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Environmental Impact Assessment (EIA) of CPEC road project by following EIA index approach for sustainability

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ABSTRACT

Environmental impact assessment (EIA) is a framework to provide all the socioeconomic and environmental impacts of mega projects for sustainability. Section 12 of Pakistan Environmental Protection Act (PEPA) 1997 regulates EIA procedure for mega projects that need to be approved by the respective Environmental Protection Agency (EPA) to reduce environmental impacts. This study identified inadequacies linked with EIA procedures of CPEC western road project initiated from Rehmani Khel to Kot Balian (package-2A). To evaluate EIA procedures for the selected road project, an EIA index has been formulated based on questionnaire responses. The respondents of this study included environmental experts, social experts, and consultants from the relevant departments. The secondary sources involved a comprehensive literature review and approved EIA reports of CPEC road project. For testing variables, statistical analysis, i.e., the gamma test, correlation analysis, and factor analysis were used. The current study revealed the environmental impacts of CPEC road project, i.e., vehicle emissions, land degradation, loss of biodiversity, and atmospheric pollution. The calculated EIA index was 0.47, which identified the deficiencies among EIA stages, i.e., environmental management efficiency index, environmental impact statement index (EISI), and mitigation index for selected road projects. Statistical analysis indicated an insignificant relationship among the variables for environmental sustainability for the road project. This study will provide an EIA index for implementation of EIA procedures to reduce environmental degradation and contribute to EIA literature for long-term sustainability.

Keywords: PEPA 1997, package-2A, approved EIA, EIA index, EISI, sustainability

INTRODUCTION

Environmental impact assessment (EIA) is a legal requirement for mega projects in both countries, China and Pakistan (Jaeger, 2015; Saeed et al., 2017). Pakistan Environmental Protection Agency (PEPA) 1997 enforced EIA as a mandatory document for the mega projects that needed to be approved by the respective environmental protection agencies (EPAs). EIA is an organized procedure to evaluate environmental impacts to promote sustainability and the decision-making process of a proposed project (Ferreira et al., 2016; Kuitunen et al., 2008). An EIA is a model to categorize the socioeconomic and environmental impacts of a project and provides measures to reduce these impacts (Alamgir et al., 2017; Fitzpatrick & Sinclair, 2009). The main objective of CPEC projects is to boost economic activity in the associated countries through the development of railways, infrastructure, roads, energy, and transport projects (Ishaque, 2016; Jullien et al., 2014). Sustainability aims to encounter the necessities of the current generation without compromising the necessities of future generations (Purvis et al., 2019). Road projects promote sustainability, i.e., economic, health facilities, education services, and employment opportunities (Islam & Al Hadhrami, 2012; Valipour et al., 2014). Sustainable development goals have emerged as a key role in socioeconomic development (Boni & Adeney, 2020). From the perspective of the sustainability of construction projects, major research was carried out to conclude the sustainable development goals to ensure sustainability and suggest mitigation measures (Eales & Sheate, 2011; Mura et al., 2018). CPEC road project may have various socioeconomic opportunities, while also has various environmental consequences, i.e., CO_2 emissions, agricultural land loss, biodiversity loss, and deforestation (Iarocci et al., 2019; Karlson et al., 2014; Saqib et al., 2023). Environmental sustainability of road projects is crucial to carry out the negative environmental impacts of mega projects and ensure

long-term benefits (Makhdoom et al., 2018; Saqib et al., 2023). Road development projects are major sources of CO_2 emissions, biodiversity loss, water pollution, agricultural land loss, and soil pollution (Iarocci et al., 2019; Saqib et al., 2022; Zhang et al., 2013). Noise pollution, air pollution, reduction of natural resources, deforestation, and increasing waste are examples of adverse environmental impacts (Hassaan et al., 2016; Kanwal et al., 2020; Saqib et al., 2018). Deforestation and melting of glaciers may also cause harmful impacts on the natural environment (Jaafari et al., 2015; Lamorgese & Geneletti, 2013; Yang et al., 2015). The gradual increase in transportation may cause CO_2 emissions and atmospheric pollution (Nabi et al., 2017; Saqib et al., 2023). To assess environmental performance, many systematic and widespread methods have been used, i.e., multi-criteria modeling and metadata analysis (Pirrone et al., 2005). In Pakistan, EIA procedure is not effectively utilized to determine the pre-construction and post-construction environmental impacts of proposed projects (Aslam, 2006; Villarroya & Puig, 2013; Zubair et al., 2011). Therefore, this study was conducted to evaluate EIA report of CPEC road project initiated from Rehmani Khel (District Dera Ismail Khan, KPK) to Kot Balian (District and Tehsil Mianwali, Punjab) package-2A, which is a sub-route of the "Hakla (Islamabad) on M-1 to Yarik (D. I. Khan)" CPEC road project. This study provided an EIA index to evaluate the deficiencies and gaps linked with EIA stages of CPEC road project in accordance with assessment tools, i.e., appropriate screening index (ASI), scoping efficiency index (SEI), mitigation index (MI), environmental monitoring and efficiency index (EMEI), environmental management index (EMI), and environmental impact statement index (EISI), which have not been undertaken as expected (NHA, 2017; Saeed et al., 2012).

MATERIAL AND METHODS

The study aimed to evaluate EIA performance and efficiency for the development of road projects in Pakistan. EIA index was designed for the analysis of EIA stages to assess the socioeconomic and environmental aspects of road projects to ensure sustainability. The current research provides an EIA index to mitigate environmental impacts.

Research Site

This study was carried out during the construction of the western road project of CPEC from Rehmani Khel to Kot Balian (package-2A), which is a sub-route of CPEC motorway project from "Hakla on M-1 to Yarik". This road project is planned to extend the link between the less developed areas of Mianwali (Punjab) and Dera Ismail Khan (KPK) by a total length of 285 kilometers (**Figure 1**).

Research Objectives

1. To identify the inadequacies related to EIA reports of the road project.
2. To analyze the environmental impacts of the road project.
3. To design an EIA index of CPEC road project for sustainability.

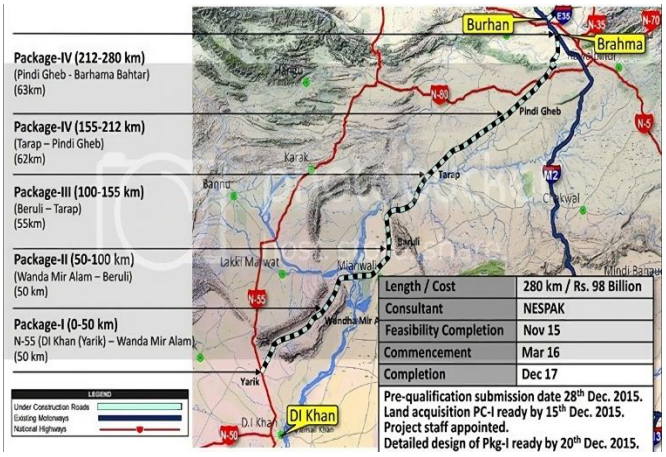

Figure 1. Four lane motorway project of CPEC (https://cpec.gov.pk/project-details/84)

Research Methodology

The primary data was collected through a close-ended questionnaire. The questionnaire was comprised of questions related to EIA stages, i.e., screening, scoping, environmental management plan (EMP), legal framework (LF), public participation, EIA review and decision-making. The sample size was 500 respondents (n=500), which included environmental consultants, experts, and academic scholars. The secondary data involved a comprehensive literature review and EIA reports of the selected CPEC road project (NHA, 2017). The responses to the questionnaires were measured by applying EIA index mechanism (Brombal et al., 2017; Saeed et al., 2012). The scale design for each question was "strongly agree" at a score of "1", "agree" at a score of "0.5" and a score of "0" was considered "disagree". The responses were calculated based on a maximum value of 100 and a minimum value of 0.00. The sub-indices were measured by using following equation:

Sub-indices=(obtain value-minimum value/maximum value-minimum value)×100.

After the calculations, each index was measured by adding sub-indices and calculating their average values. The final EIA index was calculated by adding the indices of all EIA stages and calculating the average.

Figure 2 depicts the theoretical framework of the research.

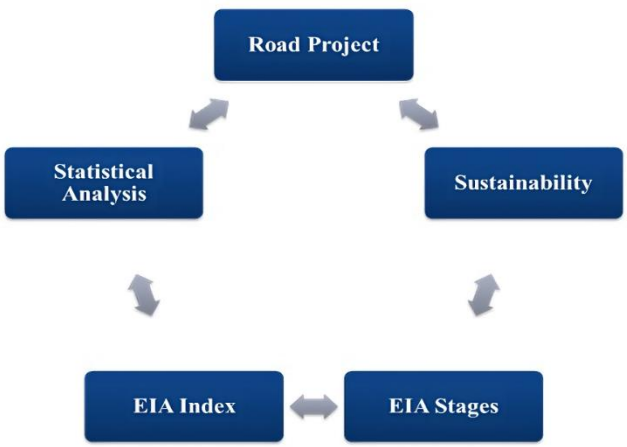

Figure 2. Theoretical framework of the research (Source: Authors' own elaboration)

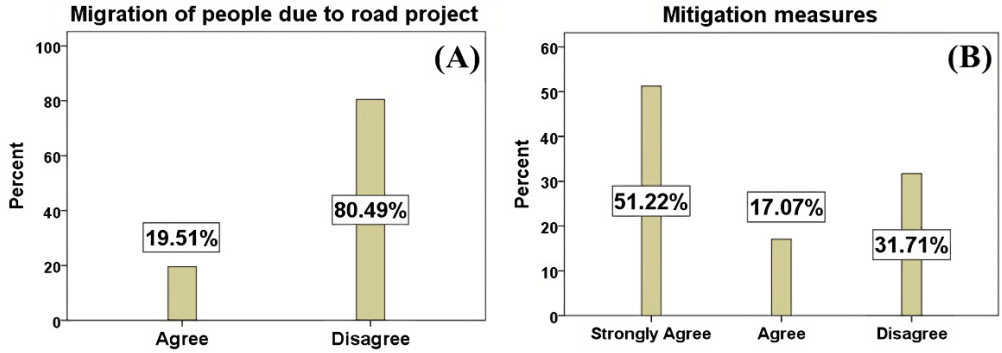

Figure 3. EIA variables for screening & scoping: migration of people (A) & mitigation measures (B) (Source: Authors' own elaboration, using SPSS v.21)

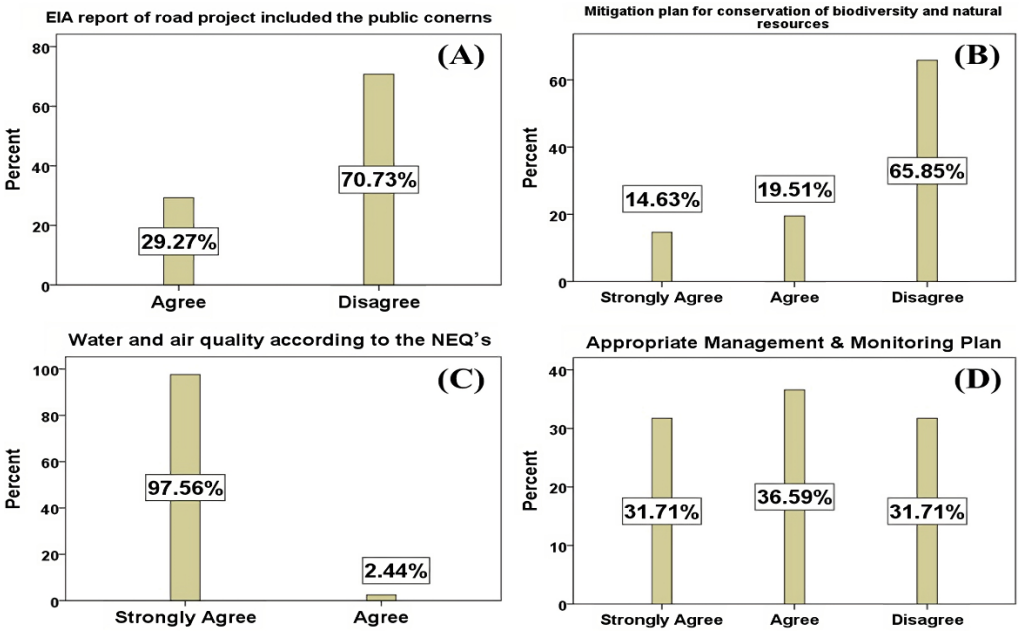

Figure 4. EIA variables for mitigation & environmental management plan: public concerns (A), conservation of biodiversity & natural resources (B), water & air quality according to NEQs (C), & management & monitoring plan (D) (Source: Authors' own elaboration, using SPSS v.21)

RESULTS AND DISCUSSION

This study provided a critical review of EIA stages of selected road projects. The results of the survey were analyzed by implementing EIA index mechanism (Saeed et al., 2012). It is a model to depict the socioeconomic and environmental impacts of a project for decision-making. Statistical analysis, i.e., gamma test, and correlation analysis, were used.

Descriptive Analysis of EIA Variables

The questionnaire-based study comprised variables to assess EIA performance of the selected road project. These variables were screening, scoping, mitigation, an EMP, review & monitoring (RM), reporting, and LF. The responses to the questionnaire described the gaps and inefficiencies identified during EIA of the road project. The results were evaluated using SPSS version 21 and MS Excel.

Figure 3 shows EIA variables for screening and scoping. Part A in **Figure 3** shows that at least 80% of respondents disagree about people migrating during the development of a road project. Part B in **Figure 3** shows that 51% of respondents agreed that CPEC road project's EIA report included mitigation measures. These results show that screening and scoping were perfectly conducted during EIA of CPEC road project (NHA, 2017). Basically, all the megaprojects included the proper implementation of screening and scoping procedures during EIA (Saeed et al., 2012).

Figure 4 represents EIA variables for mitigation and EMP. Part A in **Figure 4** shows that the majority of 70% of respondents disagreed that CPEC motorway project's EIA report addressed public concerns. Part B in **Figure 4** shows that the majority of 65% of respondents disagreed that EIA report of CPEC road project did not include an effective mitigation plan for the conservation of biodiversity and natural resources. Part C in **Figure 4** shows that the majority of 97% of respondents agreed that EIA report included necessary measures to conserve natural air and water quality according to national quality standards (NEQs) of Pakistan. Part D in **Figure 4** shows that the majority of 36% of respondents agreed that EIA report included an appropriate management and monitoring plan to enhance the quality

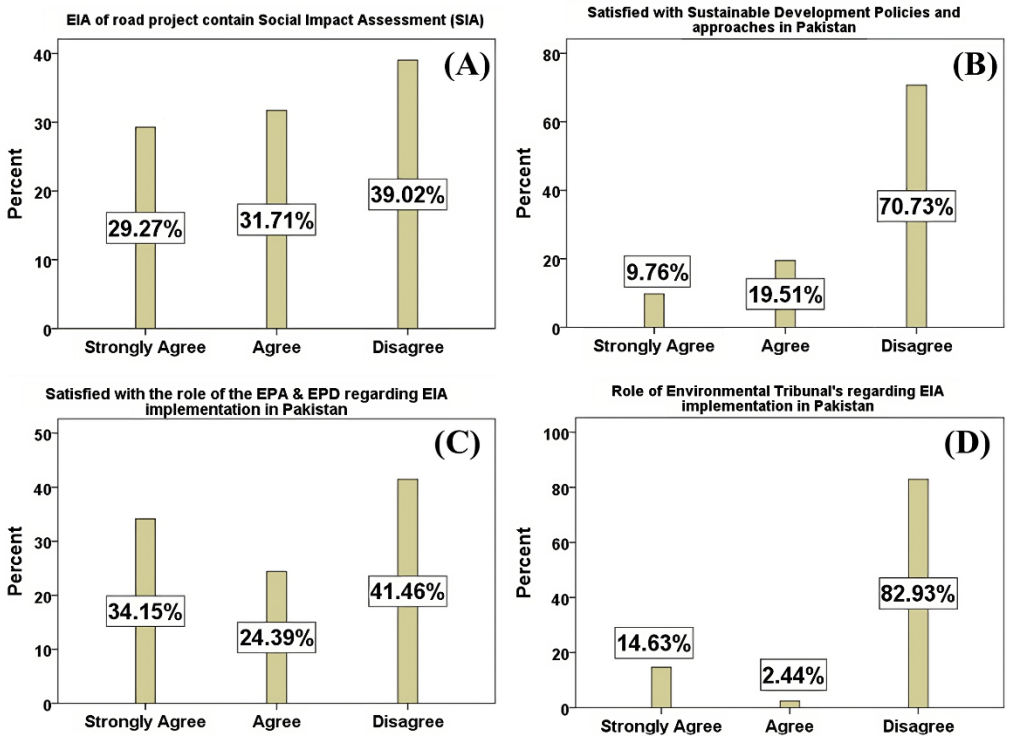

Figure 5. EIA variables for reporting & LF: social impact assessment (A), sustainable development policies & approaches in Pakistan (B), role of EPA & EPD for EIA implementation in Pakistan (C), role of environmental tribunals in Pakistan (D) (Source: Authors' own elaboration, using SPSS v.21)

assurance of the proposed project. EIA reports of mega projects included effective measures, but it is observed that practical steps for mitigation measures are not implemented to overcome environmental degradation (Saeed et al., 2012).

Figure 5 represents EIA variables for reporting and LF. Part A in **Figure 5** shows that 39% of respondents agreed that EIA report lacked effective measures for social impact assessment (SIA). CPEC road project will create jobs and raise the standard of living in nearby communities, but proper alternatives, such as high land prices and agricultural land alternatives, were not effectively provided. Part B in **Figure 5** shows that the majority of 70% of respondents are concerned that Pakistan's sustainable development policies have not effectively addressed the socioeconomic and environmental concerns of stakeholders and that these policies need to be revised and decommissioned according to the SDGs and Agenda 21. Part C in **Figure 5** shows the majority of 41% of respondents disagreed, reporting that EPA and Environmental Protection Department (EPD)'s performance in reporting the environmental impacts of megaprojects are inadequate. The role of EPA and EPD is limited to EIA and initial environmental examination (IEE) reporting only, while the environmental authorities must negotiate environmental concerns with the stakeholders and proponents involved in the development of mega projects in Pakistan (Saeed et al., 2012). Part D in **Figure 5** depicts the concerns of the majority of 82% of respondents who believe that environmental tribunals are Pakistan's supreme authorities for enforcing environmental legislation in order to conserve the environment. EIA reports of CPEC road projects are according to the legislation, but for other projects in Pakistan, i.e., construction, energy, roads, infrastructure, hotels, and industries, it is also necessary to develop according to the environmental laws to avoid the post-construction environmental impacts of projects. Environmental lawyers, courts, and tribunals can play a vital role in the enforcement of environmental legislation, i.e., PEPA 1997, NEQs, Climate Act, and other necessary ordinances to preserve environment (Saqib et al., 2023).

EIA Stages

Pakistan Environmental Protection Act (PEPA) of 1997 provided guidelines for EIA stages. This study explored various stages of EIA report for CPEC road project, which included screening, scoping, an EMP, LF, public participation, EIA review, and decision-making (Khan & Chaudhry, 2021).

Screening

Screening is the preliminary phase of EIA procedure. Screening includes an initial procedure to assess the post-construction impacts of a project. PEPA 1997 provided necessary guidelines for mega projects in various schedules under section 12 (Saeed et al., 2012). The screening stage of CPEC road project was properly conducted (NHA, 2017). The estimated cost for the planned four-lane motorway project of CPEC was around $129.781 million. EIA for the proposed road project was developed and approved by Government of Pakistan through National Highway Authority. The project was assigned to Pakistan National Engineering Service (NESPAK) and MM Pakistan as joint consultants to carry out the feasibility study and EIA of CPEC road project (Laurance et al., 2017; NHA, 2017).

Scoping

Scoping determines EIA aspects of EIA report. In the preliminary stages, scoping identifies the occurrence of

impacts from a development project. Scoping is an interactive procedure for describing concerns and impacts that will be vital in decision-making and essential to be addressed in EIA procedures. Scoping is accomplished when the comprehensive studies obligatory in an EIA have been identified, i.e., terms of reference (TOR) and sectorial guidelines.

The scoping of CPEC road project included baseline information, mitigation actions, and an environmental management and monitoring plan (EMMP) (Saeed et al., 2012). However, the operational and post-construction impacts of selected road projects were not discussed effectively. The post-construction planning to reduce environmental impacts was not effectively discussed. EIA report of selected road projects included conventional pre-construction physical, biological, and socio-economic parameters, but post-construction environmental strategies were not effectively discussed (NHA, 2017).

Environmental management plan

An EMP is designed during EIA process, which describes methods and procedures for mitigation of the identified impacts of a proposed project to enhance environmental benefits (Tian et al., 2022). EMP was used to design strategies to conserve the natural resources of a specified area (Loro et al., 2015; Saeed et al., 2012). EIA reports of CPEC road project did not include any strategic measures or conservation strategies for the post-construction environmental impacts of the proposed project. The proper EMP for the conservation of biodiversity and alternatives for agricultural land loss was not satisfactory (NHA, 2017). This study revealed that the EMP of CPEC road project was not considered. The post-construction environmental impacts, i.e., CO_2 emissions, loss of biodiversity, improper management of construction materials, and reduction in agricultural land, would occur. This study identified the needs of EMP to conserve natural resources and design mitigation measures to reduce the environmental impacts of CPEC road project.

Legal framework

EIA is a legal requirement for the proposed project in Pakistan. These regulations provide guidelines for IEE and EIA for the proposed project (PEPA, 1997). After the 18th amendment to the Constitution of Pakistan in 1973, each province in Pakistan was assigned an environmental agency. All the provinces in Pakistan have developed their own regulations for the estimation of the socioeconomic and environmental impacts of development projects. A legal environment assessment (LEA) is another tool of EIA procedure to identify all legal and regulatory obligations of a proposed project that provide a gateway to advocacy and action for an enabling law, rights, and policy environment. The environmental policies of Pakistan are based on an approach to environmental management and work towards the goal of sustainable development. The principal legislation for proposed projects should be in accordance with the following legislation:

1. Pakistan Environmental Protection Act (PEPA), 1997.
2. Environmental Tribunals Rules (procedure and functions), 1999.
3. Pakistan Environmental Protection Agency (review of IEE/EIA) Regulations, 2000.
4. Punjab Environmental Protection Act, 1997, amended in 2012.
5. Khyber Pakhtunkhwa Environmental Protection Agency (EPA), 2014.

These acts, rules, and regulations are responsible for environmental protection and are established under Ministry of Climate Change (MOCC), as well as federal and provincial agencies. However, all the legal obligations and necessary guidelines for the construction of CPEC road project were followed in accordance with national legislation.

All the necessary documentation was satisfactory and included all the legal aspects of the construction phases of the road project. The planned CPEC road project involves the design of a legislative framework according to PEPA of 1997, Punjab Environmental Protection Act (2012), and Khyber Pakhtunkhwa Environmental Protection Agency (KPK-EPA) of 2014 (NHA, 2017).

Public participation

Public participation is an interactive process that involves a stakeholder's commitment to resolving public concerns about the proposed project (Hasan et al., 2018; Saeed et al., 2012). Stakeholders' involvement in public hearings is frequently ignored as a major element in EIA procedure in Pakistan (Nadeem & Fischer, 2011; Saeed et al., 2012). The overall procedure of EIA is organized in a manner to ensure the minimum amount of public involvement, whereas the venue of the public hearing is decided far away from the directly affected people of the proposed project.

At the local level, public participation was not ensured while a questionnaire-based, small-scale public participation was conducted during EIA of the road project. Public participation in each area of the road project was not properly ensured. Therefore, the actual issues of the public have not emerged and need to be reviewed to minimize the impacts of the selected road project. EIA report for CPEC road project recognizes that the length of the road project is 285 kilometers. The participation of the public in the areas lying within this limit was too small to access the adverse impacts of the project. This study has addressed all the public concerns and inaccuracies, i.e., agricultural land loss, biodiversity loss, and post-construction environmental impacts linked with EIA report on the road project.

EIA review and decision making

EIA report is a process to identify, evaluate, and provide information on the socioeconomic and environmental impacts of a project for policymaking. The objective of the review is to ensure monitoring and quality assurance and to indicate and resolve all the impacts of the development projects. All the financial assistance, technical capacities, and legislative obligations are considered in the review of EIA report (Saeed et al., 2012; Sueyoshi & Goto, 2013). However, EIA report for CPEC road project indicated a lack of these measures for the proposed project.

This study revealed the pre-construction, operational, and post-construction environmental impacts, i.e., solid waste

Table 1. Measured variables & score for EIA stages of CPEC road project

N	EIA stages	Evaluation variable	Score
1	Screening	Public satisfaction with road project	23
		Accessibility to health services	15
		Accessibility to education facilities	27
		Public migration	12
		Public participation	8
2	Scoping	Employment opportunities	4
		Income level	20
		Tourism	17
		Avenues for business & trade	22
		Land value	20
		Short distance facility	26
3	Mitigation	Appropriate mitigation measures	21
		Public hearing & potential concerns	12
		Appropriate alternatives for replacing	0
		Appropriate mitigation plan	21
		Mitigation for seismic hazards	20
		Mitigation plan for resource conservation	13
		Mitigation plan for biodiversity conservation	11
		Water & air quality standards & NEQs	6
4	EMP	Appropriate management & monitoring plan	13
		Social impact assessment	12
5	R&M	Emissions & other pollutants	25
		Consideration air quality	5
		Affect soil properties	19
		Contamination/degradation of ground water	3
		Noise pollution	29
6	Reporting	Quality of EIA report	7
		Damage to plant species	12
		Harm to animal species	3
		Affect climatic conditions	6
		Loss of agricultural land	15
		Waste generation from construction material	19
7	LF	Sustainability objectives	24
		Trade connectivity	7
		Sustainable development policy in Pakistan	14
		Role of EPA & EPD	6
		Role of environmental tribunal	18

Table 2. Measured sub-indices & index values of CPEC road project

PS	Sub-indices scale	SIV	IN	Index
76.6	Satisfaction index (SI)	0.76		
50.0	Health index (HI)	0.50		
90.0	Education index (EI)	0.90	ASI	0.56
40.3	Mitigation index (MI)	0.40		
26.6	Public participation index (PPI)	0.26		
13.0	Employment index (EI)	0.13		
66.6	Income level index (ILI)	0.66		
56.0	Tourism index (TI)	0.56	SEI	0.6
73.0	Business & trade index (BTI)	0.73		
66.0	Land value index (LVI)	0.66		
86.0	SDFI	0.86		
70.0	Mitigation measures (MMI)	0.70		
40.0	PHPI	0.40		
0.0	Alternatives for replacing (AFR)	0.00		
70.0	Mitigation plan index (MPI)	0.70	MI	0.43
66.7	SHMI	0.66		
43.3	RCI	0.43		
36.6	BCI	0.36		
20.0	AWCI	0.20		
43.0	Monitoring index (MI)	0.43	EMEI	0.4
40.0	SIAI	0.40		
83.3	Emission index (EI)	0.83		
11.7	Air quality index (AQI)	0.11		
63.3	Soil properties index (SPI)	0.63	EMI	0.52
10.0	Ground water index (GWI)	0.10		
96.6	Noise pollution index (NPI)	0.96		
23.3	EIA quality index (EIAQI)	0.23		
40.0	Plant damage index (PDI)	0.40		
10.0	Animal harm index (AHI)	0.10	EISI	0.34
20.0	Climatic index (CI)	0.20		
50.0	Agricultural land index (ALI)	0.50		
63.3	Waste generation index (WGI)	0.63		
80.0	Sustainability index (SI)	0.80		
23.3	Trade connectivity index (TCI)	0.23		
46.0	SDI	0.46	LFI	0.45
20.0	EPA index (EPAI)	0.20		
60.0	ETI	0.60		
EIA index for selected CPEC road project				**0.47**

Note. PS: Percent score; SIV: Sub-indices values; & IN: Index name

issues, wastewater problems, biodiversity loss, agricultural land loss, and deforestation, which were not identified in EIA report of selected road projects. This study also suggested the review of EIA report of the selected road project to reduce the post-construction socio-economic and environmental impacts and promote long-term sustainability.

EIA Index

EIA index included various EIA stages, i.e., screening, scoping, mitigation, EMP, EIA RM, reporting, and LF (Saeed et al., 2012). The variables were designed to calculate the scores of EIA stages as shown in **Table 1**, whereas measured sub-indices and index values for CPEC road project are provided in **Table 2**.

Table 1 provides EIA stages and their variables to calculate the score of each stage. The screening included variables for public satisfaction, health and education services, public participation, and migration. Scoping included employment opportunities, income level, and tourism. Mitigation measures include public hearings, biodiversity conservation, and water and air quality standards. Review and monitoring included air and soil quality. Reporting included the status of EIA report, damage to plant and animal species, and agricultural land loss. LF included sustainability objectives, the role of EPDs, and environmental tribunals. The respective scores of all variables were calculated and presented in **Table 2**.

Table 2 indicated the values of EIA index that were calculated from the sub-indices for each phase of EIA, i.e., satisfaction index (SI) 0.76, health index (HI) 0.5, education index (EI) 0.9, MI 0.4, public participation index (PPI) 0.26, employment index (EI) 0.13, income level index (ILI) 0.66, tourism index (TI) 0.56, business and trade index (BTI) 0.73, land value index (LVI) 0.66, short distance facility index (SDFI) 0.86, mitigation measures index (MMI) 0.7, public hearing and potential index (PHPI) 40, alternatives for replacing (AFR), mitigation plan index (MPI) 0.7, seismic hazard mitigation index (SHMI) 0.66, resource conservation index (RCI) 0.43, biodiversity conservation index (BCI) 0.36, air water quality index (AWCI) 0.2, monitoring index (MI) 0.43, social impact assessment index (SIAI) 0.4, emission index (EI) 0.83, air quality index (AQI) 0.11, soil properties index (SPI) 0.63, ground water index (GWI) 0.1, noise pollution index (NPI)

Table 3. Correlation analysis

Variables	Measures	Mitigation	EMP	RM	Reporting	LF
Mitigation	Pearson correlation	1	-.454**	-.626**	-.011	.530**
	Sig. (2-tailed)		.003	.000	.947	.000
	n	500	500	500	500	500
EMP	Pearson correlation	-.454**	1	.319*	.301	.037
	Sig. (2-tailed)	.003		.042	.056	.819
	n	500	500	500	500	500
RM	Pearson correlation	-.626**	.319*	1	-.132	-.264
	Sig. (2-tailed)	.000	.042		.411	.096
	n	500	500	500	500	500
Reporting	Pearson correlation	-.011	.301	-.132	1	-.089
	Sig. (2-tailed)	.947	.056	.411		.581
	n	500	500	500	500	500
LF	Pearson correlation	.530**	.037	-.264	-.089	1
	Sig. (2-tailed)	.000	.819	.096	.581	
	n	500	500	500	500	500

Note. EMP: Environmental management plan; RM: Review & monitoring; & LF: Legal framework

0.96, EIA quality index (EIAQI) 0.23, plant damage index (PDI) 0.4, animal harm index (AHI) 0.1, climatic index (CI) 0.2, agricultural land index (ALI) 0.5, waste generation index (WGI) 0.63, sustainability index (SI) 0.8, trade connectivity index (TCI) 0.23, sustainable development index (SDI) 0.46, environmental protection agency index (EPAI) 0.2 and environmental tribunal index (ETI) was 0.6. EIA index of CPEC road projects included ASI, SEI, MI, environmental management efficiency index (EMEI), environmental monitoring index (EMI), EISI, and legal framework index (LFI). The calculated EIA index for the selected road project of CPEC was 0.47. An EIA index value of 0.47 is considered a weak EIA implementation, whereas a good index value is considered at least 0.8 in environmental experts' opinions (Brombal et al., 2017; Saeed et al., 2012). The comparison of all stages of EIA concluded that the weakest phase of EIA procedure was EISI, whereas the strongest relationship among the whole EIA procedure was SEI, which was very strong and appropriate. However, the values of the sub-indices below 0.5 exhibit an alarming situation for EIA phases of road projects in Pakistan. The calculated values of EIA stages were presented as index values, i.e., ASI was 0.56; SEI was 0.6; MI was 0.43; EMEI was 0.4; EMI was 0.52; EISI was 0.34; and LFI was 0.45. The values of EIA index show the inadequacies and deficiencies of the planned project. EIA reports of CPEC road project are composed of various gaps that need to be revised to reduce environmental impacts for long-term sustainability. This study identified that MOCC and other relevant environmental authorities need to improve EIA phases of road projects in Pakistan, which include mitigation measures, environmental management, the implementation of laws and regulations, and environmental impact statements.

STATISTICAL ANALYSIS

The gamma test was used to calculate the relationship between the ordinal variables of EIA stages. This study also included the Pearson correlation coefficient to determine the linear correlation among the variables of EIA stages. Factor analysis was also used to exchange large variables into small variables.

Gamma Test

The gamma test was used to measure the association among the variables of EIA stages, i.e., mitigation, EMP, RM, and reporting. The association between mitigation and EMP indicated a weak negative relationship at the $p<0.5$ for the conditions (value=-.394, p=0.004, respondents [n]=500). The statistical results indicated that mitigation measures and EMP were adversely linked with EIA of CPEC road project, which indicated that EIA report of CPEC road project did not include effective mitigation measures for post-construction environmental impacts. Therefore, EMP was not very effective due to the lack of mitigation strategies. The association between RM, and reporting indicated a weak negative relationship at the $p<0.5$ for the conditions (value=-.109, p=0.457, respondents [n]=500). The statistical outcomes indicated that, RM and reporting were adversely linked with EIA of CPEC road project, which clarified flaws and gaps associated with the proper monitoring of EIA of the road project, and these gaps were not reported accordingly. Furthermore, the outcomes of the gamma test endorsed that mitigation measures and adaptation plans for CPEC road project should be designed and included in EMP. After indicating these measures, the review and proper implementation of these actions should be reported to minimize the negative environmental impacts, i.e., CO_2 emissions, biodiversity loss, agricultural land loss, and water pollution linked with the development of CPEC road project. The results of this study recommend a proper EIA of CPEC road project to ensure environmental sustainability and long-term benefits (Aslam, 2006; Hassan et al., 2022; Zhang et al., 2013).

Correlation Analysis

The current research provided the bivariate Pearson correlation coefficient that was intended to evaluate the linear relationship between the variables of EIA stages, i.e., mitigation, EMP, RM, reporting, and LF (**Table 3**).

The output of the correlation analysis predicted that there was a perfect negative relationship between the mitigation and EMP at $p<0.5$, r=-.454, n=500, p=0.03, this predicts that improper EMP was conducted for CPEC road project. Hence, no satisfactory mitigation measures were designed to cope with environmental impacts. There was a moderately negative

Table 4. Factor analysis (PCA)

Factors	Initial	Extraction
Screening	1.000	.575
Scoping	1.000	.760
Mitigation	1.000	.826
EMP	1.000	.532
Review & monitoring	1.000	.626
Reporting	1.000	.741
Legal framework	1.000	.335

Table 5. Cumulative variance explained

Factors	Eigenvalues	% of variance	Cumulative %
Screening	2.919	41.697	41.697
Scoping	1.477	21.102	62.799
Mitigation	.989	14.132	76.930
EMP	.792	11.319	88.249
Review & monitoring	.344	4.921	93.170
Reporting	.262	3.740	96.910
Legal framework	.216	3.090	100.000

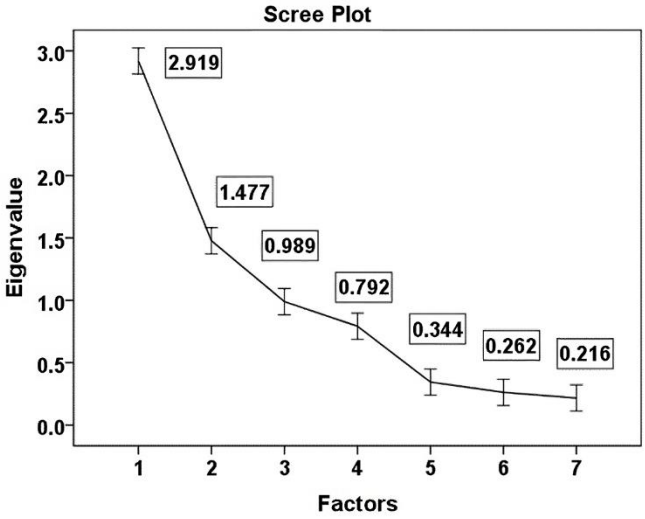

Figure 6. Factor scree plot & eigenvalue (Source: Authors' own elaboration, using PCA–SPSS)

relationship between mitigation and RM at p<0.5, r=-.626; n=500, p=0.00, which indicated that review and monitoring of megaprojects are necessary to identify which mitigation measures are needed to reduce environmental impacts. Moreover, review and monitoring briefly explain the regular progress and analysis of relevant strategies for the development projects to reduce pre- and post-construction impacts. Unfortunately, the mitigation measures, review and monitoring of CPEC road project were not properly implemented. There was a positive relationship between mitigation and legal formwork at p<0.5, r=.530, n=500, which indicated that the legal aspects of CPEC road project were properly adopted according to PEPA, 1997, and mitigation measures were also considered.

There was a positive relationship between EMP and RM at p<0.5, r=.319, n=500, p=0.04, which indicated that review and monitoring of EMP are necessary for the proper adaptation measures and to reduce the environmental impacts of mega projects. Basically, EMP and RM are directly linked to each other for proper auditing and evaluating the impacts of a project. It also analyzes the cost-benefit analysis (CBA) and long-term socioeconomic and environmental sustainability of the megaprojects. The discoveries of current research are supported by the literature (Asuero et al., 2006; Benesty et al., 2009; Zubair et al., 2011).

Factor Analysis

This study used factor analysis to exchange large variables into small variables and to aggregate all variables into a single dataset by taking the most average variance from each variable. Principal component analysis (PCA) was used as the extraction technique for the variable reduction approach and shared similarities with the FA of 500 questionnaires interrelated to the variables for EIA index, i.e., screening, scoping, mitigation, EMP, RM, reporting, and LF. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy attained the sample value at p>0.5 was 0.62 (KMO=.62), which depicts that sufficient samples were collected to conduct the research study. Bartlett's test of sphericity was significant at (X2 [21]=100.166, p<.001) and depicted that this study included an adequate number of correlations between variables for factor analysis. By using both the scree plot and eigenvalues >1 to determine the underlying components, the analysis yields seven factors explaining a total of 62.79% of the variance in the data.

Table 4 presents the extraction values of the variables of EIA index, i.e., 0.575 from screening, 0.760 from scoping, 0.826 from mitigation, 0.532 from an EMP, 0.626 from review and monitoring, 0.741 from reporting, and 0.335 from LF.

In this study, 500 respondents (n=500) have finished a questionnaire by reporting on a rating scale (strongly agree, agree, and disagree) with variables related to EIA index of CPEC road project. The eigenvalues are presented in **Table 5**. The variance explained in the initial eigenvalues for factors was: 41% for screening, 62% for scoping, 76% for mitigation, 88% for EMP, 93% for review and monitoring, 96% for reporting, and 100% for LF.

Figure 6 shows the scree plot of the eigenvalue for all seven factors in this study. The eigenvalue is a score that was measured for all factors and can be used to determine the number of factors to be extracted. The vertical scaling presents the eigenvalue on the y-axis, while the horizontal scaling presents the factor values on the x-axis. The eigenvalues calculated from the cumulative variance for the screening were 2.919 (41.697%), which was very strong and depicted the strong procedure of EIA for CPEC road project; the eigenvalue for the scoping was 1.477 (21.102%) and depicted the moderate procedure of EIA for CPEC road project. The weak procedures of EIA of CPEC road project involved the eigenvalue for the mitigation being 0.989 (14.13%), EMP being 0.792 (11.31%), review and monitoring being 0.344 (4.92%), reporting being 0.262 (3.74%), and LF being 0.216 (3.09%), which signify a very weak relationship between EIA procedures for the progress of CPEC road project in terms of environmental impacts and long term sustainability.

CONCLUSIONS

The present research identified the significance of EIA for the sustainability of CPEC road projects. According to section 12 of the PEPA 1997, EIA procedure is a crucial report for megaprojects that need to be approved by the respective EPA in Pakistan.

This study identified the inadequacies and gaps related to EIA of CPEC road project by following environmental impact assessment index (EIAI) based on a questionnaire methodology to conclude EIAI performance for CPEC road projects in Pakistan in accordance with experts' opinions. EIAI was calculated from sub-indices for each EIA stage, i.e., ASI, SEI, MI, EMEI, EMI, EISI, and LFI. This study has provided an insignificant EIA index of 0.47, which shows that EIA procedures for road projects in Pakistan were not satisfactory. The values of sub-indices less than 0.5 predict an alarming situation in EIA procedures; MI of 0.43, EMEI of 0.4, and EISI were weak areas in EIA procedures in Pakistan. Some of the variables for EIA procedures were insignificant at $p>0.5$ and had a negative association with the environmental sustainability of CPEC road project. This study indicated the unsatisfactory EIA performance in Pakistan for CPEC road project (package-2A). This study suggested the review of EISI and EMEI for current and future developments. This study also provided an MI that included appropriate mitigation measures, public hearings and potential concerns, appropriate alternatives for replacing, an appropriate mitigation plan, mitigation for seismic hazards, a mitigation plan for resource conservation, a mitigation plan for biodiversity conservation, water and air quality standards, and NEQs for stakeholders and environmental authorities to reduce the environmental impacts of CPEC road project (package-2A) and future road projects to promote sustainability.

Limitations of the Study

The current research is limited to an extraordinary level due to reliable data from government sectors. However, the available resources have made this study useful for carrying out a critical analysis of EIA and indicating all the flaws and inefficiencies related to EIA of the project. This study would be significant for the implementation of EIA stages by applying EIA index in a way to reduce environmental impacts for development projects.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

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