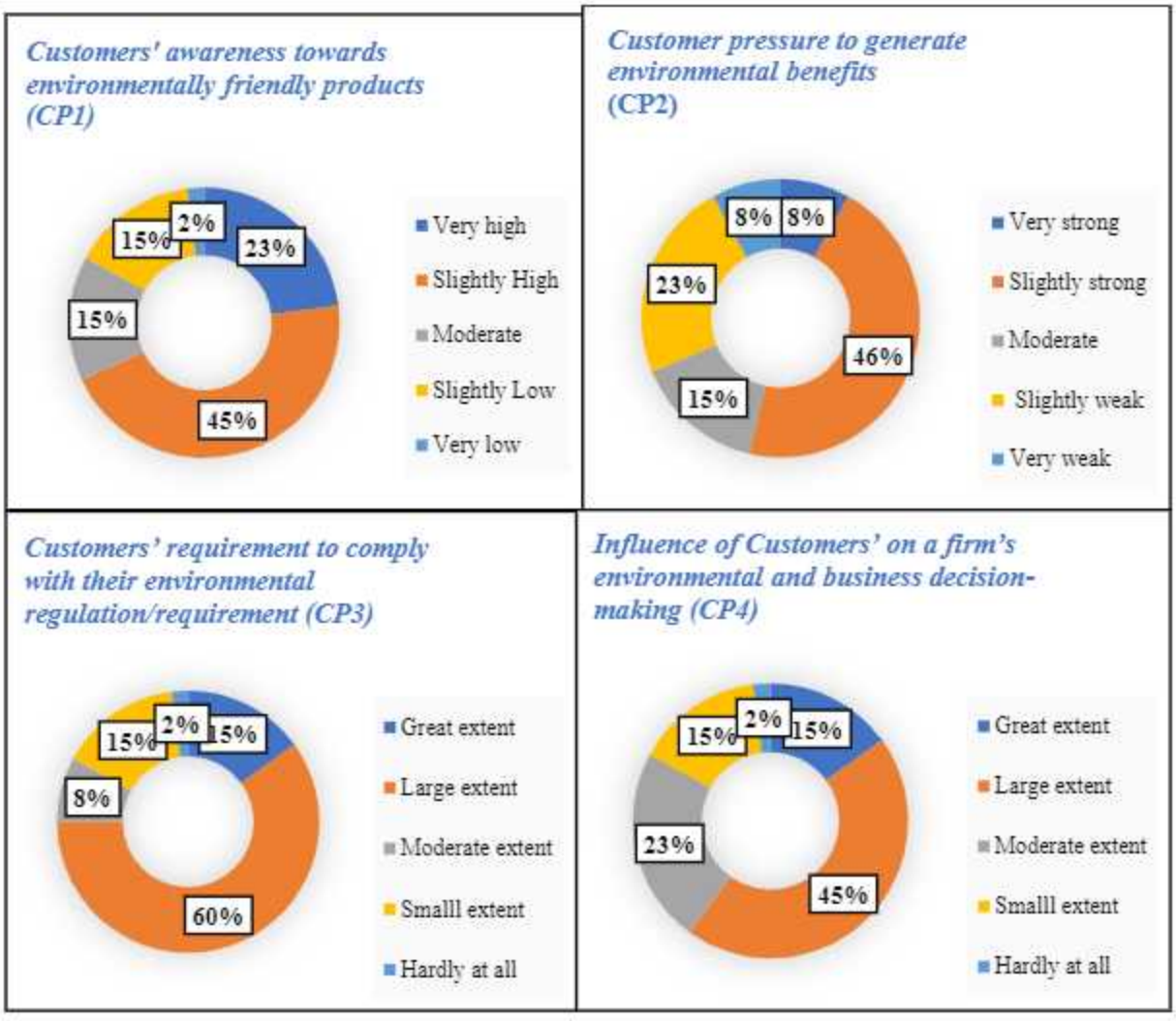
Table 9. Quarries for ranking customer pressure (CP1-CP4) in industries.

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 45% responded that customers' awareness towards environmentally friendly products is at slightly high level. However, 15% of respondents rate the customers' attention about sustainable products in the organizations in the range of low to slightly low.
- ***CP2***: Many responded (46%) with a view of high stemming from customers. However, 15% responded customers' pressure as a driving force for the industry to generate environmental benefits is moderate.
- ***CP3***: About 60% have the opinion customer requirement to comply with their environmental regulations and procedures is, to a high extent.
- ***CP4***: 45% think customers' environmental regulations influence industry decision-making at a high extent, whereas 15% responded that customers' influence on decision-making is small.

Fig 11. 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 10 shows the quarries related to cost barrier.

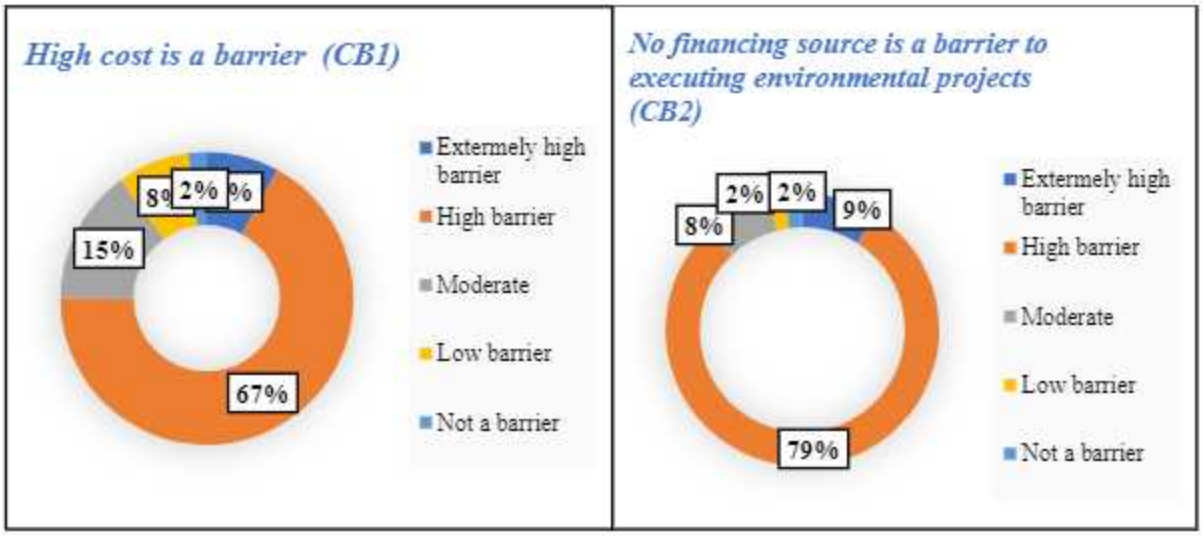
Table 10. Quarries for ranking customer barrier (CB1-CB3) in industries.

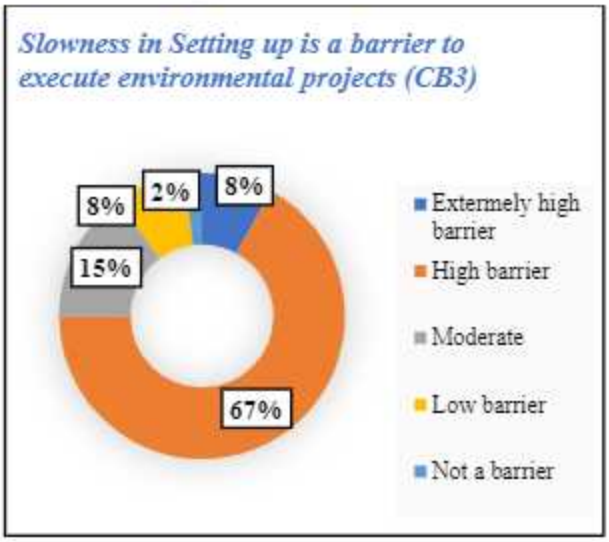
Cost Barrier (CB)	**CB1:** High cost is a barrier to executing environmental projects/activities /innovations.
	CB2: No financing source is a barrier to executing environmental projects/activities/ innovations.
	CB3: Slowness in creating funds is a barrier to initiating environmental projects/activities/innovations.

Findings:

- ***CB1***: About 67% respondents believe that high cost is a barrier for industries to introduce innovations. While only 2% thought the financing source was not a barrier.
- ***CB2***: 79% responded that the high cost to execute environmental projects is high to a high barrier.
- ***CB3***: 67% have similar opinions that it is a high barrier. Whereas 2% responded think it is a not a barrier.

Fig 12. Status of cost barrier (CB1-CB3) in industries





IDENTIFICATION OF ECO-INNOVATION OPTION

The steel sector is engaged in Pakistan to fulfil local needs and export. The steel sector's environmental issues are mostly energy-related and air emissions. The water is used in the steel sector primarily for cooling purposes during casting and re-rolling. The study project team came up with a list of environmental policies that have been established by various industries around the world. During the in-person or online discussions with the experts, the identified environmental measures were closely examined while considering the local circumstances for the steel sector. The identified eco-innovation options were concentrated on industrial activities, including best management practices for resource consumption reduction, recycling/reuse, resource conservation, and minimization of pollutant emissions (zero discharge, etc.), which necessitates a thorough cost-benefit analysis, including payback periods.

Table 11: Eco-Innovation Options for Steel Sector

Steel Industry	
Eco-Innovation options	**Description**
Environmental Issues: Energy	
Use of stack flue gas for secondary power generation	The temperature of stake gas in electric arc furnaces and subsequent re-rolling process remain 700-1100 °C. This hot stack air can be used for steam generation and then secondary power generation
Environmental Issues: Resource conservation	

Recovery of Zinc and Iron from Steel dust technologies [3]	Metal Recovery from SMD Processes **Physical Processes** • These processes include mechanical separation, hydro-cyclone dezincification, and magnetic separation. • Used to separate zinc particles of different sizes, ranging from high to low. • Mostly fine particles of zinc are separated from steel mill dust. • Centrifugal force or gravitational force is used to separate zinc particles of different sizes. • Coarser particles are used again in the steel-making process, and Fine particles are further processed for zinc recovery. • Magnetic dust can be utilized as a raw material for manufacturing iron after magnetic separation. • Low-cost zinc recovery process. • It is a pretreatment method of the hydrometallurgical process. **Hydrometallurgical Process** • This process separated zinc particles of different sizes, ranging from moderate to high. • The acid leaching method is used to recover zinc. • Hydrochloric acid and sulfuric acid are used in the acid-leaching process. • This process has higher efficiency in zinc recovery.
Environmental Issues: Water usage and management	
• **Optimization of water usage** • **Water recovery and utilization** **[4]**	• Water is used in the steel industry, especially for cooling purposes such as cooling the furnace or the continuous caster. • It is also used to clean flue gases in blast furnaces and for descaling in hot rolling mills. • Water can be recycled to produce steam.
Environmental Issues: Solid Waste	
• **Metal Recovery** • **Use in concrete blocks or construction material.** **[5]**	Mainly two types of solid waste are generated: Slag and Steel Dust Which can be further used for resource recovery and other applications.
Environmental Issues: Carbon emission	
• **Carbon Capture and Storage,** • **Carbon Capture and Usage** **[6]**	• The off gas from the furnace contains CO_2, Sulfur dioxide, hydrogen sulfide, oxides of Nitrogen, Particulates matter, plus traces of Volatile Organic Compounds (VOC), dioxins, and furans. • These compounds are toxic and generate air pollution alone or in conjunction with other emissions. • Therefore, carbon capture and storage or carbon capture and usage practices need to be adapted in the steel industries.

Conclusion

The steel industry in Pakistan has adopted eco-innovation and is working towards environmental sustainability. However, the lack of a formal environmental management system needs to be addressed to expand its export potential. The focus is on Process Technology and Product eco-innovations, but the traditional production process used by most steel industries in Pakistan is still an issue. Taking environmental initiatives requires a high initial capital cost, which poses a challenge for small-scale producers. Most steel industries in Pakistan have a neutral opinion on environmental regulation and view environmental activities as a means to fulfill buyer requirements. The high cost of eco-innovation options poses a significant barrier, and there is a lack of collaboration between individual organizations and research institutes. As a result, there is a lack of research and development activities and a lack of viability for eco-innovation in the country.

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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

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zahmed.uspcasw@faculty.muet.edu.pk