DEVELOPMENT CORRIDORS PARTNERSHIP

IMPACT ASSESSMENT FOR CORRIDORS: FROM INFRASTRUCTURE TO DEVELOPMENT CORRIDORS

Edited by:
Jonathan Hobbs and Diego Juffe Bignoli

2022

The Development Corridors Partnership

The Development Corridors Partnership (DCP) is a research and capacity development initiative. It is a collaboration between institutions from China, Kenya, Tanzania and the UK. The main objective is to deliver effective research and capacity-building to help improve corridor planning and management. It aims to ensure that development corridor decision-making is based on sound scientific evidence and effective use of available planning tools and procedures, to ensure that risks are avoided and opportunities exploited. The DCP comprises partners from the University of York, the University of Cambridge, London School of Economics, Sokoine University of Agriculture, the University of Nairobi, as well as the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), African Conservation Centre, the World Wide Fund for Nature (WWF), the Chinese Academy of Agricultural Sciences and the Chinese Academy of International Trade and Economic Cooperation (CAITEC).

DCP Partners:

For the purposes of this publication, DCP collaboration was extended to experts representing Netherlands Commission for Environmental Assessment, the Centre for Energy, Petroleum and Mineral Law and Policy at the University of Dundee, the University of Queensland, the Columbia Centre on Sustainable Investment, the GOBI Framework for Sustainable Infrastructure Initiative (comprising the University of Oxford, University of Central Asia and the Independent Research Institute of Mongolia), The Biodiversity Consultancy, the Wildlife Institute of India, the Endangered Wildlife Trust and Ecotecnia Ingenieros Consultores SRL.

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Foreword

In the course of a long and varied working life, I have been privileged to work with, or learn from, a stimulating panoply of individuals who are committed to contributing to the economic, social, and environmental development of all aspects of the United Nations Sustainable Development Goals.

Jon Hobbs and Diego Juffe-Bignoli are, thankfully, two of these individuals. I was delighted to learn that they had come together to produce, for the Development Corridors Partnership, a rich and stimulating collection of research reports, case studies and assessments relating to the array of efforts made under the rubric of 'development corridors'. They were determined to express the conviction that decisions made, primarily by governments, regarding the planning and building of Corridors, really must be informed by an evidence-based understanding of the consequences – positive or negative – of these decisions. And they have succeeded. But Jon Hobbs will never read these words. He was hospitalized after the bulk of the work was complete, and, to the deep sadness and regret of all who knew him, he passed away at the end of September, 2021.

Jon and Diego sought out and recruited a daunting array of researchers, scholars and stakeholders to shed light on the processes currently underlying the world of development corridors today. They certainly succeeded.

The work was initiated before the onset of the COVID-19 pandemic, and as governments turn to the formidable challenge of restoring economic vitality without further damage to the climate, it becomes even more imperative that impact assessment be understood, embraced and improved. Jon and Diego have shown us the way forward for a journey which absolutely must be embarked upon.

They would be first to recognise that the Development Corridors Partnership as a whole must be commended for showing – in many different ways and places – that, not only is the need for impact assessment clear and present, but so are the skills and commitment of researchers, scholars and stakeholders. These are to be found in an impressive coming together of universities, civil society organizations and business groups, and communities.

All are part of an outstanding initiative, funded by the UK Research and Innovation Council, and managed by the UNEP-WCMC. This initiative has been embraced by some of the best minds that have been turned to the task of ensuring that – while we attempt to bring economic and social benefits to people, in line with the United Nations Sustainable Development Goals – we do not risk significant environmental and social costs, and thus actually undermine long-term development successes.

So, I urge you to read this book, and figure out how you might improve your own contribution to the challenges ahead. Jon and Diego have set out a case. It needs to be taken up, not set aside; acted on, not just talked about. It is in your hands.

John Harker

Chair of the Development Corridors Partnership Independent Advisory Board,
Nova Scotia, Canada.

Dedicated to the memory of Jon Hobbs
who was the architect and driving force of this book

Executive Summary

Driven by increasing globalisation, the development aspirations of nations, and the need to access resources, an infrastructure boom is impacting many regions of our planet. New infrastructure projects are traversing diverse landscapes over hundreds of kilometres, often crossing international borders and penetrating into remote areas previously unaffected by industrialisation and urbanisation. These large-scale projects, mostly spanning several regions in a same country, but often linear and transnational in nature, are generically called corridors. Depending on the nature and objectives, they can be transport, infrastructure, growth, resource or economic corridors.

The rapid development of corridors globally presents environmental planning professionals with numerous challenges. **The primary need is to ensure that decisions about these developments are informed by an evidence-based understanding of their consequences – both positive and negative.** This will enable infrastructure development to meet development needs without adversely impacting ecological systems or human welfare. Improving the quality of infrastructure policies, plans, programmes and projects, by ensuring they include the necessary environmental and social scrutiny, is urgently required now - and will be for the foreseeable future. This challenge is the unifying theme of this publication.

Using insights from Africa, Asia and South America, this sourcebook compiles 24 contributed papers written in 2021, covering many facets of the opportunities and challenges presented by the rapidly growing number of infrastructure and corridor developments around the world. Prevailing planning practices are reviewed through case studies along with the efficacy of some of the available tools to conduct systematic and comprehensive impact assessments. The latter includes Strategic Environmental Impact Assessment (SEA) and Environmental Impact Assessment (EIA).

As the title suggests the underlying thesis of this publication is that, where they are justified, **there are significant benefits in ensuring that corridors that contain single purpose infrastructure developments (utility, infrastructure or transport) progress through a carefully planned sequential process of diversification and expansion to ensure the maximisation of benefits in full-blown 'development corridors'.** In this book, development corridors are therefore aspirational. They comprise areas identified as priorities for investment to catalyse economic growth and development. They should be developed with multiple stakeholders and social, economic and environmental interests and interdependencies in mind. With the integration of sustainability principles and appropriate environmental and social standards, development corridors could become true '(sustainable) development corridors'. They should be planned to maximise positive opportunities and minimise negative risks. Without this, today's short-term successes will become tomorrow's challenges and long-term human welfare and ecosystem integrity will be undermined.

Overview of contents

This book brings together a wide range of perspectives from experts, researchers, and practitioners around the world with the purpose to foster greater collaboration and increase our global understanding of corridors and their benefits and potential negative impacts. 13 of the 24 chapters are written by independent experts and researchers from Australia, Bolivia, Brazil, China, India, Kenya, Mongolia, South Africa, Tanzania, UK, and the USA. The book also includes 11 chapters containing material gathered by the Development Corridors Partnership, a programme of work led by UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and funded by the UK Government via their Global Challenges Research Fund.

The collection of papers in this sourcebook is divided into five sections. First an introductory section where we introduce some key terms and definitions that underpin this work (Chapter 1). We then explore some key principles and aspirations of corridors such as delivering the Sustainable Development Goals (Chapter 2), ensuring theory and practice align (Chapter 3), ensuring financial sustainability (Chapter 4), properly assessing environmental sensitivity (Chapter 5) respecting human rights (Chapter 6), or maximising, co-benefits (Chapter 7).

In the next three sections, we present 15 case studies from three continents: Africa, Asia, and Latin America. These case studies explore key challenges and lessons learned from specific planned, ongoing, and already implemented developments. They are presented as individual stories that readers can explore.

The final and fifth section aims to summarise lessons learned from a 4-year research and capacity building programme specifically aiming to understand the key challenges and opportunities around corridors and that has been the major driving force of this work: The Development Corridors Partnership project (DCP). DCP is a collaborative partnership across UK, Kenya, Tanzania and China, funded by the UK Research and Innovation Global Challenges Research Fund (see Chapter 23).

The book finishes with an overview of the lessons learned from the contributed papers included in this book and develops ten principles for corridor planning and delivering a meaningful and comprehensive impact assessment (Chapter 24), which we summarise here as ten key messages.

Key messages

1

Corridors must seek to achieve positive sustainability outcomes:

The mindset underwriting environmental planning of most infrastructure developments has been to mitigate negative impacts. The planning of few existing corridors is based on their role in supporting a sustainability vision for a country or region in which they are situated. Corridor developments must therefore be based on sustainability principles and support progress towards national, regional and international sustainable development goals. A true development corridor will seek to do good, as well as to mitigate negative impacts.

2

Integrated and inter-disciplinary approaches are needed:

Corridor developments are extensive, complex, multifaceted features traversing many landscapes. They can bring about significant transformational change to physical, economic, social, and cultural systems, and serve as interconnecting features. Yet engagement in corridor planning is often constrained by limited disciplinary and institutional involvement, with projects often superimposed upon communities. Corridor developments need diverse expertise and experience in their planning and management, including local stakeholder knowledge, avoiding disciplinary, institutional, or sectoral silos, that can result in policy conflicts, contradictions, and inconsistencies.

3

Corridor proponents should clearly demonstrate consideration of alternatives:

Corridor options should not be limited to a preferred proposal favoured by an elite. Corridor developments must consider all feasible alternatives (including maintenance of the status quo and no corridor development) and make the risks and opportunities of each option explicit and transparent through meaningful consultation. An important requirement in all corridor planning is to justify the need for a wide choice of options and an explanation of the potential benefits it will bring and to whom, in comparison with the alternatives. Any necessary trade-offs and how any significant potential negative impacts will be effectively managed, and opportunities created must be explained.

4

Public participation and stakeholder engagement should be at the core of corridor planning:

Corridor planning frequently fails to include meaningful participation of all stakeholders. Corridors can profoundly affect the lives and rights of indigenous peoples and local communities, potentially for generations. A common failing is that the first opportunity for local stakeholders to engage arises only after all strategic decisions have already been made and the only option remaining is for them to react negatively to a fait accompli. The meaningful engagement of all stakeholders is necessary to ensure their role is more than reactive. The way corridors are viewed by different stakeholders must be identified, understood, and addressed. Corridor developments must ensure that all interested and affected people are provided with adequate information about a proposal and have meaningful ways to engage in decision-making processes from the outset of strategic planning.

5

Mainstreaming and tiering are fundamental for corridor success:

Corridor planning requires a tiered assessment process, ensuring that environmental and social issues are considered alongside financial and technical considerations from the start of strategic planning or programme development, right though to project specifics. Conceptual corridor planning is frequently dominated by technical and financial suitability criteria with environmental, social, cultural, and human rights sensitivity issues being considered, at best, as externalities, retrospectively, once issues and problems arise. Strategic planning is important because it is when the full range of options is still open for discussion. It also establishes the parameters that will frame and implement a corridor plan or programme. Environmental and social considerations (and the interactions between them) should be considered early in strategic decision-making alongside (and to inform) technical, financial, and economic considerations.

6

An iterative process is needed:

Corridors exist in dynamic environments and need to be responsive to changing circumstances and priorities. Planning must adjust as circumstances and available information changes. The process should identify, map, and engage all interested and affected stakeholders from the earliest stage of corridor planning and throughout the planning and management of the corridor. New concerns and evidence will likely emerge as a corridor development progresses. Corridor planning frequently places undue emphasis on the production of a report (Environmental Impact Report) and its influence on the decision to proceed. The process may not be so linear in nature. It may involve many adjustments and decisions as new evidence emerges and predictions improve. A good-quality report and recommendations is necessary, but they are dependent upon a comprehensive process of ongoing dialogue and engagement with all stakeholders.

7

Corridors must ensure effective use of available tools:

Many corridor environmental impact assessments fail to meet required international standards. Corridor planning and management should make systematic and adequate use of available impact assessment procedures, methods, techniques, and tools to ensure good-quality decisions. The available procedures discussed in this publication (notably Strategic Environmental Assessment and Environmental Impact Assessment) and their associated methods, tools and techniques should be used when appropriate to help ensure that a systematic process identifies all significant potential benefits and development outcomes, and that they outweigh the costs and risks to affected people and their livelihoods and environments. The objectivity and quality of corridor decisions are dependent upon the effective use of the available tools.

8

Plan corridors with resilience and adaptability in mind:

Prevention will always be better than cure in addressing the negative impacts of corridors, and this should be the priority. However, some circumstances dictate an inevitability of negative impacts. Corridors, therefore, need to be designed to be made resilient to anticipated changes and adaptation measures may be necessary as 'coping' mechanisms or to offset unavoidable impacts, such as the impacts caused by climate change. The suitability of measures will require ongoing monitoring and adaptation as needs arise.

9

Seek impact, influence, and implementation capacity:

The decision to proceed with a corridor is ultimately the responsibility of decision makers. They are usually the representatives of all stakeholders' interests and custodians of their natural resources. Any impact assessment report must provide adequate information to ensure sufficiently good-quality decisions. If they are to be effectively implement the recommendations provided. Attempts to improve the performance of planning and associated assessment processes of corridors must tackle the ways in which outcomes are shaped by political contexts and institutional capacities. Approaches to working on assessment processes should integrate political economy analyses and institutional capacity assessment from the outset and on an ongoing basis. Resulting insights should inform the design and implementation of interventions intended to improve planning practice.

10

Evolve from Infrastructure to Development Corridors:

The prospects for linear infrastructure projects to evolve into comprehensive development corridors are often left to chance and spontaneity. Infrastructure projects are often developed in isolation and in an incremental way. For infrastructure projects to progress and become true development corridors, the transition must be systematically sequenced into planning from the start. Assessments must include consideration of potential induced, secondary, synergistic, transboundary, and cumulative impacts likely to result from the corridor development. The progression from infrastructure to development corridors must be based on a systematic, comprehensive, and integrated assessment of the potential positive environmental, social and economic opportunities and the rigorous avoidance or management of negative impacts.

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Strategic Environmental Assessment for a Sustainable Mining Corridor: Addressing the Social and Environmental Risks of Tailings Dam Disasters after Mariana and Brumadinho

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ABSTRACT

The catastrophic tailings dam (TD) failures in Mariana (2015) and Brumadinho (2019), both in the Iron Quadrangle of Minas Gerais, in the southeast of Brazil, shocked the whole world. The flood of tailing waste caused significant environmental degradation, and hundreds of people lost their lives. The mining infrastructure in the Iron Quadrangle has provided an economic stimulus to the communities along the development corridors. However, public authorities and companies have failed to prevent the known high risks posed by hundreds of cumulative structures in this region containing significant levels of hazardous materials, such as heavy metals and other pollutants, to the nearby communities and the environment. In the aftermaths of these disasters, legislation and regulation in Brazil, and more rigorous standards at the international level have been updated to prevent future tailings failures and put safety first. The disasters' responses include the Netherlands Commission on Environmental Assessment (NCEA) mission to develop a Strategic Environmental Assessment (SEA) for iron ore plans for Minas Gerais. This chapter analyses the SEA's role in the Iron Quadrangle and its potential contribution to the strategies for disaster risk reduction in tailings dam failures. Through the evidence, this chapter aims to establish that, after the disasters, the integrity of the SEA for the Iron Quadrangle requires robust preventive measures and meaningful public participation. The SEA should contemplate adopting the latest devices for monitoring dams' risks, considering that one of the main challenges of implementing the Brazilian law and policy on dams' safety is the shortage of staff. Moreover, the SEA can enhance governance of the TDs in the Iron Quadrangle, mainly because the overall strategy will support the Environmental Impact Assessment (EIA) and licensing practice, focusing on the local communities.

22.1 Introduction

The state of Minas Gerais in southeast Brazil suffered two catastrophic TD collapses in three years, leaving a trail of extreme destruction in the affected communities and environment. In 2015, a TD in Mariana collapsed, and this was followed by a similar event in Brumadinho in 2019. Both Mariana and Brumadinho are part of a 7,000km^2 region known as the Iron Quadrangle, which accounts for 11 per cent of worldwide iron ore production (Lima *et al.* 2020).

The mining infrastructure in the Iron Quadrangle has provided economic stimulus to the communities along the broad-based development corridor. However, public authorities and companies have failed to prevent the known high risks posed by the incremental growth of hundreds of structures in this region containing significant levels of hazardous materials, such as heavy metals and other pollutants, to the nearby communities and the environment. The following questions arose in relation to these disasters:

» What could have been done to prevent or mitigate such events?

» How can catastrophes such as these be avoided in the future?

There are different approaches to answer these questions. From the perspective of the public duty to protect the society and the environment, they may include the preventive role of the EIA and SEA.

Under Brazilian law, EIA is a mandatory requirement to promote compatibility between socioeconomic development and the preservation of the environment (The National Environmental Policy [NEP] Law 6,938/1981 regulated by Decree 99,274/1990). Despite being a well-established process and a recognized practice in Brazil, the EIA is far from perfect. Some of the risks involving the TDs in Mariana and Brumadinho were allegedly not captured in their EIAs and respective licensing processes, triggering concerns about the effectiveness of such instruments.

minerals) to allow the government to ensure that environmental assessment is not limited to a project-by-project approach. Such assessment would include impacts on the policies, plans and programmes (PPPs). Although there have been some SEA experiences in Brazil, its practice is less advanced than that of EIAs. Furthermore, no direct references are made in Brazilian law concerning its application.

In August 2020, after a visit by risk reduction experts, the government of Minas Gerais (MG) signed a Memorandum of Understanding with the NCEA to advise on the development of an SEA for a proposed state mining plan, in particular in the iron ore subsector. Although progress has been hampered by the COVID-19 outbreak, the NCEA will potentially act as an independent advisor and quality assessor in the process, whether the SEA proposal is motivated by the administrative needs of the MG or the need to re-establish societal trust for the mining sector after the tailings disasters is currently being assessed and will shape the nature of the SEA.

This chapter analyses the role of the SEA in the Iron Quadrangle and its potential contributions in the strategies for disaster risk reduction. It starts with a brief description of the Iron Quadrangle's resources, followed by an overview of the disasters at the Mariana and Brumadinho TDs and the judicial and legislative responses to them. In the next part, the chapter considers inconsistencies in the EIA and licensing of the TDs that collapsed in Mariana and Brumadinho, to analyse the challenges faced by a country where economic interests are often prioritized over environmental and social impacts. It then proceeds to consider the observations of the NCEA regarding the objectives of the SEA for iron ore, such as the need to reconcile economic activities with social and environmental protection, crisis responses and public participation. Through this evidence, the chapter aims to establish that, after the disasters, the integrity of the SEA in the Iron Quadrangle requires robust preventive measures and meaningful public participation.

22.2 Background

22.2.1 The Iron Quadrangle: human and natural resources

Minas Gerais has abundant and high-quality mineral resources, such as iron ore, manganese, bauxite and niobium. Mining has been a part of Minas Gerais's economy since colonial times, especially after the discovery of gold at the end of the 17th century. The vast scale of Minas Gerais's mineral wealth is indicated by its name, which means general mines in Portuguese. In the early 1980s, multinational companies intensified modern large-scale mining operations in the Iron Quadrangle by installing large dams. Since the mines are invariably far from the coast, they rely heavily upon transportation logistics networks (e.g. railways and maritime ports). These infrastructural additions assist in integrating the mining facilities and their minerals into the global systems of production and trade. For instance, the 900km Vitória-Minas Railway line connects the states of Minas Gerais (landlocked) and Espírito Santo (which has an extensive coastline), where the leading ports of the country are located. The transportation infrastructure is a competitiveness factor for the iron ore supply chain and its connectivity needs (Comtois and Slack 2016). As iron ore is a low-priced, but high-bulk commodity, the iron ore market demands high production volumes served by extensive transportation infrastructure to enable the production flow (Comtois and Slack 2016).

Alongside its geological heritage, the Iron Quadrangle is a place of cultural and environmental

significance. The historical centre of the town of Ouro Preto, which is listed as a United Nations Educational, Scientific and Cultural Organization World Heritage site, preserves the prosperity of the 18th-century gold rush in its Baroque-style buildings and churches. Furthermore, the area of the Iron Quadrangle overlaps with conservation units in the transition area between the Atlantic rainforest and the Cerrado savanna. It consists of the Espinhaço mountain range endowed with rupestrian natural caves, grasslands and exceptional biodiversity and endemism, which have been threatened by mining activities (Pena *et al*. 2017). The Iron Quadrangle is composed of 33 municipalities, including the capital Belo Horizonte, with an estimated population of 4.6 million. The mining companies co-exist in the region with numerous minority and vulnerable groups that are strongly linked with the land and its natural resources, such as indigenous tribes, *quilombolas* (runaway slaves), small-scale artisanal miners and farmers.

Iron ore is one of the highly mined commodities of the country, consistently playing a vital role in Brazil's balance of trade. For instance, in 2019, Brazil accounted for US$ 22.7 billion of iron ore exports (Ministério de Minas e Energia, 2020). The municipalities of the Iron Quadrangle benefit from the financial support through mining royalties and value-added tax that can potentially contribute to jobs, as well as the health and education systems of the communities in the region. It is estimated that, in five decades, the production will have increased from 40 Mt/a to 250 Mt/a (Lima *et al*. 2020). However, the increased production escalates the volumes of the tailings disposed of in the dams (Lima *et al*. 2020).

22.3 The Mariana and Brumadinho TD disasters: losses and reactions[182]

In November 2015, the upstream TD Fundão in Mariana collapsed, unleashing more than 60 million m^3 of mining waste, enough to fill 20,000 Olympic swimming pools. The flood of tailing waste caused 19 deaths and resulted in the worst environmental disaster in Brazilian history. Mining waste sediment was deposited into 600km of the River Doce and its tributaries, reaching the Atlantic Ocean. Affected communities of around 1.4 million inhabitants along the river corridor lost their settlements and livelihoods, including the three indigenous reserves, Krenak, Tupiniquim and Guarani. The flood also caused the destruction of houses and infrastructure, the death of animals and fish, deterioration of the Atlantic forest, and interruption of essential activities, such as water supply, fishing and agriculture. In January 2019, another fatal disaster occurred in Brumadinho, about 87km from Mariana, when the upstream TD Corrego do Feijão collapsed abruptly without warning. The dam had released 12 million m^3 of tailing (enough to fill 4,200 Olympic swimming pools), causing 270 deaths and large-scale environmental damage. The damage extended to soil contamination, impairment of water resources (e.g. the Paraopeba River), biodiversity loss, and extensive destruction of forests. The Fundão dam is controlled by Samarco Mineração S.A. (a joint venture between the Brazilian Vale and the Anglo-Australian BHP Billiton), and the Corrego do Feijão dam is owned by Vale.

182 The information about facts of the disasters, lawsuits, draft bills and laws has been obtained from the following sources: newspapers 'Estado de Minas' (https://www.em.com.br/), 'O Estado de São Paulo' (https://www.estadao.com.br/), 'The Guardian' (https://www.theguardian.com/uk), and 'The Wall Street Journal' (https://www.wsj.com/); the broadcasting company BBC News (https://www.bbc.com/); and Brazilian institutions' official websites, including The Minas Gerais State Public Prosecutors' Office (https://www.mpmg.mp.br/), Federal Public Prosecutors' Office (http://www.mpf.mp.br/), Legislative Assembly of Minas Gerais (https://www.almg.gov.br/home/index.html), Chamber of Deputies (https://www.camara.leg.br/), Federal Senate (https://www12.senado.leg.br/hpsenado), and Brazil's government legislation portal (https://www.planalto.gov.br/).

The Minas Gerais State Prosecutors' Office submitted a report on the Mariana case, indicating the occurrence of a liquefaction phenomenon, in which stored waste suddenly becomes a murky liquid that can flow quickly, for long distances (Morgenstern *et al*. 2016). This problem was coupled with some drainage system issues caused by changes in the dam's design between 2011 and 2012 (Morgenstern *et al*. 2016). A small earthquake 90 minutes before the disaster may have accelerated the process (Morgenstern *et al*. 2016). Prosecutors found evidence that Samarco had not taken any preventive action, even though it was aware of the risks.

So far, Vale's internal investigations into the causes of the Brumadinho disaster suggest that the dam's rupture was caused by liquefaction and excessive water pressure, aggravated by the season of heavy rainfall (Robertson *et al*. 2019). The dam had been in operation since the 1970s and, in 2016, the decommissioning process was initiated. Evidence indicated that Vale was concerned about the drainage system's imminent risks and had undertaken repair works (Robertson *et al*. 2019). Nevertheless, an inspection by the German auditor Tüv Süd had certified the dam as stable, although some problems had remained unresolved. According to Vale's internal report, there was no visible sign of distress in the dam before its collapse (Robertson *et al*. 2019). However, a recent study on the use of satellite-based monitoring techniques indicated that the timing of the dam collapse was foreseeable (Grebby *et al*. 2021). The study claims that the satellite image data would have detected the ground movement's acceleration, causing deformation in the dam's wall and tailings – a failure precursor (Grebby *et al*. 2021).

ronment. The Brazilian Constitution stipulates the polluters' clean-up obligation for environmental degradation (Article 225, § 2). Regarding the environmental damage, Brazilian law imposes a strict liability regime, namely the obligation to compensate irrespective of fault (Law 6,938/1981, Article 14; Civil Code, Article 942). Moreover, Brazilian law mandates liability to corporate environmental crimes be imposed against polluters, and penalty under these offences may include fines and imprisonment (Law 9,605/1998).

After both disasters, the Brazilian Public Prosecutor's Office did not take long to file lawsuits. Currently, there are several ongoing lawsuits in Brazil for the attribution of civil, criminal and environmental liabilities, and the environmental agency has imposed administrative fines. The mining companies face billions of reals in terms of liability for compensation for damage of lives and properties lost, clean-up and restoration. In both the Mariana and Brumadinho cases, the criminal charges include homicides, personal injuries, flood and landslide, and environmental crimes. However, none of the defendants have been held criminally or civilly liable due to delays in the Brazilian courts caused by the persistent congestion of cases.

In 2016, Samarco, Vale and BHP created the redress scheme, the Renova Foundation, for the Mariana case, resulting from a legal commitment in a lawsuit with public authorities that remains suspended in case of non-compliance. Under this scheme, several claimants received payment, and programmes were implemented for financial aid for indigenous people, rebuilding villages and establishing an alternative water supply (Fundação Renova 2021). A group of victims has opposed the decision-making powers given to Renova to provide effective remediation. They believe Renova lacks independence, since it has not disclosed essential information about the environmental impacts, and consider its compensation programme to be slow, bureaucratic and inadequate (Ridley and Shabalala 2020). During a 2019 visit to the Iron Quadrangle region, the United Nations Human Rights Council Special Rapporteur supported these views, recommending that Renova should be composed of independent experts (Tuncak 2020).

In parallel, around 200,000 victims of the Mariana case are seeking compensation for the damage in the UK courts.[183] In November 2020, the judge struck out the claims on the grounds that they are an abuse of the UK legal system. The decision concluded that the UK action duplicates ongoing litigation claims in Brazil, leading to risks of inconsistent findings and wasted time and costs. One of the crucial factors in the decision is that the claimants would be able to obtain justice in Brazil, including through the existing route of redress from the Renova scheme, without any costs for engagement. This decision is subject to appeal, and the claimants may interpret it as an obstruction of access to justice (Weiner 2020), diverting from precedents allowing English courts' jurisdiction on the parent companies' duty of care for the actions of their subsidiaries abroad.[184]

In February 2021, Vale settled the lawsuit filed by the Minas Gerais State and agreed to pay R$ 37 billion (£ 5 billion) in compensation for the socioeconomic and environmental damage, excluding individual and criminal claims. Nevertheless, representatives of the victims have declared that they have been excluded from the negotiations and have brought an appeal against the settlement to the Federal Supreme Court (Supremo Tribunal Federal 2021). In January 2021, the municipality of Brumadinho and relatives of the victims submitted a group action against Tüv Süd in Germany for its contribution to the accident. Tüv Süd also faces criminal charges in Brazil and Germany.

183 Município De Mariana & Ors v. BHP Group Plc & Anor (Rev 1) [2020] EWHC 2930 (TCC).

184 For instance, in the case Vedanta Resources PLC and another v Lungowe and others [2019] UKSC 20, the Supreme Court accepted the English courts' jurisdiction to hear a claim from Zambian villagers against a mining company related to damage arising from river pollution in Zambia.

The disasters elicited responses from legislative and policymaking quarters. Although state and national proposals for more strict legislation on the safety and monitoring of dams have been implemented with immediate effect, in many cases, the procedures are bureaucratic and lengthy, allowing no substantive changes to be implemented. At the State level, Law 23,291/19 imposed a ban on upstream TDs and forbade the granting of environmental licenses for dams located close to communities or water springs within a minimum distance of 10km. The social movement, Mar de Lama Nunca Mais (sea of mud never again), created after the Mariana disaster, actively participated in the formation of the final draft, which was based on a proposal supported by more than 60,000 people. Another draft bill to implement social licensing to guarantee the restoration process and socioeconomic development of the victims of the TD failures (PL 3,312/2016) was dropped without approval. This would have been a progressive step, with detailed measures that should be taken by the mining companies to develop projects with broader participation of the affected communities.

In practice, the Mariana disaster highlighted some flaws in the application of the National Policy of Dam Safety (Law 12,334/2010), which was finally amended in September 2020 by Law 14,066, after an extended debate. The new law determines the ban of all upstream TDs by 2022 and establishes the possibility of financial assurance for clean-up and remediation. Furthermore, new objectives for the national policy were added, such as the definition of emergency procedures through the instruments of the Emergency Action Plan (PAE) and Self-Rescue Zones (ZAS). The PAE is mandatory for all TDs in the mining sector, irrespective of the classification of risks. The law provides a detailed list of the contents of the PAE, including the emergency rescue plans and training, registration of the population and indication of their vulnerabilities, communication plan, flood maps and escape routes. The ZAS consists of the downstream valley of the dam, where there is not enough time for intervention in an emergency, as described by the flood map. If there are inhabitants in such zones, no new TDs can be installed and only workers in charge of the operation or maintenance of the dam will be allowed to enter them. For the TDs currently in operation in the ZAS, either the TDs or the population should be removed, or the TDs should be reinforced.

Another relevant change of the new law was the strengthening of the criteria for the classification of dams. Before this law was enacted, due to the lack of material resources and skilled personnel, the mining agency had prioritized the inspections of dams listed as critical risks (probability of failure), overlooking those with associated potential damage (impacts in case of failures). As Fundão and Córrego do Feijão were rated as TDs with low critical risks and high associated potential risk, they were not among the inspection priorities. Addressing this issue, the recent law included the benchmarks technical characteristics, state of conservation and security plan compliance, as well as the new additions of construction method and structure age.

Furthermore, the National Agency of Mining (ANM) has intensified the inspection of TDs. When the Brumadinho dam collapsed, the ANM had only eight experts to inspect the mining dams, and the mining companies and their auditors were allowed to certify the dams' safety. The number of staff has been increased, and more than 220 dams were inspected in 2020 (National Agency of Mining 2020). Currently, there are 436 TDs for mining purposes registered in the integrated management system for the mining dams that was created in 2017 (Sistema Integrado de Gestão em Segurança de Barragem de Mineração). Almost half of the TDs, 216, are in Minas Gerais (National Agency of Mining 2020). Following the national criteria for assessing risks, Minas Gerais has 43 TDs classified into emergency levels, three of which are under the risk of imminent rupture (National Agency of Mining 2020).

The vulnerabilities of TDs have long been known, as previous failures worldwide (e.g. Italy, Canada and the US, among others) have caused significant loss of life and damage to property and the environment. While the majority of the responses were given within

the limits of each jurisdiction, efforts at the international level include guidelines for the design, construction and closure of safe TDs (i.e. the 2001 report *Tailing dams: Risks of dangerous occurrences* from the International Council on Large Dams). The accidents in the Iron Quadrangle led to considerable international attention to review and improve guidance in tailings safety and management. One example is the 2017 United Nations Environment Programme (UNEP)/GRID-Arendal report *Mine tailings storage: Safety is no accident*, which gathered policy actions that stem from the recommendation priority of safety first (Roche, Thygesen and Baker 2017). Another example is the development of an international industry standard represented by the 2020 report *Global industry standard on tailings management*, with the goal of zero harm to people and the environment, co-convened by the International Council on Mining and Metals (ICMM), UNEP and Principles for Responsible Investment. It covers the entire life cycle of TDs, from the design, construction, management and monitoring to closure and post-closure, focusing on local communities' perspectives.

This report is part of a series of interventions by the Investor Mining and Tailings Safety Initiative that were implemented in the aftermath of the Brumadinho disaster by a group of institutional investors in the mining industry, led by the Church of England. Other interventions from this group include the public database Global Tailing Portal, tracking the TDs worldwide based on data submitted by publicly listed mining companies, supported by the UNEP (GRID-Arendal 2021). A preliminary analysis of the information disclosed by mining companies comprising 1,743 facilities (i.e. representing an average of 36 per cent of global commodity production) found that the stability risks of upstream TDs are higher than those of the average tailings facilities (Franks *et al.* 2021). The second phase of this project will test the use of satellite radar for monitoring, which according to recent research, would have been an effective technique to foresee the Brumadinho disaster (see section 22.2. above; Grebby *et al.* 2021). Other plans of the Investor Mining and Tailings Safety Initiative include pressure on the mining sector with disinvestment to persuade it to adhere to the global tailings standards (Venditti 2021).

These initiatives constitute the background and implementation of the United Nations Environment Assembly (UNEA) 2019 UNEA-4 Resolution on Mineral Resource Governance in the 21st Century (United Nations Environment Assembly 2019). While recognizing the governance challenge of TDs, it encourages efforts to facilitate international cooperation, failure prevention and crisis response.

22.4 The EIA in Mariana and Brumadinho: failures in the social and environmental protection and evolving laws

In recent decades, EIA process and practice has become consolidated in Brazil. The EIA, which was introduced by the NEP, follows the guidance of the National Council of the Environment (Conselho Nacional do Meio Ambiente [CONAMA]), a deliberative organ in charge of the NEP formulation and coordination. The EIA is tied to the licensing of projects, and the licencing types include provisional, installation and operating permits (CONAMA Resolutions 01/1986 and 237/1997). The responsibilities related to the EIA and environmental licensing are decentralized, and the distribution of competencies depends on where the impacts occur, with the states and the municipalities handling local projects. At

the national level, the environmental agency Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis has the power to supervise and rationalize the use of natural resources under the Ministry of the Environment. It is also responsible for the evaluation of impacts on multiple states or transboundary impacts alongside impacts on complex large-scale developments (Supplementary Law 140/2011). The EIA framework was later accepted by the Brazilian Constitution 1988, and amended in 1995 to incorporate a whole chapter dedicated to the environment. According to Article 225, Paragraph 1, item IV, to assure environmental protection, the public power must require an EIA for the installation of work or activity that may cause significant environmental degradation.

While the causes of the accidents at Mariana and Brumadinho remain under investigation, substantial claims were made about the unsatisfactory EIA and licensing processes. These instruments were aimed at addressing the prevention of accidents such as the dam rupture mitigation risks and their socioenvironmental implications. In the Mariana case, significant flaws were found during the dam licensing process, since some of the licenses for provisional, installation, operating and renewal permits were granted ad referendum to Samarco very quickly without evidence of full compliance (Salinas 2016). A license is deliberated ad referendum when a federal agency decides on the matter on an urgent basis pending a decision from a technical or decision-making agency (Salinas 2016). According to the prosecutors, the 2005 EIA submitted for the provisional permit lacked a detailed engineering design of the dam, and the 2007 emergency response plan for the installation permit failed to provide an emergency communication system, such as alarms and sirens (Salinas 2016).

of the accident (General Comptrollership of Minas Gerais 2019). In particular, the CGE-MG indicated that Vale had not applied for new permits for the latest modifications regarding the increase in the dam height. Moreover, it observed that Vale did not submit the EIA until 2015, since the environmental authorities had requested merely a Report of Environmental Control (RCA) during the Provisional permit procedures in 2008. The RCA is less rigorous than the EIA and can be applied for activities that do not generate significant environmental impacts (CONAMA Resolution 10/1990), which, in this case, was not adequate according to the CGE-MG.

It is not within the scope of this work to analyse the peculiarities of the Mariana and Brumadinho dams' EIA and licensing, since the facts are still under deliberation. However, the issues raised coincide with factors generally recognized as limitations of the effectiveness of the EIA and licensing in Brazil. For instance, the procedures are controlled by public entities, and it is well known that many of them lack material resources and have only a few trained and skilled personnel (Glasson and Salvador 2000). This insufficiency results not only in lengthy bureaucratic procedures, but also in the scant analysis of the project's details (Glasson and Salvador 2000). Moreover, although public participation is required by law, there are limitations in the actual involvement of the impacted communities. It is clear that they are not central to the process and the public hearings often result in a mere formality without substantial influence on the actual decision-making. Furthermore, local communities can experience difficulties in understanding the EIA's highly technical language or interpreting the impacts of the project on their lives (Hochstetler 2018). Typically, some communities that speak the indigenous language or have low education levels may not have meaningful participation without assistance (Hochstetler 2018). Ultimately, corporations can be highly influential in economic and political matters of developmental projects. In practice, the EIA works to improve the sustainability of economic projects from the proponent's perspective, instead of gathering collective views on whether and how the project should be done (Glasson Therivel and Chadwick 2012).

These concerns are now being examined in challenging times, as several draft bills on a fast-track EIA/licensing version to streamline the licensing in Brazil can inevitably reduce the effectiveness of the environmental assessment. For instance, PSL 654/2015, among others, intends to exempt the EIA for activities related to strategic and national interest, such as the exploration of natural resources and eliminating opportunities for direct public participation. The rapporteur of the proposed legislation expressly mentions that the licensing is a "villain", delaying investments needed for the development of the country. To comply with the short timescale, the government would probably need to rely on the companies' information, instead of performing a systematic investigation. Similarly, PEC 65/2012 proposes that a project cannot be suspended or cancelled once an EIA is submitted, unless there are changes in the circumstances of the elucidation of the first EIA. This proposal reveals the discontent with the "judicialization" of important projects when the court injunctions can delay or stop the licensing process. An example of this is the construction of the Belo Monte hydropower dam in the Amazon region, which was temporarily postponed by provisional court decisions to analyse allegations that the EIA process had not taken into account the impacts in the Xingu indigenous people's lands (Khatri 2013). However, access to justice is an essential power of heavily impacted communities whose safety can be ignored by large infrastructure projects. Consequently, when the administrative avenues fail, the courts have an indispensable role in scrutinizing the licensing process to hold the public and private sectors accountable.

The legal reform proposals in the EIA and licensing had been under discussion for several years before the Mariana and Brumadinho disasters occurred. These proposals did not consider the lessons learned from the catastrophes. One of the legacies of the disasters is the voice given to the impacted communities, as evidenced by the powers of social movements resulting

in Minas Gerais State Law 23,291/19 (see section 22.2 above). Supposedly, the same type of constructive effort could influence meaningful public participation in the EIA and licensing in the Iron Quadrangle.

Furthermore, the United Nations International Strategy for Disaster Reduction (UNISDR) has recognized the EIA's potential to strengthen the disaster risks reduction (Sendai Framework, item 30, 'c'). The Mariana and Brumadinho disasters are perfect examples demonstrating that they could have benefitted from this approach. Although disaster management is an integral part of the environmental and societal planning of TDs, addressing disaster risks in EIAs has not been a widespread practice in either Brazil or the rest of the world (Hapuarachchi Hughey and Rennie 2016). Nevertheless, Brazilian EIAs broadly cover the "relationships of dependency between the local society and the natural resources" for the measurement of the impacts on the "health, safety and well-being of the communities" (CONAMA Resolution 01/1986). With a severe and recurrent problem in the management of TDs, Brazil could become a pioneer in mainstreaming disaster risk implications in the TD projects in the Iron Quadrangle. This would require identifying the TDs' potential impacts within the disaster risk reduction for resilience framework, selecting the specific actions in line with best practices from the UNISDR and the Brazilian National Policy on Protection and Civil Defence (Law 12,608/2012).

22.5 Approaches of the SEA for iron ore in Minas Gerais

The Mariana and Brumadinho disasters generated discussions about the SEA's benefits for the mining activities in the region. The government of Minas Gerais has approached the NCEA for further studies of an SEA for iron ore in addition to a state mining plan. An SEA has the potential to improve evaluation of the TDs' impact as a whole, within the PPPs for sustainable mining in Minas Gerais, in synergy with the EIA practice in large-scale project developments.

In Brazil, the SEA is not a formal and compulsory process. The NEP refers broadly to "the evaluation of environmental impacts", which includes the SEA as a decision-making instrument related to a phase prior to specific projects. No progress has been made in the attempts to give the SEA the status of a legal instrument, and the draft bills are still under analysis (PL 261/2011 and 4,996/2013, among others). However, the absence of a legal framework has not discouraged some experiences. For example, both the Brazil-Bolivia gas pipeline and the Jirau and Santo Antonio hydropower dams in the Amazon basin have conducted SEAs in response to a requirement from the IDB and the World Bank for approval of investments. Another example of the SEA in Brazil is the voluntary initiative of the Rodoanel Mario Covas, a roadway system constructed in the dense urban area of São Paulo Metropolitan Region. On this occasion, many of the relevant strategic aspects of the roadway were overlooked, which was partially attributed to the absence of guidelines and low levels of expertise in strategic planning (Sánchez and Silva-Sánchez 2008).

The SEA for iron ore design is at an early stage and only a few details have been revealed. The NCEA has emphasized the need for consultation with the stakeholders in the decision-making process before, during and after the undertaking of the SEA. This process would also be in line with best practices and international standards (Netherlands Commission for Environmental Assessment 2020). To facilitate the consultation process, the NCEA suggested the creation of a stakeholder platform with representatives of the civil society, mining industry and public institutions (Netherlands Commission for Environmental

Assessment 2020). Working in collaboration with the NCEA, the organization Dutch Risk Reduction (DRR) presented the key findings on the technical stability and safety of TDs in Minas Gerais and governance (Dutch Risk Reduction 2019). The DRR highlighted that the application of the law and policy on the dams' safety can be improved, and suggested that the shortage of staff in the regulatory institutions be addressed since it is a major challenge for the law and policy enforcement. According to the DRR, the SEA is an opportunity to reconcile the interests of the mining companies, society and government, while also improving levels of trust and accountability and the coordination among regulatory authorities from multiple sectors. The SEA will provide short- to long-term strategies (for at least 20 years), and the decision-making will be informed by data derived from the technical and scientific studies. These would also be accompanied by information obtained through public participation. According to the DRR, some of the relevant data to build an SEA is related to vulnerable communities, flood-prone areas, early warning systems, waste disposal methods, as well as a guide for the spatial zone of future mining activities, among others (Dutch Risk Reduction 2019).

Depending on the quality of the collected data and the level of public engagement, the SEA for iron ore can enhance the governance of the TDs in the Iron Quadrangle. The first advantage is the synergy between the SEA and the EIA (Alshuwaikhat 2005). They can be connected as different stages of the same policy and resulting projects in a way that the SEA adds to the EIA levels of generality in greater proportions and encompasses a wider range of environmental impacts. The SEA's broader lens has a certain level of abstraction regarding the details of the EIA's projects. Nevertheless, it can ensure the accuracy, particularly with respect to the cumulative effects on the surrounding communities and environment caused by the group of dams together in the Iron Quadrangle. Dealing with the above-mentioned aspects as a whole and beyond the individual project level allows for coherency and uniformity in the decision-making (Alshuwaikhat 2005). Conversely, it is unlikely that the SEA will solve some of the major problems of the EIA in Brazil, for instance, the shortage of qualified professionals and the failures in the monitoring. Similarly, although not tied to the licensing, the SEA can still be subject to economic and political pressures from sectorial groups affected by the PPPs.

Moreover, the integrative approach of the SEA can facilitate the coordination of institutions, policies and standards that have their own agendas and priorities and act in a fragmented way. The governance of the Iron Quadrangle is a complex process, spanning a network of entities comprising mining, environmental and societal interests. These entities operate in different scales at the municipal, state, national and international levels. The SEA can contribute to integrating all these standpoints into the decision-making of PPPs. It can also link the TDs' social and environmental impacts to the Sustainable Development Goals of 2030 United Nations Agenda for Sustainable Development and to the adaptation measures of the 2015 Paris Agreement on Climate Change. The SEA for iron ore is timely, since the new legislation and policy on dam safety have just came into force as a reaction to the disasters. The SEA will deal with several new standards of safety, which are designed to be more rigorous and it can identify how the different sources of rules and standards work together. Such sources range from the Minas Gerais State, the federal level and the ANM to the ICMM with its recent international guidelines. It can be a test to apply this mosaic of standards to the strategies, providing tailor-made solutions and clarifying inconsistencies and gaps, and baseline studies, particularly the new features in Law 14,066/2020 related to the PAE and the ZAS.

Most importantly, as discussed in the case of the EIA, the SEA will be an opportunity to incorporate the disaster risk reduction framework into the strategies of PPPs, affecting the developmental objectives of the government and the mining sector in the region. It has become evident that the existence of TDs in the region implies the risks of disasters that are preventable, and

this is the most challenging circumstance to which the SEA should be applied. Typically, the SEA can deal with common technological solutions for disaster reduction mechanisms in Minas Gerais, for instance, by enabling information systems for effective early warning to minimise losses of lives and emergency response for assistance and recovery (Organisation for Economic Cooperation and Development 2010).

In the context of the TDs, the integration of the SEA and the DRR framework will require adopting the latest devices for monitoring dams' risks. In the Brumadinho case, Vale used ground-based devices, and it alleged that it was not possible to detect precursors to failures in the dam since the tailings' movements were too small and slow (Robertson *et al*. 2019). However, the latest research indicates that satellite radar monitoring effectively detects the tailings deformations, such as those in the Brumadinho case, within a week of it happening (see section 22.2. above). Researchers are developing this satellite monitoring software for the mining industry to be used alongside on-the-ground sensors (Grebby *et al*. 2021). The SEA is an opportunity to implement changes in the monitoring technology that can forecast disasters in a reliable way. Anticipated disaster detection, mapping and predicting the imminent risk of dams' failure, increases the chances of success in the subsequent phases in disaster risk reduction. Well-timed communication, warning information and evacuation of the population will ultimately impact on saving lives.

22.6 Conclusion and policy implications

The main lesson learned from the disasters of Mariana and Brumadinho in the Iron Quadrangle is that the risks of TDs' failures were predicted and they could have been prevented. In addition, there are ways to ensure they will not happen again, or at least not in the same catastrophic dimensions. The two pillars of the SEA for Iron Ore are public participation and prevention/disaster risk reduction, and they should be explicitly incorporated into the SEA.

The Iron Quadrangle is a development corridor that was planned many decades ago, for which a broader environmental strategy was never a priority. Despite the widespread use of the EIA as a condition for environmental licensing for individual projects, it has often neglected the public participation contributions in the decision-making and the public's understanding of the implications of living in a region populated by TDs. Furthermore, in the cases of Brumadinho and Mariana, the lack of an adequate number of experts to oversee the dams effectively resulted in overreliance on the information given by the companies, although a more active role of the public authorities in the disaster reduction was desired. In this context, the state-of-the-art technological devices such as the satellite radar monitoring can be decisive in forecasting a dam's failure, triggering the disaster risk response that can save lives.

A combination of the EIA and the SEA in the Iron Quadrangle may not address the current issues in the EIA practice, namely the scarcity of resources for the implementation and political pressures that prioritize the economic development. However, the SEA will provide a comprehensive approach to support the government of Minas Gerais in implementing strategy focused on rigorous preventive measures to reduce the social and environmental impacts of the TDs, including disaster risks. This can improve the practice of the EIA, as the analysis of each new EIA and licensing will be supported by the overall strategy.

The Mariana and Brumadinho disasters caused so much destruction in the impacted communities and environment in Minas Gerais that reparation and restoration will

probably never be made. They also created distrust among the local population in the government and companies. For this reason, the SEA for iron ore must be centred in the local communities, and their risks, concerns, vulnerabilities, health and relationship with the environment. It is expected that, with a collaborative effort over time, the population's perceptions of the large-scale development projects in the region can be improved.

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