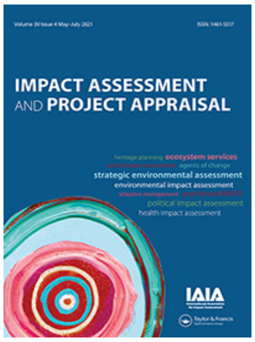

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ARTICLE

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Scoping review of the inclusion of economic analysis in impact studies of natural resource extraction projects

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ABSTRACT
The extraction of natural resources, such as minerals, oil, and gas, can have profound economic effects. The application of economic analysis methods in impact studies of resource extraction projects holds potential to inform decision-making in order to optimise gains and minimise negative externalities. This paper aims to identify and characterise peer-reviewed publications that report on economic studies implemented as part of impact assessments of resource extraction projects. We conducted a systematic scoping review in PubMed and Scopus of articles published between 1998 and 2020. Out of 1,579 raw hits, we identified 13 articles describing 15 economic analyses of resource extraction projects. Half of the identified papers presented economic analyses conducted in the context of mining and oil/gas projects. The majority of the identified studies dealt with the cost and/or benefits of environmental and/or social impacts. Only one study investigated economic aspects associated with potential health impacts. Given the small number of papers identified, economic analysis of impacts associated with natural resource extraction projects seems to be a small field of published research. Yet the inclusion of economic analysis in impact assessment of resource extraction projects holds promise to better harness benefits for local communities and governments while minimising negative externalities.

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KEYWORDS
Economic analysis; extractive industry; impact assessment; resource extraction; scoping review

Background

To achieve the Sustainable Development Goals (SDGs) of the Agenda 2030, it is estimated that US$ 5–7 trillion are needed annually, which corresponds to approximately a third of the gross domestic product (GDP) of the United States of America (US$ 21 trillion in 2019) (United Nations 2014; World investment report 2014; World Bank 2020a; World Bank 2020b). In the same report, investment needs in developing countries alone were estimated at US$ 3.3–4.5 trillion per year, corresponding to several times the annual GDP of sub-Saharan Africa (US$ 1.75 trillion in 2019) (United Nations. 2014). Hence, a significant contribution is expected from the private sector to jointly strive towards the SDGs, particularly in low- and middle-income countries (LMICs) (Scheyvens et al. 2016; Stafford-Smith et al. 2017; Mawdsley 2018; Ike et al. 2019; Aust et al. 2020).

The abundance of natural resources in many LMICs is an opportunity for the private sector to be an essential player in promoting economic growth and societal development (IPIECA 2017; World Bank 2017). Particularly in Africa, which is endowed with over 30% of the world's global mineral reserves and over 60 different metals (United Nations 2011), the mining industry might play an even more important role in a low carbon future (Slavova and Bankova 2017; Sturman et al. 2020). Indeed, renewable energy sources, such as wind, solar, and hydrogen, are significantly more material-intensive than current traditional fossil fuel-based energy supply systems, resulting in a rapidly increasing demand for relevant metals (Arrobas et al. 2017; Valero et al. 2018; Giurco et al. 2019).

Extractive industries and the SDGs

Tax revenues and royalties paid by the extractive industries are essential for local and national governments to work towards all SDGs (Otto et al. 2006). The resulting increased government revenue can be used to promote investments in schools, health facilities, and other public infrastructures, ultimately leading to improved health and well-being (SDG3), better education (SDG4), and access to clean drinking water and sanitation (SDG6) (Carter and Danert 2003; Morrison-Saunders and Retief 2012; Knoblauch et al. 2014). The creation of employment and income can reduce poverty (SDG1) along with improving housing conditions (SDG11) and health insurance coverage (SDG3) (Bradley et al. 2013; Langston et al. 2015; Von Der Goltz and Barnwal 2019). Hence, the development and operation of natural resource extraction projects

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(NREPs) come with many opportunities for sustainable development, which holds particularly true in LMICs (Horn and Grugel 2018).

Despite these opportunities, there is also evidence that extractive industries can trigger negative socio-economic effects at the local and national levels; thus opposing progress towards the SDGs (Papyrakis 2017; Sachs et al. 2019). Indeed, the resource curse – also known as the '*paradox of abundance*' – draws a negative link between a country's natural resource wealth and its impact on economic development (Mehlum et al. 2006). Several studies have explained this curse through the negative effects of the extractive sector on the governance of producing countries (Busse and Gröning 2013; James 2015; Hong 2018). Governance in many LMICs with a strong extractive sector is marked by (i) inadequate funding for important development sectors such as education and health (Calain 2008; Cockx and Francken 2014), (ii) a reduction in the competitiveness of the non-resource sectors (e.g. manufacturing sector or agriculture) due to high foreign exchange rates (called 'Dutch disease') (Brahmbhatt et al. 2010), and (iii) an increased frequency of violent conflicts (Ross 2004). Indeed, at the national level, a study found that from 1960 to 1990, the increase in GDP of mineral-rich countries was lower (1.7%) than that of other countries (2.5–3.5%) (Meijia and Castel 2012). At the local level, environmental, social, and public health challenges induced by NREPs have direct and indirect costs for communities. For example, NREPs can potentially exacerbate poverty in marginalised population groups (SDG1 and SDG10) (Winkler et al. 2012; Carney and Gushulak 2016). Another important concern is the overburdening of local health systems through project-induced immigration and alterations in local disease patterns (SDG3) (Winkler et al. 2012; Schrecker et al. 2018).

The potential of economic analyses

Economic analyses are applicable to all domains of sustainable development (e.g. economy, environment, and society) and to all sectors of development (e.g. construction, agriculture, industry). To estimate changes in employment and levels of business activity that may result from a proposed project, economic impact assessment (EcIA) can be applied as part of the feasibility studies (Rushton et al. 1999; International Association for Impact Assessment 2021a). Within EcIA, or as a standalone process, different types of economic analyses can be carried out (Hitch 2014). For example, cost-benefit analysis (CBA) can be used to estimate the net public benefits of a project by comparing the total benefits (e.g. jobs created, tax revenues) with the cost of the same project (e.g. cost of economic, social, or environmental impacts) (Briggs and O'Brien 2001; Abelson 2015). Cost-effectiveness analysis (CEA) can be applied to compare the relative cost of one or several courses of action (e.g. financing of revenue-generating activities by the mining project *versus* professional training of the members of the households displaced by a mining project) and the resulting outcomes (e.g. the economic well-being of displaced households) (Drummond et al. 2015). Cost minimisation analyses (CMA) aim to select the cheapest method by comparing the cost of two or more interventions with the same results (Rudmik and Drummond 2013). Finally, cost-utility analysis (CUA) compares the incremental cost of a program/intervention (e.g. knee arthroplasty in the treatment of osteoarthritis) to incremental costs of quantitative and qualitative aspects of the consequences (e.g. cost of quality-adjusted life years) (Gui et al. 2019). An economic analysis is full or complete if it compares both the cost and the consequences (effectiveness or benefits) of two or more interventions, as is done in CBA. Otherwise, the analysis is partial, for instance, if only costs are analysed (Drummond et al. 2015; Ciani and Federici 2020). The different types of economic analyses can be done through prospective studies (referred to as 'assessments' in this paper) or as retrospective studies ('evaluations') (International Association for Impact Assessment 2021b). In the present study, we apply the term 'economic studies' to encompass both assessments and evaluations.

Economic analysis in impact studies of NREPs

Impact assessments (IA) are a structured process for considering the implications of proposed actions for people and their environment at the planning stage (International Association for Impact Assessment 2021b). IA can be applied at all levels of decision-making, ranging from policies to specific projects. Hence, through the inclusion of economic analysis in prospective impact assessments of NREPs, economic considerations can be incorporated into the decision-making process, thus promoting profitable projects with minimal negative financial externalities (Adamiak 2006; Petrou and Gray 2011; Wonderling 2011). In addition, economic analysis can support the selection of corporate social responsibility (CSR) interventions and, at the same time, promote public-private partnerships for jointly working towards the 2030 Agenda for Sustainable Development (Araja 2012; Jomo et al. 2016; Winkler et al. 2020a). Hence, the application of economic analysis in impact assessments and evaluations (referred to as 'impact studies') holds the potential to create a more sustainable extractive sector.

The objective of this paper is to identify economic analysis methods and scientific case studies that can support our on-going research efforts studying impacts of NREPs in sub-Saharan Africa (Farnham et al. 2020; Winkler et al. 2020a). For this purpose, we conducted a scoping literature review to systematically identify and characterise peer-reviewed publications that report on economic studies that apply a community-perspective and have been implemented as part of impact studies of NREPs globally. The research was guided by the following research questions: In the context of which types of NREPs have economic analysis methods been applied in the frame of impact assessments or evaluations, as reported in the peer reviewed literature? What types of impacts (environmental, social, economic, or health) were considered in the economic analyses identified? What are the types of economic analyses that were applied?

Methods

The methodology of our scoping literature review was inspired by a recent paper by Leuenberger et al. (2019) who carried out a scoping review on the topic of health impact assessment and health equity in sub-Saharan Africa. The search for articles was conducted in accordance with the principles outlined in the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) statement (Moher et al. 2009). The search targeted peer-reviewed articles only. Grey literature was excluded as the objective of the scoping review is to identify economic analysis methods that can be applied in scientific research. Methods and case studies that have been published in the peer-reviewed journals were scrutinised by experts in the field and can therefore be considered robust. In addition, journal search and indexing databases, such as PubMed and Scopus, provide the possibility to conduct systematic literature searches using elaborated search strings. This cannot be done for grey literature searches.

Search strategy

The search terminology consisted of three components: (i) NREPs, specified by a wide range of natural resources (e.g. gold, aluminum, coal, gas, oil) and other NREP-related terminologies such as mining, industry, and exploration; (ii) different types of impact studies (e.g. economic impact analysis, environmental impact assessment, health impact evaluation); and (iii) different types of economic analyses (e.g. CBA, CEA). The full search terminology is available in Appendix I and Appendix II. The search terms were applied in PubMed and Scopus. The search was restricted to records published between 1 January 1998 and 30 September 2020. No geographical restriction was applied.

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Peer-reviewed original research article or systematic review • Focusing on an extractive industry projects • Presents an economic or financial study • Oriented towards public economic perspective • Impacts on the society, environment or health are assessed or evaluated • Written in English or French • Abstract available	• Study not reporting original data • Paper not presenting details of methodology and results • No full text available

Paper selection and characterisation

All identified publications were screened for the inclusion and exclusion criteria listed in Table 1. English and French original peer-reviewed research articles and systematic reviews were included if they complied with the inclusion criteria: (i) paper investigated environmental, social, or health impacts of NREPs, and (ii) determined the financial and/or economic costs and/or benefits of NREPs from a community-perspective. Articles that (i) were not based on original data, (ii) did not present full details of the methodology applied and the results obtained, or (iii) did not have an abstract or full text available within the access rights of the University of Basel were excluded from further analysis.

In a three-step process, two independent researchers (HZ and DD) performed the screening of the papers. In the first step, titles and abstracts were screened to assess the inclusion criteria. The exclusion criteria were applied to the full-texts of the retained publications in a second step. Discrepancies were discussed among the two independent reviewers and, if needed, with a third author until consensus was reached on which papers to include in the final sample. Zotero Version 5.0.34 (George Mason University, Fairfax, Virginia, USA) was used for extracting and managing the records. In the final step, articles selected for the full-text analysis were read in detail and previously specified characteristics (i.e. project location, nature of NREP studied, production stages, type of impacts studied and economic analysis applied) were extracted and entered into an Excel spreadsheet for subsequent descriptive interpretation (Microsoft Excel 2010, Microsoft Corp.; Redmond, WA, USA).

Data analysis

The articles selected for the full-text analysis were grouped in an Excel sheet and selected characteristics (e.g. project location, nature of NREP studied, production stages, type of impacts studied, and economic analysis applied) were recorded. In the full-text screening, we also determined whether a single paper presented one or several economic studies.

Results

Peer-reviewed literature

In total, 1,579 articles were found in PubMed and Scopus. After removing 47 duplicates, 1,532 articles were included for the title and abstract screening. Of those, 1,459 articles did not meet the inclusion criteria and were excluded at this step (Figure 1).

Thus, 73 articles were included for full-text screening (rough description of papers available in Appendix III and Appendix IV). After the full-text screening, 13 papers remained for the final analysis. As one of the articles presented three case studies (Damigos 2006), the final dataset of the scoping review consisted of 13 papers reporting on economic studies that were carried out in the context of 15 NREPs. An overview of the articles is provided in Table 2.

Characterisation of studies identified

Out of the 15 economic studies identified, seven presented on economic analyses in the context of mining (n = 4) and oil/gas projects (n = 3) (see Figure 2) (Netalieva et al. 2005; Damigos 2006; Damigos and Kaliampakos 2006; Franks et al. 2010; Considine et al. 2016). The majority of included papers (n = 7) reported on economic studies in the context of water resource projects (Morimoto and Hope 2004; Hjerpe and Kim 2007; Alp and Yetis 2010; Mirumachi and Torriti 2012; Tajziehchi et al. 2013, 2014; Fanaian et al. 2015). One economic study was carried out in the context of a biofuel project (Miranda and Hale 2001).

The economic studies were carried out at different stages of the project development cycle of the NREPs: pre-production (n = 2); production (n = 9); and post-production (n = 4). The included papers were published between 2001 and 2017. As illustrated in Figure 2, most of the 15 economic studies had a focus on Asian countries (n = 6), whereas others were conducted in America (n = 4), Europe (n = 4) and Africa (n = 1).

Types of impacts studied

The characterisation of the economic studies in terms of the impact domains studied (i.e. environment, social, or health) revealed that eight of the economic analyses considered more than one impact domain (see Table 2). Among those studies, most (n = 6) dealt with both environmental and social impacts. The remaining two considered environmental, social, and economic impacts (n = 1) and socio-economic impacts (n = 1). All other studies (n = 7) focused on a single impact domain: environment (n = 3), social (n = 2), ecological (n = 1), and health (n = 1).

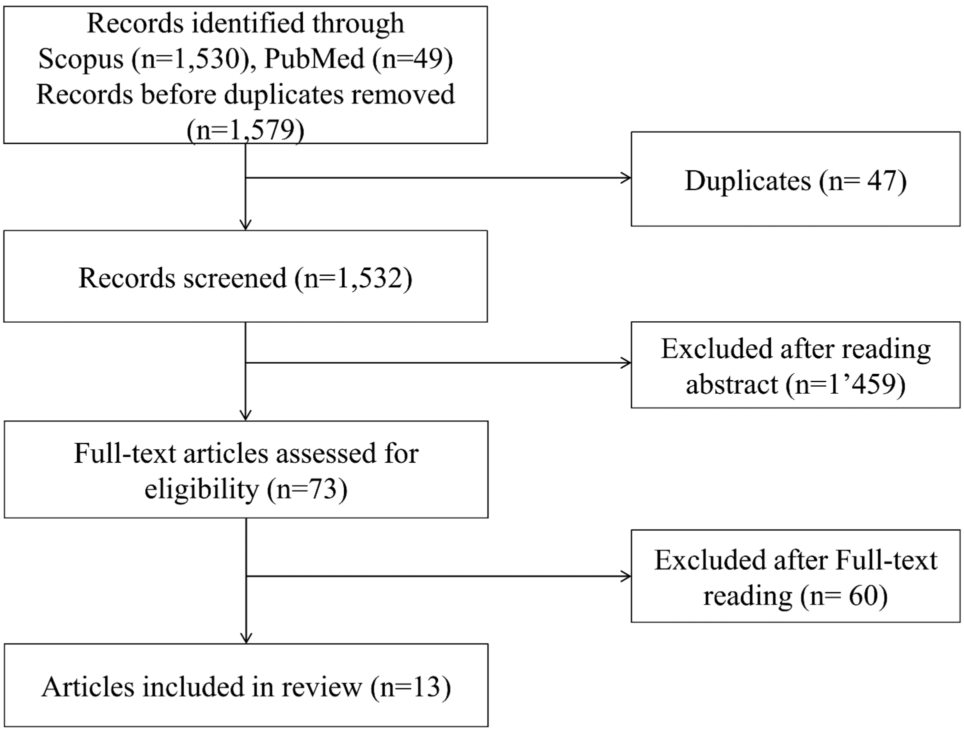

Figure 1. PRISMA flowchart illustrating the article selection process.

Table 2. Appraisal of included articles and studied projects.

References Country	Project characteristics				Type of Analysis
	Types of NREP	Name of NREP	Production stage	Type of impact	
Moran et al. 2017 United States of America	Oil/gas	Not available[a]	Production	Environment-social	CA
Considine et al. 2016 United States of America	Oil/gas	Marcellus Shale of Pennsylvania	Production	Environment	CBA
Fanaian et al. 2015 Mozambique	Water resource	Zambezi river	Production	Ecological	BA
Tajziehchi et al. 2014 Iran	Water resource	Alborz Dam in northern Iran	Production	Social	CBA
Tajziehchi et al. 2013 Iran	Water resource	Alborz Hydropower Plant	Pre-production	Social	CA
Mirumachi and Torriti 2012 Laos	Water resource	Theun 2 hydropower project	Production	Environment-social	CBA
Alp and Yetis 2010 Turkey	Water resource	Yusufeli dam & Hydroelectric power plant	Production	Environment	CA
Hjerpe and Kim 2007 United States of America	Water resource	The Grand Canyo	Production	Socio-economic	CBA
Damigos and Kaliampakos 2006 Greece	Mining	Perama gold project	Post-production	Environment-social	CBA
	Mining	Eagle Mine	Post-production	Environment	CA
Damigos 2006 United States of America	Mining	P. Viaropoulos quarry	Post-production	Environment-social	BA
	Mining	Perama gold mine project	Post-production	Environment-social	CBA
Netalieva et al. 2005 Kazakhstan	Oil/gas	Astana & Atyrau town oil industries	Production	Health	CBA
Morimoto and Hope 2004 China	Water resource	The Three Gorges project	Pre-production	Environment-social-economic	CBA
Miranda and Hale 2001 Sweden	Biofuel	Not available[2]	Production	Environment-social	CA

[a]Unconventional oil and gas development regions; [2]Energy production; CBA: cost-benefit analyis, BA: Benefit analysis, CA: Cost analysis

Types of economic analyses applied

Three main types of economic analysis were applied in the 15 included studies: CBA (n = 8); cost analysis (n = 5); and benefit analysis (n = 2). Hence, seven of the economic analyses identified were incomplete analyses (five cost analyses and two benefit analyses). The eight CBAs were used in socio-environmental impact studies of water resources (n = 4), mining (n = 2), oil/gas (n = 2) developments. The five cost analyses were applied in socio-environmental impact studies of water resources (n = 2), mining (n = 1), oil/gas (n = 1), and biofuel (n = 1) projects. The two benefit analyses were embedded in socio-environmental impact studies of a water resource development (n = 1) and a mining project (n = 1).

Discussion

This scoping review reveals that few papers exist in the peer-reviewed literature presenting on economic analyses that were included in impact studies of extractive industry projects. The thirteen papers identified in our review were mainly oriented towards environmental or social impacts, with only one study investigating economic aspects associated with potential health impacts. In terms of geographical representation, we identified a similar number of papers focussing on projects in the global north (North America and Europe) and the global south (Asia and Africa). Most economic studies identified were conducted in the context of water resource developments and mining projects.

Our paper aligns with previous papers that made an attempt to characterise impact studies in the context of large infrastructure projects. For example, a systematic review of scientific papers investigating the health and economic outcomes of mining on surrounding communities in LMICs found no more than 12 relevant articles (Mactaggart et al. 2018). Hodbod and Tomei could only identify 17 peer-reviewed papers studying the social and economic impacts of biofuel projects (Hodbod and Tomei 2013). A more substantial number of papers (n = 52) were identified in a systematic review on the inclusion of poverty considerations in impact studies of resource extraction projects (Gamu et al. 2015). Overall, the limited number of peer-reviewed papers presenting economic analyses that were included in impact studies of extractive industry projects shows that this is not a very active field of published research. This is unfortunate when considering the important role economic analysis could play in impact assessment of extractive projects (Scheyvens et al. 2016; Stafford-Smith et al. 2017; Mawdsley 2018; Ike et al. 2019; Aust et al. 2020). However, it is important to note that the number of publications in the peer-reviewed literature only partly reflects the number of economic analyses done in impact studies of extractive industry projects. Many of the completed EcIA are presented in reports ('grey literature') that are, in the best case, found on websites of organisations and companies. But as neither grey

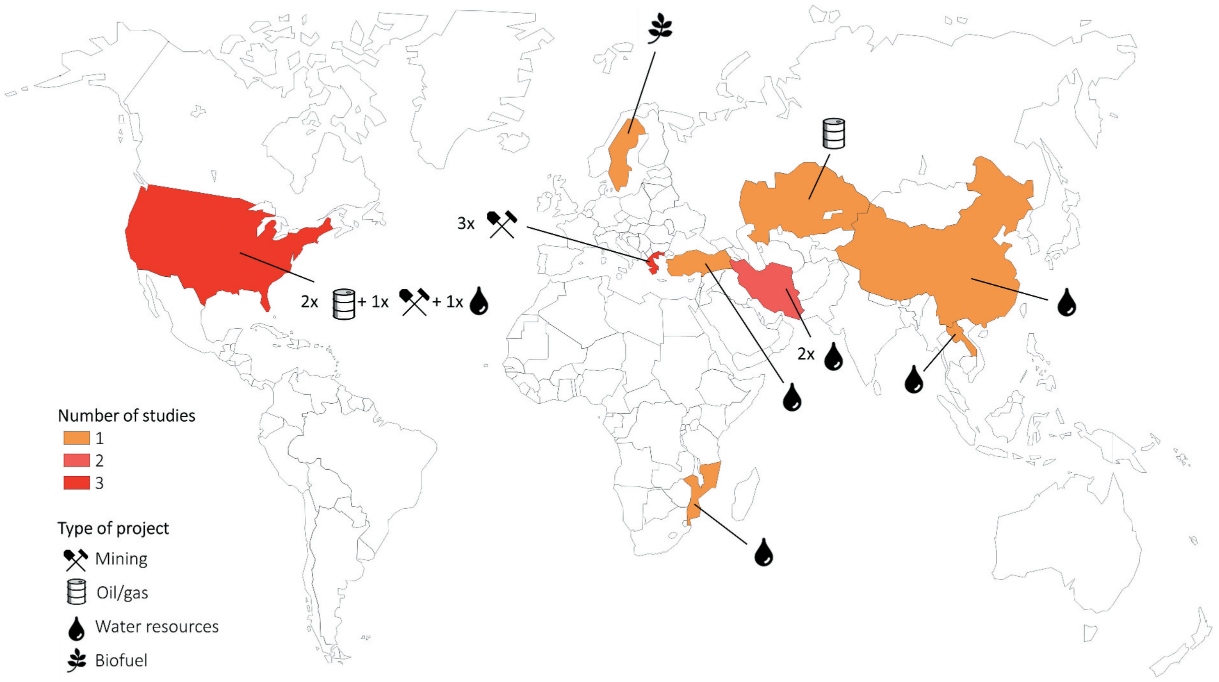

Figure 2. Geographical location of economic studies included and types of NREPs investigated.

literature nor websites were included in the present scoping review, we cannot make any judgment about EcIA practice in different world regions.

None of the studies included in our scoping review presented an economic analysis that was conducted in the framework of a prospective impact assessment on the African continent. This finding is not unexpected given previous papers that have identified weaknesses in impact assessment research and practice in Africa (Erlanger et al. 2008; Winkler et al. 2013). At the same time, it is a relevant finding, as it contrasts with the booming extractive industries sectors in many African countries (Grégoire 2011). If negative externalities associated with NREPs are to be prevented at the local and national level, strong impact assessment practice is required (Joyce et al. 2018). Therefore, governments and project financing institutions should make an effort to strengthen the application of impact assessments of NREPs on the African continent, placing emphasis on inter-disciplinary approaches that include economic analysis components. Importantly, this needs to be coupled with capacity building efforts, as the paucity of technical expertise and capacity has been identified as an important barrier to impact assessment practice (Winkler et al. 2020b).

Despite the multilateral impacts of NREPs, many studies have focused on one type of impact only, with environmental and social impacts being considered most frequently. This finding is consistent with other studies that have found that impact assessment and evaluation studies of NREPs have mainly focused on environmental impacts (Rafael Fernandes De Mesquita et al. 2017; Dietler et al. 2020). This is concerning as the multiplicity and diversity of effects triggered by the development and operation of NREPs have been well documented (Downey et al. 2010; Franks et al. 2010; Papyrakis et al. 2017; Mancini and Sala 2018; Buse et al. 2019). However, based on our findings we cannot determine whether the limited number of studies focused on health or socio-economic impacts identified in our scoping review is due to a lack of appropriate methodologies, capabilities or interest.

According to the types of economic analyses identified, almost half of the fifteen studies can be considered partial since they only considered costs or benefits (Drummond et al. 2015; Ciani and Federici 2020). This is in line with the findings of a systematic review of Ayuk et al. (2013), concluding that CBAs are insufficiently integrated into impact assessments of mining projects in sub-Saharan Africa. This is unfortunate, as the challenge in measuring the contribution of the mining sector to society lies mainly in the estimation of added economic value, which requires a complete CBA (Mancini and Sala 2018). Overall, there is a paucity of scientific papers presenting on both economic gains and losses of NREPs. This deprives policy-makers of the information needed to adjust the financial and economic contributions of NREPs to match the costs of their negative externalities. In addition, there is a lack of evidence to inform appropriate strategies to minimise negative impacts of NREPs on local and national economies. In order to overcome these shortcomings, impact assessment practice of extractive projects could attempt to learn from other fields of impact assessment application how to more proactively incorporate economic analysis in the impact assessment process. For example, in transport planning economic considerations have been systematically integrated in strategic environmental assessment (Fischer 2006).

Limitations

The research presented comes with several limitations. First, our research strategy only targeted published scientific articles. Consequently, unpublished studies or grey literature such as EcIA reports of NREPs are not included in our scoping review, inducing a publication bias towards the peer-reviewed literature. Thus, the research presented refrains from making any appraisal of EcIA practice. Second, our scoping may have missed some relevant articles. For example, our research was done in Scopus and PubMed, while other studies may be published in other databases that we did not include. However, these databases included all major economic or environmental journals in which EcIA reports or economic analyses are commonly published. Third, since impact assessments are commonly conducted for large-scale infrastructure projects, our scoping review was oriented towards the industrial extraction of natural resources, excluding artisanal and small-scale mining. Finally, the search string of our scoping review was only in English and the papers included were restricted to English and French. Hence, we might have missed relevant papers presented in other languages.

Conclusion

This scoping review shows that economic analysis of impacts associated with the development and operation of natural resource extraction projects is a relatively small field of published research. Hence, compared to other impact assessment domains, such as environmental, social or health impact assessment, research capacity in EcIA of extractive industry projects seems limited. This is unfortunate since the inclusion of economic analysis in impact assessment of resource extraction projects is needed to incorporate economic considerations in the decision-making process for promoting sustainable projects with minimal negative financial externalities. The EcIA community should make an effort to publish their findings and methodologies of economic analyses in the context of natural resource extraction projects. This will not only increase transparency on economic risks and benefits associated with the development of extractive industry projects, but also promote EcIA research and practice.

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Disclosure statement

The authors declare that they have no conflict of interest.

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Appendix I: Search terms and results in Scopus

Set	Search term and strategy	Hits (01.01.1998–-30.09.2020)
#1 NREPs	TITLE-ABS-KEY ((exploration OR exploitation OR extractive OR extraction OR mine OR mines OR mining OR industry OR industries OR factory OR factories OR plantation OR production OR dam OR drilling) AND (asbestos OR carbon OR coal OR diamond OR diamonds OR fluorite OR gas OR 'natural gas' OR metal OR metals OR salt OR aluminum OR alumina OR bauxite OR cobalt OR copper OR chrome OR chromium OR gold OR iron OR 'iron ore' OR lead OR manganese OR nickel OR phosphate OR phosphor OR palladium OR platinum OR potassium OR silver OR steel OR sulphate OR sulphur OR tin OR titanium OR tungsten OR uranium OR vermiculite OR zinc OR zirconium OR hydrocarbon OR oil OR petrol OR gas OR hydroelectric OR hydropower OR biofuel OR biofuels OR timber OR electricity OR electricities OR cement) OR ('extractive industry' OR 'extractive industries' OR 'mining development' OR 'mining industry' OR 'mining industries' OR 'resource curse' OR 'resource extraction' OR 'power plant' OR 'power plants'))	**2'131'194**
#2 Economic/ finance	TITLE-ABS-KEY ("economic impact analysis" OR 'economic evaluation*' OR 'economic assessment' OR 'financial evaluation*' OR 'financial assessment' OR 'cost-effectiveness analysis' OR 'cost minimization analysis*' OR ' cost-utility analysis' OR 'cost-benefit analysis')	**308'797**
#3 Impact assessments/ evaluation	TITLE-ABS-KEY ('economic impact assessment*'OR eia OR 'environmental impact' OR 'environmental impacts' OR 'environmental impact assessment' OR hia OR 'health impact' OR 'health impacts' OR 'health impact assessment' OR sia OR 'social impact' OR 'social impacts' OR 'social impact assessment' OR esia OR eshia OR 'integrated impact' OR 'integrated impacts' OR 'integrated impact assessment')	**262'290**
#1AND #2 AND #3	**NREPs AND Economic/finance AND Impact assessments**	**1'530**

Appendix II: Search terms and results in PubMed

Set	Search term and strategy	Hits (30.09.2020)
#1 NREPs	(exploration[tiab] OR exploitation[tiab] OR extractive[tiab] OR extraction[tiab] OR mine[tiab] OR mines[tiab] OR mining[tiab] OR industry[tiab] OR industries[tiab] OR factory[tiab] OR factories[tiab] OR plantation[tiab] OR production[tiab] OR dam[tiab] OR drilling[tiab]) AND (asbestos[tiab] OR carbon[tiab] OR coal[tiab] OR diamond[tiab] OR diamonds[tiab] OR fluorite[tiab] OR gas[tiab] OR 'natural gas'[tiab] OR metal[tiab] OR metals[tiab] OR salt[tiab] OR aluminum[tiab] OR alumina[tiab] OR bauxite[tiab] OR cobalt[tiab] OR copper[tiab] OR chrome[tiab] OR chromium[tiab] OR gold[tiab] OR iron[tiab] OR 'iron ore'[tiab] OR lead[tiab] OR manganese[tiab] OR nickel[tiab] OR phosphate[tiab] OR phosphor[tiab] OR palladium[tiab] OR platinum[tiab] OR potassium[tiab] OR silver[tiab] OR steel[tiab] OR sulphate[tiab] OR sulphur[tiab] OR tin[tiab] OR titanium[tiab] OR tungsten[tiab] OR uranium[tiab] OR vermiculite[tiab] OR zinc[tiab] OR zirconium[tiab] OR hydrocarbon[tiab] OR oil[tiab] OR petrol[tiab] OR gas [tiab] OR hydroelectric[tiab] OR hydropower[tiab] OR biofuel[tiab] OR biofuels[tiab] OR timber[tiab] OR electricity[tiab] OR electricities[tiab] OR cement[tiab] OR 'natural resources'[tiab]) OR ('extractive industry' [tiab] OR 'extractive industries'[tiab] OR 'mining development'[tiab] OR 'mining industry'[tiab] OR 'mining industries'[tiab] OR 'resource curse'[tiab] OR 'resource extraction'[tiab] OR 'Extraction and Processing Industry'[tiab])	**249'517**
#2 Economic/ finance	('economic impact analysis' [tiab] OR 'economic evaluation*' [tiab] OR 'economic assessment' [tiab] OR 'financial evaluation*'[tiab] OR 'financial assessment'[tiab] OR 'cost-effectiveness analysis'[tiab] OR 'cost minimization analysis*'[tiab] OR 'cost-utility analysis'[tiab] OR 'cost-benefit analysis'[tiab])	**25'473**
#3 Impact assessments/ evaluations	('economic impact assessment'[tiab] OR eia [tiab] OR 'environmental impact'[tiab] OR 'environmental impacts'[tiab] OR hia[tiab] OR 'health impact'[tiab] OR 'health impacts'[tiab] OR 'health impact assessment'[tiab] OR sia[tiab] OR 'social impact'[tiab] OR 'social impacts'[tiab] OR 'social impact assessment'[tiab] OR esia[tiab] OR eshia[tiab] OR 'integrated impact'[tiab] OR 'integrated impacts'[tiab])	**33'473**
#1AND #2 AND #3	**NREPs AND Economic/finance AND Impact assessments**	**49**

Appendix III: Articles excluded after the full text screening with exclusion reason

Final exclusion reasons
Title

No full text available
- Economic assessment of market and non-market damages of oil spills
- The environmental impact of auriferous mining excavation from the perspective of the cost-benefit analysis
  - Assessment of the socio-economic impacts of quarrying and processing of limestone at Obajana, Nigeria

Study not concerning NREPs
- Marginal cost pricing for coal fired electricity in coastal cities of China: The case of Mawan electricity plant in Shenzhen City, China
- Manufacturing variability drives significant environmental and economic impact: The case of carbon fiber reinforced polymer composites in the aerospace industry
- Net Social Impact of Illegal Unconventional Onshore Tin Mining in South Bangka, Bangka Island
- Economic, environmental, and job impacts of increased efficiency in existing coal-fired power plants
- Cost benefit analysis for solar water heating systems
- Avança Brasil: Environmental and social consequences of Brazil's planned infrastructure in Amazonia
- A decision-aid framework to provide guidance for the enhanced use of best available techniques in industry
- Environmental costs of mercury pollution
- Estimating human health impacts and costs due to Iranian fossil fuel power plant emissions through the impact pathway approach
- Optimal Ozone Control with Inclusion of Spatiotemporal Marginal Damages and Electricity Demand
- Analysis of the environmental impact of a biomass plant for the production of bioenergy
- Environmental and socioeconomic impacts of utilising waste for biochar in rural areas in Indonesia–a systems perspective
  - Applying cost analyses to drive policy that protects children: Mercury as a case study

Conference paper
- Conceptual design and economic evaluation on OTEC power plants in japan

Not focusing in public economic perspective or not a economic/financial study
- Economic and environmental impact evaluation of various biomass feedstock for bioethanol production and correlations to lignocellulosic composition
- Sustainability analysis of bioethanol promotion in Thailand using a cost-benefit approach
- Environmental and socio-economic assessment of cork waste gasification: Life cycle and cost analysis
- Assessment of the environmental impact and economic benefits of the adoption of cleaner production in a Brazilian metal finishing industry
- Natural gas as a transitional solution for railway powering systems: Environmental and economic assessment of a fuel cell based powering system
- Biodiesel production from Nannochloropsis gaditana using supercritical CO2 for lipid extraction and immobilised lipase transesterification: Economic and environmental impact assessments
- Economic and environmental evaluation of aluminium recycling based on a belgian case study
- Economic and environmental impact evaluation of various biomass feedstock for bioethanol production and correlations to lignocellulosic composition
- Realising the values of natural capital for inclusive, sustainable development: Informing China's new ecological development strategy
- Modeling the costs and benefits of dam construction from a multidisciplinary perspective
- Considerations of Project Scale and Sustainability of Modern Bioenergy Systems in Uganda
- Bioshale FP6 European project: Exploiting black shale ores using biotechnologies?
- Bioenergy project appraisal in sub-Saharan Africa: Sustainability barriers and opportunities in Zambia
- Brazil's Samuel Dam: Lessons for hydroelectric development policy and the environment in Amazonia
- Political benefits as barriers to assessment of environmental costs in Brazil's Amazonian development planning: The example of the Jatapu Dam in Roraima
- Demystifying the social impacts of biofuels at local levels: Where is the evidence?
- Review of risks to communities from shale energy development
- The benefits of a Brazilian agro-industrial symbiosis system and the strategies to make it happen
- Hydropower royalties: A comparative analysis of major producing countries (China, Brazil, Canada and the United States)
- Holistic environmental assessment and offshore oil field exploration and production
- Valuing the environmental impacts of electricity production: A critical review of some 'first-generation' studies
- An integrated assessment of energy conversion processes by means of thermodynamic, economic and environmental parameters

Theoretical study
- The cost of unconventional gas extraction: A hedonic analysis
- The economic, social and environmental impact of shale gas exploitation in Romania: A cost-benefit analysis
- A CBA model of a hydro project in Sri Lanka
- Public acceptance of surface mining projects and the determination of the marginal environmental cost
- Promoting biofuels use in Spain: A cost-benefit analysis
- The social cost of dredging: The Bahia Blanca Estuary case

Paper does not present a full economic evaluation/assessment, including a detailed methodology and original results
- Proximate analysis of Lakhra coal power plant and its health and environmental impact
- The determination of reclamation parameters and cost analysis in mining sites
- Mining in the Arctic environment – A review from ecological, socioeconomic and legal perspectives

Not written in English
- Benchmarking – Austrian Waste Management: Are the objectives of waste management achieved?
- The external cost of coal power chain in China
- Energy evaluation for ecological impacts of small hydropower in China

Appendix IV: main results of the included studies

Author, (year) Country, continent	NREP Name	Mean economic objectives	Mean data sources	Type of impact - Impact on what	Economic analysis - What is measured	Main economic results
Moran et al. 2017 America	Oil and gas	To measure land-use Estimate ecosystem services costs in eight oil and gas regions in the US from 2004 until 2015	Previously study and public land survey system	**Environmental** -Land-use by well -Ecosystem services *Social impact -Habitat change	**Cost analysis** -Ecosystem services cost calculations using a linear function with sensitivity analysis -Habitat comparison using satellite images with the situation of oil wells	- From 2004 to 2015, more than 200,000 hectares of land were developed or modified - By 2015, annual ecosystem services costs were estimated at US$ 272 million in 2015 and US$ 1.4 billion in total - By 2040, this cost will be between US$ 9.4 billion to US $ 31.9 billion.
Considine et al. 2016 Pennsylvania, America	Marcellus Shale of	Pennsylvania	To conduct a cost-benefit analysis of developing natural gas from the Marcellus shale formation in Pennsylvania	Existing data	**Environmental** -Environmental violations, air, land, and water	**Cost-benefit analysis** -Cost of environmental damage and air pollution -The benefit is a total of direct and indirect cost, including impacts
Marcellus shale is beneficial for public perspective: - Well economic benefits are about US$ 23 million fits -			Environmental damage costs about US$ 360,000 - Net benefits is between (US $13,896.6 – US $30,539.6)			
Fanaian et al. 2015 Mozambique, Africa	Zambezi river	To demonstrate the value of alternative flow regimes in a river	Published studies	**Ecological-economic** -River flow impact on public economy	**Benefit analysis** - Ecosystem goods e.g. Prawn and freshwater fisheries, tourism, hydropower, irrigated agriculture	- Ecosystem goods value for US$ 283 million of which 55% (or US$ 154 million) for hydropower -6 flow regime scenarios (pre-dam flows, Post-dam flows, December high flow, February medium high flow, January and February high flow, February high flow) were given respectively US$ 222, 285, 263, 294, 313 and 259 million for 2010
Tajziehchi et al. 2014 Ira, Asia	Alborz Dam in northern Iran	To examine whether the SIMPACTS software model output complies with the existing realities or not	SIMPACTS software modified by programming a new cost-benefit model	**Social** -Hydropower dam with all anthropogenic activities in the basin of the Alborz Dam	**Cost-benefit analysis** -Costs of power generation, irrigation and drainage, aquatics, drinking water -Benefits from electricity sales, elimination of pollutants, increased cultivated area, aquaculture practice, prevention of flood	Alborz Dam is beneficial for public perspective: -Total costs estimated to US$ 32,182,945 -Total revenues estimated to US$ 61,152,127 -The benefit over cost ratio of 1.90
Tajziehchi et al. 2013 Iran, Asia	Alborz Hydropower Plant	To calculate the real cost of generating electricity imposed on communities and environment	IMPACT software	**Social** -Population -Economic activities	**Cost analysis** - Resettlement cost, loss of land, agricultural and livestock production -Economic losses: increased disease incidents, air pollution	- Socioeconomic cost is US$ 4.8 million/year - Need to take into account benefits in the IMPACT software

(*Continued*)

(Continued).

Author, (year) Country, continent	**NREP Name**	**Mean economic objectives**	**Mean data sources**	**Type of impact** - Impact on what	**Economic analysis** - What is measured	**Main economic results**
Mirumachi and Torriti 2012 Laos, Asia	Theun 2 Hydropower Project	To examine the role of the Asian	Development Bank (ADB) in facilitating public involvement to gain public acceptance	Secondary data: (wCD, 2000), (MAFF, 1999))	**Environmental-social** -Environmental ecosystem costs -Human resettlement	**Cost-benefit analysis** - Indirect costs: resettlement, fisheries losses, watershed sedimentation -Benefit: power generation, agricultural irrigation, water supply, flood control
-Asian Development Bank was only partially involved in facilitating public participation -			Environmental and social impacts were treated as market values only -Discount rates were set discretionarily			
Alp and Yetis 2010 Turkeum, Asia	Yusufeli dam and	hydroelectric power plant	To estimate the cost of environmental damage caused by Yusufeli dam and hydroelcetric power plant	Population of 04 villages	**Environmental** -Local environmental damage due to dam	**Cost analysis** - Willingness to pay (WTP) value - No market value estimation with cost analysis
- WTP is US$ 761 per person						
Hjerpe and Kim 2007, America	Grand Canyon river	To determine the regional economic impacts, and to examine the attributes of these economic impacts in terms of regional multipliers, leakage, and types of jobs created.	The Grand Canyon region of northern Arizona	**Socioeconomic** -Recreation and tourism -Job creation	**Cost-benefit analysis** - Cost: regional commercial rafting expenditures - Benefit: regional expenditure of rafting	• Indirect and induced total expenditures: US$21,100,000 • Potential total postive impacts: US$23,415,000
Damigos and Kaliampakos (2006)Greece, Europe	Perama gold project	To assess the mining investment, namely "Perama gold project", for the extraction of a gold and silver	Mining firms	**Environmental-Social** - Social Net - Present Value (SNPV) and Social Internal Rate of Return	**Cost-benefit analysis** -Benefits: salaries, imported tariffs, taxes paid, benefits to the community -Cost: environmental impact by 03 scenarios (A = simultaneous approach, B = major accident, C = additive approach)	Total benefits (e.g: to communities 498,644€ during the construction period and 523,000€ per annum; employees 206,150€ per annum, training 300,000€, imported tariffs 249,332€) surpass the total costs for all the 3 scenarios Cost: 1,400,000–4,900,000€ per annum for the neighboring communities.

(*Continued*)

(Continued).

Author, (year) Country, continent	**NREP Name**	**Mean economic objectives**	**Mean data sources**	**Type of impact** - Impact on what	**Economic analysis** - What is measured	**Main economic results**
Damigos 2006 Colorado, America	Eagle Mine	To estimate the damages caused by the mine	Eagle County survey	**Environmental** -Contingent valuation - Hedonic property	**Cost-benefit analysis** -Fishing, hiking, camping, drinking water, passive use service flows, and the aesthetic quality of the river -Willingness to pay (WTP)	Cost: US$ 26,163 (linear model) to US$ 24,400 (semi-log model) WTP: median between US$ 4.16- US $16.01
	P. Viaropoulos quarry	To estimate the economic value that could potentially be derived from the reclamation of the quarry site	200 households interviews, Fuzzy Delphi Method	**Environmental-Social** - Quarry site rehabilitation - Apartment pricing	**Cost-benefit analysis** -Willingness to pay (WTP) by scenario (1: reforestation, 2: backfilling, 3: partial backfilling) -Apartment price	-WTP: 56% could pay, 820 apartments within -WTP by scenario: 3 = €58.20; 2 = €49.47; 1 = €30.75 –820 apartments would attract a premium of between €17,700,000 and €35,500,000 - Price by apartment €31,200
	Perama gold mine project	To estimate the cost of the	environmental impacts of the project	Databases EVRI (Environmental Valuation Reference Inventory_)	**Environmental** • Landscape, intrusion, biodiversity, water, air pollution, noise	**Cost-benefit analysis** - Cost: environmental impact by 03 scenarios (A = simultaneous approach, B = major accident, C = additive approach)
By scenario/ annum: -A: Neighbouring					area = €1,320,000 Broader	area = €9,000,000–13,000,000 -B: Neighbouring area = €1,400,000-€4,900,000 Broader area €9,000,000- €12,000,000 -C: Neighbouring area = €4,000,000 to 182,500,000; Broader area €9,000,000 and 13,000,000
Netalieva et al. 2005 Kazakhstan, Asia	Atyrauskaya and Akmolinska procinces oil industries	To estimate the health benefits that can result from reducing air pollution	–497 interviews -Levels of pollution (hydro-meteorological forecast service)	**Heath** - Excess case of disease - Working days and incomes losses	**Cost-benefit analysis** - Benefit: decrease in health costs from reduced air pollution - Cost: income losses due to respiratory diseases	Benefits: about US$ million 0.46 per year Cost: least US$ million 5.1 per year
Morimoto and Hope 2004 China, Asia	The	ThreeGorges project (TGP)	To bring the major economic, environmental and social impacts	-World Bank - TGP staff	**Environmental-Social- Economic** - Mean present value - Cumulative net present value	**Cost benefit analysis** - Benefit: economic grow, power generation, clean power - Cost: construction, lost archeological sites, resettlement
Mean present value Benefit: US $ billion 138 Cost: US $ billion 89.3						
Miranda and Hale 2001 Sweden, Europe	Sweden	To estimate production and	environmental costs for various forest residue, coal, oil and natural gas energy production systems	Center for Business and Policy Studies in Stockholm	**Full social cost analysis** - Production cost, producers pay - Environmental (air and water pollution)	**Cost analysis** - Production cost: forest residue, fossil fuel - Environmental cost: residue removal, forest residue combustion, ash disposal

(*Continued*)

(Continued).

Author, (year) Country, continent	NREP Name	Mean economic objectives	Mean data sources	Type of impact - Impact on what	Economic analysis - What is measured	Main economic results
Cost (SEK/ Mwhheat) - Production: 265–200 - Environment: 200 - Social: 172–587 - Full social cost: 285–587						