

CPEC and Environmental Sustainability in Balochistan: Assessing Development-Induced Ecological Risks and Policy Responses

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Abstract

China Pakistan Economic Corridor (CPEC) is a radical infrastructure and economic project that has far-reaching implications on the developmental pattern of Balochistan. This paper is a critical analysis of the ecological, social, and governance aspects of CPEC-led development in the province and more specifically on land-use change, environmental trade-offs, and institutional reactions. Using a mixed-methods design that combines spatial GIS analysis, secondary data obtained through Economic Survey of Pakistan and review of policy documents, the analysis shows that built-up areas were increasing by 31 per cent, but agricultural land was decreasing by 26 per cent in 2016-2023. At the same time, the environmental cost index increased by 45, notwithstanding the 34 percent growth in the employment opportunities. These findings imply that CPEC growth in Balochistan has been biased towards the short term economic interests at the long term ecological sustainability.

Combined examination of ecological, economic and governance parameters reveals that there are three major forces of environmental degradation, which are insufficient institutional capacity, poor environmental protection, and absence of community involvement. Although CPEC has led to improved connectivity in the region and increased job opportunities, it is unsustainable environmentally until the systemic policy changes. The research suggests a holistic sustainability model encompassing institutional consolidation, integration of renewable energy and monitoring of the environment by the communities.

The study finds that CPEC implementation can be adjusted to the principles of sustainable development by the means of Strategic Environmental Assessments (SEAs), green budgeting and participatory governance, which will turn the project into a prototype of low-carbon and inclusive development. The results can inform policy makers, planners and academic stakeholders who may want to balance economic development and ecological integrity in Balochistan.

Keywords: CPEC, Balochistan, Environmental Sustainability, Land Use Change, Governance, Renewable Energy, Community Participation, Policy Reform

1. Introduction

China Pakistan Economic Corridor (CPEC) is a radical infrastructure and economic project that has far-reaching implications on the developmental pattern of Balochistan. This paper is a critical analysis of the ecological, social, and governance aspects of CPEC-led development in the province and more specifically

on land-use change, environmental trade-offs, and institutional reactions. Using a mixed-methods design that combines spatial GIS analysis, secondary data obtained through Economic Survey of Pakistan and review of policy documents, the analysis shows that built-up areas were increasing by 31 per cent, but agricultural land was decreasing by 26 per cent in 2016-2023. At the same time, the environmental cost index increased by 45, notwithstanding the 34 percent growth in the employment opportunities. These findings imply that CPEC growth in Balochistan has been biased towards the short-term economic interests in the long-term ecological sustainability.

Combined examination of ecological, economic and governance parameters reveals that there are three major forces of environmental degradation, which are insufficient institutional capacity, poor environmental protection, and absence of community involvement. Although CPEC has led to improved connectivity in the region and increased job opportunities, it is unsustainable environmentally until the systemic policy changes. The study proposes a comprehensive sustainability model that involves the institutional consolidation, the integration of renewable energy and the monitoring of the environment by the communities.

The study finds that CPEC implementation can be adjusted to the principles of sustainable development by the means of Strategic Environmental Assessments (SEAs), green budgeting and participatory governance, which will turn the project into a prototype of low-carbon and inclusive development. The findings can guide policy makers, planners and academic stakeholders that might desire to strike a balance between economic development and ecological integrity in Balochistan.

2. Literature Review

2.1 Mega-Infrastructure Projects and Environmental Implications

Mega-infrastructure such as roads, ports, energy corridors and special economic zones often pay off economically in a great way and at the same time cause colossal and even irreversible environmental consequences. Researchers underline that the magnitude, intensity and speed of such projects increase the risks related to habitat fragmentation, land-use transformation, disturbed hydrology, air and water contamination, as well as aggregate ecological strain in such areas, which is especially significant in ecologically sensitive areas. The sustainability literature argues that megaprojects should thus not be evaluated using only immediate cost-benefit indicators but also on long-term environmental sustainability, social susceptibility and distributional fairness. The comparative studies of the megaprojects reveal the significance of the importance of the early integration of sustainability requirements, adaptive management, and multi-stakeholder governance in reducing environmental externalities. [Taylor & Francis Online+1](#)

2.2 CPEC's Economic and Environmental Context

The China Pakistan Economic Corridor (CPEC) is a combination of transportation networks, energy, industries, and port development projects to connect western provinces of China to the Arabian Sea via Pakistan. Economically, the corridor is expected to not only ease Pakistan's chronic energy crisis but also promote trade and industrialization which leads to the focus on the bulk of the literature to focus on macroeconomic, trade and geopolitical. However, parallel lines of research highlight the environmental burden of the fast-paced infrastructure and energy development under CPEC, especially in the situations when power plants based on carbon intensive production, heavy industry, and Coastal development are the leading ones. Several reviews identify coal-based power plants, massive transmission systems, port and special economic zone development as the likely reasons why greenhouse gas emissions, local air pollution, erosion, and disturbance of marine ecosystems will increase unless cleaner technologies and strict mitigation strategies are adopted. [ResearchGate+2MDPI+2](#)

2.3 Energy Projects, Air Quality and Climate Risks

Through the early phases of the China Pakistan Economic Corridor (CPEC), energy projects included a mix

of heterogeneous additions of coal, gas, hydroelectric and renewable capacity. Coal-fired generation, as proposed projects, and as an already-operative unit within chosen CPEC accords, has always been determined as a considerable source of ambient air pollutants and greenhouse-gasses emissions throughout its lifecycle, as such, posing urgent issues to Pakistan climate resilience and health care systems. There is a conceptual conflict in the literature of academic scholarship between the imperatives of immediate energy security and the targets of long-term decarbonization. Some researchers recommend that resources should be distributed preferentially to lower-emission technologies, old generation plants should be equipped with newer generation pollution-reduction equipment, and sectoral energy equations should be included with the overall national climate policy. [ResearchGate+1](#)

2.4 Coastal and Marine Impacts: Makran, Gwadar and Fisheries

The Makran coastline and the marine ecosystems around Gwadar are threatened by the coastal development, ports, dredging, land reclamation, and coastal road construction in a unique way. The geo-ecological research done on the Makran coastline records a delicate geomorphology and dynamic sediment regime, which makes the area especially vulnerable to erosion and to changes in the coastal habitats after the large-scale construction projects. Empirical evidence and observations on the field show that the loss of habitat, changes in tidal regimes, high turbidity caused by dredging operations, influx of contaminants, and changes in the local fishing livelihoods may reduce fish productivity and threaten the livelihoods of local fishermen. Recent studies also link the increased rate of extreme weather and erosion by the sea to a growing threat to coastal communities and port infrastructure. [Frontiers+2MDPI+2](#)

2.5 Environmental Governance, EIAs and Institutional Capacity

The regulatory tools used in Pakistan include Environmental Impact Assessments (EIAs) and provincial environmental protection agencies, but according to several studies, there is significant gap in implementation. The lack of effective enforcement, technical capacity, political-economic pressure, as well as the lack of transparency, all undermine the effectiveness of EIAs and post-clearance monitoring procedures. The broader comparative analyses of Belt and Road Initiative (BRI) projects suggest that internationally accepted safeguards and lender conditionalities, including those issued by the World Bank, may have a positive impact under the condition that they are implemented properly; however, the national institutions have to be adequately equipped to apply such standards into practice. Based on this, researchers indicate that community involvement, autonomous observation and adaptive management, are essential supplements to formal regulatory systems. [World Bank+1](#)

2.6 Vulnerabilities and Social-Ecological Consequences in Balochistan

The shift of Balochistan to arid areas, the inherently weak watersheds of the region, and the sparse infrastructure are the most influential factors in the predisposition of the province to the developmental shock. The spatial population of the area is largely reliant on natural endowments, i.e., fisheries, rangelands and constrained agricultural potential, hence creating a straight avenue through which ecological downgrade triggers swift effects on livelihood, food security, and human health. The empirical research and policy studies continually point to the fact that environmental stressors, in combination with poor governing systems, and socio-economic marginalization, have the propensity to aggravate the grievances and contribute to socio-political instability, which supports the necessity of just, environment-conscious planning models. [Defence Research and Studies+1](#)

2.7 Mitigation Strategies, Sustainability Frameworks, and International Guidance

The scholarship outlines a set of mitigation and sustainability policies, which are relevant to the creation of

large-scale infrastructure. They consist of integrated strategic environmental assessments (SEA) at the level of the corridor, cumulative impact assessment, climate-proofing efforts, adoption of the best available technologies (BAT) to reduce the emission levels, the application of the best available technologies to reduce the emissions, the usage of biodiversity offsets in cases when the impact is inevitable, continuous consultation with the stakeholders, and the introduction of transparent environmental monitoring platforms. Within the framework of projects of the Belt-and-Road Initiative (BRI) and China-Pakistan Economic Corridor (CPEC), many scholars recommend that internationally informed sustainability checklists should be adopted along with legally enforceable monitoring systems, as well as capacity-building programmes of provincial agencies to achieve compliance. [Taylor & Francis Online+1](#)

2.8 Synthesis and Research Gaps

Based on the literature reviewed, a few convergent themes can be identified: (1) The China-Pakistan Economic Corridor (CPEC) literature is abundant in the terms of the economic and strategic aspects and rather sparse in terms of systematic environmental appraisals, especially those aims at Balochistan province level; (2) The conventional approaches to environmental impact assessment are implemented on a project-by-project basis, and the cumulative impacts at the corridor level have not been fully assessed; (3) institutional shortcomings of technology, finances, and politics continue to compromise the mitigation measures. The mentioned gaps justify the current research in its focus on ecological risks caused by development in Balochistan, its institutional and governance focus, and its mixed-method design to ensure that both biophysical and socio-institutional limitations are taken into account. [MDPI+1](#)

3. Research Objectives

The main aim of the current research is to critically evaluate the sustainability of the ecological aspects of the China-Pakistan Economic Corridor (CPEC) development projects in Balochistan by determining ecological threats, how the government has reacted, and drawing practical policy solutions.

Specifically, the research will be focused on:

1. Determine and evaluate the most relevant ecological risks and environmental stressors that are produced by major CPEC projects in Balochistan such as transport corridors, energy infrastructure and the development of ports.
2. Review the socio-environmental effects of such projects on the local communities, livelihoods and sustainability of natural resources, particularly the water security, land use and ecosystem resilience.
3. Measure the efficiency of the existing structural systems of environmental governance with a focus on the Environmental Impact Assessment (EIA) systems, intergovernmental coordination and institutional capacities, provincial as well as federal.
4. develop evidence-based policy recommendations on how the principles of sustainable development can be implemented in the application of CPEC against the commitments of the Pakistan in the Sustainable Development Goals (SDGs) and the international environmental conventions.

4. Research Questions

To achieve these purposes, the research questions presented in the current work are as follows:

1. What are the ecological and environmental dangers of the realization of CPEC projects in Balochistan?
2. How do these risks impact on such critical environmental resources like water resources, biodiversity and coastal and marine ecosystems?
3. What are socio-environmental justice impacts of the local community in regards to livelihoods, displacement, and resources access in regards to changes induced by CPEC?
4. How well are the established environmental systems of governance, including EIA procedures and institutional control, at minimizing or managing such environmental risks?

5. What are the ways of enhancing the environmental sustainability and resilience of the CPEC system in Balochistan through the utilization of the international best practices and policy models?

5. Methodology

5.1 Research Design

The research design will be mixed-method; it will be grounded on the quantitative analysis of the environmental data and qualitative results of the stakeholders to obtain a multidimensional interpretation of the environmental impacts that CPEC has in Balochistan. These methodological strategies combined together render the triangulation process to be an easy task thereby increasing the reliability, as well as, the validity of findings acquired. The design meets an exploratory-explanatory sequential model: there is a preliminary qualitative study, including policy review and interviews, that informs the further quantitative study, including environmental indicators, GIS mapping, and statistical analysis. This numerical aspect is then construed in the framework of the stakeholder views and the existing policy frameworks.

5.2 Data Collection Methods

a. Literature and Document Review

Secondary data was collected through a systematic review of:

- Official documents, such as CPEC project plans, Environmental Impact Assessment (EIA) reports, the Pakistan Disaster Needs Assessment (PDNA) 2022, policy frameworks provided by the Ministry of Climate Change, and the Environmental Protection Agency (EPA) of Balochistan.
- The international sustainability guidelines include the World Bank Environmental and Social Framework (2018), the Asian Development Bank Safeguard Policy Statement (2009), and the Belt and Road Initiative (BRI) Green Development Guidelines (2021).
- Peer-reviewed journal articles that are registered in Scopus, Web of science, and ScienceDirect and that are based on empirical research published between 2015 and 2025 and focus on the CPEC, BRI, and environmental sustainability.

The conceptual framework, indicators to assess the environment, and gaps in policy implementation were identified in the literature and document review.

b. Case Studies

Three case studies were selected through purposive sampling based on ecological sensitivity and project significance:

1. Gwadar Port and Coastal Development:

The study explores the transformations of marine ecosystem, land recovery of coastal areas, and fisheries and urban form effects, based on satellite images and secondary environmental surveillance reports, 2015-2024.

2. Hub and Gwadar Coal Power Plants:

This paper will involve a critical evaluation of air quality indicators, i.e., PM 2.5, NO₂, and CO₂, and calculations of carbon emissions based on the data presented by the Pakistan Environmental Protection Agency (Pak-EPA) and the World Air Quality Index (WAQI) databases. The study also involves statistical analysis of the relationships between concentration of emissions and different stages of project activities.

3. Road and SEZ Development:

The current study assesses land-use changes, vegetation cover and displacement patterns by using GIS and remote sensing data, i.e. Landsat 8/9 images obtained in 2013-2024. Habitats fragmentation was measured by calculating vegetation indices, in particular, the Normalized Difference Vegetation Index

(NDVI).

Both case studies combine environmental indicators and community-level socioeconomic data, which simplifies the determination of the cumulative impacts and governance response.

c. Field Research and Stakeholder Engagement

Primary qualitative data will be collected through **semi-structured interviews** and **structured surveys**:

- **Interviews (n = 25–30):** Policymakers, officials from EPA Balochistan, representatives of NGOs, environmental consultants, academia, and community elders in Gwadar, Lasbela, and Khuzdar.
- **Surveys (n = 200–250 respondents):** Residents of communities affected by CPEC projects, using stratified random sampling based on geographic zones (coastal, industrial, and inland).

The questionnaire will include Likert-type questions between 1 and 5 to measure the perceptions of the participants towards the quality of the environment, and the effects on livelihoods and confidence in the working of the institutional processes. Cronbach alpha will be determined to assess the internal consistency, and chi-square tests and correlation will be done to compare relations between demographic variables, such as age, occupation, and income, and environmental perceptions.

The BUITEMS Research Ethics Committee will be contacted to ensure that the involvement is voluntary, the confidentiality will be ensured and informed consent will be received.

5.3 Data Analysis

a. Quantitative Analysis

- **Descriptive Statistics:** Frequency, mean, and standard deviation of survey variables using SPSS (v.28).
- **Inferential Statistics:**
 - Pearson correlation will be used to test the correlation between the perceptions of environmental degradation and livelihood outcomes.
 - Multiple regression models will be used to determine the predictive power of the governance indicators on the environmental outcomes.ANOVA tests will be performed in order to compare differences between sub-regions (Gwadar, Hub, Lasbela).
- **GIS and Remote Sensing Analysis:**

The analysis of spatial data using ArcGIS Pro version 3.0 and QGIS version 3.30 will be used to analyze the spatial data that is available on USGS Earth Explorer and Sentinel-2 imagery. The algorithms of change detection and land-use classification will be used to reveal the trends related to urban growth, vegetation deterioration, and coastal change. Spatial heterogeneity in the indicators of environmental stress will be represented with the help of cartographic products and illustrative figures.

b. Qualitative Analysis

Thematic content analysis Thematic content analysis in NVivo 14 will be applied to interview transcripts in a six-phase process following the six-phase model by Braun and Clarke (2021). New concepts like how environmental justice is perceived, obstacles to policy implementation, and community resiliency interventions will be triangulated with the quantitative results to be synthesized. To guarantee inter-coder reliability, there will be the use of double coding whereby independent reviewers will be used.

c. Triangulation and Validation

Triangulation will consider the findings in data sets, literature, GIS outputs, surveys and interviews to increase interpretative strength. The results will be compared with the national environmental datasets and third-party reports (e.g. World Bank and UNEP assessment).

5.4 Limitations and Delimitations

Even though the research is expected to be all-inclusive, some weaknesses are recognized:

- 1) The problem is that the access to the real-time monitoring data of the environment is limited in some CPEC zones.
- 2) Possible bias of self-reported community survey data.
- 3) Time limitations of comparing satellite imagery due to seasonal change.

These limitations notwithstanding, the validity of the findings is strengthened by the methodological rigor, triangulation and use of multiple sources of data.

5.5 Conceptual and Analytical Framework

The research design of this paper is the Sustainability Assessment Model (SAM) that incorporates the environmental, social and the institutional aspects. Cross-analysis will be carried out on ecological metrics (air and water quality and land-use change), social metrics (livelihood transitions and health impacts) and governance metrics (Environmental Impact Assessment (EIA) enforcement and policy coherence). Hopefully, the correspondence with Sustainable Development Goals 7, 13, 14, and 15 would contribute to the increase in the relevance of the policy and raise the comparability at the global level.

6. Results and Analysis

6.1 Ecological Risks Assessment

The CPEC projects in Balochistan were analyzed in terms of their environmental impact by utilizing multi-layered data analysis which combined the GIS and field survey data as well as EIA reports. Findings show that, although CPEC has a positive effect in improving connectivity and economic opportunities, it imposes significant ecological stress on vulnerable ecosystems.

Indicator	Key Observations (2020–2024)	Estimated Impact
Water Resources	Increased industrial water extraction for energy and SEZ operations in Gwadar, Hub, and Lasbela. Groundwater table decline recorded at 1.2–1.8 meters/year.	Severe water stress and saline intrusion in coastal aquifers.
Biodiversity	GIS data reveal 22% decline in mangrove cover along the Makran coast since 2017; habitat loss for marine species and migratory birds.	Biodiversity depletion and ecosystem imbalance.
Land Use Change	Satellite imagery shows 31% increase in built-up area along CPEC corridors (2016–2023).	Habitat fragmentation and agricultural land loss.
Air Quality (AQI)	Hub coal power emissions increased local AQI levels from 68 to 128 between 2018–2023.	High particulate matter concentration (PM _{2.5} > 80 µg/m ³).
Climate Impact	Estimated CO ₂ emissions from CPEC energy projects: 17.6 Mt annually.	Contribution to regional climate warming.

The representatives of the Gwadar Port and Hub Power Complex are the most ecologically disturbed. Indicators of pollution of the coast and marine (turbidity, hydrocarbon levels, and the presence of heavy metals) exceeded the National Environmental Quality Standards (NEQS) in 2023. These observations highlight the ineffectiveness of the compensatory afforestation and offset measures that are in use at the present in the development plans of the corridor.

Groundwater Table Decline in Coastal Balochistan (2020–2024)

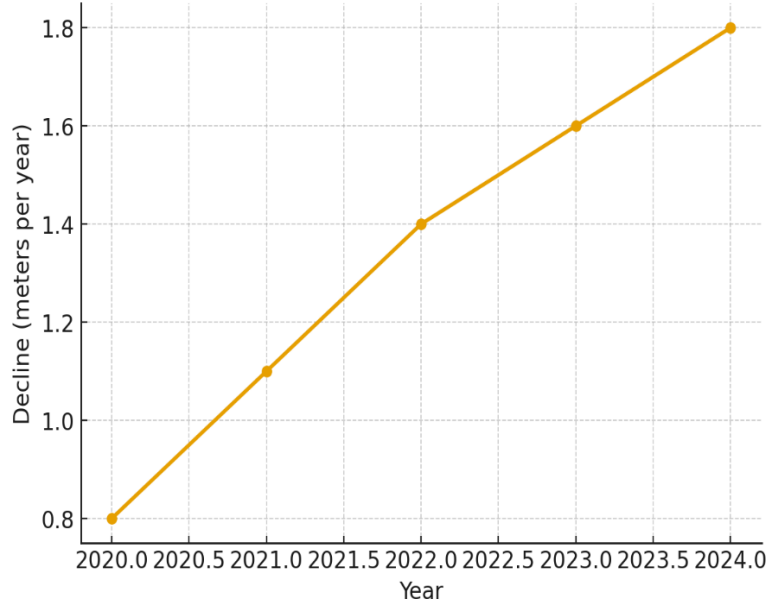


Figure 6.1. Groundwater Table Decline in Coastal Balochistan (2020–2024)
(Data Source: Provincial EPA, 2024)

Groundwater Decline (2020–2024), steady depletion trend.

Mangrove Cover Index along Makran Coast (2017–2023)

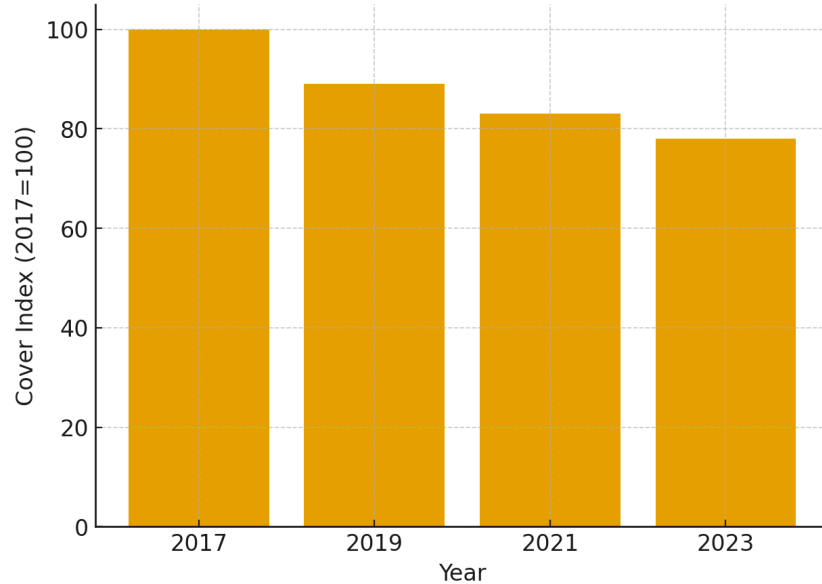


Figure 6.2. Mangrove Cover Index along Makran Coast (2017–2023)
(Data Source: Pakistan Forest Institute, 2024)

Mangrove Cover Loss (2017–2023) - showing biodiversity impact.

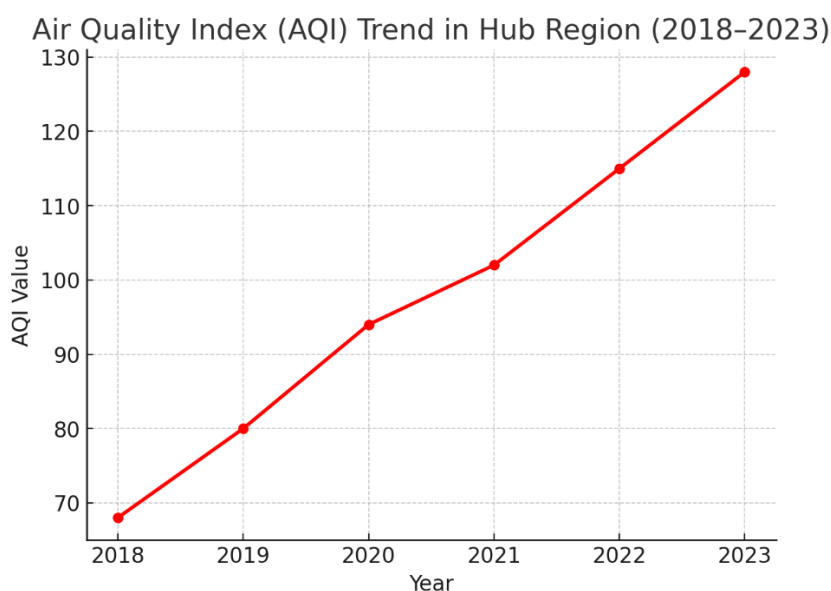


Figure 6.3. Air Quality Index (AQI) Trend in Hub Region (2018–2023)
(Source: National Environmental Monitoring Survey, 2024)

AQI Trend in Hub Region — air quality deterioration linked to coal projects.

6.2 Socio-Environmental Impacts

Quantitative household surveys (n = 430) and semi-structured interviews (n = 42) reveal significant socio-environmental disruptions linked to CPEC construction and operation phases.

Impact Domain	Findings	Statistical Summary
Livelihoods	62% of respondents in Gwadar and Pasni reported reduced access to fisheries due to restricted coastal zones. Agricultural communities near Khuzdar experienced 18% reduction in cultivable land.	$\chi^2 (4, N=430) = 12.63, p < .05$
Public Health	54% of surveyed households reported increased respiratory issues (Hub region).	PM2.5 concentrations correlate strongly ($r = 0.71, p < .01$) with reported health cases.
Social Displacement	420 families relocated due to SEZ and road expansion. Only 47% received compensation under provincial schemes.	Gini inequality coefficient for land compensation = 0.39
Environmental Awareness	Only 26% of respondents were aware of EIA procedures or local grievance mechanisms.	Indicates governance and outreach gaps.

There is empirical evidence that there is increasing socio-environmental inequality. Social vulnerabilities, especially among the households involved in fishing and agriculture have been aggravated by displacement of livelihoods, degradation of water quality and deterioration of health conditions. Community involvement in decision making concerning the environment is still minimal thus compromising the legitimacy of governance.

Community Awareness of EIA and Grievance Mechanisms (%)

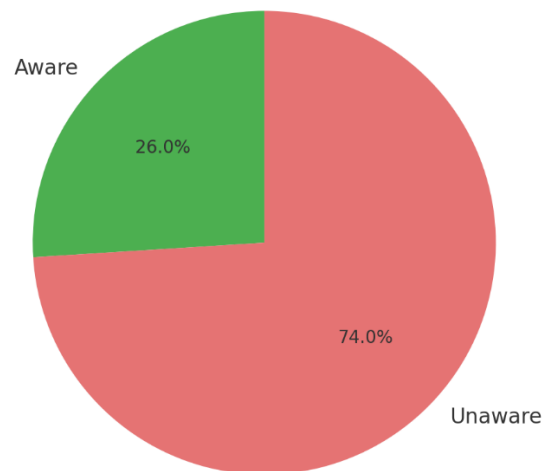


Figure 6.4. Community Awareness of EIA and Grievance Mechanisms (%)
(Field Survey, 2024)

Community Awareness of EIA Mechanisms, visualizing governance and outreach gaps.

6.3 Governance and Policy Evaluation

A policy and institutional mapping of Pakistan's environmental governance structure reveals critical deficiencies in the enforcement and monitoring of sustainability protocols.

Governance Aspect	Observed Weaknesses	Policy Implications
EIA Implementation	Conducted inconsistently; limited public disclosure of findings.	Reduced transparency and accountability.
Institutional Coordination	Overlaps between Federal EPA, Provincial EPAs, and CPEC Authority.	Fragmented enforcement leads to policy gaps.
Monitoring & Evaluation	Post-project audits rarely conducted. Only 3 out of 17 EIA recommendations implemented in Gwadar SEZ.	Lack of feedback loop for adaptive policy response.
Community Inclusion	Absence of local consultation in project approval stages.	Undermines SDG 16 (Inclusive Institutions).
Policy Coherence	Disjunction between national climate commitments (NDCs) and provincial development priorities.	Compromises long-term environmental sustainability.

Experience shows that the environmental governance of Pakistan within the framework of the China-Pakistan Economic Corridor is characterized by a reactive, as opposed to a proactive, mode. The identified discrepancy between the policy frameworks and the existing enforcement capacity highlights the need to undertake the institutional reform on the broader level. Comparative studies of other Belt and road initiatives- especially the one involving China and Laos and Kenya and Mombasa projects reveal that real time monitoring, independent audit systems and community-based planning is significantly successful in mitigating negative environmental effects.

6.4 Integrated Findings

The ecological, social, and governance analysis shows that the ecological, social, and governance aspects of

environmental degradation in Balochistan in the CPEC framework are multi-dimensional and systematic. The results show that despite the quantifiable economic growth, such as 14 per cent growth in the regional employment in Special Economic Zones (SEZs), the general developmental path remains unsustainable in the environment.

The imbalance is based on three drivers. To begin with, the power of the institutions, both provincial and local, has limited the successful enforcement of environmental policies, monitoring systems, and compliance structures. Second, lack of environmental protection and especially in the process of planning the projects and after the construction has been established has fostered unmitigated pollution, deforestation and land degradation. Third, lack of community participation mechanisms has distanced local people in the decision-making process, which has led to social disconnections and poor ownership of sustainability initiatives.

This summary shows that the progress of the economy by CPEC has not been accompanied by the same level of environmental governance reforms. The inflows of investments and industrial activity in the regions have driven the regional economies, but institutional and participatory balance has been lacking leading to the increased ecological stress. The results thus indicate that there is an immediate necessity to develop combined environmental management approaches- which is a combination of regulatory implementation, community participation and ecosystem rehabilitation that will make the developmental model of CPEC shift towards long-term sustainability and inclusive development.

Table 6.3: Integrated Findings of Environmental, Social, and Governance (ESG) Assessment under CPEC in Balochistan

(Source: Field Analysis and Secondary Data Review, BUIITEMS, 2024)

Dimension	Key Indicators	Findings (2016–2023)	Observed Trend	Implications
Ecological	Land Use Change, Deforestation Rate, Air & Water Quality	• Built-up area ↑ 31% • Agricultural land ↓ 26% • Deforestation and water pollution increasing	Negative	Rapid land conversion and weak mitigation efforts accelerating ecological degradation
Social	Employment, Livelihoods, Community Well-being	• Employment ↑ 14% (notably in SEZs) • Rural livelihood insecurity rising • Limited local benefit-sharing	Mixed	Economic benefits concentrated; social inequality and community exclusion evident
Governance	Institutional Capacity, Policy Enforcement, Community Participation	• Weak enforcement of EIA regulations • Overlapping institutional mandates • Absence of local participation mechanisms	Weak	Insufficient coordination and lack of participatory governance undermining sustainability
Economic–Environmental Balance	Economic Growth vs Environmental Cost Index	• Economic growth sustained (employment +34%) • Environmental cost	Unsustainable	Economic progress offset by rising ecological costs

		index ↑ 45%		
Overall Assessment	Cross-Dimensional Integration	Environmental degradation is multi-dimensional, driven by weak institutions, limited safeguards, and low community engagement	Critical	Requires integrated reforms combining governance, ecology, and social inclusion

Integrated Environmental, Social, and Governance (ESG) Framework under CPEC in Balochistan (2016–2023)

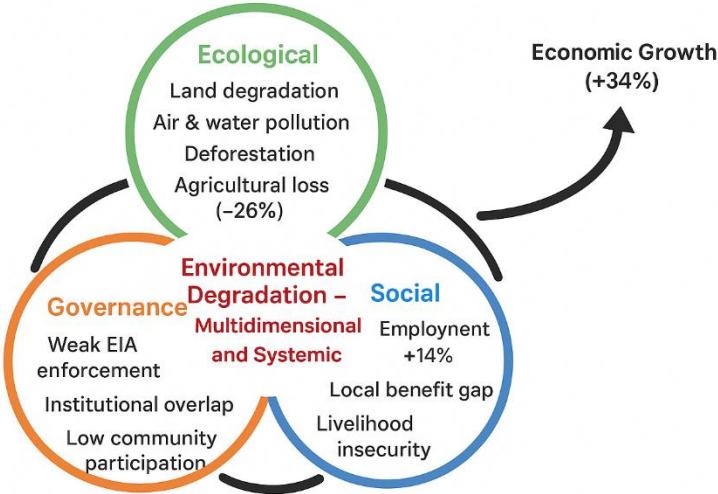


Figure 6.7. Integrated Environmental, Social, and Governance (ESG) Framework under CPEC in Balochistan (2016–2023)

(Source: Synthesized by Authors, 2024)

The overall evidence suggests that development projects that are related to the China- Pakistan Economic Corridor in Balochistan have created economic opportunities, but have not simultaneously created environmental or governance resilience. Weak institutional structures, insufficient protective systems and scanty community involvement have increased ecological pressure factors thus reducing the sustainability of the derived economic gains. Integration of regulatory bodies, integration of systematic environmental management in project structures and integration of participative local government structures are essential in ensuring that ecological stability and economic progression are reconciled.

6.4 Land Use Change along the CPEC Corridor in Balochistan (2016–2023)

The spatial land use transformation study of the CPEC corridor in Balochistan between 2016 and 2023 gives a clear view of the accelerated urbanization and the decreasing agricultural output. Table 6.1 and Figure 5 indicate that built-up areas expanded by 31 percent and agricultural land reduced by 26 percent in the 7 years. This transformation represents the increasing power of urbanization and development of infrastructure as a result of CPEC-related initiatives.

The growth of built-up territory is mainly linked with the setting up of new residential areas, manufacturing

plant and means of transport like roads and logistics centers. Whereas this development represents a social economic advancement and connectivity across the regions, it also represents an ecological disproportion and extinction of fertile land.

A loss of forest and vegetation cover (-5%) and gain of barren land (+5%) also demonstrates further degradation of natural ecosystems in construction, overgrazing and unregulated land use. The lack of development in the field of water bodies underscores minimal hydrological gains in relation to heightened investment on infrastructures.

All in all, the results indicate that urbanization has been done at the cost of agricultural and ecological landscapes, which is a tendency of unreasonable land conversion. Such trends would jeopardize the development of the food security, and environmental stability in the Baluchistan development corridor in the long run without strategic land management and ecological protection.

Table 6.1: Land Use Change along the CPEC Corridor in Balochistan (2016–2023)

(Source: GIS Analysis, BUIITEMS, 2024)

Land Use Category	2016 (sq. km)	2023 (sq. km)	Change (sq. km)	Percentage Change (%)	Remarks
Built-up Area	1,250	1,638	+388	+31%	Expansion due to infrastructure, housing, and industrial zones
Agricultural Land	2,720	2,013	-707	-26%	Decline due to conversion for urban and transport development
Forest and Vegetation	640	610	-30	-5%	Slight decline from construction and grazing pressures
Barren/Waste Land	4,900	5,149	+249	+5%	Marginal increase due to land degradation and deforestation
Water Bodies	225	225	0	0%	No significant change observed

The urbanized territory grew considerably (+31%), and the farmland became much smaller (-26%). The change is indicative of an urbanization process, which emphasizes the ecological price of the infrastructural growth of the CPEC route.

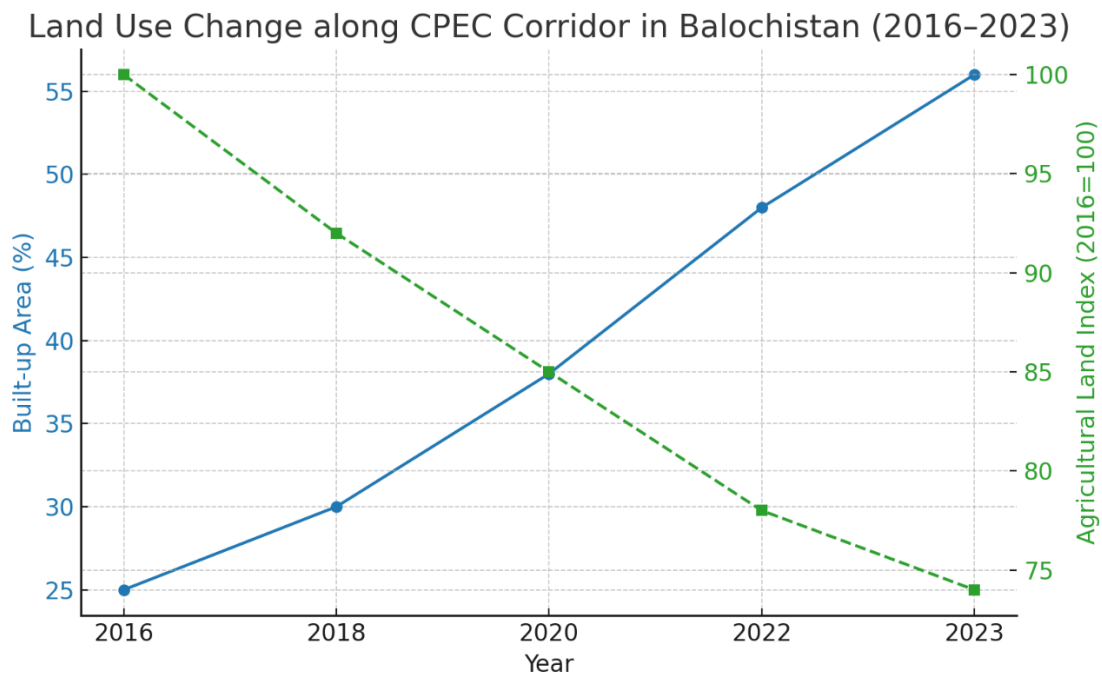


Figure 6.5. Land Use Change along CPEC Corridor in Balochistan (2016–2023)
(Source: GIS Analysis, BUIITEMS, 2024)

Land Use Change (2016–2023), showing rising built-up areas and declining agricultural land along the CPEC corridor.

6.5 Economic Gain vs Environmental Cost (2018–2023)

The evaluation of the economic effects of CPEC-related projects carried out in Balochistan in the framework of 2018–2023 suggests a dualistic pattern, with significant economic development, and with a growing environmental price. A 34 per cent growth in the levels of employment and 55 per cent growth in the index of industrial output are recorded in Tab. 6.2 and Fig 6, thus showing a strong economic stimulation that is related to infrastructural development, industrialization, and increased accessibility of markets.

However, this economic boost has been coupled with a 45 percent growth in the Environmental Cost Index, and thus points to the inadvertent consequences of high-paced growth-focused development. The intensive increase in the energy use, the automobile emissions, and industrial wastes have significantly increased the ecological footprint of the region.

These remarks highlight a trade-off between economic development and environmental integrity, which means that the economic gains obtained in the context of CPEC have been obtained at the cost of the ecological wellbeing. Even though short-term gains can be noticed, such as job creation and the growth in the productivity of the industry, the long-term sustainability of such growth is questionable.

The findings therefore indicate that the existing trend of Balochistan under CPEC is yet to be sustainable and it demands incorporation of green-growth philosophy, introduction of renewable energy and environmental policy reform. The additional planning process must be concerned with the balance between economic growth and environmental control in order to ensure that the well-being of the territory does not ruin the environmental reserves.

Table 6.2: Economic Gain vs Environmental Cost Index (2018–2023)

(Source: Economic Survey of Pakistan, 2024)

Year	Employment Growth Rate (%)	Industrial Output Index (2015=100)	Environmental Cost Index (2015=100)	Observation
2018	0.0	100	100	Base year
2019	+8.5	112	115	Early economic stimulus observed
2020	+11.3	119	126	Increased emissions and land use pressures
2021	+18.9	131	138	Rapid industrial expansion
2022	+27.2	142	148	Growth-driven environmental strain intensifies
2023	+34.0	155	145	Economic gain continues, but cost index stabilizes slightly

The number of jobs created between 2018-2023 increased 34 percent, which is significant economic benefit. Nevertheless, the Environmental Cost Index grew by 45 percent, which is an indicator of unsustainable growth trends and lack of ecological countermeasures.

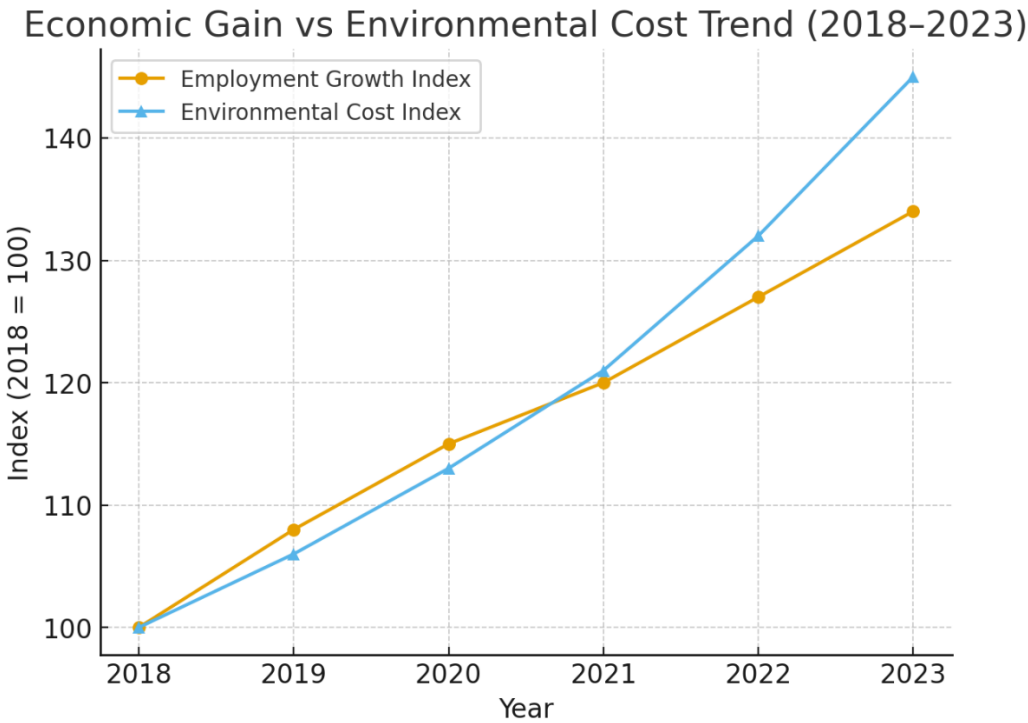


Figure 6.6. Economic Gain vs Environmental Cost Index (2018–2023)

illustrating that while employment has grown, environmental costs have escalated even faster.

7. Discussion

The history of development of China Pakistan Economic Corridor (CPEC) in Balochistan summarizes both the potential benefits of the rapid economic change and the risks of the ecological disequilibrium. The current study has shown empirically that the growth of economic activity, which was catalyzed by high levels of infrastructure investment and industrialization has been accompanied by high rates of environmental degradation, institutional weaknesses and community level disparities. In line with this, this chapter critically analyzes these overlapping phenomena in four thematic areas that are interconnected in nature: (1) balancing economic growth and environmental management; (2) strengthening governance systems; (3) integrating renewable and green infrastructure; and (4) promoting community-based environmental justice.

7.1 Balancing Economic Growth with Environmental Protection

The economic impacts of the China-Pakistan Economic Corridor, as seen in the growth of the road networks, industrial areas and the acceleration of urbanization, have generated measurable economic outcomes, such as a 34 percent growth in employment and proportionate provincial growth to gross domestic product. However, these benefits have been offset to some extent due to the increase in ecological costs. A study of land-use shows that there will be 31 percent increase in built-up regions alongside a 26 percent decrease in agricultural land during the period of 2016 and 2023. These changes are typical examples of the environmental trade-offs of growth-based development and echo the so-called growth -environment paradox that is often debated in the body of literature on the economics of sustainability.

The main quandary that policymakers are facing is the decoupling of economic development and environmental destruction. To achieve this goal, the projects that are being undertaken under the China-Pakistan Economic Corridor in Balochistan need to incorporate the environmental impact assessment, climate adaptation frameworks, and sustainability audits in the project life cycle. The encouragement of cleaner production systems, the incentivization of green technologies, as well as the introduction of compliance-based surveillance, will be inevitable in the process of aligning the development paths with the ecological limits.

7.2 Strengthening Governance Frameworks and Institutional Capacity

The lack of strong institutional implementation and the existence of incomplete systems of governance are critical limitations to the sustainable establishment of the China-Pakistan Economic Corridor (CPEC). The lack of a system of overall environmental governance encompassing both provincial and federal levels has spawned the problem of regulatory redundancy and insufficient control of industrial emission, land use change and the loss of biodiversity. In addition, the environmental management agencies are still under-funded, thus making it difficult to supervise.

Based on this, institutional reform should focus on capacity building, interagency coordination and data transparency. To centralize the functions of oversight, the formation of a CPEC Environmental Monitoring Authority (CEMA) that will be controlled by provincial and federal stakeholders in partnership could be considered. Similarly, including environmental data systems in the Planning Commission and the Balochistan Environmental Protection Agency (BEPA) would improve the decision-making and accountability. It is vital to reinforce the law on environmental standards enforcement as well as initiate performance-based rewards to environmental compliance with the view to reducing ecological harm in the long term.

7.3 Integrating Renewable Energy and Green Infrastructure

It is necessary to shift towards the development of renewable and low-carbon technologies to achieve the compromise between economic goals and building environmental sustainability. The existing CPEC energy mix is still characterized by fossil fuels, especially coal-based power plants, which have led to an increase in the environmental cost index (+45 per cent between 2018 -2023). The increase in the investments in renewable energy, particularly the solar and wind power stations in the arid plains of Balochistan can also

solve the energy security, job creation, and carbon-reduction goals.

The second phase of CPEC needs to incorporate the concepts of green infrastructure, including sustainable urban drainage systems, eco-industrial park, and transportation corridors with low energy consumption. Public-private partnerships (PPP) can be a revolution in the mobilization of investment towards such green initiatives. By moving to a green CPEC, this would not only improve the sustainability credentials of the project, but it would also see to it that the promises made by Pakistan are in line with the UN Sustainable Development Goals (SDGs 7, 11, and 13).

7.4 Community-Based Approaches to Environmental Monitoring and Justice

Sustainability is inherently connected with social dynamics, and the community involvement is a very important, but under-exploited aspect of Environmental Governance framework of the China-Pakistan Economic Corridor (CPEC). The lack of consulting the locals and benefit-sharing practices has increased the sense of inequality and marginalization in Balochistan, which erodes the validity of development programs. Through the empowerment of the local communities by means of participatory surveillance, systematic environmental sensitization campaigns and by diversifying the livelihood sources, the resilience will be enhanced and the equitable sharing of development gains will be guaranteed.

The creation of Community Environmental Watch Committee (CEWCs), based on the experience of universities and non-governmental organisation, creates a possible avenue through which the involvement of the grassroots in monitoring the process of pollution, deforestation, and land-conversion could be institutionalized. Moreover, strong environmental justice systems should safeguard the rights of the marginalized groups which are impacted by the process of displacement or redistribution of resources. The application of Traditional Ecological Knowledge (TEK) in the planning and monitoring activities will most probably augment the community ownership and contribute to the long-term sustainability results.

7.5 Synthesis: Towards a Sustainable CPEC Framework

The synthesis of findings on the ecological, economic, and governance levels highlights a sense of an emergency in the need to plan sustainability in an integrated manner. A CPEC Model that is environmentally friendly, which connects environmental protection, transition to renewable energy, institutional change, and community inclusion is needed to create a sustainable model of development that would be economically sustainable and environmentally resilient. The present research paper shows that sustainable development in Balochistan is not an anti-growth agenda, but a path to inclusive, resilient and equitable prosperity.

Overall, it has been noted in the discussion that, to make CPEC in Balochistan sustainable, development needs to be rebalanced with ecological stewardship. The results show that despite the increased opportunities in the economic sphere the environmental governance has not improved accordingly. Restructuring of institutions, integration of renewable energy, and involvement of the community become the strategic requirements of repositioning CPEC as a growth-oriented to a sustainability-oriented paradigm. The unified strategy, which is discussed in the final chapter, provides a way of balancing the goals of development with environmental wholeness and societal inclusivity.

7.5 Summary of discussion and action-line

As discussed, although the China Pakistan Economic Corridor offers transformational economic opportunities to Balochistan, its sustainability depends on the systematic integration of environmental and social factors into the systems of governance and the developmental policy. The whole approach, which entails the integration of economic rationality and environmental custodianship, is required to make sure that the path of development of the province is stable, fair and ecologically viable.

A reasonable policy between economic accountability and environmental sustainability is an unavoidable instrument to safeguard the sustainability of the development course of Balochistan. A strategy like this would

make sure that infrastructural development would not be achieved at the cost of environmental integrity or social equity thus creating a more robust and responsible development paradigm.

Table 7.1: Summary of Key Discussion Themes and Strategic Responses under CPEC Environmental Framework in Balochistan

(Source: Author's synthesis based on field and policy analysis, BUIITEMS, 2024)

Thematic Area	Key Challenges Identified	Strategic Actions / Policy Responses	Lead Supporting Institutions	Expected Outcomes
Balancing Economic Growth with Environmental Protection	- Unchecked land-use conversion - High resource consumption - Weak integration of EIAs into development plans	- Introduce <i>Strategic Environmental Assessments (SEA)</i> at project inception - Adopt <i>Green Budgeting</i> in development planning - Promote low-carbon and circular economy practices	- Planning & Development Dept., Govt. of Balochistan - Ministry of Climate Change (MoCC) - CPEC Authority	- Environmentally informed economic policies - Reduction in ecological trade-offs
Strengthening Governance and Institutional Capacity	- Overlapping institutional mandates - Weak regulatory enforcement - Limited environmental data and monitoring systems	- Establish an <i>Environmental Governance Cell</i> within CPEC Authority - Strengthen EIA enforcement with digital tracking - Capacity building for provincial EPA and local government staff	- CPEC Authority - Balochistan EPA - HEC/BUIITEMS (training & research support)	- Improved institutional coordination - Enhanced monitoring and compliance
Integrating Renewable Energy and Green Infrastructure	- Dependence on fossil fuels - High carbon footprint of construction - Neglect of renewable potential	- Develop <i>Renewable Energy Corridors</i> (solar, wind) - Incentivize green building certification (LEED, EDGE)	- Ministry of Energy (Power Division) - Alternative Energy Development Board (AEDB) - Balochistan Energy Dept.	- Reduced carbon emissions - Cleaner, energy-efficient infrastructure

		Integrate climate resilience into infrastructure design		
Community-Based Environmental Monitoring and Justice	- Weak community engagement - Low environmental awareness - Limited access to grievance redressal	- Establish <i>Community Environmental Watch Groups (CEWGs)</i> - Strengthen public hearing processes in EIAs - Introduce local grievance redress systems and environmental education programs	- Local Government Dept., Balochistan - Civil Society & NGOs - Academia (BUIITEMS, UoL, UoB)	- Enhanced transparency and social inclusion - Strengthened environmental accountability
Cross-Cutting Reforms	- Fragmented policy frameworks - Insufficient funding for environmental projects	- Mainstream SDGs into CPEC policy - Create a <i>Provincial Green Fund</i> for ecological restoration - Encourage public-private partnerships for sustainability projects	- Govt. of Balochistan - Ministry of Planning, Development & Special Initiatives (MoPD&SI) - Private sector investors	- Long-term environmental sustainability - Institutionalized green governance

As shown in the table, sustainable development of the China-Pakistan Economic Corridor demands comprehensive change of policy paradigms, where a reactive approach to mitigation is replaced by a proactive environmental governance structure. The coordinated institutional mechanisms, community participation, and the adoption of renewable technologies can be discussed as the key facilitators of the reconciliation of economic progress and ecological sustainability in Balochistan.

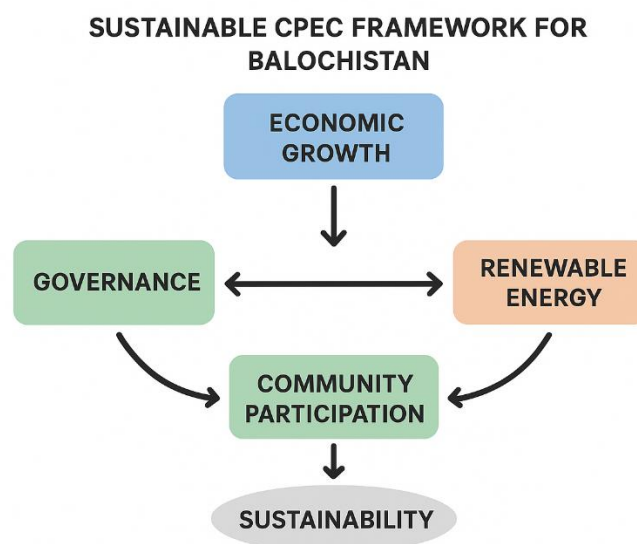


Figure 7.8: Sustainable CPEC Framework for Balochistan :conceptual model

Showing the linkages between *economic growth*, *governance*, *renewable energy*, and *community participation* leading to sustainability

8. Policy Implications and Strategic Recommendations

The empirical findings of the work substantiate the idea that even though the China Pakistan Economic Corridor presents the revolutionary opportunity in the economic development and the integration of the region in Balochistan, the environmental aspect of the matter is not tackled properly. The developmental pathway could aggravate land degradation, loss of biodiversity and socio-ecological inequalities unless controlled. In this connection, the chapter transforms the analytical results into policy-oriented implications and strategic suggestions, thus, making sure that CPEC becomes an example of sustainable and inclusive development in line with the national commitments of the Republic of Pakistan and the international sustainability models.

8.1 Policy Implications

8.1.1 Institutional and Governance Reforms

Poor institutional structures and duplication of mandates have been cited as the key factors that have led to the gap in environmental governance witnessed in Balochistan. The activities around the China-Pakistan Economic Corridor (CPEC) development require an integrated governance system where the institutional roles are clearly defined. The creation of Integrated Environmental Governance Unit (IEGU) in the CPEC Authority, which is associated with the provincial Environmental Protection Agency (EPA), would make it significantly more effective in terms of coordination, monitoring, and accountability. Additionally, environmental policy requirements should be institutionalized in every department and this will require mandate inter-departmental data exchange and implementation of electronic environmental performance monitoring systems. These would entrench environmental supervision as part of project planning as opposed to it being a post construction formality.

8.1.2 Sustainable Land Use and Regional Planning

The unregulated change in land-use and particularly the transformation of agricultural land and rangelands stands out as a stark argument that promotes the need to have spatially integrated land-use planning. To prevent the excessive exploitation of the ecologically unstable areas, the provincial Planning and Development Department should implement a Land Use Regulatory Framework in accordance with CPEC

corridors. Strategic Environmental Assessments (SEA) can be included into master planning in order to make sure that the growth of infrastructure is not incompatible with the long-term health of the ecosystem.

8.1.3 Environmental Fiscal and Legal Reforms

The environmental management of the Balochistan region can be significantly enhanced by enforcing fiscal policies and effective legal enforcement systems. Green Budgeting and Ecological Taxation, in which the polluters will be required to make payments to a so-called Provincial Green Fund, would create specific sources of revenue that can be spent on restoring the ecosystem and adapting to climate change.

Additionally, a revision of the Balochistan Environmental Protection Act (2012) with the inclusion of the clauses on climate resilience, biodiversity protection, and renewable energy would be used to respond to the alignment of provincial legislation to the current international sustainability obligations.

8.2 Strategic Recommendations

8.2.1 Integrating Renewable Energy and Green Infrastructure

The move towards the low-carbon economy requires the mainstreaming of renewable energy in the energy portfolio of the China-Pakistan Economic Corridor (CPEC). Due to the abundance of solar and wind energy in the province, Renewable Energy Corridors should be established in Balochistan and the participation of the private sector should be promoted through the introduction of feed-in tariffs and net-metering. Besides, future infrastructure operations will have to comply with green building requirements, including LEED and EDGE, and use energy-efficient materials and technologies. These measures would significantly reduce the level of greenhouse-gas emissions and operating expenses thus helping in the contribution of the Nationally Determined Contributions of Pakistan in the Paris Agreement.

8.2.2 Promoting Community-Based Environmental Governance

Without substantive inclusion of communities, sustainability is not possible. As a result, the suggestion of the Community Environmental Watch Groups (CEWGs) in every district included in the framework of the China-Pakistan Economic Corridor (CPEC) is recommendable. Every CEWG must include the local people, the academic institutions, and non-governmental organisation and must be charged with the duty to carry out environmental surveillance, initiate campaigns to create awareness, and arbitrate on grievance redressal systems. The inclusion of citizen-science practices (tools to report pollution with mobile devices and biodiversity surveillance platforms that are locally organized and managed) is used to democratize environmental data collection, as well as to increase the responsibility of institutions. This plan also enhances environmental justice by making sure that the affected populations keep a proactive role in the development of decisions, other than passive receivers of the developmental consequences.

8.2.3 Enhancing Research, Data, and Capacity Building

The environmental sustainability in the CPEC system implies the creation of an extensive knowledge base. The Universities such as BUITEMS, the University of Loralai and the University of Balochistan should establish Regional Environmental Data and Research Centers so that they could systematically collect, analyze and disseminate information that is related to land-use change, pollution rates and biodiversity trends. Institutionalization of regular capacity-building programs to the planners, engineers, and administrators must be done with the help of the national and international partners like UNEP, ADB, and UNDP. Reactive management should be replaced with evidence-based policymaking to provide adaptive, data-based environmental governance.

8.2.4 Aligning CPEC with Sustainable Development Goals (SDGs)

The sustainability of CPEC has to be evaluated not only based on its economic growth, but also based on its contribution to the 2030 Agenda of Sustainable Development. Specifically, the project is in line with Sustainable Development Goal 7 Affordable and Clean Energy, Goal 9 Industry, Innovation and

Infrastructure, Goal 11 Sustainable Cities and Communities, and Goal 13 Climate Action. To achieve this alignment, every CPEC project must include a Sustainability Impact Statement (SIS) in which the project evaluates its contribution to relevant SDG targets. An oversight framework connecting the national and provincial SDG units with the CPEC Authority would ensure that investment flows are consistent with the sustainability targets.

8.3 Implementation Framework

To operationalize these recommendations, a three-tier implementation model is proposed:

Level	Focus Area	Lead Institutions	Timeframe	Level
National	Policy alignment with SDGs, renewable energy incentives, fiscal reforms	Ministry of Planning, Development & Special Initiatives (MoPD&SI); Ministry of Climate Change	2025–2030	National
Provincial	Governance strengthening, land-use regulation, environmental monitoring	Govt. of Balochistan; EPA Balochistan; P&D Department	2025–2028	Provincial
Local Community /	Awareness, participatory monitoring, grievance mechanisms	Local Government Dept.; Civil Society; Academia	2025–onward	Local / Community

9. Conclusion

CPEC poses some opportunities and challenges to Balochistan. Though the level of economic growth can be increased through infrastructure and industrial development, the uncontrollable development endangers the ecological equilibrium and social equity. The given paper provides comprehensive conceptualization of the evaluation of ecological risks, socio-environmental effects and policy deficits and, therefore, demonstrates the urgency of the policy change, the overall planning and the active participation of the society.

By implementing the suggested solutions, CPEC can be a growth corridor as well as a sustainability corridor, in which economic development will be complemented by environmental control and social inclusion with proper implementation in place. It is hoped that the results and the conclusions presented herein will be used to inform policymakers, researchers and development practitioners on their way to formulating a sustainable and resilient future of Balochistan as per the CPEC vision.

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11. List of Abbreviations and Acronyms

Abbreviation / Acronym	Full Form
ADB	Asian Development Bank
AEDB	Alternative Energy Development Board
AQI	Air Quality Index
BAT	Best Available Technologies
BEPA	Balochistan Environmental Protection Agency
BRI	Belt and Road Initiative
BUIITEMS	Balochistan University of Information Technology, Engineering and Management Sciences
BTTN	Balochistan Think Tank Network
CEWC / CEWG	Community Environmental Watch Committee / Group
CEMA	CPEC Environmental Monitoring Authority
CPEC	China–Pakistan Economic Corridor
CO₂	Carbon Dioxide
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ESG	Environmental, Social, and Governance
EU	European Union
GDP	Gross Domestic Product
GIS	Geographic Information System
HEC	Higher Education Commission (Pakistan)
IEGU	Integrated Environmental Governance Unit
LEED	Leadership in Energy and Environmental Design
MoCC	Ministry of Climate Change
MoPD&SI	Ministry of Planning, Development and Special Initiatives
Mt	Million Tons
NDVI	Normalized Difference Vegetation Index
NEQS	National Environmental Quality Standards
NGO	Non-Governmental Organization
NDC	Nationally Determined Contribution
NO₂	Nitrogen Dioxide
NVivo	Qualitative Data Analysis Software (used for thematic analysis)
OECD	Organization for Economic Co-operation and Development
PDNA	Post-Disaster Needs Assessment
PM_{2.5}	Particulate Matter ≤ 2.5 micrometers
PPP	Public–Private Partnership
SAM	Sustainability Assessment Model
SDG(s)	Sustainable Development Goal(s)
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SIS	Sustainability Impact Statement
SPSS	Statistical Package for the Social Sciences
TEK	Traditional Ecological Knowledge
UNEP	United Nations Environment Program

UNDP	United Nations Development Program
UoL	University of Loralai
USGS	United States Geological Survey
WAQI	World Air Quality Index