Report

BRI energy infrastructure in Pakistan

Environmental and climate risks and opportunities

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November 2021

How to cite: Opitz-Stapleton, S., Cao, Y., Khan, F., Tanjangco, B. and Nadin, R. (2021) BRI Energy Infrastructure in Pakistan: environmental and climate risks and opportunities. ODI Report. London: ODI (www.odi.org/publications/bri-energy-infrastructure-in-pakistan-environmental-and-climate-risks-and-opportunities)

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Acknowledgements

The authors are grateful to the interviewees who graciously gave us their time and perspectives on various types of climate and environmental risks facing Pakistan's energy infrastructure.

ODI would also like to thank the individuals who reviewed and commented on earlier drafts of this paper: Javeria Afzal, Ellen Kelly, Tehani Pestalozzi, Ashleigh Spencer, Strahan Spencer, Emma Sundblad and Lu Rui.

Key to seeing this paper to completion were: Linda Calabrese, Josie Emanuel, Mathew Foley and Valerie Geiger.

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Contents

Acronyms

AEDB	Alternative Energy Development Board (Pakistan)
BRI	Belt and Road Initiative
CGMP	Clean Green Pakistan Movement
CPEC	China–Pakistan Economic Corridor
EIA	Environmental impact assessment
EPA	Environmental Protection Agency (Pakistan)
ETS	Emissions trading schemes
Exim Bank	Export–Import Bank of China
FDI	Foreign direct investment
GIP	Green Investment Principles for the Belt and Road (China)
IEE	Initial environmental examination
INDCs	Intended Nationally Determined Contributions
IPP	Independent power provider (Pakistan)
MoCC	Ministry of Climate Change (Pakistan)
NEPRA	National Electric Power Regulatory Authority (Pakistan)
PPDB	Punjab Power Development Board
PPIB	Private Power and Infrastructure Board (Pakistan)
SAM	South Asian Monsoon
SEA	Strategic environmental assessment
SECMC	Sindh Engro Coal Mining Company
SEZ	Special economic zone
TCFD	Task Force on Climate-related Financial Disclosure

Executive summary

Investment projects under the Belt and Road Initiative (BRI) will invariably bring environmental, climate and financial trade-offs, both opportunities and risks. In Pakistan, China–Pakistan Economic Corridor (CPEC) energy projects will increase and diversify generation capacity and support economic development. The BRI also aims to strengthen trade between China, Pakistan and the Middle East, and has the potential to create new economic opportunities for companies across Asia.

To fully realise the intended benefits of CPEC and protect them against an increasingly erratic climate and international economic priorities shifting away from fossil fuels, disaster risk management and climate resilience and mitigation need to be integrated into CPEC infrastructure plans, designs and maintenance. Infrastructure investments built today are likely to be in operation for decades to come. Investors need to be prepared for climate change impacts – including the potential for shorter than expected infrastructure lifetime in the event of a complete destruction of the infrastructure by an extreme event – and for increasing financial and governance regulations and oversight regarding emissions, environmental and social standards and an all-hazards risk management approach.

The threat of other natural hazards that are not influenced by climate change, such as earthquakes, is ever-present. And while not covered in this report, new and emerging threats, from cyber-attacks to global financial instability, also have the potential to disrupt BRI infrastructure plans or operation and could lead to financial losses for investors (Chinese and host country companies, governments and lending institutions), as well as potentially leading to severe environmental consequences for host communities should infrastructure be damaged.

Infrastructure damage, disruption and losses can have knock-on consequences for multiple companies and countries beyond those directly involved in the investment. 'The interconnectedness of supply chains and technological and financial systems in the global economy increases the exposure and vulnerability of critical infrastructure. When shocks and disruptions occur, their negative impacts can cut across sectors and borders, and even resonate globally' (OECD, 2019: 3). Depending on the financing terms, countries already dealing with high debt levels could find their debts increased should a BRI investment be damaged. Investments that fail to prepare for existing and future risks might not generate expected returns, may become stranded assets and could open investors up to legal action. In the worst-case scenarios, cascading business interruptions can exceed infrastructure damage as seen in Hurricane Katrina in 2005, the 2010 Thailand floods and the 2011 Fukushima earthquake, tsunami and nuclear accident (Zhang et al., 2019).

Reliance on coal-fired generation risks creating a wave of stranded assets if mitigation measures are not taken. Globally, it is already cheaper to build new renewable energy capacity, including battery storage, than to continue operating 39% of the world's existing coal fleet, a proportion that will increase to 73% in the next five years (Bodnar et al., 2020). Pakistan's ambitious new climate commitments exclude investments in further coal power plants, while leaving open the possibility of early retirement of existing

Chinese coal projects (Lo, 2020). The Climate Investment Funds together with the China–Latin America Cooperation Fund have demonstrated a first-of-its-kind business model to retire early coal projects while reinvesting resources into new renewable projects in Chile (CIF, 2021). This provides a workable model, backed by a Chinese financial institution, to reap the benefits of transitioning towards net zero while avoiding the risks of stranded assets, as well as the social and environmental impacts associated with coal.

There is growing government, financial institution and business recognition that comprehensive social, environmental and all-hazard risk management in infrastructure is good for businesses and can assist countries in achieving development goals in line with the Agenda 2030 Sustainable Development Goals (SDGs), United Nations Guiding Principles on Business and Human Rights, the 2015 Sendai Framework for Disaster Risk Reduction and the 2015 Paris Agreement. The *Equator Principles* (2020), a standard for risk management for financial institutions developed by the World Bank Group's International Finance Corporation, affirm the objectives of these international agreements in deciding what investments should be financed. The principles state that 'the negative impacts on Project-affected ecosystems, communities and the climate should be avoided where possible. If these impacts are unavoidable, they should be minimised and mitigated, and where residual impacts remain, clients should provide remedy for human rights impacts or offset environmental impacts as appropriate' (EPFI, 2020: 3). Through incorporating resilience in infrastructure projects, the World Bank found that risk management measures brought a return of $4 for each dollar invested (Hallegatte et al., 2019). Other studies have found similar returns in risk management investments (Rose et al., 2007).

Combining and incorporating climate and natural hazard risk management with forward-looking social and environmental risk management will bring win–win benefits to Pakistan, China and the companies involved in constructing and operating CPEC infrastructure. By doing so, Pakistan ensures that CPEC infrastructure is resilient against a variety of hazards and can contribute to its socioeconomic development goals and their alignment to the SDGs. China would gain more multi-hazard resilient trade. And companies would see their investments protected – more likely to remain functional during and post-hazard events, and less costly to repair. Adherence to international standards or to strengthened domestic environmental, social, multi-hazard and climate change risk management standards would also allow Pakistani and Chinese companies to access other sources of international financing beyond that from Chinese banks.

1 Introduction

China's Belt and Road Initiative (BRI) has the potential to open up new development pathways through infrastructure development, stimulating investment and job creation and promoting economic transformation in host countries. The BRI covers a wide range of infrastructure in partner countries, including transportation, communications, water supply and energy, financed by Chinese institutions and funds and by partner countries, either through direct financial contributions or by offering Chinese investors shares in projects, tax incentives and trade agreements.

Through its five areas of cooperation (infrastructure connectivity, trade, financial cooperation, policy and people-to-people exchanges), the BRI can be an engine for growth and development. However, this is not a given – as a powerful external change agent, the BRI also has the potential to increase a range of economic, environmental and political risks within host countries. These risks are not separate and distinct, but rather dynamically interconnected (Opitz-Stapleton et al., 2019).

Pakistan's energy needs are evolving rapidly, along with natural hazard-related and environmental risks that interact with energy provision. Until recently, Pakistan suffered from a power generation problem that hindered socioeconomic development goals. Under the aegis of the China-Pakistan Economic Corridor (CPEC), a flagship initiative of the Belt and Road, a number of power projects have been or are being developed.

In terms of energy infrastructure, CPEC is primarily focused on hydropower, coal-fired thermal power, wind and solar, and transmission lines. The Pakistan government is specifically counting on energy investments under CPEC to 'provide a significant boost the economy ... up to 1% (GDP) increase for the period 2020 to 2030' (Government of Pakistan, 2016: 7).

Fossil fuel-based generation (namely coal and some plans for syngas[1]) dominates the mix at nearly 62% of CPEC energy projects. However, renewables are gaining in importance to the Pakistan government, as announced in 2020 with the new *Alternatives and Renewably Energy Policy* and Prime Minister Imran Khan's commitment to no new coal-fired power plants. And China itself has pledged more stringent regulations of outward BRI investments in line with its growing domestic commitment to promoting green development as outlined in its draft *14th Five-Year Plan*.

Whilst much attention has been given to the political and economic risks associated with CPEC, the temporal characteristics of various climate and environmental threats to energy projects in particular have received less attention. **Risks – the potential negative impacts that could occur should a hazard event happen** – need to be factored into the design, construction, operation and maintenance of critical infrastructure with long lifetimes, such as energy infrastructure projects.

1 Syngas is synthetic natural gas often produced through the gasification of coal and can be used in energy generation.

Using a rapid qualitative risk assessment approach,[2] this report examines potential climate **risks to** and environmental **risks that could arise from** energy projects in Pakistan constructed as part of the CPEC.

It is critical that the impacts of climate change are better understood as they will be increasingly felt over the coming decades. Some extreme events, like super typhoons, could have immediate and tangible impacts, such as damaged port infrastructure or oil/chemical spills at terminals. Others, such as increasingly erratic monsoon rainfall and a longer hot season, may be slow-onset with impacts on the operations of coal-fired and solar power that only become apparent over decades; this can give the impression that some risks are not so severe, particularly if they may not be realised until the future.

Investments that fail to prepare for existing and future risks might not generate expected returns, may become stranded assets and could open investors up to legal action. Such energy investments, and other infrastructure critical to Pakistan's development, have the potential to be damaged or destroyed, and the services they provide interrupted by natural hazards, including those that will be magnified under climate change. Financial losses to borrowers, investors and insurers of projects could increase. Infrastructure companies, host countries and domestic and Chinese investors must ensure that investments under the Belt and Road framework provide a positive sustainable and resilient development impact by taking a multi-hazard risk-informed approach when planning, building and operating infrastructure. Such proactive risk management brings triple wins: 1) it helps to avoid losses; 2) it protects and unlocks resilient economic development; and 3) it can bring social co-benefits.

The report is structured as follows. Chapter 2 begins with Pakistan's energy context. It then describes the CPEC's envisioned role in supporting energy development. Chapter 3 and Chapter 4 describe how climate and environmental risks could affect energy investments, using two case studies, and the risks the investments could pose to ecosystems and natural resources. The case studies are the Engro Thar Block II coal mine and coal-fired power plant in Sindh Province and the Quaid-e-Azam Solar Park in Punjab Province. Chapter 5 maps current risk management mechanisms and technical standards employed by Pakistan and China in order to manage negative environmental and climate risks arising from infrastructure. Chapter 6 describes international good-practice risk management standards for infrastructure and uses these as the basis for recommendations for multi-hazard, climate, environmental and social risk management. Some of these recommendations are aimed at governments (not just Pakistan and China), others at investors and infrastructure companies.

2 Interviews were conducted with a small number of experts from the energy sector and climate change fields – policy-makers, non-governmental organisations and environmental journalists – to understand their perceptions of climate and environmental risks to BRI-related energy infrastructure in Pakistan. These risk perceptions were combined with a literature review of currently observed impacts and of potential environmental and climate risks, gathered from public documents (e.g. Environmental Impact Assessments), academic literature and newspaper articles to qualify potential climate and environmental risks to the two energy projects.

Box 1 Impact and risk definitions

For the purposes of this study, we use the following definition of risk. *Risks are potential negative impacts* – loss of life, injury, destroyed or damaged assets, financial disruption, etc. – which could occur to a system, society or community should one or more threats occur, recognising the diversity of values and uncertainties in potential impacts (adapted from UNISDR, 2017 and IPCC, 2018). Risks are what *could happen* (but have not yet), whereas impacts have actually occurred. Furthermore, risks cannot be attributed just to the triggering hazard or threat event; what might happen is significantly, and sometimes predominantly, influenced by underlying contexts and exposure to the hazards. Vulnerabilities and exposure, and therefore risks, can be managed through integrating disaster risk management and climate adaptation and mitigation into: 1) national and subnational policies and practice – socioeconomic development planning, land use and spatial planning, and environmental and natural resource management; and 2) into infrastructure planning, construction and operations.

2 The China–Pakistan Economic Corridor (CPEC)

2.1 Pakistan energy context

Pakistan is a socially and economically dynamic country, though still classified as a lower middle income economy (World Bank, 2019b). Population growth and a youth bulge, urbanisation and economic diversification present both opportunities and challenges for the country. For a synopsis of demographic and socioeconomic information, refer to Appendix 1.

Energy security is a government priority. Historically, frequent power outages lasted, on average, 12–16 hours a day across the country (Khan and Ashraf, 2015; GeoNews, 2020). The outages hindered economic development – estimated to cost between 2.5% and 4% of GDP – contributing to factory closures and reducing industrial output (Shahbaz, 2015). Current electricity production is achieved through four dominant sources: hydropower, thermal (coal or LNG-fired power plants; phase-outs have begun for oil-fired plants), nuclear and renewable (MoF, 2017). The 2015 estimated GHG emissions contributions from the energy sector were ~186 Mt CO_2 equivalent, or 46% of total emissions (Government of Pakistan, 2016).

The government recognises these energy challenges. Pakistan is one of the first countries to align its national development agenda with its commitment to the 2030 Agenda for Sustainable Development (Government of Pakistan, 2019). The government is pursuing aggressive expansion of energy infrastructure and supporting infrastructure under its commitments. It has set a goal of increasing electricity access to 96% by 2030, compared with ~93% in 2015. Improving rural access is a high priority. Renewable energy is to increase its share to 25% of total consumed electricity (ibid.).

Many of the last decade's engagements with funding agencies such as the International Monetary Fund (IMF), the Asian Development Bank and the World Bank have been around securing funding, building partnerships and seeking capacity-building assistance for energy, water and transportation infrastructure development (MoF, 2015; 2017). It is argued that, without more and better transport networks, reliable electricity and modern communications, Pakistan is unlikely to meet its socioeconomic development targets (CPEC, 2017; Kanwal et al., 2018). Thus, improving household and private sector access to electricity remains a priority development objective, as outlined in *Pakistan Vision 2025* and the *National Power Policy*. Improving energy security has been a key motivation in projects pursued by the Pakistan government with Chinese cooperation.

2.2 CPEC overview

The development of energy generation and transmission lines and transportation networks has formed a key focus of successive Pakistani governments as a means towards economic and social development objectives. Projects with Chinese investment and cooperation since the early 2000s have been pursued with such goals in mind.

Infrastructure and economic cooperation between Pakistan and China was further cemented with the formation of the CPEC. Part of the BRI, the CPEC is one of the corridors in which China is investing most heavily, in part due to the history of strong relations with Pakistan.

CPEC was conceptualised in 2013 and launched in February 2015 with an initial investment of $46 billion; this has since been increased to $62 billion (CPEC, 2021). The investments constitute three types of loans – commercial, concessional and interest-free – and grants (ibid.). The funding for these investments comes from a mix of sources: Chinese financing (~80%), equity (15%) and local financing (5%). The majority most likely comes in the form of long-term loans from the Silk Road Fund, AIIB, ICBC, CDB and Exim Bank (Rizvi, 2017). Most loans are commercial with interest rates at 4–5%, although some may be concessional loans to the government of Pakistan with interest rates of 2–2.5% (Chattha, 2019). The share of interest-free loans and grants is likely negligible. Publically available information on loan specifics is limited.

CPEC is primarily focused on four infrastructure types for socioeconomic development: energy infrastructure (hydropower, coal-fired thermal power, wind and solar, and transmission lines); transport networks (motorways, railways, ports and one airport); special economic zones (SEZs) with preferential trade and tax incentives; and an educational institute to build a modern technical workforce.

CPEC is divided into phases, with some $19 billion committed for 'Early Harvest' energy projects. These projects are intended to reduce Pakistan's energy gap by adding 7,000 MW of power production (CPEC, 2017). Coal-based thermal power plants make up the bulk (62.3%) of proposed energy investments. Renewables from hydropower, solar and wind have a smaller portfolio presence, as shown in Table 1.

Many of the CPEC energy investments are financed through Independent Power Producers (IPPs), which are private, for-profit companies. The *IPP Policy of 1994* led to the formation of the Private Power and Infrastructure Board (PPIB) under the Ministry of Water and Power. The Policy encouraged private investment in electricity-related projects as a means of addressing Pakistan's energy crisis. Conventional (coal, oil, LNG and hydropower) IPPs are regulated by the PPIB, which has oversight of power purchasing agreements, prescribes application fees and assists in coordinating national and provincial agencies in working with the IPPs in obtaining project consent (PPIB, 2019). IPPs using alternative energy sources (e.g., solar and wind) are overseen by the Alternative Energy Development Board (AEDB).

Table 1 CPEC energy investments (priority/actively promoted/potential)

Investment type	MW	% of CPEC energy mix
Coal-based	8,220	62.3%
Hydropower	3,571	27.1%
Wind	398	3%
Solar	1,000	7.6%
Total renewable	4,969	37.7%
Total energy	13,189	

Source: Authors' calculations from CPEC website (2021).

IPPs are intended to complement and augment generation and transmission by state-owned ventures such as the Water and Power Development Authority and the Karachi Electric Supply Corporation. Power licence applications are made to NEPRA – the National Electric Power Regulatory Authority. NEPRA specifies the details of the licence application under Schedule-3 of the *NEPRA Regulations 1999*, approves licences and sets the tariff rate that an IPP can expect as a return on investment per kWh (NEPRA, 2019). The IPPs recover costs and aim to generate profits through the tariff rate consumers are charged. The regulations for power generation mandate that the following are included in an IPP licence application: emission values, land details, cooling water source and distance to the source, and an Initial Environmental Examination (IEE) and/or an Environmental Impact Assessment (EIA – *NEPRA Licensing Application and Modification Procedure Regulations*, 1999).

Our case study sites are the Thar II Coal Mine and Engro Coal Fired Power Plant (in Tharparkar District of Sindh Province) and the Quaid-e-Azam Solar Park in the Lal Suhanra National Park in Punjab Province Solar is new to Pakistan's energy mix; the Solar Park is currently the only planned CPEC solar energy investment.

2.3 Engro Thar Block II

The Engro Thar Block II consists of two quasi-separately executed projects – the surface mining project of the Block II coal field and the coal-fired power plant. The mining project is executed by the Sindh Engro Coal Mining Company (SECMC), a public–private partnership between the Sindh government, Engro Energy Limited, China Machinery Engineering Corporation (CMEC), Habib Bank Limited, Thal Limited, and Hub Power Company; SECMC was formed in 2009 (Engro Energy, 2021). The Sindh government retains a 54.7% share in SECMC. The power plants are separately executed as a joint venture between Engro Powergen Thar (50.1% ownership) and CMEC, Habib Bank Ltd. and Liberty Mills Limited (Ibold, 2018). A syndicate of banks – China Development Bank, China Export and Credit Insurance Corporation, Habib Bank, Bank Alfalah, National Bank of Pakistan, Faysal Bank, United Bank, Construction Bank of China and the Industrial and Commercial Bank of China – provide the majority financing as a loan worth $825 million, and Engro Energy invested $275 million in equity for the power plants (Engro Powergen, 2014; Power Technology, 2020). Although the mines are operated as a public–private partnership, the power plants are IPPs. The projects are coordinated by the Ministry of Water and Power, and supervised by the PPIB (PPIB, 2019).

Engro Thar Block II consists of two of the four thermal coal-fired power plants being constructed at the mines; fuel transportation distances are thus reduced. The location of the coal-fired, subcritical[3] thermal power plants was determined by the location of Pakistan's coal reserves.

The lignite coal deposits in the Thar Desert are estimated to contain between 170 billion and 185 billion tons of coal (Sanfilipo et al., 1992). Engro estimated that the Pakistani government would annually save approximately $1.6 billion in foreign exchange through reducing imports of foreign coal and transport costs (Dawn, 2019).

Table 2 Engro Thar Block II power generation statistics

Engro Thar Block II 2×330 MW Coal-fired Power Plant	
Primary energy input	Locally mined lignite coal
Technology	Subcritical thermal – constant evaporation endpoint, less efficient (38%) than a super-critical thermal power plant (42% to 44% efficiency), but does not require as high-quality water as a supercritical plant and is cheaper to construct
Installed capacity (MW)	660 (planned capacity for full Thar project is 1,320 MW across four plants)
Estimated cost (US$ million)	995.4 (the Thar Block II 2×330 MW Coal-fired Power Plant alone)
Executing companies/sponsors	Engro Energy Limited, CMEC, Habib Bank Ltd., Liberty Mills Limited
Financing	Independent Power Producer (IPP)

Source: CPEC website (2021); NEPA 2014a; Power Technology 2020.

The Engro Thar Block power projects are intended to provide much-needed power throughout Sindh Province and the national grid. The provincial government also hopes that the power projects will provide local employment. Tharparkar District, where the energy projects are located, is one of Pakistan's poorest districts. General infrastructure – roads, clean and secure water supplies, electricity – is lacking, which has in turn contributed to reduced livelihood diversification and access to markets for its largely pastoral and agropastoralist communities (see Box 2).

A foundation has been set up by SECMC to fund social development programmes in the district, but actual progress and delivery on the foundation's programmes is difficult to verify.

3 Coal-fired power plants use coal to heat water and produce steam to drive turbines that generate electricity. The temperature and pressure of the steam entering the turbines strongly influence plant efficiency. Subcritical plants operate at pressures of less than 200 bar and lower temperatures. The water is brought to a boil to create steam. Supercritical and ultracritical plants operate at higher pressures and temperatures (greater than 221 bar and 374°C), by which water is converted directly to steam without having to first boil. This increases plant efficiency and reduces emissions.

Box 2 The socioeconomic contexts of communities near Engro Thar Park II Power

Tharparkar District is in southern Sindh Province. It is poor, ranking near the bottom of districts across Pakistan in terms of human development, and is the 'most deprived district in Sindh' (Najam et al., 2017: 17). Lack of infrastructure, including roads, railway, national electrical grid connectivity and secure water supplies, hinders socioeconomic development in the district and creates poverty traps; nearly 87% of the district's population lives in poverty (ibid.). Poverty and food insecurity (sustenance cropping limited by water availability) are challenges facing many households (Ebrahim, 2017; Najam et al., 2017).

The district has a population of about 91,000 (Soomro et al., 2017; Hagler Bailly Pakistan 2014a; Makki et al., 2014). The population is a mix of semi-nomadic pastoralists and agricultural communities. Land-owning families tend to be better off, but land tenure is often informal with land passed down generations. Few can afford to go through the formal government registration process (Ebrahim, 2017).

Local populations rely on rainwater recharge and harvesting during the monsoon (July to September) and groundwater for the remainder of the year to meet domestic water needs. Communities rely on tube wells tapping one of the three aquifers underlying the Thar Desert (Hagler Bailly Pakistan, 2014a). Groundwater quality is poor, with high levels of heavy metal contamination – mercury, arsenic, fluoride and salts – due to natural rock and soil weathering (Ali et al., 2016; Soomro et al., 2017). There are no other water sources for domestic use. During extended periods without rain, quality is further degraded as metals and other pollutants are concentrated in water.

2.4 Quaid-e-Azam Solar Park

The Quaid-e-Azam Solar Park is about 25km from the mid-sized city of Bahawalpur (population 681,700 according to the 2017 census) in Punjab Province. The Park was established as a joint venture between a publicly owned, for-profit company, Punjab Power Development Board (PPDB), set up by the government of Punjab, which divested from the project in 2015 (Khawaja, 2015) and the Chinese firm Zonergy. It constitutes an IPP under Pakistani law. However, because it was the first solar park in the country, and thus considered an alternative energy source, it is jointly supervised by the AEDB and the PPDB rather than the PPIB.

Construction of the park was divided into three phases. Construction of the first phase (100 MW) by the PPDB, and the second (300 MW) and third phases (600 MW) by Zonergy, have been completed and are feeding into the national grid (CPEC, 2019). The government of Punjab provided 25% equity ($37.5 million) and $112.5 million debt was raised through the Bank of Punjab to cover the first phase (NEPRA, 2014b); phases II and III are financed through loans from Exim Bank and China Development Bank (Ibold, 2018).

Box 3 Quaid-e-Azam Solar Park

The Quaid-e-Azam Solar Park is located within the Lal Suhanra National Park and UNESCO Biosphere Reserve, on the edge of the Cholistan Desert. The desert has supported nomadic pastoral communities for hundreds of years. These communities move their herds in accordance with the strength and spatial extent of the monsoon, migrating from intermittent, ephemeral rivers and community-constructed ponds or 'tobas' to irrigated canal regions when other water supplies have failed (Soharwardi et al., 2011, 2012; Khan and Khan, 2015). Communities often have poor sanitation and insecure, untreated drinking water; few schooling opportunities; reduced access to electricity; and weak health care services for people and livestock (ibid.).

In irrigated areas, agriculture (food, cotton and fodder crops), livestock rearing, embroidery and day labour comprise dominant economic activities; the sole economic activities when communities are not at irrigated areas are livestock-rearing and animal-related products (Soharwardi et al., 2012). Ownership of irrigated land for cultivation is critical for incomes and food security; those without irrigated cultivated land are more prone to poverty (ibid.). Women and men participate equally in livestock-rearing and related economic activities for income (Khan and Khan, 2015). Irrigated land belonging to nomadic landowners is located within a 5km radius of the Quaid-e-Azam Solar Park, and shares the same water supplies as those used for the cleaning and maintenance of solar panels.

Table 3 Quaid-e-Azam statistics

Quaid-e-Azam Solar Park	
Primary energy input	Solar
Technology	Solar Photovoltaic
Installed capacity (MW)	1,000 planned; 400 completed
Estimated cost (US$ million)	1,302
Executing company/sponsor	Zonergy
Financing	Independent Power Producer (IPP)

The two projects represent a diversification of both non-renewable and renewable energy. The next two chapters outline potential exogenous climate and natural hazard risks to the coal-fired power plant and solar park, and endogenous environmental risks that could arise from them. How the two energy projects manage climate and environmental risks might provide lessons for other CPEC projects and other large-scale infrastructure investments, in order to reduce risks to such investments and protect their intended benefits.

3 Risks related to natural hazards and climate change

This chapter explores the exogenous natural hazard and global climate change risks to the Engro Thar II Coal Mine and Coal Fired Power Plant and the Quaid-e-Azam Solar Park. Natural hazards and climate change are external to the projects. Nonetheless, when such external shocks occur, such as a drought or heatwave, the functionality and capacity of infrastructure is compromised. The exogenous risks explored are based on available design specifications and operations, in which future-looking (i.e. considering climate change) risk management strategies are currently not incorporated.

3.1 Climate threats in Pakistan

Pakistan has a diverse climate linked to topographic extremes. High mountain ranges such as the Hindu-Kush in Khyber Pakhtunkhwa and the Kirthar between Sindh and Balochistan provinces direct the flow of the South Asian Monsoon (SAM) and winter westerlies, leading to copious rainfall in some parts of the country while leaving others arid. The SAM, beginning approximately in June and tapering off in September, brings the majority of annual precipitation across the country and is critical for economic and livelihood activities.

The two case study locations are characterised by some of the most arid climates in Pakistan. The Thar Desert, where the Thar Coal Mine and Power projects are located, encompasses a significant portion of Sindh Province. The Cholistan Desert in Punjab Province, the location of Quaid-e-Azam Solar Park, is also known for its extreme conditions. Daytime temperatures in both case study areas average between 38°C and 40.5°C during the hot season (March to around June) and annual precipitation is normally less than 200mm.

No statistically significant precipitation trends can be seen in recent decades, from the 1950s to 2010 (Ahmed et al., 2018; Hanif et al., 2013). While there are no overall precipitation trends, secondary climate-related hazards of flood and drought can trigger large socioeconomic losses and damage in areas without sufficient disaster risk management. Rainfall extremes such as those in July and August 2010 contributed to widespread, catastrophic flooding across the country. Droughts present the most pervasive challenges to energy, food and water security across large swathes of the country. Extreme heat waves play a dominant role in Pakistani drought formation and duration, contributing to high rates of evaporation even when precipitation might be close to average (Ahmed et al., 2018).

Climate change, in conjunction with socio-economic development and trends in land and water use, presents a number of risks to Pakistan:

> 'Future heat waves are not only projected to be significantly more severe, but heat will likely become more sustained ... Model projections suggest, however, that breaks in hot weather ... will gradually give way to continual heat with little or no interruption' (Amman et al., 2014: 15).

By the 2050s, some cities in Pakistan may have periods of extreme heat lasting 60 days or longer.

Such heat extremes pose serious risks to human health and will have implications for energy consumption, production and transmission and water management.

Water security may be greatly impacted by climate change, and there is the potential for both more flooding and more droughts, sometimes in the same year. There is little agreement among current climate models as to overall projected increases or decreases in Pakistan's seasonal to annual precipitation (MoCC, 2018; Ahmad and Rasul, 2018). Recent trends in increasing variability – particularly both wetter and drier monsoons – suggest that the next few decades might also show increased variability. Pakistan is heavily reliant on flows from the Indus River and supporting tributaries originating in the mountainous north, as well as groundwater supplies to meet water needs for domestic, agricultural and industrial purposes. Glacial melt sustains the rivers during dry months. Warmer temperatures are increasing the rates of glacial melt in many areas (but not all) of Pakistan's mountains (Forsythe et al., 2019).

Historical climate statistics and multi-study climate change projections for temperature and precipitation are presented in Appendix 1.

3.2 Business-as-usual implications for case study sites

There are limited regional studies on the impacts of climate change on energy assets, systems and the wider economy, with a focus on Asia (Cronin et al., 2018). Climate projections indicate the possibility that cloud cover could decrease in low- and mid-latitude regions, which could benefit solar power generation (Patt et al., 2013); however, existing studies for Europe and Africa show that this will often be offset by decreasing efficiency due to rising temperatures.

By the end of the century, electricity generation may change between –10% and 10% depending on where the asset is located (Crook et al., 2011; Gaetani et al., 2014; Panagea et al., 2014).

Despite limited studies on climate change impacts to South Asian energy infrastructure, it is clear that the Engro Thar and Quaid-e-Azam energy projects face the risk of reduced generation related to rainfall extremes and extreme heat, along with the potential for increasing demand during heat waves. BRI investments have the potential to:

- be damaged or destroyed directly by natural hazards – flooding, storm surge (coastal investments), drought or heat wave;
- compound environmental risks and magnify some social risk (discussed in the next chapter); and
- experience more rapid deterioration and potential loss of functioning due to heat waves, and increasing flood and drought incidence leading to lower than expected returns on investments.

A summary of key climate and natural hazard-related risks mentioned in the risk perceptions interviews and in the literature is outlined in Table 4.

Table 4 Climate and natural hazard-related risks to CPEC energy investments

Climate-related hazards	Risks to coal-fired plants	Risks to large-scale solar power
Heat waves	Exceedance of operational limits of electricity generation and transmission; increased demand for cooling; combined challenges as a thermal plant must be maintained in a hot state to reduce the time to bring the plant fully online to cope with variable loads during heat waves	Reduction in solar panel efficiency and energy production; inability to provide for (increased) energy demands at night for cooling
Heavy precipitation	Flooding; disruption of coal transportation networks; infrastructure damage and destruction > disruption of energy supply > knock-on economic impacts; lost revenue	Flooding; infrastructure damage and destruction > disruption of energy supply > knock-on economic impacts; lost revenue
Increased monsoon variability	Variability in water availability for operations; increased competition for water with local agriculture and urban demands	Variability in water availability for operations; increased competition for water with local agriculture and urban demands
Drought	Reductions in water quantity and quality; corrosion of power plant equipment; dust storms scouring infrastructure; insufficient water for operating needs	Reductions in water quantity and quality; dust storms scouring infrastructure; insufficient water for panel cleaning
Hotter days and nights in most seasons, lengthening of the hot period	Increased electricity demand for air conditioning and refrigeration for longer periods; strain on transmission grid	Increased electricity demand for air conditioning and refrigeration for longer periods; strain on transmission grid
Widespread waterlogging post-flooding	Similar risks to those associated with extreme precipitation	Similar risks to those associated with extreme precipitation
Other natural hazards		
Earthquakes	Damage and destruction of generation and transmission infrastructure > similar cascading impacts as with extreme precipitation	Damage and destruction of generation and transmission infrastructure > similar cascading impacts as with extreme precipitation

Note: The listed risks are not exhaustive.
Source: Summary of findings from interviews and literature cited in the text.

River flows are increasing in northern Pakistani river basins due to a combination of warming, melting glaciers and increasing precipitation (Bae et al., 2014). While initially this may contribute to higher flows during dry months for the next few decades, baseflows will eventually decline as glaciers retreat. This has significant implications for water security and hydropower generation along the Indus River and its tributaries. Some existing and planned hydropower plants might not be able to generate electricity due to insufficient base flows within the next 50 years. More research is needed to understand potential changes in river flows and the implications for hydropower.

Analysis of temperature impacts on thermal power plant operations in other countries indicates that the cooling technologies of such plants are vulnerable to water shortages and warmer water temperatures. Several studies show that power output could be reduced by 0.4–0.7% for each degree Celsius temperature increase due to decreased thermal efficiencies (Chuang and Sue, 2005; Durmayaz and Sogut, 2006; Linnerud et al., 2011; Ibrahim et al., 2014). Rising temperatures will also affect water resources for cooling, resulting in further reductions in electricity output. Thermal power output can drop between 0.15% and 0.5% for every 1°C increase of ambient cooling water temperature above ideal operating thresholds (Cook et al., 2015). Across Europe, thermoelectric generation is projected to decrease by up to 5% for 1.5°C average warming, 10% for 2°C and 15% for 3°C, with a few southern European countries potentially experiencing a 20% reduction in output (Tobin et al., 2018). Globally, thermoelectric power usable capacity could decrease by 7–12% in the 2050s and 6.7–19% in the 2080s (van Vliet et al., 2016). Transmission lines are also impacted by higher temperatures.

Solar parks are also not exempt from extreme heat impacts. As previously discussed, mean temperatures and extreme heat events are projected to increase across Pakistan due to climate change. Solar panels experience a reduction of power generation for every degree temperature above 25°C; power inverters also experience reduced performance under extreme heat conditions (Aziz et al., 2018; Chander et al., 2015). The exact amount of generation reduction depends on solar panel composition and measures to cool panels and inverters. During the permitting process of the Quaid-e-Azam park, concerns were raised that, at temperatures above 55°C, panel efficiencies could drop below 10%; the response rejoined, 'the figure of 55°C is overstated' (NEPRA, 2014c: 4). Respondents to shareholder comments indicated that the highest recorded temperature in Sindh Province was 53.5°C (NEPRA, 2014b); the application did not account for the possibility that higher temperatures may occur because of climate change. Weather station data for Bahawalpur is very patchy before 2010 and would have been a limiting factor, though this was not acknowledged in the application. The panels at Quaid-e-Azam are cooled via forced air cooling. Whether these measures are sufficient to withstand the more intense and frequent heat waves possible under climate change over the 25-year expected lifetime of the project is not known.

Finally, as temperatures rise and the risk of deadly heat waves increases, energy consumption will go up. Ali et al. (2013) examined the relationship between extreme hot temperatures and electricity demand in Pakistan between 1990 and 2010 and found that demand increased an average of 109.3 million KWh per 1°C above 30°C. Demand for air conditioning, refrigeration for food and medicine storage and cooling for data centres, manufacturing and other critical equipment need to be accounted for as climate change risks when planning for future energy portfolios – planning for population growth and economic change only could lead to energy shortfalls (Mahmood et al., 2016). A 1°C mean temperature rise due to climate change was projected to increase countrywide-averaged residential demand alone between 0.92% and 1.8%; this rises to between 5.1% and 7.3% if mean temperatures increase by 4°C (ibid.). Regional consumption differences emerge, with Karachi projected to need up to an additional 8.3% for residential and 5.8% for commercial demand. (ibid.)

Box 4 Select climate risks from the case study projects

Climate change impacts on temperature, water resources and flooding incidence present exogenous risks to the operations of Engro Thar Park II and the Quaid-e-Azam Solar Park.

Water shortages have the potential to curtail power generation (Miara et al., 2017; Rübbelke and Vögele, 2010), and are already common in Tharparkar as witnessed during the recent multi-year drought. The Engro Thar EIA mentions only the potential for extreme rainfall events to disrupt plant operations; it does not consider higher temperatures or extended drought conditions.

The Lal Suhanra Reserve and surrounding Cholistan Desert already face extreme temperatures of up to 50°C in summer. Current solar panel technology experiences a reduction of power generation for every degree temperature above 25°C; power inverters also experience reduced performance under extreme heat conditions (Aziz et al., 2018; Chander et al., 2015). The exact percentage of generation reduction depends on solar panel composition and measures to cool panels and inverters. The Master Plan assumes an annual power generation loss of 11.6%, but no calculations for the figure are presented; NEPRA's Permit (2014) notes that, at temperatures of 55°C, panel efficiency could drop to 10% – but again, 'calculations are not presented.

A risk that was neither mentioned in interviews nor seen in the project EIAs is the potential for large-scale infrastructure projects to create and/or exacerbate flood risks. In desert areas, scant rainfall is usually absorbed in the ground; hence no consideration was given to local drainage when constructing the Engro Thar mines and power plant (Hagler Bailly Pakistan, 2014a; 2014b). However, with changing climate patterns there have been incidences of high rainfall in the Thar Desert. In 2012, heavy rainfall in the area displaced 2.5 million people (Khan, 2013). The standing water over three districts took months to clear as natural drainage had been disrupted by infrastructure running from north to south that did not allow water to drain into the Indus. The Left Bank Outfall Drain was the biggest impediment to drainage, but roads and railways also contributed to localised flooding and waterlogging. As most of the CPEC investments are aligned in north to south corridors, unless large-scale flood drainage is considered, the infrastructure can create significant flood risks; this risk will only worsen under climate change.

3.3 Cascading financial risks

Damage to infrastructure and/or failure to operate at capacity due to climate extremes or natural hazards present potential cascading financial risks, depending on the terms of project loans. Some of Pakistan's current debt issues are related to energy production and transmission.

Electricity production and general energy consumption are highly sensitive to fluctuations in international oil/petroleum, coal and liquid natural gas markets, as Pakistan imports significant quantities of these products (MoF, 2017). Political tension, or severe weather, threatening tanker shipping routes through the Straits of Hormuz can disrupt the flow of Middle Eastern oil imports to Pakistan, and further raise costs.

Additionally, Pakistani power generation companies have at times been delinquent in paying fuel costs. Delinquency in payments has been linked to low revenues due to electricity theft, low tariffs and transmission and distribution losses. These challenges in turn have led to fuel suppliers defaulting on payments; the government then assumes more debt (Khan and Ashraf, 2015). It has also affected infrastructure maintenance and contributed to load shedding issues. Distribution companies recorded losses between 2013 and 2018 (NEPRA, 2018).

The coal power stations' contribution to total CPEC energy production is 69%. However, only half utilise local coal, with the others requiring imports. Three 1,320 MW coal-fired plants have been built with Chinese cooperation as part of the CPEC: the Sahiwal plant in Punjab, the Port Qasim plant in Sindh and the Hub plant in Balochistan (CPEC, 2019). In only three years (from 2015 to 2018), the country's coal consumption has increased 2.5 times (BP, 2019), and this rapid growth cannot be met only through indigenous production. According to the Pakistan government, the primary energy input for all three coal-fired plants will be imported coal delivered at Port Qasim.

IPP rules govern CPEC energy projects, with an estimated $35 billion going to IPPs from CPEC. Rates of return for coal, wind and solar projects (in general, not just those related to CPEC but also with other foreign and domestic investors) are guaranteed at 15% to 20%, although NEPRA is seeking to revise rates (NEPRA, 2016; 2018). As extreme heat events increase in Pakistan, the ability of the solar park or thermal power plants to generate promised electricity may be compromised without cooling mechanisms, for example. CPEC energy projects are reported to be financed over a 25-year repayment period at an interest rate of between 2.1% and 2.5% (Qureshi, 2019), although some loan terms are reported to be as high as 5% (Hurley et al., 2018). The terms of energy infrastructure projects, not just those being built under the CPEC rubric, have the potential to contribute to Pakistan's circular debt issues as the country must make annual payments regardless of whether electricity is produced or not.

Finally, damage to infrastructure and/or failure to operate at capacity due to climate extremes or natural hazards present potential cascading financial risks, depending on the terms of project loans. The extent of insurance coverage against natural hazard losses is not known for individual projects, including coverage against slow-onset climate changes. If there are no such risk-transfer mechanisms in place, it is likely the government must bear the risk.

Debt continues to weigh on Pakistan's finances. Past energy shortages were a primary factor driving approval of so many energy projects under CPEC; this has since reportedly led to supply overcapacity as improvements in transmission and distribution systems have not kept pace. This overcapacity is adding to debt pressures as distribution companies sell power at costs lower than the cost of generation (Nichols, 2021). These threats can contribute to the risks of 'circular debt and capacity payments', as acknowledged by the Pakistani government (MoF, 2019: 240). 'The power sector circular debt is touching the RS 1,200 billion mark, with continued addition of approximately 200–250 billion annually' (NEPRA, 2018: 1).

Pakistan organised some debt relief in light of the pandemic. At the end of 2020, the government concluded debt negotiations with 19 bilateral creditors from the Debt Service Suspension Initiative (MoEA, 2020). The country is estimated to have postponed the repayment of around $2.5 billion (MoF, 2021). However, not all loans are covered by the DSSI. Loans on commercial terms, such as those from the China Development Bank (CDB), are notoriously excluded. In early February 2021, Pakistan sought debt relief for power projects under the BRI (Mangi, 2021).

Table 5 Climate-related threats and cascading financial risks to energy investments

Financial threats	Associated risks
Energy security	Fluctuations in market prices of imported coal and other fossil fuels, particularly if carbon taxes or international carbon pricing markets are introduced
Stranded energy infrastructure assets	Increasing emissions regulations and GHG targets could require less efficient subcritical thermal plants to shut down or undergo retrofits: e.g., flue-gas desulfurization, electrostatic precipitators, low NOx burners, selective catalytic reduction. Plants would have to be shut down or reduce operations while undergoing retrofits
Debt	Generation and/or transmission infrastructure damaged or destroyed by natural or climate change-related hazards and unable to deliver electricity. There is a risk regarding the repayment of debt given the principal and interest must be paid regardless of cashflow. Lack of flexibility with the repayment schedule may make this difficult during emergencies (e.g. pandemic closure) and the relative debt burden would rise

Exogenous natural hazard and climate change risks to energy infrastructure are not the only risks to the sector's intended contribution to socioeconomic development. Endogenous risks arising from the infrastructure itself – during construction, operation and/or maintenance – can also hold back development and reduce the expected benefits of the infrastructure. Some 'endogenous risks, particularly environmental damage, can be traced to infrastructure. Environmental risks that could arise from energy infrastructure are explored in the next chapter.

4 Environmental risks

Environmental risks from infrastructure include pollution and loss of ecosystem services such as clean water supplies. These endogenous risks arise from the construction, operation and maintenance of such infrastructure. Some environmental risks, such as pollution of water supplies, might be exacerbated by climate and natural hazard risks. By and large, however, such environmental risks stem directly from the way infrastructure is designed and operated: they are endogenous to the infrastructure.

This chapter explores perceptions of environmental risks that could arise from CPEC energy investments, using the two case studies – the coal-fired power plant and the solar park. Perceptions of endogenous environmental risks varied among the experts interviewed, as summarised in Table 6. Two primary areas of concern were raised during the interviews:

- Pollution – particularly air and water pollution, with some concern over greenhouse gas emissions.
- Water security – impacts on infrastructure operations, with less concern over community and ecosystem impacts.

The primary concern cited by interviewees was Pakistan's entry into producing energy from local and imported coal at a time when the rest of the world is moving away from this polluting form of energy production. Pakistan has projected for growth in emissions from the energy sector from nearly 186 megatons CO_2-equivalent in 2015 to 898 megatons by 2030 under its *Intended Nationally Determined Contributions* (INDCs) under the Paris Agreement (MoCC, 2015). Similarly, there were concerns about air pollution from mining, transportation and production of energy from coal plants. Although none of the existing CPEC thermal plants has been running long enough, there is some anecdotal evidence from the Sahiwal Coal Plant that air quality has indeed deteriorated (interviewee perspective).

Table 6 Environmental threats and risks from CPEC energy investments

Environmental threats	Risks from coal-fired power	Risks from large-scale solar energy
Electricity infrastructure construction	Ecosystem destruction and disturbance; contamination of water supplies; arsenic and heavy metal contamination of soils and air through Thar dust deposits	Ecosystem destruction and disturbance; habitat loss near a nature reserve
Electricity infrastructure operation and maintenance	Soil and water pollution; ecosystem destruction and habitat loss; power plant accidents and contamination > increased risk of cardiovascular and pulmonary disease and carcinogenic risk from heavy metals (depending on scrubbers and effluent controls)	Traffic and operations present ongoing habitat and wildlife disturbance; water consumption for solar panel cleaning draw down supplies for local populations and wildlife
Coal transport	Air, soil and water pollution from transport spills and accidents; noise disturbance	
Coal mining and washing	Air, soil and water pollution; ecosystem destruction and habitat loss; species loss; noise disturbance; arsenic and heavy metal contamination of soils, water and air through dust deposits from coal mining > increased carcinogenic and non-carcinogenic health risks for local populations	
Use of lignite coal over bitumen coal	Increasing emissions regulations and GHG targets could require less efficient subcritical thermal plants to be decommissioned or undergo retrofits: e.g. flue-gas desulfurization, electrostatic precipitators, low NOx burners, selective catalytic reduction, etc. Plants would have to be shut down or reduce operations while undergoing retrofits	

Note: The listed risks are not exhaustive.
Source: Summary of findings from interviews and literature cited in the text.

Pakistan's *National Environmental Quality Standards for Gaseous Emissions* provides regulations for permissible limits of certain greenhouse gas emissions, namely carbon monoxide, nitrogen oxides and sulphur dioxides (MoCC, 2013). Emission standards specifically for coal and oil-fired thermal power plants do not include regulations for carbon dioxide and methane. Under CPEC, the government is encouraging IPPs employing both subcritical and supercritical thermal technologies (CPEC, 2019); no ultra-supercritical thermal power plants are planned. Gonzalez-Salezar et al. (2018) estimates that SC and USC plants have an average efficiency of 40% and greater than 43% respectively, whereas subcritical plants operate at between a ~33% to 39% efficiency. Super- and ultra-supercritical plants emit 722 g/kWh CO2 compared to 766–789 g/kWh for subcritical plants; this equates to an estimated emissions saving of 2.4 million tons CO_2 over the lifetime of the facility, along with reduced sulphur dioxide and particulate matter emissions (Tan et al., 2010).

Pakistan currently has no enforcement mechanisms to ensure that the supercritical plants operate in a continuous supercritical state. If plants are requested or required to reduce production, due to load balancing issues or tariff concerns, this leads to subcritical production and increased emissions. Similarly, though Pakistan is signatory to a number of international climate and environmental agreements, it does not have mechanisms and capacity to enforce them, especially on a project-by-project basis.

To date, we are unaware of any study that comprehensively attempts to calculate the cumulative emissions from project inception (including emissions from construction and land-use change) through a project operation lifetime – energy production at power plants; coal mining emissions; emissions arising from potential industrial processes at SEZs; and emissions from increased trade and transport – for *all* CPEC projects. Individual studies exist for particular aspects of the CPEC. Some indicate that Pakistan's planned growth trajectories may lead to energy consumption increases of between 41% and 90% higher by 2025/2030 compared to 2013/2014 (Mizra and Kanwal, 2017; Lin and Ahmad, 2017), in the absence of supporting policies and incentives to improve energy efficiency and conservation. Approximately 36.5 megatons of CO_2 could be released alone by trucks transiting along CPEC roadways in northern Pakistan (Nabi et al., 2017). Such a comprehensive study is needed to determine CPEC total emissions potential and subsequently identify clean technology and energy efficiency mechanisms for Pakistan so that it can meet its Clean Development Mechanisms and upcoming NDCs.

The government announced in 2020 a new renewable energy policy to address previous policy deficiencies in this area. Under the new *Alternative and Renewable Energy Policy* (*ARE Policy*), goals have been set for the country to achieve 20% of total generation capacity through alternative and renewable energy by 2025; this is to rise to 30% by 2030 (Government of Pakistan, 2020). The government also announced that no new coal-fired power plants would be constructed. While the policy lays out preferences for renewables when costs are competitive, it still allows for syngas usage. However, coal will continue to be mined for a coal gasification plant in Thar to produce syngas for gas-fired power plants and coal liquification for benzine and diesel fuel (Nichols, 2021; Hayder, 2021). The emissions implications of continued use of coal, albeit indirectly as liquified fuels for combustion engines or syngas for power generation, do not yet appear to have been assessed.

Interviewees also expressed concern related to reduction in the availability and quality of water. As a semi-arid country with a growing population, water availability and quality have been at the forefront of climatic and environmental issues in Pakistan. Many of the CPEC projects are located in semi-arid and arid parts of the country, and require significant amounts of water during construction and operation. Without stronger planning, including for the contingency of hotter and drier climates due to climate change, projects could end up taking water from local populations, and exacerbate contamination.

The CPEC coal-fired power plants located in desert areas often rely on local groundwater or abstractions from irrigation canals, as they have yet to be linked to a government supply (Hagler Bailly Pakistan, 2014a; 2014b). Combustion facilities and operations require a lot of water. 'The withdrawal of such large quantities of water has the potential to compete with other important water uses such as agricultural irrigation or drinking water sources' in these areas (Hagler Bailly Pakistan, 2008: 8). There are also concerns that effluent from plants may contaminate aquifers, which may already be a problem in some areas (see Box 5). Solar power generation is not exempt from water security concerns either. Solar panels require regular cleaning with drinking-grade water to remove dust deposition, which hinders electricity production. Ensuring water availability and water allocation are provincial, not national, government responsibilities.

While this and the previous chapter outlined climate, natural hazard and environmental risks to CPEC energy investments, Pakistan and China do have a number of risk management policies in place. The next chapter explores current risk management practices in Pakistan and Chinese overseas risk management.

Box 5 Select environmental risks from the case study projects: literature-based assessment findings

Water security – impacts on quantity and quality – is a significant environmental risk posed by Engro Thar Park II and the Quaid-e-Azam Solar Park, with the potential to create problems for local populations and ecosystems.

As noted above, southern Sindh Province is extremely arid and water supplies are scarce. The drought from 2014–2018 led to widespread crop failure, and ensuing malnutrition and starvation (ReliefWeb, 2018; 2019). The incidence of water-borne illnesses also increased (ibid.). Groundwater supplies in Tharparkar District, which form the sole water source for local pastoralist populations, are already naturally contaminated with heavy metals (Brahman et al., 2014). Coal mining operations for Thar Park II Power (including pumping water out of the mines), chemicals used in mine extraction processes, and the potential for rain to deposit contaminated dust, may lead to further contamination of supplies. The mine effluent is likely to be contaminated with solids and metals, as well as chemicals used for coal washing and processing (e.g. 4-methylcyclohexane methanol polyacrylamides, acids and alkalis (Ahmadpour and Duo, 1996; Sharma and Gihar, 1991; Biello, 2014)). An on-site waste storage pit has been proposed (Hagler Bailly Pakistan, 2014b), leachates from which can contaminate water supplies if not properly lined and continually monitored for leaks.. The EIA for the coal mine indicates that further studies are needed to determine if waste disposal systems and water storage ponds require lining (ibid.). The licence application indicates that the ash yard will be lined.

Punjab is a province of climate extremes and minimal surface water supply outside of the Indus River watershed (including tributaries). The Solar Park has the potential to present significant water security risks to the Lal Suhanra Reserve, and to pastoralist communities. The Master Plan indicates that 1,660 m³/day of water are needed for panel washing and landscaping needs, the equivalent of 1.66 million litres/day (ibid.: 52–53). Only drinking quality-grade water can be used for washing the solar panels as groundwater onsite is too brackish and will degrade the panels (Khaliq et al., 2015; ESCP and HydroChina Xibei Engineering, 2013). As the solar park is expanded to full capacity, it is possible that water use for cleaning may increase. The Master Plan proposes a number of possible supplies: pulling water from tube wells near the Ahmadpur Canal, using canal seepage and diverting additional water from the Sutlaj to recharge the tube well drawdowns during dry periods. It is not clear what the final water supply sources are, but withdrawal amounts from the existing canals or tube wells hydrologically connected to them will mean less water for irrigation and for the surrounding agropastoral communities. The IEE acknowledges that ‘water course from this canal irrigates some parts of the forest area situated at the boundary and is the sole source of surface water for occasional irrigation to agricultural fields’ (ESCP, 2013: 25). It may also impact biodiversity and fragment important wetland habitats in areas hydrologically connected to the irrigation channels, eventually drying some of them out (Grippo et al., 2015).

5 Current risk management

Pakistan has a number of policies on disaster and environmental risk management. How they are constructed, and the capacities to enforce them, have implications for CPEC. China has mandated that Chinese firms investing and building in foreign countries must adhere to the laws and policies of the project country. However, China does not have formal oversight of or enforcement mechanisms over Chinese companies acting outside its borders. A lack of capacity on the part of the provincial or federal Pakistani governments to properly design and enforce climate change, disaster risk reduction and environmental policy could lead to risk creation and perpetuation for local communities, Pakistan's critical infrastructure and Chinese investors and companies.

5.1 Climate and environmental risk management in Pakistan

Pakistan has a number of policies and institutional arrangements at the national and provincial levels for managing environmental, climate and disaster risks. Since devolution in 2010, provinces now have the mandate for environmental and disaster risk management. As a result, each province and territorial government might have different environmental regulations and standards, including criteria for infrastructure-related IEEs and EIAs, and each has its own Environmental Protection Agency (EPA). Although provinces have adopted national policies (see Appendix 1), capacities to implement and enforce these differ.

The national Ministry of Climate Change (MoCC) has primacy over climate mitigation and adaptation action. To date, no formal mechanisms have been proposed mandating that development projects, such as BRI investments, undertake climate change risks assessments in SEAs/EIAs or propose climate risk mitigation mechanisms in project Master Plans. The national-level Pakistan EPA now falls under the MoCC and has diminished regulatory oversight, serving more in an advisory capacity. The *Environmental Protection Act of 1997* mandates EIAs for most infrastructure projects, except for solar and wind power, as these were not anticipated at the time of the Act's passage. Following devolution of power to the provinces, EIAs continue to be mandated by provincial EPAs.

Disaster risk management has also been devolved. The National Disaster Management Authority focuses on disaster management and preparedness. However, its mandate does not extend to ordering hazard risk assessments for new investment projects.

In our case studies, the Engro Thar Block II power project conducted an EIA in compliance with the regulations for conventional power projects, and submitted this as part of the licence application package to NEPRA and PPIB. The EIA identified issues with water availability for running the power plant and disposal of waste water (Hagler Bailly Pakistan, 2014a; 2014b). The reports indicate that the government of Sindh will provide water for operations, and that water used for mining will be treated on site for further use in the power plant for steam generation and cooling. As mentioned previously, however, water sources in the area are shared with residents. Power plant wastewater is currently being pumped back into the aquifers, further contaminating the sole source of drinking water for Tharparkar residents. These challenges illustrate that an EIA is not a binding document, and once it is submitted there are no measures to ensure that impacts and remediation options identified in the EIA will be adhered to. If the Sindh government does not provide the requisite water, it has no incentive to declare that the environmental management plan is not being followed.

In the case of the Quaid-e-Azam Solar Park, no EIA or climate-risk assessment was conducted; its licence makes cursory mention of some environmental and social conditions (NEPRA, 2014b). The Park was exempt from conducting an EIA because of the lack of precedence and absence of solar parks in schedules mandating which projects require IEE and EIA in the *Environmental Protection Act*. The Act was subsequently adopted by Punjab province as is, making it easier to avoid conducting an EIA. In addition, the solar park area was designated as 'government land' as it was located in the Lal Suhanra National Park, further enabling bypass of an assessment of environmental impacts on local flora, fauna or semi-pastoral livelihoods.

Climate change risks, such as energy infrastructure damage and disruption by events such as heavy rain and flooding, heat waves and increased temperature in all seasons, receive only cursory discussion in some CPEC EIAs and licence applications, including for the Engro Thar Block II project.

Other projects do not mention climate change or natural hazards risk assessments, or report consideration of climate change, despite a joint international workshop on 'CPEC Natural Hazards Risk Assessment and Mitigation and Silk Roads Disaster Reduction' in 2017 (ECOSF, 2017). The workshop, jointly organised between the Institute of Mountain Hazards and Environment of the Chinese Academy of Sciences, Karakorum International University and the Pakistan Academy of Sciences, was intended to develop a risk reduction strategy for CPEC infrastructure for the 'identification of current and future natural hazards and … propose recommendations for mitigating the potential risks and hazards that are likely to affect the infrastructure projects' (ibid.). The status of the strategy's development and, if developed, its use by IPPs and other CPEC investors is unknown. The CPEC Centre of Excellence has also noted the potential for climate change to impact planned investments, as well as the investments themselves contributing to climate change, and the need for a mechanism to encourage projects to consider climate risks (Janjua and Asif, 2018). It is interesting to note that our interviewees did not perceive any climate change or natural hazard risks to or arising from CPEC; it was not on their radar until questioned.

Beyond the need to reduce the potential impacts of climate and other natural hazards on CPEC infrastructure, emissions management is becoming a priority for the federal government. Under its initial INDCs, Pakistan acknowledged that the energy and infrastructure growth needed to support national development targets could lead to 'GHG emissions … witness[ing] exponential growth, unless cleaner and sustainable technologies can intercept the development trajectory and engineer the desired change' (Government of Pakistan, 2016: 9).

Pakistan's initial INDCs sought to reduce emissions by 20% from 2030 emissions (projected if no reductions are made), with support of around $40 billion (ibid.). In December 2020, Pakistan enhanced its mitigation commitments, which forms the basis of its first NDC to be submitted to the UNFCCC, including (Lo, 2020):

- Build no more coal-based power plants, while conceding the use of indigenous coal for coal-to-syngas for gas-fired power generation and coal-to-liquefied benzine and diesel for cars. Pakistan has scrapped two CPEC coal power projects that were supposed to produce 2,600 megawatts of energy and replaced them with hydroelectric projects.[4]
- Produce 60% of energy through renewable resources by 2030.
- Run 30% of all vehicles on electricity by 2030.
- Plant 10 billion trees in the next three years (as part of the existing Billion Tree Tsunami programme) and increase the number of national parks and protected areas from 30 to 45.

A 2019 government-backed and UNFCCC-supported study investigating carbon taxes and domestic emissions trading schemes (ETS) specifically mentions the need to collaborate with China on carbon pricing and ETS around the CPEC (Aleluia et al., 2019). The MoCC is moving forward with plans for carbon pricing instruments in support of Pakistan's forthcoming NDCs.

5.2 China's overseas environmental and climate risk management

Two categories of institutions regulate China's overseas investments and construction projects: the central government, with its line ministries, and the financial institutions lending to companies 'going out'. Until recently, state policies regulating overseas investments incorporated few social and environmental safeguarding mechanisms, mandating companies only to abide by the laws and guidelines of the host country (Ren et al., 2017; Gallagher and Qi, 2018).[5] Similarly, the internal guidelines of the two state policy banks – China Development Bank (CDB) and Export–Import Bank of China (Exim Bank), the key lenders to BRI projects – lacked implementation details despite compellingly more stringent social and environmental safeguards required by borrowers (Morris, 2019). No binding regulation exists requiring lenders to disclose information on assets exposed to potential climate impacts, or requiring companies to carry out climate risk assessments for infrastructure construction projects overseas.

This is in stark contrast with the advanced regulatory system for domestic green investments in China. Spurred by the promulgation of the 2012 *Green Credit Guidelines* and the 2016 *Guidelines for Establishing the Green Financial System*, China has created a vibrant financial market for environmental, social and climate-compatible investments. According to the Climate Bonds Initiative, China's green bond market was the largest in the world by issuance volume in 2019, reaching $55.8 billion in both domestic and overseas jurisdictions (though only 56% of these met CBI and international definitions of green bonds) (Meng et al., 2020).

In 2017, in response to socio-environmental incidents related to BRI projects, and urged by the international community, the Chinese government released the *Guidance on Promoting Green Belt and Road* and the *Belt and Road Ecological and Environmental Cooperation Plan*.

4 The shelved projects are the 1,320 MW Salt Range Mine Mouth Power Project Gaddani Power Park in Balochistan and the 1,320 MW Muzaffargarh Coal Power Project in Punjab (Isaad, 2021).

5 See for instance *Guidelines on Sustainable Forest Cultivation for Chinese Enterprises Overseas of 2007*, the *Guidelines on Sustainable Operation and Utilization of Overseas Forests by Chinese Enterprises of 2009*, the *Guidelines on Environmental Protection in Overseas Investment and Cooperation of 2013* and the *Opinions on Further Guiding and Regulating Outbound Investment of 2017*.

These guidance documents envisioned deeper cooperation with BRI countries to integrate the principles of 'ecological civilisation' and achieve 'higher standards' in projects by 2025, as well as setting a timeframe of 3–5 years to develop new environmental risk prevention policies and create a fully-fledged architecture for environmental services, support institutions and guarantee instruments in 5–10 years' time.

The China–UK Green Finance Centre published the voluntary *Green Investment Principles for the Belt and Road* (GIP)[6] in 2018. Signatories include major Chinese financial institutions, including CDB and Exim Bank, leading Chinese commercial and investment banks, investment funds, insurance companies and the Hong Kong Exchanges, as well as the China International Contractors Association, which represents large Chinese engineering companies delivering infrastructure projects overseas. The GIP aligns with the recommendations of the Task Force on Climate-related Financial Disclosure (TCFD, 2017). It explicitly sets out the principles to contribute to the objectives of Agenda 2030 and the Paris Agreement in its preamble, including 'environmental friendliness, climate resilience, and social inclusiveness' (UK–China Green Finance Centre, 2018). The principles also anticipate environmental information disclosure, including on physical climate risks (principle 3):

1. Embedding sustainability into corporate governance.
2. Understanding environmental, social and governance risks.
3. Disclosing environmental information.
4. Enhancing communication with stakeholders.
5. Utilising green financial instruments.
6. Adopting green supply chain management.
7. Building capacity through collective action.

The People's Bank of China, together with other regulators, released an updated version of China's green investment taxonomy for consultation, the *Green Bond Endorsed Project Catalogue* (*2020 Edition*) *Consultation Version*. This Catalogue now aligns with international standards by excluding fossil fuels for the first time since its release in 2015 and promoting ecological protection projects (Fatin, 2020; Peiyuan et al., 2020). The catalogue is significant for overseas projects too, as the use of proceeds of green bonds for overseas low-carbon, resilient infrastructure investments has increased over the last two years (Tanjangco et al., 2021).[7] China is also co-chairing the International Platform on Sustainable Finance (IPSF) with the EU, to create a 'common ground taxonomy' for member countries (Rust, 2020).[8] This has the potential to significantly improve Chinese corporations' management of climate risks, as the new *EU Taxonomy on Sustainable Finance* developed a clear methodology to categorise investments that contribute to climate change adaptation, which the Chinese taxonomy is lacking.

Since the second half of 2020, there has been an apparent acceleration in stricter regulation of Chinese overseas projects' social, environmental and climate impacts.

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6 An initiative created by the Green Finance Committee of China Society for Finance and Banking and the City of London Corporation to fully incorporate ESG risks and principles of sustainable development into the BRI.

7 The catalogue is mandatory as all bonds must meet its requirements to be considered 'green'.

8 By the end of 2020, the platform included the EU, China, Argentina, Canada, Chile, India, Kenya, Morocco, Indonesia, New Zealand, Norway, Singapore, Switzerland and Senegal, as well as the IMF.

Following President Xi Jinping's pledge for China to achieving carbon neutrality by 2060 at the UN General Assembly in September 2020, five top ministries and regulators jointly issued the *Guidance for Promoting Climate Investment and Finance*. The document, while not legally binding, is still significant as it recommends the regulation of overseas investments in line with science-based climate targets for the first time ever in a Chinese policy document, as opposed to past policies requiring projects to adopt host-country standards and principles. A few weeks after the publication of the guidance document, the BRI International Green Development Coalition (BRIGC)[9] published the *Green Development Guidance for BRI Projects Baseline Study Report*, which proposes a traffic light system for overseas projects, where coal and other high carbon, environmentally damaging projects are categorised in the *red light* category (i.e. the 'forbidden' projects) (Solheim and Zhou, 2020). The report is yet to be officially implemented, though it has received the endorsement of the Ministry of Ecology and Environment.

Despite a shift towards more binding measures, the majority of Chinese policies regulating the social, environmental and climate impacts of overseas investment and construction projects are still voluntary. Both the Engro Thar Block II coal power project and the Quaid-e-Azam Solar Park, which predate China's shift towards more binding mechanisms in the last two years, illustrate the shortcomings of existing Chinese policies. The Engro Thar Block II case highlights a lack of policy monitoring and enforcement mechanisms on the ground by China's line ministries and lending institutions when solely relying on the implementation capacity of the host country (which is often inadequate). The Quaid-e-Azam Solar Park shows how the lack of a domestic EIA regulation for renewable energy projects should have 'activated' the clause in Chinese ministerial policies and policy banks' internal regulations to 'adopt Chinese standards or international standards' when domestic standards do not exist,[10] but this did not happen due to the grey area created by a lack of implementation clarity in both Pakistan's *Environmental Protection Act* of 1997 and China's own policies regulating overseas projects.

Given these issues, the acceleration towards binding overseas environmental and climate regulations can be expected to continue. Since the outbreak of Covid-19, China has built and spent considerable diplomatic capital to convince partner countries it is recalibrating the BRI towards 'higher quality' activities after the pandemic, including renewable energy, the digital economy, the 'Health Silk Road' and smart cities (Tanjangco et al., 2020; 2021). The *14th Five-Year Plan* (14th FYP) – China's highest mid-term programmatic document – published on 13 March 2021, stresses this commitment by dedicating a full section

9 The BRIGC was launched by China and partner countries at the Second Belt and Road Forum for International Cooperation in April 2019.

10 The *2013 Law of the People's Republic of China on Environmental Impact Assessment* mandates construction projects that may impact the environment to conduct an EIA and obtain an EIA approval, though its implementation has had mixed outcomes over the years (Zhu and Ru, 2008; Wu et al., 2011) we find that bureaucratic politics between environmental and nonenvironmental ministries has limited the legislation and implementation of strategic environmental assessment to environmental assessment (EA. The 2013 EIA Law also includes articles for conducting Strategic Environmental Assessments (SEAs), and debates about reforming the law have long included increased considerations of climate risks (Victor and Agamuthu, 2014).

on ‘Promoting the high-quality construction of the BRI’ (Chapter 41), the ‘Creation of a higher standard open economic model’ (Chapter 40), and indicating a ‘push for legislations on overseas investments’ (Chapter 13, Article 2), as well as creating other regulatory mechanisms for overseas investments (Xinhua, 2020). This contrasts with the previous policy stance of abiding by the laws and regulations of the host country. Nevertheless, the general direction of travel set by the plan and high-level announcements need careful monitoring and support from the international community if they are to be translated into formal policies.

To this end, the main challenge is not if but when these will be made into binding policies and implemented.

Despite challenges relating to Pakistan’s climate, natural hazard and environmental risk management and Chinese overseas investment risk management, there are steps that can be taken to strengthen and protect investments.

The concluding chapter outlines some good practice international standards and provides recommendations for strengthened domestic environmental, social, multi-hazard and climate change risk management standards in large-scale infrastructure. Such recommendations, including combining and incorporating climate and natural hazard risk management with forward-looking social and environmental risk management, will bring win–win benefits to Pakistan, China and the companies involved in constructing and operating CPEC infrastructure. By doing so, Pakistan ensures that CPEC infrastructure is resilient against a variety of hazards and can contribute to its socioeconomic development goals and their alignment to the SDGs. China would gain more multi-hazard resilient trade. And companies would see their investments protected – more likely to remain functional during and following hazard events, and less costly to repair.

6 Recommendations: risk management brings opportunities

Proactive risk management does not just bring benefits through avoided or reduced tangible (monetary) and intangible (non-monetary, such as loss of life or damage to a cultural site) losses when a hazard or environmental incident occurs. Some risk management strategies – particularly engaging with and building strong relationships with host communities, and adopting stringent environmental and low-carbon standards – can bring additional co-benefits from the outset of projects, and strengthen economic activity regardless of whether a hazard occurs (Tanner et al., 2015). These co-benefits can accrue for the companies and investors involved in the BRI project, and for host communities. Co-benefits can include more productive and healthier workforces, improved services and critical infrastructure for host communities, leading to reductions in pollution and illness, and healthy and functional ecosystems that provide additional livelihood opportunities (e.g. ecotourism) and services like wastewater filtration and flood risk reduction (Hallegatte et al., 2019; The Risk to Resilience Study Team, 2009).

This concluding chapter outlines some international good-practice standards on integrated risk management, and uses these to formulate recommendations for strengthening the CPEC and other types of large-scale infrastructure in which Pakistan and China may invest.

6.1 Climate and environmental risk management in infrastructure good practice

A variety of good practice international standards on integrated management of projects' social, all-hazards and environmental risks exist from which governments, lending institutions and companies making BRI investments can draw. They include:

- *Equator Principles* (2020)
- 2019 OECD reviews of *Risk Management Policies, Good Governance for Critical Infrastructure Resilience* and *Toolkit for Governance of Critical Infrastructure Resilience*
- *2018 World Bank Environmental and Social Framework, World Bank Climate Risk Screening tools*; both of these align with the *Equator Principles* (2020)
- WEF 2020 *Stakeholder Capitalism Metrics* for environmental, social and governance indicators

Besides these, there are more than 50 global initiatives or groups – in addition to hundreds of national organisations and regulators, and thousands of think tanks, universities and financial institutions – working towards greening and climate-proofing the financial system (Liebreich, 2021). The largest, Principles for Responsible Investment, has over 3,000 signatories and a cumulative $103 trillion assets under management, focusing across all types of sustainability risks. Climate Action 100+ concentrates on climate change risks (Liebreich, 2021), and for infrastructure, there is the Global Infrastructure Investor Association and the Coalition for Disaster Resistant Infrastructure (ibid.). The Powering Past

Coal Alliance is a coalition of over 100 national and subnational governments and organisations committed to phase out coal power by 2030 in the OECD and EU, and by no later than 2050 in the rest of the world (PPCA, 2021).

Underpinning all these initiatives is the expectation and commitment to increase climate disclosures, in line with the *Recommendations of the Task force on Climate Related Financial Disclosures* (TCFD, 2017). There has been an increase in mandatory disclosure schemes. Foremost among these is the new EU *Taxonomy on Sustainable Finance*, which will be applied from January 2022 (TEG, 2020), and the UK government which has created a roadmap to 2025 (HM Treasury, 2020).

Key Chinese corporates and financial institutions have signed up to the GIP. As part of their broader collaboration, the China–UK Green Finance Centre also launched the *UK–China Climate and Environmental Information Disclosure Pilot*, a four-year project involving 10 Chinese and UK financial institutions to speed up climate disclosure in China's financial sector. Despite these positive steps, there are many opportunities to further improve disclosure, as research shows Chinese financial institutions and corporates are still in the early stages of TCFD alignment (CDP, 2020; Ping An, 2020).

To avoid undermining investments and to ensure that they can produce environmentally sustainable, multi-hazard resilient and socially responsible benefits for host countries and local communities, risk-informed approaches are needed. The following recommendations are drawn from the good practice guidelines outlined above for multi-hazard, including climate change and emissions, risk management in infrastructure projects and trends in government policies and infrastructure lending.

These recommendations are consistent with increasingly strong national and subnational policies around risk management and international standards being promoted by lending agencies.

6.2 Recommendations

6.2.1 Government (general)

A risk-informed approach to investments critically involves adoption of and adherence to social and governance standards, along with an all-hazards risk assessment and management measures. An all-hazards risk assessment must encompass natural hazards (including climate change impacts and emissions management) and man-made threats (e.g. armed or cyber attacks), natural hazards (including climate impacts *and* emissions management) and man-made threats (e.g. armed attacks or cyber-attacks), in line with the recommendations of the Sendai Framework for Disaster Risk Reduction and the Paris Agreement, while recognising that environmental protection is a core part of developing and implementing nature-based solutions to support overall natural hazard risk management. This all-hazards approach must be combined with good practice social risks management through community engagement and co-design of community programmes, and aligned with individual country commitments to the SDGs.

Recommendation 1
Require semi- to full quantitative all-hazards, environmental and socioeconomic risk assessments and management plans as part of the SEA/EIA process. Assessments must include a cost analysis of potential damage and losses to infrastructure due to climate change without remediation, and benefits assessment of various remediation measures. As part of this systems

approach, consider adopting the seven risk governance principles in critical infrastructure highlighted in the *OECD Toolkit* (see OECD, 2019).

Recommendation 2
Countries should map critical infrastructure and asset interdependencies to identify critical points where failure could cause the most damage, and work to prioritise a systems approach for managing risks, rather than doing point (location-specific) management.

Recommendation 3
Require companies to include an emissions assessment, including from land-use change, to identify more suitable and multi-hazard resilient low carbon infrastructure design and/or how to improve the resilience and efficiencies of existing infrastructure and its operation. Emission values would then be reported to national climate agencies to be accounted for in INDCs/NDCs and UNFCCC reporting, and in planning emissions budgets when developing low carbon development plans.

Recommendation 4
Require companies to conduct community consultations and mediation as part of the assessment and management planning process. Community consultations and participation are crucial to reducing negative impacts on communities and helping them realise economic benefits. These measures can reduce resistance to and dissatisfaction with the project, which could lead to delays or sabotage. Importantly, community consultations also reduce the risk of exacerbating social inequalities and conflict, particularly over natural resources and the ecosystem services on which livelihoods might depend.

Recommendation 5
Require SEAs/EIAs to be published. Communities living in the vicinity of a project should be made aware of both the risks and opportunities it presents. Clear communication often assists in reducing dissatisfaction with a project. This includes providing printed copies directly to impacted communities and holding forums to discuss the assessments for those who cannot read or have limited internet and newspaper access.

Recommendation 6
Require companies to regularly monitor and update risk assessments and management plans. For long-lived critical infrastructure, such as energy generation and transmission, transportation and water and sanitation systems, risk assessments will need to be updated and retrofits considered as climate and environmental risks change. Emissions must also be monitored and regularly reported; independent monitors are needed. Failure to regularly monitor changing risk conditions and update risk assessments and management can expose critical infrastructure to new risks.

Recommendation 7
National and subnational governments seeking low-carbon, green development must develop new emissions standards where existing standards do not allow for the achievement of national targets, or national targets are low ambition, and enforce these when granting permits and overseeing investment construction and operations.

Recommendation 8
Consider participation in a national or regional risk insurance facility (where one exists) and require FDI infrastructure projects to enrol.

6.2.2 Pakistan government (national and provincial)

The risks that arise *from* investments in the two case study projects are environmental in nature, but the risks *to* them stem from global climate change. The consequences of both risk sets will be borne by the local populations, natural resource bases and ecosystems – including health damage and costs, air and water pollution and loss of habitat and biodiversity. As most impacts are related to water and air pollution, they fall within the ambit of the Clean Green Pakistan Movement of the government. So far, the CGPM has focused on improving the efficiency and sustainability of Pakistan's growing urban areas. However, the Initiative could be expanded to include large energy, communications and other infrastructure, to mitigate long-term environmental and climate change risks from and to existing and planned critical infrastructure.

Recommendation 1

Prioritise funding to low-carbon energy investments that account for and manage climate and environmental risks, including to the country's ability to deliver energy generation and transmission as the risks of hotter temperatures year around, heat waves and drought converge with increasing demand. Major infrastructure projects need to be brought in line with emissions reductions and efficiency goals, and to ensure that initiatives promoting distributed solar PV uptake can be integrated. Having a portfolio of energy efficiency and lower carbon generation and transmission options will be of critical importance as Pakistan seeks to increase households' electricity access and cleaner home fuel use:

- Prioritise development of renewables over conventional fossil fuel technologies – more solar parks, wind farms and distributed solar, rather than investing in syngas power plants. However, renewables should not be located in areas of high ecological sensitivity and value; they should be sited close to urban peripheries or within urban areas, to take advantage of existing grid infrastructure and local load demand. This will reduce transmission losses and bring electricity to where it is most needed. Wind power generation might be interspersed among agricultural fields in windy areas, but new transmission and distribution infrastructure may be needed to connect to urban centres. A World Bank (2021) study proposes numerous project sites for solar and wind across the country. In general, the government should provide sites to avoid degradation of protected areas, that are not in hazard-prone areas (e.g. floodplains) and should require biodiversity protection plans to be made integral to the renewables investment process.
- While existing imported and domestic coal may continue to form part of Pakistan's energy portfolio for a few decades due to existing infrastructure, the country should not invest further in constructing new coal-fired power plants even if those are super- or ultra-critical. This would help Pakistan stay in line with its newly announced emissions targets.
- The Pakistani and Chinese governments could consider renegotiating the financing terms of existing or about-to-be-commissioned coal-fired plants in order to retire the CPEC projects earlier and invest in renewables instead. The Pakistani government has recently successfully renegotiated PPAs with 47 other IPPs to address problems of 'circular debt', setting an important precedent. If the Pakistani government were to renegotiate financing terms, it could reinvest the freed-up resources in new renewable power facilities, whose returns could pay for existing

debt obligations tied to the thermal assets. This would minimise the costs borne by Chinese developers and investors, while deepening the cooperation between the two countries in climate-aligned areas.

- Investment in transmission infrastructure is needed to reduce losses and emissions; 2015 losses were estimated as 18% of total generation (Government of Pakistan, 2016).
- More energy-efficient buildings and retrofits of existing buildings are needed, not only to reduce emissions and energy use, but also to protect people and assets from more extreme heat events and other hazards, whose frequency and intensity is likely to increase under climate change (see for example Khan et al., 2014).
- Updating and applying energy efficiency standards for appliances, such as refrigerators and air conditioners.
- Seek additional funding and assistance from the international community to achieve these goals. The Green Climate Fund and other sources might be considered, including for capacity-building.

Recommendation 2
The government of Pakistan should focus on developing and providing capacity to the EPA and provincial EPDs to ensure that further investments are carefully vetted and, more importantly, to ensure that Environmental Action Plans identified in the EIAs are adhered to. This capacity-building could be achieved using multiple measures:

- Host a series of capacity-building workshops bringing together provincial and national-level infrastructure, land-use planning, environmental, social and climate and hazards decision-makers and practitioners to co-design and co-learn integrated risk assessment techniques to be deployed in EIAs and Environmental Management Plans. Chinese and Pakistani climate and disaster risk scientists have been trying to elevate these issues, including at the ECO Science Foundation (ECOSF) workshop in 2017; their expertise and perspectives can be used.
- Additional support to departments and ministries needs to be provided to ensure they have the resources to strengthen recommendations for policy modification; hire and train personnel for evaluating EIAs and implementing long-term monitoring and enforcement; and have the ability to proactively anticipate and manage risks, and respond better when an event occurs.
- Develop an integrated multi-hazard risks management and low carbon development handbook for infrastructure projects to which various Pakistan ministries and provincial departments can refer to when planning, approving, implementing, monitoring and enforcing regulations in infrastructure projects.

6.2.3 Lending Institutions

Lending institutions play a critical role in encouraging more low-carbon and risk-informed infrastructure development, as seen by evolutions in Chinese and other international lender requirements. Measures could include:

Recommendation 1
Offering green bonds or more favourable lending terms to governments and companies adopting low-carbon and all-hazard risk management practices. The lender could also consider stipulating that some of the loan be used to support risk management and low-carbon development capacity building. The lender would verify government and company practices through independent audit.

Recommendation 2
Adopt international Environmental, Climate and Social Standards for lending, such as those set by the *Equator Principles* (2020) or the World Bank's *Environmental and Social Framework and Climate Risk Screening*, in the absence of comparable Chinese or host country standards and/or enforcement mechanisms. These international standards have been agreed by multilateral development banks and reflect international investor consensus on risk reduction measures.

6.2.4 Infrastructure companies

Risk-informed approaches must be applied across all phases of the project lifecycle, from planning, development and operation to decommissioning. This requires adopting a multi-hazard risk assessment and management approach that accounts for interlinked social, political, economic, environmental and climate hazards and risks (Opitz-Stapleton et al., 2019).

Recommendation 1
Conduct community consultations and mediation as part of the EIA/SEA process. Consider consulting with a sociologist or local community group to address concerns. Where national or subnational policies for consultations as part of EIAs or SEAs are weak, we recommend adopting consultation principles from either the *2020 Equator Principles* (2020) or the *2018 World Bank Environmental and Social Framework*. This requires investing in on-the-ground staff and regularly consulting with communities and engaging around the issues they perceive to be important. It also requires setting up a clear process for consultations, airing grievances and resolving disputes around tenure, relocation and compensation as issues arise. Such a process should also negotiate livelihood subsidies, job training and community development funds.

Recommendation 2
Companies should routinely conduct a semi-quantitative to quantitative all-hazards and environmental risk assessment for existing or proposed investments to identify the potential impacts (monetary costs and non-monetary losses) at different timescales and to different stakeholders. Such assessments need to consider the costs of no action – that is, failing to consider various risks and their management – and the potential costs, savings and feasibility of various risk management options. This includes accounting for more stringent emissions and environmental regulations and the comparative risks of infrastructure retrofits or becoming stranded assets.

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Appendix 1 Pakistan profile

Table A1 Pakistan development context at a glance

	2000	2015	2030 (projected)
Population			
Total	142.3 million	199.4 million	262.9 million
Female	48.4%	48.5%	48.6%
Male	51.6%	51.5%	51.4%
Youth (age 0–14)	41.1%	35%	~32%
Urban	~33%	36.0%	~41%
Economy			
GDP (US$)	73.95 billion	270.56 billion	
Poverty rate (% below national poverty line)		24.3%	
Foreign direct investment	0.42%%	0.60%	
Foreign debt (% of GDP)	41.7%	24.1%	
Trade	28.1%	27.7%	
Economic sectors (% of GDP)			
Agriculture	24.1%	23.8%	
Industry (including construction)	21.7%	19.1%	
Services (some overlaps with trade)	47.2%	52.2%	
Manufacturing	13.7%	12.8%	
SDG indicators			
Electricity access	70.4% (U+R)	90% (U) 64% (R)	
Drinking water (clean)	38.1%	35.6%	
Sanitation	No data	63.5%	
Transport & communication investments (US$)	31.8 million (2002)		
Health (expenditures per capita in US$)	16.00$	38.00$	
Education (primary)		71% (F) 82% (M)	

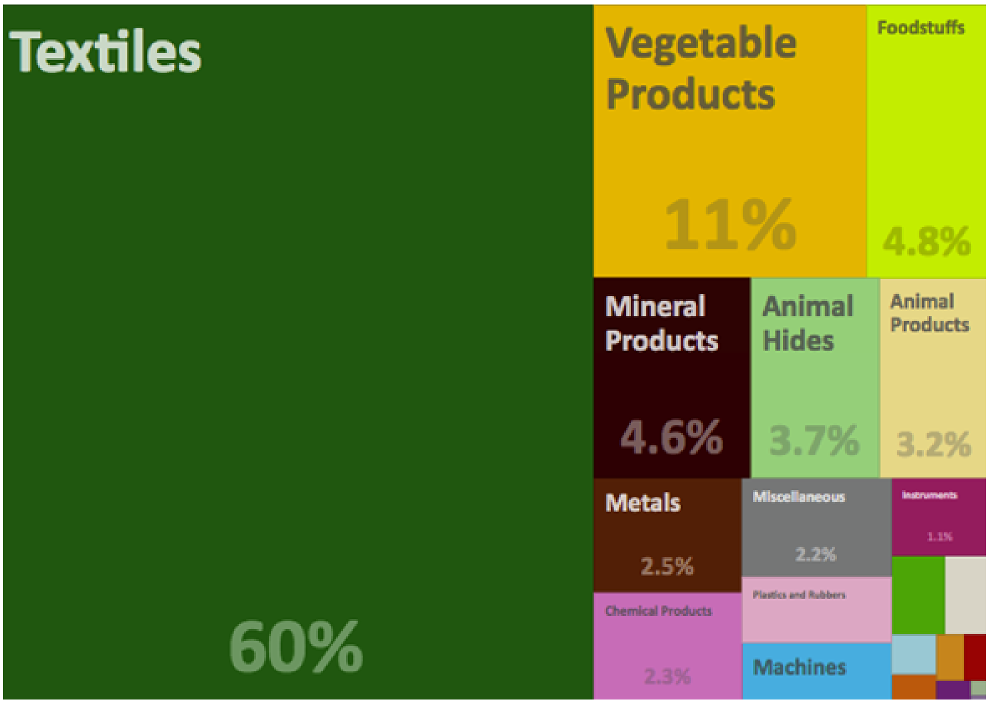
Note: U = urban; R = rural.
Sources: PBS, 2018; UNDESA, 2019, CIA Factbook, 2019; World Bank, 2019; ADB, 2019. 2030 projections represent the median value, not the spread of UNDESA, 2019 projections.

Socioeconomic profile

The agriculture sector has historically been, and continues to be, a major employer (45% in 2009 and 38.5% in 2018 of total labour), particularly for rural populations (MoF, 2019). Value-added products derived from agriculture include textiles (including cotton yarn and household linens) and apparel, and comprised nearly 60% of Pakistan's total exports in 2017, with finished foodstuffs and livestock-derived products accounting for 4.8% and 6.9% respectively (OEC, 2019).

The other two dominant economic sectors in Pakistan are industry and services. The services sector was estimated to contribute 53.3% of GDP in 2014, as well as employing 43% of the labour force (GoP, 2014). Industry rounds out economic contributions, with 2014 GDP share estimated at 20.8%, with employment of 13% (ibid.).

Figure A1 Pakistan's sectoral exports as percentages of total exports in 2017



Source: OEC 2019.

Historical climate and climate change projections

Pakistan is a land with diverse climates, owing to its topographical extremes. The mountain ranges of Karakoram and the Nanga Parbat (in Gilgit-Baltistan), the Hindu-Kush in Khyber Pakhtunkhwa and the Kirthar between Sindh and Balochistan provinces direct the flow of the South Asian Monsoon (SAM) and winter westerlies, delivering copious rainfall in some parts of the country, while leaving others in a rain shadow. The SAM, beginning approximately in June and tapering off in September, brings the majority of annual precipitation across the country and is critical for economic and livelihood activities.

Table A2 Climate normals (authors' analysis) for select cities and towns, with climate normals data from weather stations closest to the case study sites

Area	Annual	Hot season (~March/April to ~June)	Monsoon (~July to Sept)	Post-monsoon (Oct to Nov)	Cool season (Dec to ~Feb/Mar)
1971–1990 average maximum temperatures (NOAA NCEI, 2021)					
Punjab Province					
Multan	32.6°C	39.4°C	38.1°C	31.5°C	23.9°C
Bahawalangar	25.3°C	39.6°C	37.4°C	31.4°C	25.2°C
Sindh Province					
Badin	33.5°C	38.7°C	34.7°C	33.9°C	28.8°C
Hyderabad	34.8°C	40.3°C	36.4°C	34.3°C	28.2°C
1961–1990 WMO average minimum temperatures (NOAA NCEI, 2021)					
Punjab Province					
Multan	17.9°C	24.2°C	27.2°C	14.6°C	7.8°C
Bahawalangar	18.3°C	24.3°C	26.6°C	15.6°C	8.9°C
Sindh Province					
Badin	19.8°C	24.9°C	26°C	18.8°C	11.8°C
Hyderabad	21.6°C	25.6°C	26.5°C	20°C	14.3°C
1971–1990 precipitation totals in mm (NOAA NCEI, 2021)					
Punjab Province					
Multan	186.8	35	104.7	4	43.1
Bahawalangar	203.4	30.3	126.6	5.3	41.2
Sindh Province					
Badin	222.2	14	194.8	5.4	8
Hyderabad	170	14.4	132.9	7.7	15

Notes: No long-term climate data is available at either of the case study sites as monitoring only began recently. The case study sites are more arid and potentially hotter than the nearest weather stations due to their location in deserts.

Source: Data are from the reported Global Climate Normals by the World Meteorological Organization. For the selected sites, some climate data are available only back to 1971.

Table A3 Climate projections for Central-South Punjab and Southern Sindh provinces, where the BRI case studies are located

Region	Annual	Hot season (~March/April to ~June)	Monsoon (~July to Sept)	Post-monsoon (Oct to Nov)	Cool season (Dec to ~Feb/Mar)
Projected mean temperature increases above the baseline (1976/80 to 2000/05) by the 2050s					
Central/S Punjab (a, b, c)	1 to 2.3°C	2 to 2.5°C	1 to 1.75°C	1.5 to 2C°C	1.5 to 2C°C
South Sindh (a, b, c, d)	1 to 2.5°C	2 to 2.5°C	1 to 1.75°C	1.5 to 2C°C	1.5 to 2C°C
Projected increases in heat extremes above the baseline (1976/80 to 2000/05) by the 2050s					
Central to S Punjab and S Sindh – the potential for days with a heat index exceeding 37°C (e): • Up to 110 days/year by the 2030s • Up to 130 days/year by 2050, which is nearly continuous during the monsoon period of ~June through September					
Mean % change in mean annual precipitation totals compared with the baseline by the 2050s (a)					
Central/S Punjab • Poor model agreement on projected precipitation changes • –30% to +2%					
South Sindh • Poor model agreement on projected precipitation changes • –50% to +8%					
Whole Pakistan • Poor model agreement on projected precipitation changes • –23% to +39.7%					

Notes: Temperature and precipitation projections are derived from: (a) MoCC, 2018; (b) Ali et al., 2018; (c) Ali et al., 2019; (d) Rasul et al., 2012; and (e) Amman et al., 2014. Each study uses slightly different baseline periods and future projection periods. Even though the time periods used are different, the temperature projections and estimates of extreme heat events are remarkably similar.

Table A4 Timeline of key environmental, climate and disaster risk reduction policies and actions in Pakistan

Year	Initiative/action
1974	Establishment of the Environment and Urban Affairs Division (EUAD) within the Ministry of Housing and Works. EUAD has responsibility for national environmental policy formulation and for administration of national environmental impact assessment procedures.
1983	*Pakistan Environmental Protection Ordinance* is passed, which mandates Environmental Impact Assessments for projects.
1987	National Energy Conservation Centre (ENERCON) established to serve as focal point for energy conservation in all sectors.
1992	• *National Conservation Strategy* issued, laying out 14 priority areas for policy formulation and interventions. • *Forestry Sector Master Plan* issued, which envisages increasing forest area to 10% by 2018 through reforestation, afforestation, watershed management, protection of wildlife and bio-diversity, capacity- and awareness-building.
1993	*National Environmental Quality Standards* finalised, which provides standards for industrial and municipal effluents in addition to air emissions.
1994	• Pakistan ratified the UN Framework Convention on Climate Change. • The formalisation of EIA inclusion in development project decision-making processes is finalised; the 1983 Ordinance is not fully implemented until this point.
1997	• Pakistan *Environmental Protection Act* passed, replacing the *Environmental Protection Ordinance 1983*. The act empowered the creation of institutions and the regulation of activities relating to environment. Environmental protection agencies established at federal and sub-national levels. • Pakistan Environmental Protection Council, headed by the Prime Minister, was established as the apex decision-making body on environmental affairs.
2001	*The National Environmental Action Plan* was approved to follow up with the NCS, which narrows the government's policy focus on the environment to four core programmes, including clean air, clean water, waste management and ecosystem management.
2002	• Global Change Impact Studies Centre established as a dedicated institution for climate change research. • *National Action Programme to Combat Desertification* in Pakistan launched. Drought Emergency Relief Assistance planned and the DERA Unit within the Planning Commission was established to coordinate implementation, monitoring and evaluation of drought mitigation activities in affected areas.
2003	Pakistan submitted its Initial National Communiqué to UNFCCC.
2005	• The *National Environmental Policy (2005–2015)* was prepared. The policy addressed various sectoral issues, including water management and conservation, energy efficiency and renewable resources, agriculture and livestock, forestry and plantations, biodiversity and protected areas, as well as climate change, air quality, noise pollution and waste management. • Pakistan ratified Kyoto Protocol. • The Prime Minister's Committee on Climate Change was established to manage climate issues as the highest forum for monitoring and strategic guidance.

Year	Initiative/action
2006	• In order to address environmental and climate change concerns, the *Policy for Development of Renewable Energy for Power Generation* was launched. For development and promotion of renewable energy interventions, based on the renewable policy, the Alternative Energy Development Board was established. • The Prime Minister approved the Pakistan *National Operational Strategy* and established the Clean Development Mechanism to generate carbon credits. Ministry of Environment was made the Designated National Authority (DNA) for CDM affairs.
2007	• *Pakistan in the 21st Century: Vision 2030* launched, with a roadmap to achieve sustainable economic development with an emphasis on managing climate change threats in terms of mitigation and adaptation, promotion of renewables and conservation measures across sectors. • The *National Disaster Risk Management Framework*, after consultation with stakeholders and subsequent endorsement by the government, was launched. The framework outlines of a DRM system and nine priority areas to address DRR issues, with climate change as the cross-cutting theme. • The National Disaster Management Authority was created as apex entity at the federal level to deal with the entire spectrum of disaster risk management, including climate change issues under the Framework. The Framework became an Act in 2010.
2008	• The Task Force on Climate Change was constituted. The Task Force, following intensive consultations with different stakeholders and discussions, submitted a report in 2010 outlining a process to formulate a national policy on climate change. • The Technical Advisory Panel on Climate Change (TAP-CC), led by IUCN, was set up to provide technical support to the then Ministry of Environment on climate change issues.
2009	• *Integrated Energy Plan 2009–2022* launched, with strong recommendations for renewables, bio-diesel and conservation measures, with a target of 12% share of renewables towards total energy requirements by 2022. • National Impact Assessment Programme launched, which aims to contribute to sustainable development by strengthening the EIA regime and introducing Strategic Environmental Assessments in all development planning.
2010	National Economic and Environmental Development Study carried out with the support of UNFCCC. The study addresses climate change mitigation and adaptation options.
2011	• Under the *18th Constitutional Amendment*, the mandates of 18 national ministries were devolved to provincial governments, including issues pertaining to the environment and disaster management • Establishment of the Ministry of Climate Change, mandated to deal with issues of policy, legislation, plans, strategies and programmes with reference to climate change, disaster management, environmental protection and preservation, coordination, monitoring and implementation of agreements with other countries, international agencies and forums. Entities attached to the Ministry include NDMA, GCISC, PEPA, PEPC and Pakistan Environmental Planning and Architectural Consultants Limited.
2012	• The government approved the *National Climate Change Policy*. The *National Plan of Action for Climate Change* was prepared to implement the Policy. • Punjab adopts the *National Environmental Protection Act*.
2013	Balochistan passed its *Environmental Protection Act*.
2014	Provinces of KPK and Sindh passed *Environmental Protection Acts*.
2015	Pakistan prepared INDCs for the Paris Agreement.

Year	Initiative/action
2017	*National Climate Change Act* passed by parliament, which included setting up a National Climate Change Authority and National Climate Change Fund.
2018	Pakistan released its Second National Communication on Climate Change to the UNFCCC. Clean Green Pakistan Movement launched
2020	Pakistan updates its NDC.