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Environmental and social risk evaluation of overseas investment under the China-Pakistan Economic Corridor

Ruilian Zhang · Francis Andam · Guoqing Shi

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Abstract Along with the further implementation of the "One Belt, One Road" initiative and the promotion of the China-Pakistan Economic Corridor (CPEC), the construction of the CPEC will likely face challenges owing to differences between China and Pakistan in politics, economics, culture, religion, language, customs, environmental management systems, environmental protection laws, social management systems, and social management regulations. To address potential environmental and social risks associated with Chinese enterprises as they invest in the CPEC region, this paper examines previous studies addressing topics such as the environmental and social safeguards of international institutions and Pakistan's domestic environmental and social management requirements. We then systematically identify the environmental and social risk factors involved in CPEC construction, which cover risks regarding water, air, soil, noise, biodiversity, politics, economics, culture, technology, and individuals. By establishing and calculating these risks and using a multi-fuzzy comprehensive evaluation model, we found that noise and individual risks belong to a medium risk category, while others belong to a higher risk category. In view of these risks, the Chinese government must create a friendly and peaceful environment for Chinese enterprises to invest in the CPEC region, and Chinese enterprises must adopt a development strategy of strength and capacity building and establish enterprises capable of addressing environmental and social issues during the investment process. All stakeholders must understand that if no determined and diligent steps are taken, CPEC construction might be doomed for failure from the start.

Keywords "One Belt, One Road" initiative · CPEC · Overseas investment · Environmental and social risks

Introduction

In March 2015, to promote the implementation of "One Belt, One Road," the Chinese government drew up and issued a vision statement, "Vision and Actions on Jointly Building a Silk Road Economic Belt and 21st-Century Maritime Silk Road," also known as Vision and Actions (V&A) of One Belt and One Road (B&R). The development initiative and framework proposed by the Chinese government focuses on connectivity and cooperation among countries, primarily between the People's Republic of China and the rest of Eurasia. The proposed project comprises two main components, the land-based "Silk Road Economic Belt" (SREB) and the oceangoing "Maritime Silk Road" (MSR). The V&A has eight main parts, including background, principles, framework, cooperation priorities, and cooperation mechanisms. China is ready to consult on equal footing with all

R. Zhang (✉) · F. Andam · G. Shi
School of Public Administration, Hohai University, No. 8, Focheng West Road, 21100 Nanjing, People's Republic of China
e-mail: zhangruilian321@163.com

F. Andam
e-mail: fakorfulandam@hhu.edu.cn

countries along the B&R to seize the opportunities provided by the B&R initiative and promote opening-up and large-scale communication and integration among countries, with higher standards and at deeper levels, while considering the interests and aspirations of all parties. The Chinese government notes that B&R will rely on six major economic corridors of interaction within countries and with the outside world, including the New Eurasian Continental Bridge Economic Corridor, China-Mongolia-Russia Economic Corridor, China Central Asia-West Asia Economic Corridor, China-Pakistan Economic Corridor (CPEC), China-India-Burma Economic Corridor, and China-IndoChina Peninsula Economic Corridor, to achieve policy communication, facility connections, trade flows, financial intermediation, and interaction between people. The CPEC, one of the "six economic corridors" and a particularly important part of the overall project, is the "construction pioneer" and "flagship project" of B&R (Chen and Zhang 2016). Summarizing the experience of the construction of the CPEC, learning about outstanding problems and seeking solutions to them are not only important and meaningful in fostering the crucial construction of the CEPC but also have important implications for the implementation of B&R (Liu 2016). To some extent, the establishment of CPEC has given a new connotation to the China-Pakistan relationship, helping promote Pakistan's economic development and social stability and bringing China-Pakistan diplomacy to a new stage (Fan et al. 2016).

In April 2015, President Xi Jinping pledged a total of $46 billion as part of an investment and cooperation agreement during a visit to Pakistan. The leaders signed more than 50 project files concerning approximately 30 of Pakistan's economic corridor construction projects, with an initial investment outlay of $28 billion. President Xi Jinping observed that the two countries should regard CPEC construction as the centerpiece of the project, with the Gwadar Port, transportation infrastructure, and energy and industrial cooperation as the focus, forming a "1 + 4" cooperative layout. The countries would thereby realize win-win cooperation and common development and achieve a significant demonstration of major projects in the construction of local area interconnections (Yao 2015).

CPEC energy projects will serve as the backbone of a strategy to overcome the energy crisis in Pakistan. The Planning Commission of Pakistan is the lead agency for the CPEC in Pakistan. Projects are approved under the CPEC in energy, transport, and infrastructure (Table 1).

However, as Chinese enterprises invest abroad, a growing number of problems, such as the Myanmar Myitsone hydropower station investment failure and the railway storm between China and Thailand, are gradually being exposed. These problems have motivated Chinese enterprises to pay more attention to the environmental risks (ERs) and social risks (SRs) of overseas investment. Chinese enterprises must take measures to protect the interests of enterprises and the country's reputation. The terrorism threat and implementation difficulties of projects of the CPEC are both potential and realistic (Gao 2014; Liu 2016; Yao 2015). Pakistan's central government has limited control over the provinces and regions under its jurisdiction. Future CPEC Projects will likely face various kinds of interference by third countries, which should remind China and Pakistan that they should pay more attention to such threats (Zhang 2014; Zheng 2016). Economic development and infrastructure construction in Pakistan is weak and backward, and Pakistan is facing serious problems of power shortages and political turmoil (Zhang 2016). Although previous studies have focused on SRs from a macro perspective, enterprises cannot obtain detailed risk information that they need to invest in the CEPE region. Therefore, this paper analyzes the environmental and social risks (ESRs) related to CPEC construction and seeks to assess the level of risk to provide points of reference for Chinese enterprises investing in the CPEC region.

Table 1 Projects approved under the CPEC in energy, transport, and infrastructure

CPEC projects portfolio	Cost in $ million	Percentage
Energy	33,793	76%
Transport and infrastructure		
Roads	6100	24%
Rail network	3690	
Gwadar Port	786	
Others	44	
Total	44,413	100%

Source: Planning Commission of Pakistan, 2014

Literature review

Social impact assessment and environmental impact assessment

One purpose of an environmental impact assessment (EIA) is to identify and evaluate important environmental consequences of proposed projects in advance (Kuitunen et al. 2008), while a social impact assessment (SIA) is a research and analytical process intended to influence decision-making and management regarding social issues affecting the daily lives of people (Esteves et al. 2012). Some scholars have cited the social protection concept in explaining SR management and its goals. Social protection is generally defined as a public measure intended to provide income security to individuals. The experience of East Asia has demonstrated that high economic growth rates over many decades can impressively reduce poverty (Holzmann and Jorgensen 2001).

Potential social and economic effects, both positive and negative, can be predicted from the perspective of regional sustainable development. The integration of a social and economic impact assessment into a sourcing strategy can be an effective tool for optimizing the benefits to local communities of development projects (Esteves and Galina 2016). Additionally, some scholars have used the concept of "vulnerability" to assess the social environment (Eakin and Luers 2015).

Furthermore, a growing number of institutions and scholars have begun to pay much more attention to SIA in different countries and different industries. The report "Social Impact Assessment in The Mining Industry: Current Situation and Future Directions" of the International Institution for Environment and Development (IIED) provides a clear introduction to SIA in the Mining Industry, where it notes the challenges and opportunities (International Institute for Environment and Development (IIED) 2001). The social impact of oil production on small holder farmers in oil-producing communities of the agricultural zone of Delta State, Nigeria, was assessed through data analysis and comparison (Ofuoku et al. 2014). Some studies have extended the analysis to certain special industries, such as e-waste recycling. Informal e-waste recycling in Pakistan affects working hours, health and safety, community engagement, public contributions to sustainability issues, and social responsibility promotion (Umair et al. 2015).

Study of the risks of investment in different regions and countries

Ukraine's economic investment status and investment and environmental problems mainly concern infrastructural issues, the financial system, science and technology, legal issues, and the investment tax system (Pekna 2012). Vietnam's infrastructure is relatively backward. Additionally, its industrial support capacity and governmental efficiency are relatively low, while the law enforcement efforts of government officials are insufficient, fees are too high, and corruption is a serious problem (Zhao 2008). The risks to Chinese enterprises investing in ASEAN include war or civil unrest, nationalization and expropriation, exchange restrictions, and default (Nie and Yan 2007). Labor laws in Latin American countries attach great importance to protecting the interests of workers, and the proportions of foreign and local workers are strictly limited (Zhang 2015). There are a small number of regions with significant investment potential and minimal investment risk, reflecting the complexity and diversity of investment risk factors (Xu 2015).

Study of investment risk in different industries

Political risk is an important issue for China in investing in oil-gas exploration (Zhao 2011). Among countries whose coal potential has been studied, overall risk is lower in developed countries than in other countries (Shen and Chai 2015). Xiao Hui analyzed the external and internal risk factors of finance and management. On this basis, a mechanism for transnational investment by China in mining enterprises has been proposed (Xiao 2013). Other scholars have also analyzed foreign investment risk factors from different perspectives in different industries (Yun 2013; Zhang 2011).

Study of the environmental responsibility of overseas investment

Based on Chinese domestic law and international law, the author has tentatively proposed an idea for environmental protection law pertaining to overseas investment by China, namely the "Environmental Protection Ordinance for Overseas Investment of Chinese Enterprises" (Han 2010). Chinese enterprises must seek to protect the local environment of the host country. Only in this way can overseas investment by China

develop on a sound basis (Ren 2015). A sense of social and environmental responsibility on the part of multinational manufacturing enterprises should be established. Moreover, enterprises should reduce ERs of investment by implementing environment liability insurance (Chen 2014).

Study of the political risk of overseas investment

Empirical research has shown that political risk and institutional distance differ for different types of enterprises (Li 2014). Terrorism, social unrest, civil war, and negative changes of host country policies are the main political risks faced by Chinese enterprises (Zhang and Ren 2014). Bilateral relations between China and target countries are a major concern of enterprises involved in overseas investment, and Chinese enterprises characteristically weight political risk heavily and SR lightly (Meng and Dong 2015).

Numerous scholars have extensively studied the overseas investment risks of Chinese enterprises. Such scholars have discussed in detail the risks associated with investment in different regions, countries, and industries and proposed corresponding risk response measures. Additionally, some scholars have studied the political risks of overseas investment and proposed measures to mitigate it. In previous research, the risks of overseas investment in different regions, countries, or industries have been analyzed from a macro perspective, with a focus mainly on political, economic, cultural, and resource issues. Such studies have identified useful and important risk factors for this study.

Materials and methods

Study area

The study area is located in the Indus River Basin between latitudes 23°13′ N and 40°18′ N and longitudes 60°00′ E and 79°57′ E and has an area of approximately 992,048 km^2 and a population of approximately 189,319,400 people. Most parts of the study area cross the Himalaya Mountains from the north to the Indus River Basin, linking the city of Gwadar in southwestern Pakistan to China's northwestern Kashgar of the autonomous region of Xinjiang via a vast network of highways and railways (Fig. 1).

Indicator recognition of ERs and SRs in international institutions

ESR assessment is conducted to eliminate or minimize negative environmental and social effects due to the implementation of investment projects. Furthermore, such assessments seek to realize environmental protection and social development goals during the early, preparation, operation, and post-management stages of a project; account for the project's overall economic, environmental, and social benefits; and contribute to local regional social development goals, such as the protection and improvement of the environment, reduction or elimination of poverty, promotion of gender equality, and maintenance of social stability.

The operational manual of the World Bank (WB) sets out environmental and social policies related to risks involved in the investment process. It mainly addresses issues of environmental assessment, natural habitat, involuntary resettlement, indigenous people, cultural property, and some specific issues. The International Finance Corporation (IFC) approved the performance standards of the "Assessment and Management of Environmental and Social Risks and Impacts," which includes eight items. Because the IFC is part of the WB group, the policy items are very similar to those of the WB. The Asian Development Bank (ADB) issued a safeguard policy statement (SPS), noting that safeguard policy has come to be understood as a practical policy. The purpose is to avoid or reduce the negative effects of a project on the environment and society. In addition, in some regions, safeguard policies concerning ESRs are issued by banks, such as the Inter-American Development Bank (IDB), African Development Bank (AFDB), and European Bank for Reconstruction and Development (EBRD).

Of particular note, the International Hydropower Association (IHA) approved the latest Hydropower Sustainability Assess*ment Protocol* in 2010. The protocol was designed with four assessment parts, including the early, preparation, implementation, and operation stages. Through the assessment of both basic and high-level expectations, early versions of the tool can be used to conduct risk

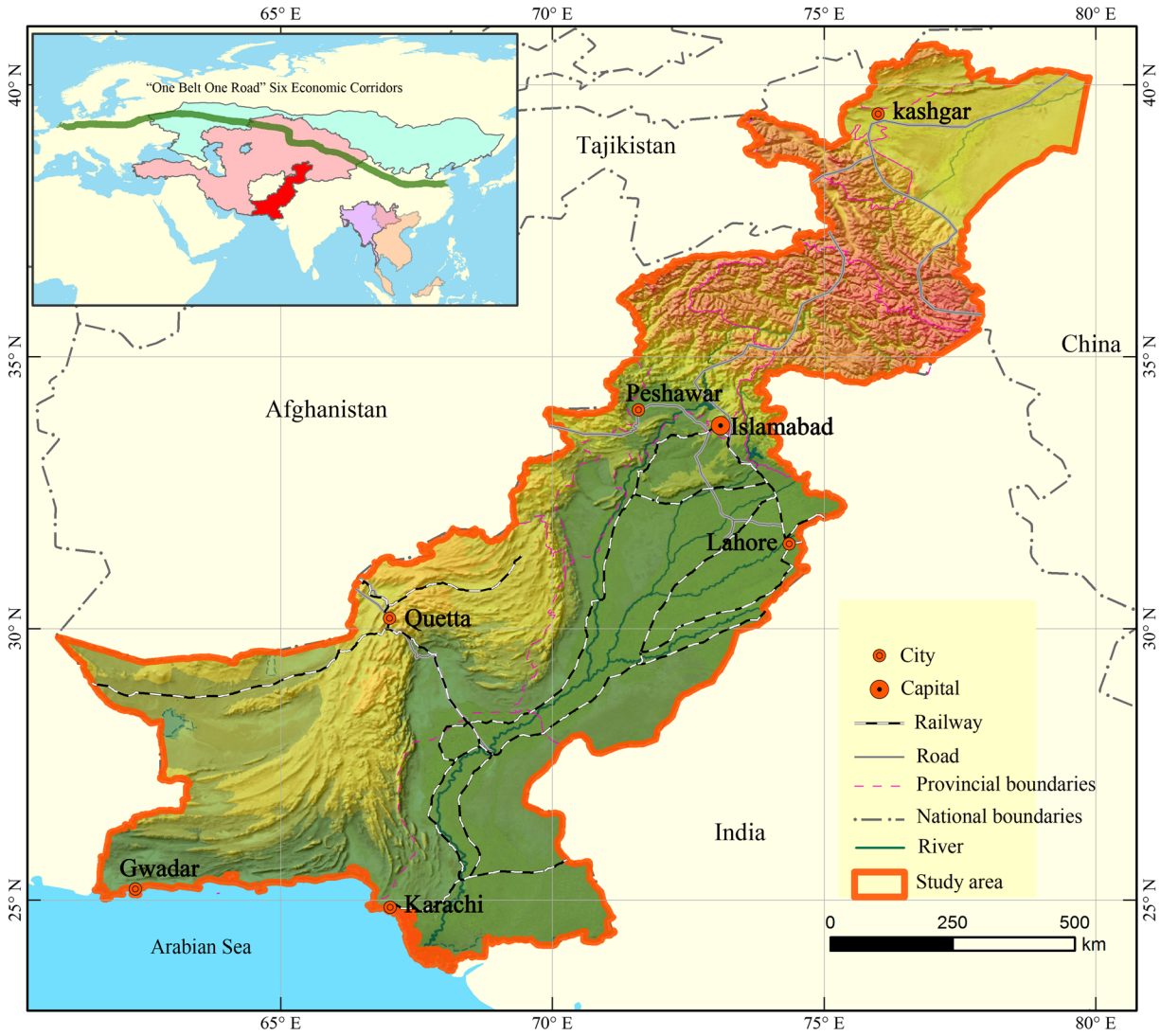

Fig. 1 Map of the CPEC. The CPEC is one of six economic corridors of B&R initiative, which is located in the Indus River Basin between latitudes 23°13′ N and 40°18′ N and longitudes 60°00′ E and 79°57′ E, linking the city of Gwadar in southwestern Pakistan to China's northwestern Kashgar of the autonomous region of Xinjiang via a vast network of highways and railways

assessment and detailed planning of a project before dialog about it begins.

Indicator recognition of ERs and SRs in Pakistan

Environment protection laws and regulations in Pakistan

In the Constitution of Pakistan, which was promulgated in 1973, environmental protection is not identified as a basic right or principle of public policy. In fact, environmental issues are addressed in the "common provisions" of item 24, and the federal and provincial governments have legislative power over "environmental pollution and ecology."

In 1997, the Pakistan Environmental Protection Act replaced the ordinance of 1983, an act intended to protect, preserve, restore, and improve the environment as well as prevent and control pollution and promote sustainable development. The new act added some environmental issues to those specified by the ordinance of 1983, and uniquely, the promulgation of this law was widely discussed by the public, raising the role of public opinion in shaping the law. The 1997 act adopted the

Table 2 Environmental and social risk factors of investment

Risk factor category	First indicator	Second indicator
Environmental risk (ER)	Water	Water pollution
		Excessive exploitation of water resources
		Seasonal distribution of river runoff
		Erosion and deposition of sediment
		Downstream hydrological regime
		Low-level industrial wastewater treatment
		Soluble hazardous materials leakage
	Air	Nitrogen oxides, carbon dioxide, sulfur dioxide, and other excessive emissions
		Ozone depletion substances
		Excessive discharge of dust and particulate matter
		Excessive emissions of volatile organic compounds
		Excessive greenhouse gas emissions
		Volatile hazardous materials leakage
	Soil	Soil pollution
		Decreased soil fertility
		Soil salinization and desertification
		Land subsidence
		Solid waste landfill
		Induced landslide, debris flow, and other geological disasters
	Noise	High decibel noise of equipment operation
		Specific activities producing noise, such as blasting
		Motor vehicle transport noise
	Biodiversity	Outbreak of diseases, insects, and pests
		Alien species invasion
		Natural habitat degradation
		Destruction of endangered species habitat
		Impact of terrestrial animal migration channels
		Blocking species migration route
Social risk (SR)	Political risk	Communication barriers with government departments
		Delivery of improper benefits (such as bribery and corruption)
		Protests organized by NGO
		Cross border project triggers international conflict (Kashmir region)
	Economic risk	Temporary or permanent land acquisition, resulting in impaired income
		Unemployment and poverty
		Increased consumption burden and lower living standards
	Cultural risk	Destruction of historical and cultural heritage
		Local language, customs, and barriers
		Religious belief conflict
		Psychological and cultural integration of land acquisition and resettlement
	Technical risk	Man-made technical operation error
		Imperfect daily management system
		Imperfect emergency management system
	Individual risk	Minorities and indigenous peoples' rights and interests abuse
		Aggravation of gender inequality

Table 2 (continued)

Risk factor category	First indicator	Second indicator
		Lack of labor security
		Affected normal public service supply
		Disease prevention and public health
		Reconstruction of social relationship network
		Threat to community safety
		Differences in benefit and compensation that intensify contradictions between groups

institutional framework created in 1983. According to its provisions, the Pakistan Environmental Protection Council (PEPC) remains the highest environmental decision-making body, and the Pakistan Environmental Protection Agency (PEPA) remains responsible for the PEPC and the Environmental Protection Agency (EPA) of each province.

A more complete environmental regulatory system was established by the Pakistan government on the basis of the Pakistan Environmental Protection Act (1997), with new provisions mainly concerning national environmental quality standards (including an industrial self-supervision and reporting system, a certificate of environmental laboratory practices, air quality, drinking water, noise, vehicle exhaust, and others), a provincial sustainable development fund committee system, an industrial pollution fee (calculation and collection system), drinking water, the environment, demolition, sewage policy, a national strategy for a clean development mechanism, the clean air project, EIA procedures, specific industry environmental projects, and a checklist.

The federal government can formulate regulations to implement the law, such as by implementing the international environmental agreements listed in the appendix of the bill, according to provision 31 of the 1997 act. Some rules and regulations, such as the National Environmental Quality Standards (Enterprise Self-monitoring and Reporting) Ordinance (2001), Provincial Sustainable Development Fund (Procedure) Regulation (2002), Provincial Sustainable Development Fund (Using) Ordinance (2002), Industrial Pollution Penalties (Estimation and Acquisition) Ordinance (2002), Environmental Sample Regulations (2001), Medical Waste Management Regulation (2005), Environmental Court Ordinance (1999), and Biological Safety Regulation of Pakistan (2005), were enacted after they had entered into force. On the other hand, others, such as the Provisions of the EIA/EEI (2000), Environmental Laboratory Certification regulation (2001), and Animal Population and Plant Community Trading Control Act of 2010, were not.

The environmental protection laws, acts, or ordinances of the four provinces in Pakistan are as follows: On March 7, 2012, Punjab Province approved the province's environmental protection law, which differs in some ways from the Pakistan Environmental

Table 3 The scale and its meaning in the judgment matrix

Scale u_{ij}	Meaning
1	Representing the comparison between u_i and u_j; they have equal importance
3	Representing the comparison between u_i and u_j; u_i is slightly more important than u_j
5	Representing the comparison between u_i and u_j; u_i is demonstrably more important than u_j
7	Representing the comparison between u_i and u_j; u_i is significantly more important than u_j
9	Representing the comparison between u_i and u_j; u_i is highly significantly more important than u_j
2, 4, 6, 8	2, 4, 6, 8 represent adjacent judgments for the medians of 1–3, 3–5, 5–7, 7–9
Reciprocal	u_{ij} results from a comparison between u_i and u_j; $u_{ji} = \frac{1}{u_{ij}}$ results from a comparison between u_j and u_i.

Table 4 The value of RI from the 1–11 order judgment matrix

n	1	2	3	4	5	6	7	8	9	10	11
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Protection Act (1997). According to the first part of the 17th section, the fine has changed from 1 million rupees to more than 5 million rupees. In cases of continued illegal pollution, an amount of up to 100,000 rupees per day will be added. The 12th section of the law concerns the EIA system, and the various aspects of the provisions are mandatory.

The Sindh Province parliament passed the Environmental Protection Law of Sindh Province of 2014 on March 20 of that year. Owing to Sindh Province's important geographical location, industry has developed successfully and smoothly over several decades. Therefore, this important industrial province has made important modifications to the environmental protection act. The fine has also increased from 1 million to 5 million rupees, and if a polluter violates the provisions of the 17th section, the fine will exceed 5 million rupees. Section 17 of the provision concerns the mandatory laws on environmental impact identification and EIA provisions. If a polluter's actions go beyond the provisions of section 17, it will be fined under the provisions of section 22.

The Environmental Protection Law of Khyber Pakhtunkhwa Province of 2012 was issued by the Khyber Pakhtunkhwa provincial parliament on November 25, 2012. At the same time, the parliament announced that the law would enter into effect on December 4, 2014. The formulation of the law has made environmental protection a general concern.

The Environmental Protection Law of Balochistan Province of 2012 was approved by the Baluchistan Province parliament in 2012. Balochistan Province is the most extensive area of Pakistan, with a vast coastal area covering 676 km. According to the provisions of the 15th section of this law, the EIA system is set out in the mandatory provisions of the law. If an individual violates the mandatory provisions, he or she should be fined 1 million rupees, as provided in the 25th section of the provision. If an individual violates the provisions of the state, he or she will be fined a larger amount, and if the illegal behavior continues, an additional fine of 100,000 rupees per day will be assessed.

Social management laws and regulations in Pakistan

Project Implementation and Resettlement of Affected Persons Ordinance, 2001, was promulgated by the PEPA in February 2002. The National Resettlement Policy was then issued in March 2002, and to implement the National Resettlement Policy, the National Resettlement Policy Implementation Guidelines were drawn up and issued in October 2002.

The Land Acquisition Act, 1894, was issued in 1894. This act, which has a long history, is constantly updated for the purpose of public use, with the aim of solving problems related to the implementation of land acquisition and compensation. Its use is limited to land acquisition in which public use is involved. Under the act, as long as a project is for public purposes, the government can resolve the land acquisition problem for the project company in accordance with the law of land acquisition, without considering whether the company is state or privately owned. Moreover, the market price of land serves as a benchmark. According to the act, the government and land owners (or other stakeholders) must try to assess the standard of land compensation through consultation.

The Ministry of Information, Broadcasting and National Heritage (MIBNH) is responsible for the protection of cultural heritage, and the Information, Broadcasting and Heritage Division is charged with protecting the domestic cultural heritage. The National Fund for Culture Heritage Act was issued in 1994 by the MIBNH. The primary purpose of the fund is to promote the conservation and preservation of the national

Table 5 The weight of each subsystem of environmental rule layer

Environment subsystem	Water	Air	Soil	Noise	Biodiversity
Weight	0.4185	0.2675	0.1710	0.0464	0.0967

Table 6 The weight of each index of water subsystem

Indicator	Water pollution	Excessive exploitation of water resources	Seasonal distribution of river runoff	Erosion and deposition of sediment	Downstream hydrological regime	Low-level industrial wastewater treatment	Soluble hazardous materials leakage
Weight	0.2365	0.2296	0.1055	0.1645	0.0156	0.1535	0.0948

heritage of Pakistan through various means, including financial and technical assistance, and to create public awareness of the need for the appreciation and preservation of the archeological, architectural, historical, and cultural heritage of Pakistan. To strengthen efforts to protect national heritage, the Pakistan government, in 2002, published the *National Institute of Folk and Traditional Heritage Ordinance, 2002*.

The Ministry of Law, Justice Law and Human Rights is responsible for the protection of employee rights in Pakistan. In 1951, the Pakistan government issued The Employment (Record of Services) Act 1951 to protect the reasonable rights of employers. It also imposed detailed requirements for a record of services. The Tea Plantations Labor Ordinance, 1962, proclaimed in 1962, was specifically targeted at employer protection in tea plantations.

The Employment (Record of Services) Act 1951 makes compulsory the maintenance of the records of service of persons in certain classes of employment in certain areas. It clearly defines employees and employers, the form of the service book, entries in the service book, and the power of inspection and penalties.

The Protection Against Harassment of Women at the Workplace Act, 2010, which is designed to protect the lawful rights of women in the workplace, was issued in 2010. The act requires that every company or organization set up an inquiry committee within 30 days of the enactment of this act for claims of harassment by women. Investigations of sexual harassment claims must be conducted in accordance with the act. The inquiry committee should comprise three persons, including at least one woman.

The protection policy for minorities in Pakistan mainly consists of the Protection of Communal Properties of Minorities Ordinance, 2002, which clearly states that property of minorities for public use cannot be bought, sold, or transferred to any person who has not obtained NOC from the federal government. Any violation of the above provision is punishable by 7 years in prison and a fine of at least 100,000 rupees. At the same time, any sale or transfer transactions in violation of this provision are without legal effect.

By examining international organizations, bilateral international agencies, Pakistan's domestic laws and regulations, and various scholarly studies, this paper has summarized the ESR factors of CPEC projects. ERs include risks to water, air, soil, noise, and biodiversity, while SRs include political, economic, cultural, technical, and individual risks. Additionally, each risk includes many sub-risks with complex contents and characteristics (see Table 2).

Methods

ESR assessment of overseas investment is a complex system issue. The fuzzy comprehensive evaluation method (FCEM) is based on fuzzy sets that are used to assess degrees of risk comprehensively with a number of indicators. ESR assessment involves different human activities with many uncertainties. Therefore, a large number of indicators must be considered in the assessment process. FCEM divides items into different ranges. On the one hand, a hierarchy of objects can be taken into account in presenting the evaluation standard and the

Table 7 The weight of each index of air subsystem

Indicator	Nitrogen oxides, carbon dioxide, sulfur dioxide and other excessive emissions	Ozone depletion substances	Excessive discharge of dust and particulate matter	Excessive emissions of volatile organic compounds	Excessive greenhouse gas emissions	Volatile hazardous materials leakage
Weight	0.3345	0.2369	0.1216	0.1173	0.1015	0.0882

Table 8 The weight of each index of soil subsystem

Indicator	Soil pollution	Decreased soil fertility	Soil salinization and desertification	Land subsidence	Solid waste landfill	Induced landslide, debris flow, and other geological disasters
Weight	0.3655	0.2865	0.1103	0.1138	0.1022	0.0217

fuzziness of influence factors. On the other hand, full play can be given to people's experiences, making the evaluation results more objective and more in line with the actual situation.

This paper is based on fuzzy set theory, which transforms a qualitative indicator into a quantitative indicator. Furthermore, based on the opinions of experts, the paper uses both qualitative indicators and quantitative indicators mixed with a comprehensive evaluation model to describe fuzzy boundaries. Fuzzy comprehensive evaluation can be performed by combining qualitative and quantitative factors and thus expanding the amount of information utilized, such that the evaluation number can be improved and the evaluation results will be credible.

Steps:

1. Determine the factor (indicator) set: $U = \{u_1, u_2, \cdots, u_n\}$;
2. Determine the evaluation set: $V = \{v_1, v_2, \cdots, v_m\}$;
3. Obtain the membership degree vector by single factor evaluation, $r_i = (r_{i1}, r_{i2}, \cdots, r_{im})$, and form the membership degree matrix:

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{pmatrix}$$

4. Determine the weight vector of the factor set and normalize the comment set.

Table 9 The weight of each index of noise subsystem

Indicator	High decibel noise of equipment operation	Specific activities produce noise, such as blasting	Motor vehicle transport noise
Weight	0.4796	0.2365	0.2839

Using the analytic hierarchy process (AHP) method, the weights are determined in four basic steps:

(a) Set goals A and evaluation factors U.

In determining the weights that will act as criteria, ER A_1 comprises U, which includes water, air, soil, noise, and biodiversity in the factor set; SR A_2 comprises political risk, economic risk, cultural risk, technical risk, and individual risk. In determining the indicator weight of water risk, the goal A_1 is water, and Uincludes water pollution, excessive exploitation of water resources, and seasonal distribution of river runoff.

(b) Judgment matrix

Represent A as a target, u_i as the comment factor, $u_i \in U(i = 1, 2, \cdots n)$, u_{ij}, and let the relative importance value vary between u_i and $u_j(j = 1, 2, \cdots n)$. Please see the scale and its meaning in the judgment matrix in Table 3.

The judgment matrix P is obtained by the abovementioned scales.

$$P = \begin{bmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ u_{n1} & u_{n2} & \cdots & u_{nn} \end{bmatrix}$$ also called the $A-U$ judgment matrix

(c) Use the root mean square method to calculate the weight:

(i) Calculate the product M_i of each line element of the judgment matrix:

$$M_i = \prod_{j=1}^{n} u_{ij}; (i = 1, 2, \cdots n)$$

Table 10 The weight of each index of biodiversity subsystem

Indicator	Outbreak of diseases and insect pests	Alien species invasion	Natural habitat degradation	Destruction of endangered species habitat	Impact of terrestrial animal migration channels	Blocking species migration route
Weight	0.0176	0.0822	0.1018	0.3235	0.2381	0.2368

(ii) Calculate M_i root n mean square ϖ_i:

$$\varpi_i = \sqrt[n]{M_i}; (i = 1, 2, \cdots n)$$

(iii) Normalize $\varpi = (\varpi_1, \varpi_2, \cdots \varpi_n)$:

$$\omega_i = \frac{\varpi_i}{\sum_{j=1}^{n} \varpi_j}; (i = 1, 2, \cdots n)$$

$\omega = (\omega_1, \omega_2, \cdots, \omega_n)$ are the weights.

(d) Consistency check

To determine the consistency of the judgment matrix (whether the weight distribution is reasonable), use the following formula:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}$$

where

CR—random consistency ratio of the judgment matrix.

CI—the general consistency indicator of the judgment matrix, which is determined by the formula: $\mathrm{CI} = \frac{1}{n-1}(\lambda_{\max} - n)$.

RI—the average random consistency indicator of the judgment matrix. For the 1–11 order judgment matrix, the value of RI is as follows (Table 4).

Table 11 The weight of each subsystem of social rule layer

Social subsystem	Political	Economic	Cultural	Technical	Individual
Weight	0.4235	0.2356	0.3128	0.0125	0.0156

Criterion: when CR<0.10, the judgment matrix has satisfactory consistency, and the weight distribution is reasonable. Otherwise, the judgment matrix must be adjusted until a satisfactory consistency is achieved.

5. Calculate the comprehensive judgment (comprehensive membership degree) vector: for weights $A = (a_1, a_2, \cdots, a_n)$, calculate $B = A \circ R$,

where $\circ$ is the fuzzy operator with four calculation methods.

$$\text{Main factor operator}_{M(\wedge,\vee)}\ \mathrm{B}_k = \bigvee_{j=1}^{m} \left(a_j \wedge r_{jk}\right) = \max_{1 \le j \le m} \left\{\min\left(a_j, r_{jk}\right)\right\}, k = 1, 2, \cdots, n$$

$$\text{Main factor operator}_{M(\wedge,\vee)}\ \mathrm{B}_k = \bigvee_{j=1}^{m} \left(a_j \cdot r_{jk}\right) = \max_{1 \le j \le m} \left\{a_j \cdot r_{jk}\right\}, k = 1, 2, \cdots, n$$

$$\text{Weighted averaging operator}_{M(\wedge,\oplus)}\ \mathrm{B}_k = \sum_{j=1}^{m} \min\left(a_j, r_{jk}\right)\ k = 1, 2, \cdots, n$$

$$\text{Weighted averaging operator}_{M(\cdot,\oplus)}\ \mathrm{B}_k = \sum_{j=1}^{m} a_j r_{jk}, k = 1, 2, \cdots, n$$

6. In accordance with the maximum principle of membership, make a judgment or calculate the value of comprehensive evaluation.

Table 12 The weight of each index of political subsystem

Indicator	Communication barriers with government departments	Delivery of improper benefits (such as bribery and corruption)	Protests organized by NGO	Cross border project triggered international conflict (Kashmir region)
Weight	0.2245	0.1214	0.4256	0.2285

Multi-fuzzy comprehensive evaluation model for environmental and social risks

Steps

(1) Determine the set of evaluation objects$P$= environmental and social risks of overseas investment

(2) Determine the set of evaluation factors:

$E = \{E_1, E_2, \ldots \ldots E_5\} = \{\text{water, air, soil, noise, biodiversity}\}$

$S = \{S_1, S_2 \ldots\ldots, S_5\}$

$= \{\text{political, economic, cultural, technical, individual}\}$

(3) Determine evaluation set V:

$$v = \{v_1, v_2, \ldots\ldots, v_5\} = \{\text{highest risk, higher risk, middle risk, lower risk, lowest risk}\}$$

(4) Calculate the indicator weights:

Use the AHP to calculate the weights for the first indicator and second indicator of ESRs.

To set the judgment matrix of each second indicator, use Matlab to calculate the largest eigenvalue, consistency check, and reasonable weight coefficient.

Use the weighted averaging operator $M(\bullet, \oplus)$ to calculate A and R and thereby obtain the fuzzy comprehensive evaluation result vector$B$. A small algorithm has commonly been used in fuzzy comprehensive evaluation. However, when there are many factors and when the weight of each factor is often very small, a large amount of information can be lost in the fuzzy synthesis operation, leading to an unreasonable result (i.e., an invalid model). Therefore, in view of the above opinion, the weighted averaging operator is used. The formula is given by:

$$B_k = \sum_{j=1}^{m} a_j r_{jk}, \quad k = 1, 2, \cdots, n$$

In the formula, B_k,a_j,r_{jk} belong to the k degree of membership. The weight of the evaluation indicator of j and the evaluation indicator j belong to the k degree of membership.

(5) Establishment of decision group

To assess the ESRs of overseas investment, a group of experts comprising scientists, local plan-

Table 13 The weight of each index of economic subsystem

Indicator	Temporary or permanent land acquisition resulting in impaired income	Unemployment and poverty	Increased consumption burden and lower living standards
Weight	0.4585	0.3295	0.212

Table 14 The weight of each index of cultural subsystem

Indicator	Destruction of historical and cultural heritage	Local language, customs and barriers	Religious belief conflict	The psychological and cultural integration of the land acquisition and resettlement
Weight	0.3565	0.2284	0.3319	0.0832

Table 15 The weight of each index of technical subsystem

Indicator	Man-made technical operation error	Daily management system is not perfect	Emergency management system is not perfect
Weight	0.2245	0.3891	0.3864

ning authorities, government officials, entrepreneurs from state-owned enterprises, and other specialists should be formed. Subject coverage and different academic viewpoints should also be considered when determining membership in the group. In this study, we undertook a series of interviews among experts who are directly involved in both overseas investment and ESR research (five from the environmental protection ministry, six from enterprises, five NGOs focused on environment protection, and six WB social experts) in the fuzzy comprehensive evaluation process. These experts were asked to provide their judgments for each indicator.

Results and discussion

To undertake a comprehensive evaluation, this paper analyzed the evaluations of the indicators by 22 experts and used the AHP to calculate the weights of risk factors. The results are presented in Tables 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16.

From the results for indictor weights, we can see that in the environment subsystem, the weight of water is 0.4185 and the weight of air is 0.2675. Thus, water and air issues are more important than others. Water and air are essential to life, and investment activities will directly affect water and air. In the social subsystem, the weights of political, economic, and cultural factors are 0.4235, 0.2356, and 0.3128, respectively. To a certain extent, these results indicate that the effects of political, economic, and cultural factors are more serious, and we know that the purpose of investment is to share the benefits with local governments, local communities, and local peoples. Cultural circumstances are different in different regions and have a long history. Therefore, it is difficult to change the cultural atmosphere and cultivate a cultural identity in a new environment.

To incorporate the statistical data from the expert questionnaire into the model, calculate the fuzzy comprehensive evaluation vector.

Evaluation vector of the ER indicator

$$E_L = e \circ R = (0.4185,\ 0.2675,\ 0.1710,\ 0.0464,\ 0.0967) \circ \begin{Bmatrix} 0.453,\ 0.325,\ 0.103,\ 0.035,\ 0.084 \\ 0.337,\ 0.358,\ 0.144,\ 0.056,\ 0.105 \\ 0.442,\ 0.315,\ 0.136,\ 0.068,\ 0.039 \\ 0.515,\ 0.236,\ 0.098,\ 0.089,\ 0.062 \\ 0.395,\ 0.245,\ 0.155,\ 0.035,\ 0.170 \end{Bmatrix}$$

$$= (0.4174025,\ 0.3202844,\ 0.1244172,\ 0.0487696,\ 0.0892263)$$

Comprehensive evaluation vector after normalization: (0.417, 0.320, 0.124, 0.049, 0.089).

Evaluation vector of the SR indicator

$$S_L = s \circ R = (0.4235, 0.2356, 0.3128, 0.0125, 0.0156) \circ \begin{Bmatrix} 0.521, 0.156, 0.215, 0.057, 0.051 \\ 0.489, 0.205, 0.215, 0.014, 0.077 \\ 0.419, 0.158, 0.223, 0.115, 0.085 \\ 0.333, 0.195, 0.345, 0.052, 0.075 \\ 0.413, 0.238, 0.229, 0.098, 0.022 \end{Bmatrix}$$

$$= (0.4775204, 0.1699367, 0.2193458, 0.0655887, 0.0676084)$$

Comprehensive evaluation vector after normalization: (0.478, 0.170, 0.219, 0.066, 0.068).

Therefore, the comprehensive evaluation vector of risks pertaining to water, air, soil, noise, biodiversity, politics, economics, culture, technology, and individuals after normalization is as follows:

$$W = (0.503, 0.205, 0.136, 0.087, 0.069)$$
$$A = (0.465, 0.204, 0.154, 0.114, 0.063)$$
$$S_l = (0.411, 0.328, 0.113, 0.064, 0.084)$$
$$N = (0.222, 0.231, 0.122, 0.149, 0.276)$$
$$B = (0.423, 0.309, 0.138, 0.073, 0.057)$$
$$P = (0.404, 0.214, 0.193, 0.146, 0.043)$$
$$E_c = (0.324, 0.218, 0.228, 0.189, 0.041)$$
$$C = (0.417, 0.254, 0.198, 0.063, 0.068)$$
$$T = (0.288, 0.165, 0.139, 0.235, 0.173)$$
$$I = (0.254, 0.135, 0.147, 0.124, 0.340)$$

In the design of the questionnaire, indicators are measured based on a Likert scale, which has been divided into five levels: higher, high, middle, low, and lower risk. To make calculation convenient, we quantify

Table 16 The weight of each index of individual subsystem

Indicator	Minorities and indigenous peoples' rights and interests damaged	Aggravate gender inequality	Lack of labor security	Affect the normal public service supply	Disease prevention and public health	Reconstruction of social relationship network	Threat to community safety	Benefit compensation differences to intensify the contradiction between groups
Weight	0.2636	0.1805	0.2345	0.0125	0.0065	0.1018	0.0145	0.1861

the subjective evaluations of the linguistic scale, assigning values of 5, 4, 3, 2, and 1.

Through the establishment and calculation of ESRs using the multi-fuzzy comprehensive evaluation model, we find that noise and individual risks are medium level risks, while others are higher risks (Fig. 2). Overall, ESRs are high, according to this evaluation. In the target layer of ERs, the risks to water, air, and biodiversity are significantly greater than the risks to soil and noise. We found that the Indian River Plain (IRP), which is the world's largest alluvial plain, is located in this area from the Himalayan foothills of southern Asia extending to the Arabian Sea, covering 1280 km from north to south. Rich in wheat, rice, and cotton, the IRP is the economic and cultural center of Pakistan, with four fifths of the population of the country. As the construction of investment projects has the most direct and obvious impacts on water, air, and biodiversity, it will be faced with different levels of risk. Among SRs, political and cultural risks are significantly greater than economic, technical, and individual risks. Political risk is mainly occasioned by the Pakistan Prime Minister Nawaz Sharif, who has sought to put former President Pervez Musharraf on trial. At the same time, many people believe that Sharif's election fraud has brought about domestic political turmoil.

The Kashmir region, located at the border of India and Pakistan, is the core issue of the long dispute between the two countries. Although there have been three wars between India and Pakistan and negotiations over many years, the issue of Kashmir has not been effectively resolved, rendering the region among the most controversial and frequent areas of dispute. Cultural risk arises from differences in social customs, religion, ethnicity, and language between China and Pakistan. In fact, 95% of the population of Pakistan believes in Islam. Risks first arise from land acquisition and construction, which may affect local religious culture or religious facilities, possibly leading to resistance by believers; second, differences in resettlement

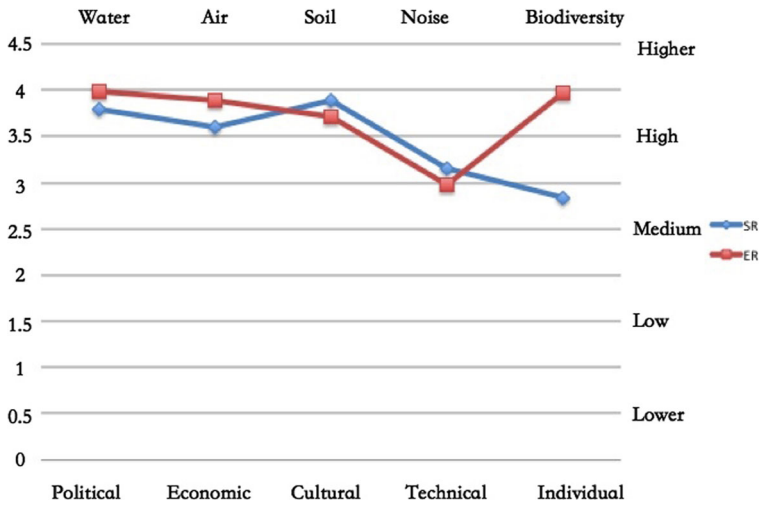

Fig. 2 Risk distribution map. Indicators are measured based on a Likert scale, which has been divided into five levels: 4–5 belongs to higher risk, 3–4 belongs to high risk, 2–3 belongs to middle risk, 1–2 belongs to low risk, and 0–1 belongs to lower risk. Through the establishment and calculation of ESRs using the multi-fuzzy comprehensive evaluation model, we find that noise and individual risks are medium level risks, while others are higher risks

compensation and standards may lead to conflict between different religious groups; third, because of a lack of understanding, Chinese employees may violate the taboos of local customs and religion, causing local resistance and rejection.

Environmental and social risk evaluation:

$$R_E = 0.417 \times 5 + 0.320 \times 4 + 0.124 \times 3 + 0.049 \times 2 + 0.089 \times 1 = 3.928$$
$$R_S = 0.478 \times 5 + 0.170 \times 4 + 0.219 \times 3 + 0.066 \times 2 + 0.068 \times 1 = 3.924$$

Risk evaluation for each subsystem:

$$R_w = 0.503 \times 5 + 0.205 \times 4 + 0.136 \times 3 + 0.087 \times 2 + 0.069 \times 1 = 3.986$$
$$R_a = 0.465 \times 5 + 0.204 \times 4 + 0.154 \times 3 + 0.114 \times 2 + 0.063 \times 1 = 3.894$$
$$R_s = 0.411 \times 5 + 0.228 \times 4 + 0.113 \times 3 + 0.164 \times 2 + 0.084 \times 1 = 3.718$$
$$R_n = 0.222 \times 5 + 0.231 \times 4 + 0.122 \times 3 + 0.149 \times 2 + 0.276 \times 1 = 2.974$$
$$R_b = 0.423 \times 5 + 0.309 \times 4 + 0.138 \times 3 + 0.073 \times 2 + 0.057 \times 1 = 3.968$$
$$R_p = 0.404 \times 5 + 0.214 \times 4 + 0.193 \times 3 + 0.146 \times 2 + 0.043 \times 1 = 3.790$$
$$R_e = 0.324 \times 5 + 0.218 \times 4 + 0.228 \times 3 + 0.189 \times 2 + 0.041 \times 1 = 3.595$$
$$R_c = 0.417 \times 5 + 0.254 \times 4 + 0.198 \times 3 + 0.063 \times 2 + 0.068 \times 1 = 3.889$$
$$R_t = 0.228 \times 5 + 0.165 \times 4 + 0.139 \times 3 + 0.235 \times 2 + 0.173 \times 1 = 3.160$$
$$R_i = 0.254 \times 5 + 0.135 \times 4 + 0.147 \times 3 + 0.124 \times 2 + 0.340 \times 1 = 2.839$$

Conclusion

In accordance with the ambitions of the Chinese and Pakistan governments, the CPEC will be implemented step by step. It will face various ESRs owing to investment activities. Through comprehensive consideration and choice, an ESR evaluation indicator system has been developed, although the ESR indicator system of selection remains to be further discussed. To a certain extent, it has covered most ESRs of overseas investment. Using the FCEM, combined with expert scoring, interviews, and investigation, we have evaluated the degree of risk of overseas investment in the CPEC. To address these potential risks, the Chinese government must first create a friendly and peaceful environment for Chinese enterprises to invest in the CPEC region, using political and economic tools; second, Chinese enterprises must adopt a strong development strategy of capacity building and establish enterprises capable of dealing with environmental and social issues during the investment process; third, all stakeholders should recognize that if no determined and diligent steps are taken, CPEC construction might be doomed for failure from the start.

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Compliance with ethical standards

Disclosure of potential conflicts of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals This article does not contain any studies with human participants or animals performed by any of the authors.

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References

Chen, J. D., & Zhang, J. Q. (2016). Location of Sino-Pakistan economic corridor in “one belt one road” construction. *Journal of Xinjiang Normal University(Philosophy And Social Sciences), 37*(4), 125–133.

Chen, Z. H. (2014). *On multinational's environmental responsibility—case of environmental finance*. Changchun: Jilin University.

Eakin, H., & Luers, A. L. (2015). Assessing the vulnerability of social. *Environmental Systems, 31*, 36–94. doi:10.1146/annurev.energy.30.050504.144352.

Esteves, A. M., & Galina, I. (2016). Using social and economic impact assessment to guide local supplier development initiatives. *Handbook of Research Methods and Applications in Economic Geography, 5*, 1–30. doi:10.4337/9780857932679.00035.

Esteves, A. M., Franks, D., & Vanclay, F. (2012). Social impact assessment: the state of the art. *Impact Assessment and Project Appraisal, 30*(1), 34–42. doi:10.1080/14615517.2012.660356.

Fan, Y. T., Liu, W. D., & Wang, S. D. (2016). Research on cross-border cooperation between China-Pakistan needs and risk under the background of "China-Pakistan economic corridor". *Industrial Economy Review, 3*(6), 617–625.

Gao, H. P. (2014). Analysis on the risk of Pakistan in the construction of China—Pak economic corridor. *Southeast Asia & South Asian Studies, 1*, 64–68.

Han, X. L. (2010). Environmental protection to China's overseas investment location-home country's regulation approach. *Journal of International Economic Law, 3*, 138–162.

Holzmann, R., & Jorgensen, S. (2001). Social risk management: a new conceptual framework for social protection, and beyond. *International Tax and Public Finance, 8*(4), 529–556. doi:10.1023/A:1011247814590.

International Institute for Environment and Development (IIED). (2001). Social impact assessment in the mining industry: current situation and future directions. IIED and WBCSD.

Kuitunen, M., Jalava, K., & Hirvonen, K. (2008). Testing the usability of the rapid impact assessment matrix (RIAM) method for comparison of EIA and SEA results. *Environmental Impact Assessment Review, 28*(4–5), 312–320. doi:10.1016/j.eiar.2007.06.004.

Li, K. (2014). *Outward foreign direct investment motivation, political risk, institutional distance and location choice*. Beijing: Beijing University of Posts and Telecommunications.

Liu, Z. Y. (2016). Construction of the China-Pakistan economic corridor: progress and challenges. *International Studies, 3*, 122–125.

Meng, X., & Dong, Y. D. (2015). Social and political risks and location choices of China's outward foreign direct investment. *Journal of International Trade, 4*, 106–115.

Nie, M. H., & Yan, X. H. (2007). The political risks of China's direct investment in ASEAN and its legal prevention. *Journal of Contemporary Asia-Pacific Studies, 1*, 36–43.

Ofuoku, A. O. U., Emuh, F. N., & Ezeonu, O. (2014). Social impact assessment of crude oil pollution on small scale farmers in oil producing communities of the central agricultural zone of Delta State, Nigeria. *Asian Journal of Agriculture and Rural Development, 4*(3), 233–241.

Pekna, T. (2012). *Research of Chinese direct investment in Ukraine*. Harbin: Harbin Engineering University.

Ren, B. Y. (2015). *Study on the environment protection problem of Chinese overseas direct investment*. Changchun: Jilin University.

Shen, W., & Chai, W. (2015). Study on risk evaluation of oversea investment nationality for coal industry. *Coal Economic Research, 7*, 80–84.

Umair, S., Björklund, A., & Petersen, E. E. (2015). Social impact assessment of informal recycling of electronic ICT waste in Pakistan using UNEP SETAC guidelines. *Resources, Conservation and Recycling, 95*, 46–57. doi:10.1016/j.resconrec.2014.11.008.

Xiao, H. (2013). *Research on early warning and monitoring of transnational investment risk in Chinese mining enterprises*. Wuhan: Wuhan University of Technology.

Xu, Y. D. (2015). Analysis of investment environment and location selection in various regions of Russia. *Russian Studies, 1*, 149–196.

Yao, Y. (2015). China-Pakistan economic corridor: a risk analysis. *South Asian Study, 2*, 35–45.

Yun, X. F. (2013). *Risk analysis of Chinese petroleum enterprises' foreign investment*. Beijing: Minzu University of China.

Zhang, C. Z. (2014). Building of China-Pakistan economic corridor: opportunities and challenges. *South Asian Studies Quarterly, 2*, 79–84.

Zhang, L. W. (2016). The basis and challenges of the construction of China-Pakistan economic corridor under one belt and one road. *Reformation & Strategy, 32*(10), 160–164.

Zhang, M. D. (2015). Investment in Latin America: risk and response. *International Studies, 6*, 122–131.

Zhang, W. J., & Ren, R. M. (2014). The political risk and countermeasures of Chinese enterprises' overseas investment. *Modern Management Science, 12*, 97–99.

Zhang, Y. T. (2011). China's mining enterprises transnational investment projects. *Modern Economy, 7*, 120–123.

Zhao, M. (2011). *Venezuela and gas exploration and development of the investment environment research*. Wuhan: China University of Geosciences.

Zhao, Y. X. (2008). Vietnam investment environment and the strategies of investment. *Special Zone Economy, 6*, 89–91.

Zheng, G. (2016). The risk challenges of CPEC, an analysis of grand strategy and countermeasures. *Pacific Journal, 24*(4), 89–95.