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Development of a Tool to Conduct a Semi-Quantitative Pre-screening Assessment of Environmental & Social Risks of Renewable Energy Projects/Portfolios

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A todas as mulheres da minha família...obrigada.

Resumo

A identificação precoce de riscos ambientais e sociais (A&S) assume um papel cada vez mais central no planeamento de projetos de energias renováveis (ER), sobretudo em contextos marcados pela multiplicidade de diferentes partes interessadas e por exigências rigorosas dos financiadores internacionais. A crescente complexidade dos projetos, associada à necessidade de garantir a conformidade com as normas internacionais e à procura de financiamento sustentável, tem reforçado a importância de mecanismos que permitam a triagem de riscos de forma sistemática, metodologicamente consistente e adaptada a diferentes tipologias de projetos e jurisdições.

Neste enquadramento, o presente trabalho teve como objetivo desenvolver e validar de forma preliminar uma ferramenta de apoio à decisão para a pré-avaliação de riscos A&S, a "E&S Risk Screening Tool", concebida para promover maior consistência, transparência e eficiência nas avaliações preliminares de risco em projetos e portefólios de ER. O desenvolvimento desta ferramenta surge como resposta a lacunas identificadas em abordagens existentes, nomeadamente a falta de padronização, a dificuldade de replicabilidade de resultados e a necessidade de alinhar práticas de avaliação com as atuais exigências de standards reconhecidos globalmente. A ferramenta foi desenvolvida com base em referências normativas semelhantes e amplamente reconhecidas a nível internacional, nomeadamente os *standards* da Corporação Financeira Internacional (IFC), do Banco Mundial (WB), do Banco Europeu para a Reconstrução e o Desenvolvimento (EBRD) e do Banco Interamericano de Desenvolvimento (IDB). Estes *standards* serviram de referência para a definição da estrutura da ferramenta e conferindo-lhe robustez metodológica e aplicabilidade prática em diversos contextos tecnológicos e geográficos. A metodologia adotada para o seu desenvolvimento envolveu várias fases: análise dos principais *standards* internacionais em matéria de riscos A&S; selecção de um método de avaliação de risco semi-quantitativo; construção de uma estrutura hierárquica de indicadores de risco organizada por fatores e subfatores; recolha de juízos de peritos para atribuição de pesos através do método Processo Analítico Hierárquico (AHP), um método de Análise Multicritério de Decisão (MCDA); e, por fim, o desenvolvimento da ferramenta num formato acessível em Microsoft Excel, com funcionalidades gráficas e automatizadas de apoio à análise e comparação entre projetos. Este processo metodológico permitiu não apenas assegurar a robustez teórica da ferramenta, mas também garantir a sua usabilidade por diferentes perfis de utilizadores, desde analistas técnicos a decisores estratégicos.

A ferramenta foi aplicada a um estudo de caso constituído por dois projetos eólicos em fase de construção, selecionados para testar também a sua funcionalidade de comparação de perfis de risco. Ambos os projetos estão localizados em Espanha e foram avaliados por duas profissionais com experiência consolidada na área de licenciamento e conformidade ambiental e social de projetos de ER. Salienta-se ainda que estes projetos foram anteriormente submetidos a processo de *Environmental and Social Due Diligence* (ESDD), conduzidos pelas mesmas avaliadoras sem o apoio da ferramenta desenvolvida. Esta condição permitiu realizar uma comparação retrospetiva entre os resultados obtidos nas avaliações tradicionais e os produzidos com o suporte da ferramenta, possibilitando testar a sua coerência analítica, aplicabilidade prática e valor acrescentado. A aplicação-piloto demonstrou que a ferramenta contribui para a estruturação da apreciação crítica profissional, promove a comparabilidade entre projetos e oferece uma plataforma visual e sistemática que facilita a identificação preliminar de riscos prioritários, mesmo em contextos com constrangimentos de tempo ou informação limitada. Esta análise reforça o potencial da ferramenta como um instrumento de triagem eficaz, com utilidade concreta em processos de planeamento estratégico, seleção de projetos e no apoio de decisões de priorização para desenvolvimento subsequente ou submissão a processos de financiamento junto de instituições internacionais.

Do ponto de vista quantitativo, os resultados demonstraram que a ferramenta é eficaz na identificação estruturada dos fatores e subfatores de risco mais críticos, permitindo destacar riscos que potencialmente poderão ser negligenciados em avaliações sem a utilização da ferramenta, especialmente relacionados com género, inclusão social e fatores institucionais. A identificação destes riscos representa um contributo na abordagem de seleção, ao alinhar-se com tendências internacionais que privilegiam a inclusão, a equidade e a governação ambiental e social. Ambos os projetos obtiveram perfis de risco semelhantes, e os fatores Sócio-Políticos e de Sistemas de Gestão Ambiental e Social destacaram-se como os mais relevantes. Apesar das diferenças na atribuição de níveis de risco e consequentes pontuações obtidas por cada avaliadora, reflexo natural de interpretações subjectivas no domínio qualitativo, observou-se uma convergência considerável na identificação dos domínios de risco prioritários. Estes resultados indicam que a ferramenta é capaz de estruturar a apreciação profissional sem a substituir, promovendo comparações consistentes entre projetos. Do ponto de vista qualitativo, as opiniões recolhidas através de um formulário estruturado com 17 questões permitiram avaliar dimensões como a clareza metodológica, facilidade de utilização, utilidade prática e limitações observadas durante a aplicação real. Ambas as avaliadoras consideraram a ferramenta clara, intuitiva e útil para efeitos de triagem de projetos. Destacaram, ainda, a utilidade dos gráficos automáticos para comunicação de resultados e a sua aplicabilidade em contextos de avaliação sob pressão temporal, nomeadamente quando não é possível realizar análises aprofundadas numa fase inicial. Não obstante, foram também referidas limitações e áreas de melhoria. Uma das limitações mencionadas refere-se à dificuldade de aplicação da ferramenta em projetos com limitação de documentação, característica comum em fases muito preliminares de desenvolvimento. Embora seja uma dificuldade inevitável e presente em qualquer tipo de cenário, i.e., na utilização ou não da ferramenta, sugere-se o fortalecimento das orientações metodológicas, de forma a clarificar os procedimentos para a aplicação dos fatores e subfatores de risco em contextos caracterizados pela limitação ou ausência de informação dos projetos. Outra crítica centrou-se na ambiguidade associada à classificação "Não Aplicável", sendo recomendado o desenvolvimento de orientações padronizadas para garantir coerência na sua aplicação. Foi igualmente sugerida a possibilidade de modular a ferramenta para permitir selecção de *standards* específicos (por exemplo, Princípios do Equador - EPs, *Green Loan Principles* - GLPs), conforme os requisitos de cada financiador. Estas recomendações revelam que, embora funcional, a ferramenta pode beneficiar de maior flexibilidade configuracional e de um guia metodológico mais detalhado, o que reforçaria a sua adaptabilidade a diferentes contextos de aplicação. Importa também referir que os pesos atribuídos aos fatores de risco foram obtidos com base nos juízos de um painel de especialistas e agregados por média geométrica, permitindo mitigar o impacto de avaliações extremas. No entanto, a composição desse painel (perfil, experiência, setor de atuação) influenciou inevitavelmente os pesos finais, o que sugere que estes devem ser revistos periodicamente à medida que novos contextos, tecnologias e jurisdições surjam. Este processo de revisão contínua é essencial para assegurar que a ferramenta permanece atualizada, relevante e sensível a alterações no panorama regulatório e no perfil dos riscos emergentes. No conjunto, os resultados da aplicação-piloto confirmam que a ferramenta responde positivamente à pergunta de investigação central: "É possível desenvolver uma ferramenta de triagem que permita uma avaliação prática, consistente e metodologicamente sólida dos riscos ambientais e sociais, aplicável a projetos ou portefólios no setor das energias renováveis?". Com base na evidência empírica, conclui-se que sim, desde que seja aplicada com discernimento e complementada por outras formas de análise mais detalhadas, sempre que necessário.

Em síntese, a E&S Risk Screening Tool representa um contributo prático e metodológico para a avaliação preliminar de riscos ambientais e sociais de projetos de energias renováveis. Ao permitir comparações estruturadas entre projetos, identificar riscos subvalorizados, facilitar a tomada de decisão e alinhar-se com normas internacionais de referência, a ferramenta acrescenta valor real aos processos

de planeamento e financiamento sustentável. Ainda que não substitua estudos de d*ue diligence* aprofundados, constitui um instrumento complementar relevante, que ajuda a estruturar e alinhar recursos, antecipar desafios e promover decisões mais estratégicas.

Palavras-chave: Priorização de riscos, normas internacionais ambientais e sociais, análise multicritério, processo analítico hierárquico (AHP), tomada de decisão.

Abstract

The early identification of environmental and social (E&S) risks is increasingly critical in renewable energy (RE) project planning, particularly in complex stakeholder and financing contexts. This research develops and validates a semi-quantitative decision-support tool, the E&S Risk Screening Tool, designed to improve consistency, transparency, and efficiency in preliminary E&S risk assessments for RE projects or portfolios. Grounded in internationally recognised standards (IFC, WB, EBRD, IDB), the tool integrates a weighted scoring system based on expert judgment and structured through the Analytic Hierarchy Process (AHP), a Multi-criteria Decision Analysis (MCDA) method. Its aim is to support early-stage screening by helping developers, consultants, and financial institutions to identify and compare project risks, and prioritise where deeper analysis is most needed. The methodology involved analysing key international benchmarks, selecting a risk evaluation method, designing a hierarchical structure of E&S indicators, eliciting expert input to weight subfactors, and building a user-friendly Excel-based tool. The tool was applied to a case study comprising two wind farm projects under construction, which was also designed to assess its functionality in comparing risk profiles between and up to three projects. Each project was assessed by two experienced E&S professionals and showed that the tool enables structured and consistent assessments, supports early-stage decision-making, and allows for risk comparisons across portfolios. It balances standardisation with expert discretion, highlighting often under-assessed social risks, such as gender and inclusion-related issues. While limitations were observed, including the need for clearer guidance on subfactor applicability and sensitivity to documentation gaps in early project stages, the tool's usability, the comparison between projects, and alignment with international standards reinforce its role as a practical complement to more detailed due diligence. It is not intended to replace in-depth studies but to flag areas requiring further attention, as well as offering decision-makers enhanced strategic visibility in identifying the project with comparatively lower E&S risk exposure, thereby supporting prioritisation for further development or submission to international financial institutions during early-stage financing processes.

Key-words: Risk Prioritization, international environmental and social standards, multi-criteria analysis, analytic hierarchy process (AHP), decision-making.

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List of Abbreviations

AHP	Analytic Hierarchy Process
CBA	Cost-Benefit Analysis
CEA	Cost Effectiveness Analysis
CH_4	Methane
CO_2	Carbon Dioxide
COP28	28th Conference of the Parties
EIA	Environmental Impact Assessment
EBRD	European Bank for Reconstruction and Development
E&S	Environmental and Social
EPs	Equator Principles
ESDD	Environmental and Social Due Diligence
ESF	Environmental and Social Framework
ESFs	Environmental and Social Frameworks
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMF	Environmental and Social Management Framework
ESMS	Environmental and Social Management System
ESPS	Environmental and Social Policy Standards (IDB)
ESSs	Environmental and Social Standards
ELECTRE	*ELimination Et Choix Traduisant la REalite*
FIs	Financial Instituitions
GHGs	Greenhouse Gases
GLPs	Green Loan Principles
H_2O	Water Vapour
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IFIs	International Finance Institutions
IRENA	International Renewable Energy Agency
LCA	Life Cycle Assessment
MAUT	Multi-Attribute Utility Theory
MAVT	Multi-Attribute Value Theory
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision Making
MDB	Multilateral Development Banks
MRE	Marine Renewable Energy
NO_x	Nitrogen Oxides
N_2O	Nitrous Oxide
O_3	Ozone
PM	Project Manager
PRs	Performance Requirements (EBRD)
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluations

PS	Performance Standards (IFC)
PV	Photovoltaic
RE	Renewable Energy
REP	Renewable Energy Production
RES	Renewable Energy Sources
SD	Sustainable Development
SEPs	Stakeholder Engagement Plans
SO_2	Sulphur Dioxide
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
UNEP	United Nations Environment Programme
USD	United States Dollar

1. Introduction

As the global shift toward renewable energy (RE) intensifies and consequently the projects complexity increases, the early identification, assessment, and mitigation of environmental and social (E&S) risks in infrastructure projects had become a critical element for ensuring sustainable development. Global environmental problems have placed increasing pressure on firms to be green, as they are viewed as key causes of environmental dilemmas (Walker & Wan, 2012). Therefore, in order to ensure sustainable development, the International Financial Institutions (IFIs) as World Bank (WB), International Finance Corporation (IFC) , European Bank for Reconstruction and Development (EBRD) and Inter-American Development Bank (IDB), have developed a set of original environmental and social safeguard policies documents that establish operational standards that aim to safeguard people and the environment while ensuring the long-term viability of financed projects (Sohn, 2018). RE projects are no exception; those financed by international institutions or private capital, in particular, must comply with increasingly stringent E&S requirements. These are shaped by evolving legal frameworks, financial standards, and stakeholder expectations. However, addressing these challenges requires a more harmonised and practical approach to environmental and social compliance, one that enables early-stage risk identification, aligns with the expectations of multiple financial institutions, and supports project viability from the outset. In this context, it becomes essential to develop approaches and tools capable of supporting consistent and effective E&S risk screening across diverse geographies, technologies, national legislations, and project stages.

To establish a foundation for such tools, it is necessary to explore how international environmental and social standards inform project planning and decision-making. These frameworks introduce complex but crucial benchmarks that guide investors, developers, and consultants in structuring responsible and bankable projects. The convergence and divergence among these standards create both opportunities and challenges for early-stage E&S assessments, especially in the context of limited information and evolving project scopes. Traditional assessment approaches like Environmental and Social Due Diligence (ESDD) process enables lenders to examine in detail the environmental and social documentation provided by the customer in order to evaluate whether the project aligns with institutional standards and legal requirements (Sohn, 2018). Nevertheless, ESDDs, tend to be comprehensive and resource-intensive, which can limit their practicality during initial screening phases. As such, there is a growing interest in lighter, semi-quantitative instruments that support informed prioritisation without requiring full due diligence inputs.

Hence, this thesis addresses the potential of Multi-Criteria Decision Analysis (MCDA) methods, specifically the Analytic Hierarchy Process (AHP), to structure risk assessments in a semi-quantitative, systematic, and streamlined way. The use of expert judgment, structured weighting, and standardised scoring systems allows the integration of both qualitative and quantitative dimensions of risk. By applying AHP principles, it becomes possible to aggregate diverse expert inputs while reducing subjectivity in risk ranking and comparison. Finally, this research presents the development and pilot application of an Excel-based "E&S Risk Screening Tool" designed to support preliminary assessments in RE projects. The tool was tested through a pilot case study and expert feedback.

1.1 Environmental & Social Risk Assessment

What is risk and what is a risk assessment? These terms are in common usage, but with a number of different meanings to people (Kerns & Ager, 2007). Risk refers to the "exposure to the chance of loss" and typically involves likelihood estimates and probable outcomes In a more contemporary definition, The Society for Risk Analysis (2018) defines risk as "the potential for realization of unwanted, negative consequences of an event". Although outcomes are traditionally defined as adverse consequences such as property loss, harm, or injury, risk analysis can also include positive effects and net outcomes across both time and space (Kerns & Ager, 2007).

Following Rowe (1988), risk assessment is the process of estimating probabilities of adverse events over given time frames. This assessment is the major bridge linking science to policy (Ronald & Vandegehuchte, 2006), translating it into a powerful framework for taking informed decisions (Keith, 2015). Risk assessments are conducted when outcomes cannot be predicted, but possible outcomes can be described and likelihoods estimated (Kerns & Ager, 2007). By quantifying the probability of an undesirable event or impact, risk assessment is very useful to establish mitigation measures aiming at preventing or hinder those impacts (Holsman et al., 2017). Risk can be estimated, but uncertainty still exists across many components of the risk assessment such as sampling, model parameters, human values, etc. (Kerns & Ager, 2007). Therefore, the identification of possible sources of risk is an essential stage in the risk management process because it allows project parties to discern specific instances of uncertainty; thereby, the potential impact of these uncertainties can be analysed and appropriate strategies for anticipating and mitigating their effects can be developed (Zayed et al., 2008). Furthermore, structured and detailed risk identification provides a basis for later stages ensuring risk management effectiveness (Banaitiene & Banaitis, 2012).

The global financial community is increasingly becoming aware that E&S issues associated with customers' business activities can create risks to financial institutions themselves (EBRD, 2014). E&S risks are the potential negative consequences to a business that result from its impacts (or perceived impacts) on the natural environment (i.e., air, water, soil) or communities of people (e.g. employees, customers, local residents) (EBRD, 2014). Environmental issues may present themselves as temporary or permanent changes to the atmosphere, water, and land due to human activities, which can result in impacts that may be either reversible or irreversible, as well as, social issues that may emerge in the workplace and may also impact surrounding communities (RBLBANK, 2023). Figure 1.1 illustrates the main types of risks that may arise due to project developers' business operations. The intensity and degree of risks will vary as per the type of industry, scale and location, manufacturing processes adopted, etc. (RBLBANK, 2023).

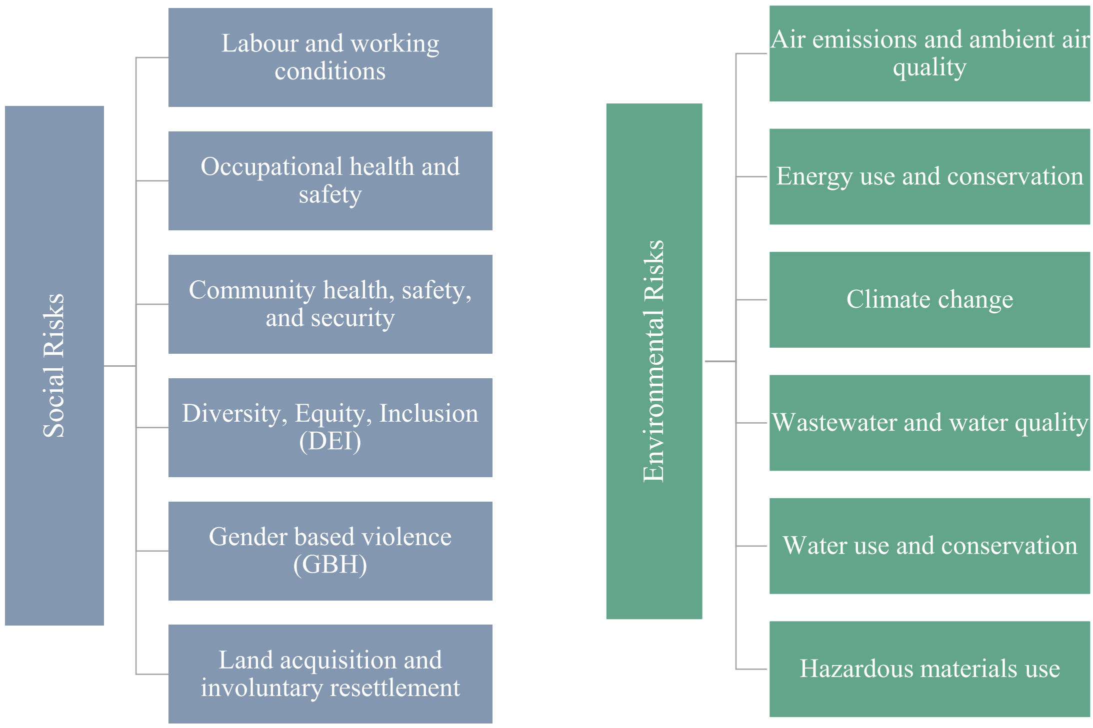


Figure 1.1: Examples of Environmental and Social risks. Adapted from RBLBANK, (2023).

The E&S risk assessment is the primary means of ensuring projects are environmentally and socially sound and sustainable and will be used to inform decision making (The World Bank, 2017). Such importance placed on environmental and social dimensions is a result of increasing global activities and corresponding evolving centres of power, which not only control production but also influence ways of life and consumer preferences (Beske et al., 2008). The environmental and social assessment is a flexible process, that can use different tools and methods depending on the details of the project and the circumstances of the borrower (The World Bank, 2017). These tools include documentation reviews; information-gathering techniques (brainstorming, the Delphi technique, interviewing, root cause analysis, questionnaires, and risk workshops); checklist analysis; assumption analysis; diagramming techniques (cause-and-effect diagrams, system or process flow charts, and influence diagrams); strengths, weaknesses, opportunities, and threats, (SWOT) analysis; expert judgment; fault tree analysis; decision tree analysis; and failure mode and effect analysis (Grimaldi et al., 2012; Marle & Gidel, 2014; PMI, 2013; Siraj & Fayek, 2019). The breadth, depth, and type of analysis undertaken as part of the E&S assessment will depend on the nature and scale of the project, and the potential environmental and social risks and impacts that could result (The World Bank, 2017).

In the past two decades, E&S risk became a serious threat for FIs (Financial Institutions) (Nolet et al., 2014). It is therefore important to identify and assess any environmental and social risks at the planning stage of the project cycle so that management of these risks can be made an integral part of project design and implementation (UNCTAD & World Bank, 2018). Those that are not systematically assessed may incorrectly be assumed irrelevant (Nolet et al., 2014). The borrower will undertake the environmental and social assessment at the scale and level of detail appropriate to the potential risks and impacts (The World Bank, 2017) considering that the analysis should identify those sectors and clients that have significant E&S risks and impacts and review current procedures to manage these risks (Nolet et al., 2014). Based on the analysis and review, a gap analysis will define the type of procedures, policies, and documents that will need to be developed or updated to ensure that the Environmental and Social Management System (ESMS) will meet recommended standards (Nolet et al., 2014). Failure to effectively manage E&S issues in a business may lead to a range of financial, legal and reputational consequences for the company (EBRD, 2014). As a result, E&S management has steadily gained a place in the risk management best practices of the financial sector (Nolet et al., 2014). By identifying and managing the E&S risks related to clients and their business activities, FIs can improve their risk profile portfolios (IFC, 2007). The negative E&S risks affect the enterprise, but also the bank that financed the project whose implications may have financial or legal consequences and/or reflect poorly on the FI's reputation (Nolet et al., 2014). Recognising this, development banks and international finance institutions (IFIs), encouraged by government shareholders, have instated frameworks to minimise and manage environmental and social risks associated with development projects (Morgado & Taşkın, 2019).

1.2 Role of Financial Institutions in Shaping E&S Standards

Global development banks and other FIs, also known as Multilateral Development Banks (MDB), have been imposing environmental and social (E&S) requirements on borrowers in project finance matters since the 1990s (Polk, 2017). Project Finance is a recent technique applied in large investments projects and it is defined by Finnerty (2013) as "the raising of funds on a limited-recourse or nonrecourse basis to finance an economically separable capital investment project in which the providers of the funds look primarily to the cash flow from the project as the source of funds to service their loans and provide the return of and a return on their equity invested in the project" . During the last decades of the 20th century Project Finance has enabled to provide financial solutions for large infrastructure, energy and environmental projects (Bernabeu et al., 2014). Thus, IFIs have adopted environmental and social safeguards systems to minimise and manage the environmental and social risks associated with their projects (Morgado & Taşkın, 2019). Cultural considerations, reputation, stakeholder pressure and, in the case of development banks, a desire to protect and support the communities and natural resources in their relevant geographic areas, all drive these requirements, but the ultimate goal is sustainable development (Polk, 2017). The development of environmental standards at financial institutions is arguably among the most important international environmental law developments in the past two decades (Hunter, 2008).

Standardization can be associated with the generic term "unification", allowing a reduction of complexity (Köhl et al., 2000; Manrodt & Vitasek, 2004). The E&S standards set out the requirements for borrowers relating to the identification and assessment of environmental and social risks and impacts associated with projects supported by the bank through Investment Project Financing (The World Bank, 2017) and take measures to avoid, mitigate or minimise such impacts (Soni, 2021). They are considered by many to be "best practice" in environmental and social management, most directly for the private sector, though they now are referenced by public sector agencies as well (e.g., European Development Finance Institutions) (IFC, 2012b). The reasons for banks and project companies to apply these E&S standards can be identified in Table 1.1 (Mertens et al., 2023).

Table 1.1: Reasons for banks and project companies to apply E&S standards (Mertens, et al., 2023).

Banks	**Project Companies**
Sustainability reasons	Sustainability reasons
Reputation of banks (partially disproved)	Politically driven
Politically driven (e.g. EU taxonomy)	Tools for risk management
Risk Management for Project: minimize impact	Definition of boundary conditions
Global trend (peer pressure, because almost all banks are committed to sustainability)	Frameworks are well established

Legal certainty (already established including jurisprudence)	Competitive advantage if national standards are not sufficient
Marketing argument for banks	Best cost-benefit ratio

The implementation of E&S standards can cause several consequences and effects for the banks, project companies, but also the project itself (Mertens, et al., 2023). The bank believes that the application of these standards, by focusing on the identification and management of environmental and social risks, will support borrowers in their goal to reduce poverty and increase prosperity in a sustainable manner for the benefit of the environment and their citizens (The World Bank, 2017). Concerning a bank's strategy, frameworks have the potential to shift a bank's intention away from a purely financial perspective towards a more socioenvironmental orientation, for example, entire projects with a certain amount of fossil resources have been restructured with a reduced share of carbon (Mertens et al., 2023). The World Bank (2017) believes that the standards will (a) support borrowers in achieving good international practice relating to environmental and social sustainability; (b) assist borrowers in fulfilling their national and international environmental and social obligations; (c) enhance non-discrimination, transparency, participation, accountability and governance; and (d) enhance the sustainable development outcomes of projects through ongoing stakeholder engagement. Overall, these standards are also boosting environmental protection, good environmental governance, corporate social responsibility, social responsibility of host governments and generating Sustainable Development (SD)-oriented partnerships, such as Private Sector Partnerships and Public-Private Sector Partnerships, which contribute to betterment of the welfare of citizens, generic human wellbeing and environmentally-sound and socio-economically equitable growth, prosperity and SD in developing countries (Bristol-Alagbariya, 2020). Mertens, et al., (2023) identified general effects and advantages of the application of E&S standards presented in Table 1.2:

Table 1.2: Effects of the application of E&S standards (Mertens, et al., 2023).

General Effects	Change in bank strategy (exclusion of non-sustainable projects; move away from purely financial benefits).
	Change of behaviour towards bank customers (customer must follow bank's path) Rethink consequences + develop alternatives Serve as guidelines/ instructions for concrete actions.
	Risk management.
	Create a common understanding between different professional groups.
	Change of organizational structure/ creating new positions.
	Partially change project requirements (e.g. higher environmental standards of wastewater treatment plants required by standards; if necessary, full documentation review).
Advantages	Avoidance of wrong decisions.
	Mitigate negative E&S consequences: loss of reputation (reason for introduction, as well as effect of standards).
	Protect loss of value of the project (if e.g. environmentally harmful technology is used).
	Better comparability of offers.

1.2.1 Key International Finance Institutions and their Environmental and Social Standards

Economic growth in developing countries has gone hand in hand with extensive degradation of natural resources and other environmental impacts, which in turn affect livelihoods as well as the health and well-being of people everywhere (Morgado, & Taşkın, 2019). The IFIs have been supporting infrastructure and development projects in developing countries by investing billions of dollars per year in such projects as loans or grants, one of the biggest financers of infrastructure projects around the world (Soni, 2021). Development banks and IFIs serve as important channels for development co-operation and green investment (Morgado, & Taşkın, 2019). Green finance encompasses the financial instruments that provide funds to support firms or projects that address climate change and environmental benefits (Dogan et al., 2022). Green finance has an impact on environmental outcomes through its effects on capital support, resource allocation, and technological innovation (He et al., 2018).Therefore, banks as lenders, have begun to assess those risks associated with exposure to their loans by adopting these risk management frameworks such as the Equator Principles or the IFC Performance Standards (Mertens, et al., 2023).

Traditionally, only financial aspects of projects have been considered like capital requirement of projects, returns of such investment, the risk involved to investments etc., and even today continue to be primary considerations of investment decisions, which no doubt is rational (Soni, 2021). But it is also essential to consider the impact of infrastructure projects on both the environment and society, as these projects often have wide-reaching and long-term consequences - not only for direct beneficiaries but also for other affected stakeholders. Given their substantial financial resources, IFIs bear a heightened responsibility in promoting economic, social, and environmental well-being at a broader, macro level. Hence, all the IFIs have come up with guidelines or frameworks which serve as for investing in infrastructure projects by these institutions, including IFIs such as the WBG, which includes the IFC, among others, as well as other institutions like the EBRD and the IDB. These frameworks include best practices to ensure better management of E&S risks of the projects and improve development outcomes in line with Sustainable Development Goals (SDG) (World Bank, 2017). As infrastructure has a long lifespan, failing to invest in sustainable and resilient infrastructure will not only cause damage to the environment and society but may also cause financial instability and harm growth prospects (OECD, 2019). In order to contextualise the development and application of Environmental and Social Frameworks (ESFs), it is pertinent to briefly examine the background, mandate, and regional scope of the main IFIs responsible for their establishment and implementation:

WBG is the most influential organization, which includes a group of multiple organisations: IFC, WB, IBRD and IDA. They were set up between 1944 and 1960, and work on developmental projects by providing financial assistance and technical assistance to countries to end poverty and help create sustainable economic development. In 2016 the WB adopted a new ESF that aims to protect people and the environment from potential adverse project impacts while promoting **SD** (Independent Evaluation Group, 2025). It consists of a Vision for Sustainable Development: 10 Environmental and Social Standards (ESSs), which set out the requirements that apply to borrowers projects meet through the project life cycle, with the aim of ending extreme poverty and promoting shared prosperity (WBG & IBRD, 2017). The ESSs are as follows:

- ESS1: Assessment and Management of Environmental and Social Risks and Impacts;
- ESS2: Labor and Working Conditions;
- ESS3: Resource Efficiency and Pollution Prevention and Management;

- ESS4: Community Health and Safety;
- ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement;
- ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- ESS7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities;
- ESS8: Cultural Heritage;
- ESS9: Financial Intermediaries;
- ESS10: Stakeholder Engagement and Information Disclosure.

The topics of the referred 10 ESSs are generally balanced between environmental and social aspects with a higher focus on the social side (Sohn, 2018). The ESS1 applies to all projects for which Bank Investment Project Financing is sought. ESS1 establishes the importance of: (a) assessing the adequacy of the borrower's existing environmental and social framework to effectively manage the project's risks and impacts; (b) an integrated environmental and social assessment to identify the risks and impacts of a project; (c) effective community engagement through disclosure of project-related information, consultation and effective feedback; and (d) management of environmental and social risks and impacts by the borrower throughout the project life cycle (WBG & IBRD, 2017). The bank requires that all E&S risks and impacts of the project be addressed as part of the environmental and social assessment conducted in accordance with ESS1. Three of these ESSs (ESS1, ESS9, ESS10) deal with environmental and social aspects, and five of these ESSs (ESS2, ESS4, ESS5, ESS7, and ESS8) are more centered on social-related topics, whereas only two of these ESSs (ESS3 and ESS6) focus mainly on environment-related aspects (Sohn, 2018). These standards establish objectives and requirements to avoid, minimize, reduce and mitigate risks and impacts, and where significant residual impacts remain, to compensate for or offset such impacts (WBG & IBRD, 2017).

IFC was founded in 1956 as a member of the WBG to stimulate economic growth in developing countries through the direct financing of private sector investments (Bristol-Alagbariya, 2020). IFC also mobilizes capital in international financial markets and provides technical assistance and advice to governments and businesses. The corporation's performance standards (PS) on E&S are directed towards its clients, to provide guidance on how they can identify risks and other adverse impacts. These standards are designed to commit the corporation's clients to embark on information disclosure and engagement of their stakeholders, as well as to help them avoid, mitigate and manage risks and other negative impacts of the projects associated with them (Bristol-Alagbariya, 2020). They are as follows:

- PS1: Assessment and Management of Environmental and Social Risks and Impacts;
- PS2: Labor and Working Conditions;
- PS3: Resource Efficiency and Pollution Prevention;
- PS4: Community Health, Safety, and Security;
- PS5: Land Acquisition and Involuntary Resettlement;
- PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- PS7: Indigenous Peoples;
- PS8: Cultural Heritage.

As stated in the framework published by IFC (2012), PS1 establishes the importance of (i) integrated assessment to identify the E&S impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and (iii) the client's management of E&S performance throughout the life of the project. PS2 through PS8 establish objectives and requirements to avoid, minimize, and where residual impacts remain, to compensate/offset for risks and impacts to workers, affected communities, and the environment. While all relevant E&S risks and potential impacts should be considered as part of the assessment, PS2 through PS8 describe potential E&S risks and impacts that require particular attention. Where E&S risks and impacts are identified, the client is required to manage them through its ESMS consistent with PS1.

Today, the PSs of the IFC are considered the guiding framework for robust E&S standards (Lauer et al., 2024). These PSs now have the status as the 'International Standards' and its guidance documents as 'International Best Practice' (Bristol-Alagbariya, 2020). In a variety of cases, companies' projects may also be subject to stakeholder pressure to conform to IFC standards even if no IFC financing is involved (Wagner & Armstrong, 2010). Given that these are international regulatory standards, they are soft law instruments or mechanisms, implemented in the domestic jurisdictions of developing countries in the course of project financing and corporate financing associated with the IFC (Bristol-Alagbariya, 2020).

IDB was set up in 1959 and works in the Latin America and the Caribbean (LAC) to improve health, education and other infrastructure to reduce poverty and inequality using loans, grants or technical assistance (Citaristi, 2022). In September 2020 the Board of Executive Directors of the IDB approved a new Environmental and Social Policy Framework (ESPF), which became effective on the 1st of November 2021. The new Framework was developed to respond to the changing environmental and social context of the LAC region since the development of the IDB's existing safeguards policies more than 15 years ago (Gibbons et al., 2022). The ESPSs are as follows:

- ESPS1: Assessment and Management of Environmental and Social Risks and Impacts;
- ESPS2: Labour and Working Conditions;
- ESPS3: Resource Efficiency and Pollution Prevention;
- ESPS4: Community Health, Safety and Security;
- ESPS5. Land Acquisition and Involuntary Resettlement;
- ESPS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- ESPS7: Indigenous Peoples;
- ESPS8: Cultural Heritage;
- ESPS9: Gender Equality;
- ESPS10: Stakeholder Engagement and Information Disclosure.

The IDB appears to also adopt WB standards, incorporating much of their wording into its strategies (IDB, 2020). Regarding participation, the focus is on acknowledging rights, and social safeguards, as well as ensuring participation in project benefits when possible (Busck-Lumholt et al., 2025). However, the IDB is the first MDB with a stand-alone standard on gender equality that explicitly includes protections for people of diverse sexual orientations and gender identities (IDB, 2020).

EBRD was established in 1991 to invest in projects, businesses and policy reform when communism was collapsing in central and eastern Europe and ex-Soviet countries needed support to nurture a new private sector in a democratic environment (EBRD, 2019). EBRD has adopted a comprehensive set of specific Performance Requirements (PRs) for key areas of environmental and social sustainability that projects are required to meet. Central to the PRs is the application of the mitigation hierarchy and good international practice. They are as follows:

- PR1: Assessment and Management of Environmental and Social Risks and Impacts;
- PR 2: Labour and Working Conditions;
- PR 3: Resource Efficiency and Pollution Prevention;
- PR 4: Health, Safety and Security;
- PR 5: Land Acquisition, restrictions on land use and involuntary resettlement;
- PR 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- PR 7: Indigenous Peoples;
- PR 8: Cultural Heritage;
- PR 9: Financial Intermediaries;
- PR 10: Stakeholder engagement.

The titles and the objectives of the 10 PRs are highly similar to the WB ESF (Sohn, 2018). PRs 1 to PRs 8 and PR 10 include the requirements for direct investment projects, where PR10 serves also to identify people or communities that are or could be affected by the project, as well as other interested parties. Regarding environmental risk management, in particular, the most relevant PRs are PR 1 and PR 3. PR5 addresses land acquisition and is generally similar to the IFCs PS 5. PR6 requires identification of critical habitat that might be affected by a project as well as identification of potential impacts on it and appropriate application of the mitigation hierarchy. PR 2, PR 9 and the occupational safety and health requirements of PR 4 include the requirements for IFIs projects (EBRD, 2019). Each PR includes specific requirements for EBRD clients in respect of projects financed by EBRD regardless of whether it is carried out directly by the client or through third parties. Compliance with relevant national law is an integral part of all PRs.

Despite the diversity in organizational structure, purpose, membership, and interactions with national governments, these agencies share a common role as supervising partners within a project management framework for local implementing organizations and beneficiaries (Busck-Lumholt et al., 2025). In the few years since their adoption, the IFC PSs have become a global benchmark for managing E&S risk by financial institutions. Some regional development banks explicitly reference the IFC standards, while others have analogous standards. For example, the environmental and social policy of the EBRD contains standards that closely parallel the IFC Performance Standards. The IDB has a variety of policies on environment and human rights topics (Wagner & Armstrong, 2010).Today, these standards and the resettlement policies of the various other multilateral development banks have converged, and now have similarities in their scope, architecture, principles, thematic coverage and formulation (Table 1.3) (Esteves et al., 2024). In addition, adopting IFC PS has been mostly becoming compulsory nowadays when dealing with financial institutions to support a project financing to be considered as green financing

Table 1.3: Comparative summary overview of E&S Standards across the selected FIs. Adapted from Polk, (2017) and Getzel & Humphrey (2024).

Category	**Requirement/Standard**	**EBRD**	**IDB**	**IFC**	**WB**
General information	Date Standards first established	1991	2006	1998	1990s
	Effective date of current standard	2019	2021	2012	2016
Environmental	Assessment of Environmental and Social Risks	✓	✓	✓	✓

	Biodiversity and Natural Habitats	✓	✓	✓	✓
	Community Health	✓	✓	✓	✓
	Cultural Heritage	✓	✓	✓	✓
	Stakeholder engagement and information disclosure	✓	✓	✓	✓
	Gender equality	x	✓	x	x
	Indigenous People	✓	✓	✓	✓
	Labour and Working Conditions	✓	✓	✓	✓
	Pollution	✓	✓	✓	✓
	Resettlement	✓	✓	✓	✓
Other Requirements	Categorization of Projects	✓	✓	✓	✓
	Complain Mechanism	✓	✓	✓	x
	Penalties for Violations/Disincentives	x	✓	✓	✓
	Financial Intermediaries Standards	✓	x	✓	✓
	Incorporate World Bank EHS Standards	✓	✓	✓	✓ (By definition)
	Incorporate IFC Performance Standards	Not explicitly	✓	✓ (By definition)	Not applicable
	Monitor Compliance	✓	✓	✓	✓
	Requires Covenants Terms in Loan Documentation	✓	✓	✓	No information found

Whether developed by central banks, regulators, and international development agencies (e.g., the United Nations Environment Programme-UNEP or the EBRD), or by industry associations (e.g., the Equator Principles Association), most sustainable finance initiatives are increasingly converging and aligning with one another (Amirkhanova & Vogelsberger, 2015). For borrowers, integrating the different but overlapping E&S standards at the outset is critical to success: the standards impose complex and comprehensive requirements, the compliance with which can affect the timing and viability of the loan, and success of the project overall (Polk, 2017).

1.2.2 Projects Compliance against Standards of Reference

It is almost certain that a project manager (PM) will have to ensure that the project accommodates and complies with some type of regulatory agency and the requirements they enforce (Schwierking & Anantatmula, 2019). From this perspective, a PM's compliance can be understood as an individual's responses to project governance requirements (Too & Weaver, 2014). Non-adherence to these standardised requirements by PMs will have direct and negative effects on projects and on organisational performance (Gemünden et al., 2005). In detail, failure to meet regulatory requirements, to identify applicable regulatory authorities, to provide appropriate plans and build to accepted specifications, schedule for inspections and meet the intent of the law or regulation, can result in failure to meet project's cost, scope, schedule and/or quality requirements, and loss of certification, lawsuits, fines and civil and/ or criminal enforcement actions or other negative effects for the organization or its personnel

(Schwierking & Anantatmula, 2019; SCCE & HCCA, 2020). These outcomes can, in turn, adversely affect the company's share price, and ability to raise project finance and gain access to acreage and other opportunities in an increasingly competitive business environment (Wagner & Armstrong, 2010).

Running business often assumes compliance with the E&S commitments as a part of the regulation, contract, or the condition for obtaining the license or credit. The most complex standards are usually associated with environmental commitments (Boehmer & Zaytsev, 2021). Therefore, reporting environmental and social standards compliance is an accountability mechanism helping to engage with a wide range of stakeholders, including employees, consumers, investors (Boehmer & Zaytsev, 2021), translating into a tool for communicating the economic, environmental, and social opportunities and challenges of corporations to stakeholders while addressing their potential and real inquiries. Additionally, compliance fosters fair competition among companies and thus a favourable investment climate (OECD, 2024). Thus, the first step to verify compliance with processes, policies and methodologies is to identify them and to know their content, as well as the comprehensiveness of the training given to project managers (Scoleze Ferrer et al., 2020). Consequently, it is important for PM's, borrowers and financial institutions to be familiar and have a facility with the varying E&S standards (Mertens, et al., 2023).

Among the critical transactions in international project finance is the conduct of due diligence by the project lenders (Desierto, 2020). Prior to the approval for financial support from an MDB, an ESDD process is applied to the project (Sohn, 2018). Due diligence, in this context, refers to 'the process of reviewing and analysing the various project participants and contracts for the purpose of determining risks present in a project (Hoffman, 2001). The main purpose of due diligence in international project financing is risk identification (Desierto, 2020). To this aim, it is required to conduct an 'interdisciplinary process of legal, technical, environmental, and financial specialties, designed to detect events that might result in total or partial project failure' (Hoffman, 2001). Precisely because the nature of lending in project financing makes repayment dependent on the project's future expected income stream, project lenders must undertake as comprehensive an assessment of foreseeable risks as possible, balancing such risks against the stream of expected returns from project revenues and all other income derived from the multi- year operation of the project (Desierto, 2020). Therefore, MDBs necessitate the borrowers, or the clients, to submit environmental and social instruments (e.g., Environmental and Social Impact Assessment (ESIA) report, Environmental and Social Management Plan (ESMP), Environmental and Social Management Framework (ESMF)) to the bank for projects with the possibility to cause adverse environmental and social impacts (Sohn, 2018). The instruments are then further scrutinized to ensure that all assessments and mitigation measures for the environmental and social issues comply with the environmental and social safeguard policies of each MDB. The lender's responsibility for full investigation and surveillance extends to the whole process of the financing of the project, including the reasonably foreseeable consequences. A lender is therefore under the duty to consider factors such as the likely environmental effects of the project, the consequence of the project for indigenous peoples in affected areas, possible damage to archaeological or culture heritage sites and so forth (Desierto, 2020). Thus, the mitigation measures implemented to manage E&S impacts and risks also includes changes to the original project design, therefore allowing the environmental and social assessment and management to play a decisive role in the project planning. Furthermore, failure to comply with the E&S safeguards may also result in the disapproval or withdrawal of the financial support for a project, leading to a halt in project implementation (Sohn, 2018).

This ESDD practice originally emerged as an approach used by lenders or investors to manage environmental risks and liabilities stemming from an investment decision and has lately evolved as a way for financial institutions to incorporate environmental and social considerations in their investment review process (Desierto, 2020). This need is especially pressing in the renewable energy sector, as concerns about climate change and sustainable development have grown, MDBs have prioritized supporting energy efficiency and renewable energy technologies since the 2000s (Steffen & Schmidt, 2018). In emerging economies, aggressive increase in private investment has contributed to supporting renewable energy projects (Kim & Lee, 2021).

1.3 Renewable Energy Projects: Context and Environmental and Social Risk Landscape

In recent decades, the urgent need to address climate change and build resilience to its impacts has become increasingly evident (Ekechukwu & Simpa, 2024). The population expansion and technological advancements have led to an exponential increase in fossil fuel usage, which is limited in resources and has significant environmental consequences reflected in global warming, climate change and pollution (E. Sayed et al., 2023). Global warming is a huge hazard which is being caused by burning of coal, oil and natural gas (Shahzad, 2015). In addition to contributing to climate change, the combustion of fossil fuels releases air pollutants such as particulate matter, nitrogen oxides (NO_x), and sulfur dioxide (SO_2), which are linked to serious public health issues, including respiratory and cardiovascular diseases (WHO, 2021). Furthermore, these pollutants contribute to environmental degradation through acid rain and ecosystem damage. In detail, the energy obtained from the consumption of fossil fuels is considered the primary cause of rising Green House Gas (GHG) emissions (Bölük & Mert, 2014). With the levels of GHGs (such as Carbon dioxide (CO_2), water (H_2O) vapour, methane (CH_4) , Nitrous oxid (N_2O), and Ozone (O_3)) in the atmosphere rising at a hazardous rate, it is important to develop sources of non-fossil fuel based energy in addition to determining ways to reduce CO_2 (Qazi et al., 2019). This has led to a growing need for renewable and ecologically friendly alternatives to these (Sayed et al., 2023). In contrast to fossil fuels, RE offers alternative sources of clean energy (Qazi et al., 2019). Therefore, RE integration has emerged as a key strategy in this endeavour, offering a pathway to decarbonize energy systems and mitigate the adverse effects of climate change (Arent et al., 2022). Moreover, it is also expected to reduce energy crises by playing a key role in meeting future electricity demands. Solar and wind energy are the most promising forms of the RE sources that encourage interest in increasing their use worldwide (Qazi et al., 2019)

1.3.1 Renewable Energy Sector Overview

Renewable energy sources (RES) or alternative energy sources are considered all the energy sources that can be renewed, produce energy over and over, and are inexhaustible (Halkos & Gkampoura, 2020). RES are hygienic sources of energy that have a much lesser negative environmental impact than conventional fossil energy technologies (Shahzad, 2012). RES are hygienic sources of energy that have a much lesser negative environmental impact than conventional fossil energy technologies (Shahzad, 2012). Thus, RES are a very important part of the concept of sustainable development and sustainable energy. Sustainable development of energy merges the RESs concept with economic, social, and environmental dimensions (Relich, 2024). and these energy sources are environmentally friendly in nature (Dey et al., 2022).

According to several authors, increasing renewable energy production (REP) is considered essential to slowing the pace of climate change and achieving sustainable economic development (Tiwari & Mishra, 2011; Owusu & Asumadu-Sarkodie, 2016; and Ozturk et al., 2025). The potential of renewable energy is vast, and in principle, these resources could far exceed global energy demand (Ellabban et al., 2014). As energy demand continues to rise rapidly, driven by population growth and economic development, it becomes increasingly urgent to adopt sustainable energy solutions that can meet future needs and avoid energy crises (Qazi et al., 2019). At present, however, most of the world's energy is still produced from non-renewable sources such as coal-fired power plants, as seen in Figure 1.2. Using 2004 as a baseline, global energy demand is expected to increase by 65% by 2030 (Qazi et al., 2019). In this context, accelerating the deployment of renewable energy is not only a climate imperative, but also a development necessity. In 2023, global installed renewable energy capacity increased by 50% compared to the previous year, the fastest growth rate in two decades (World Economic Forum, 2024). This momentum aligns with the target set during COP28, which called for a tripling of global renewable energy capacity by 2030 (IEA, 2024). A key driver behind this expansion is the urgent need to decarbonize the global energy system, which is fundamental to ensuring a sustainable and climate-resilient future (Ozturk et al., 2025).

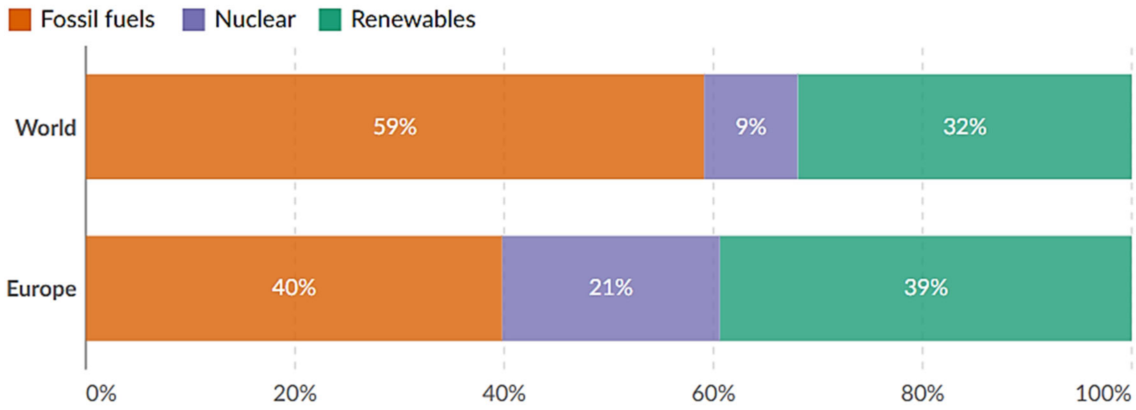


Figure 1.2: Per capita electricity generation from fossil fuels, nuclear and renewables in 2023. Comparison of the percentage distribution of electricity generation sources between Europe and the World, distinguishing between fossil fuels, nuclear energy, and renewables. Europe shows a lower dependence on fossil fuels (44%) compared to the global average (61%) and stands out for a higher share of nuclear energy (21% versus 9.1%). Adapted from Ember (2025); Energy Institute - Statistical Review of World Energy (2024).

This phenomenal growth transcends a variety of renewable energy types, including the core sectors of solar, wind, hydropower, marine, geothermal and bioenergy as presented in Figure 1.3 (Hassan et al., 2024). Each of these sectors has been a beneficiary of relentless advancements in technology, operational efficiency, and cost-competitiveness, making renewable energy an increasingly attractive option on the international stage (Hassan et al., 2024). Globally, these renewable energy sources are considered the most effective solution to minimize the social and environmental problems associated with non-renewable energy sources (Farghali et al., 2023).

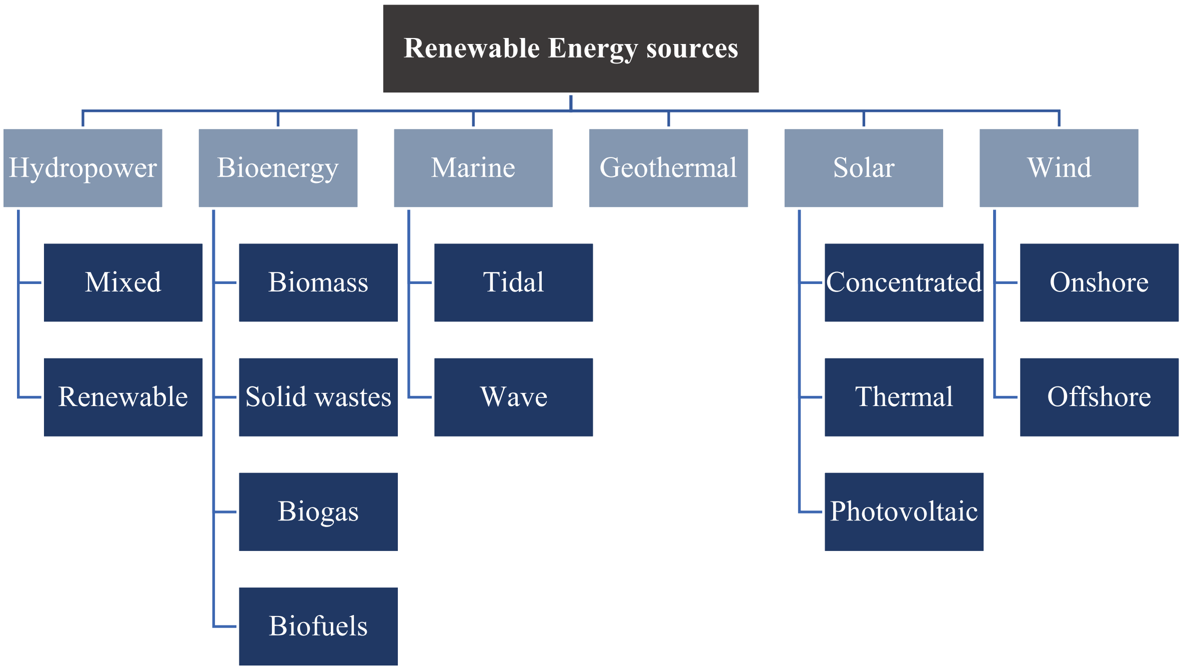


Figure 1.3: The main different types of renewable energy technologies.

The field of renewable energy technology encompasses various methodologies, including solar, wind, geothermal, biomass, and hydropower energy generation. Integrating renewable energy into the electricity grid is crucial to addressing global climate change. Solar and wind energy have particularly stood out as exemplars of rapid progression (Hassan et al., 2024). The cost of solar photovoltaic (PV) energy, for instance, has experienced a precipitous drop, attributed to technological breakthroughs and the advantages reaped from economies of scale (Timilsina & Shah, 2022). This has positioned solar energy as a competitive contender against traditional fossil fuel-based power in numerous global regions (Hassan et al., 2024). Similarly, wind energy, inclusive of both onshore and offshore varieties, has seen marked improvements in efficiency and cost-effectiveness (Bertagnolio et al., 2023). In 2020, solar photovoltaic (PV) and onshore wind energy each had more than 700 GW of installed power generation capacity globally (Rozon et al., 2023). Combined, this represents nearly 80 times the installed solar and wind generation capacity that prevailed in 2000 (Rozon et al., 2023). These trends are illustrated in Figure 1.4, which shows the evolution of global installed capacity for major renewable energy technologies between 2010 and 2023. These positive trends are anticipated to continue unabated, laying down a strong foundation for augmented penetration of renewable energy into the global energy mix (Hassan et al., 2024).

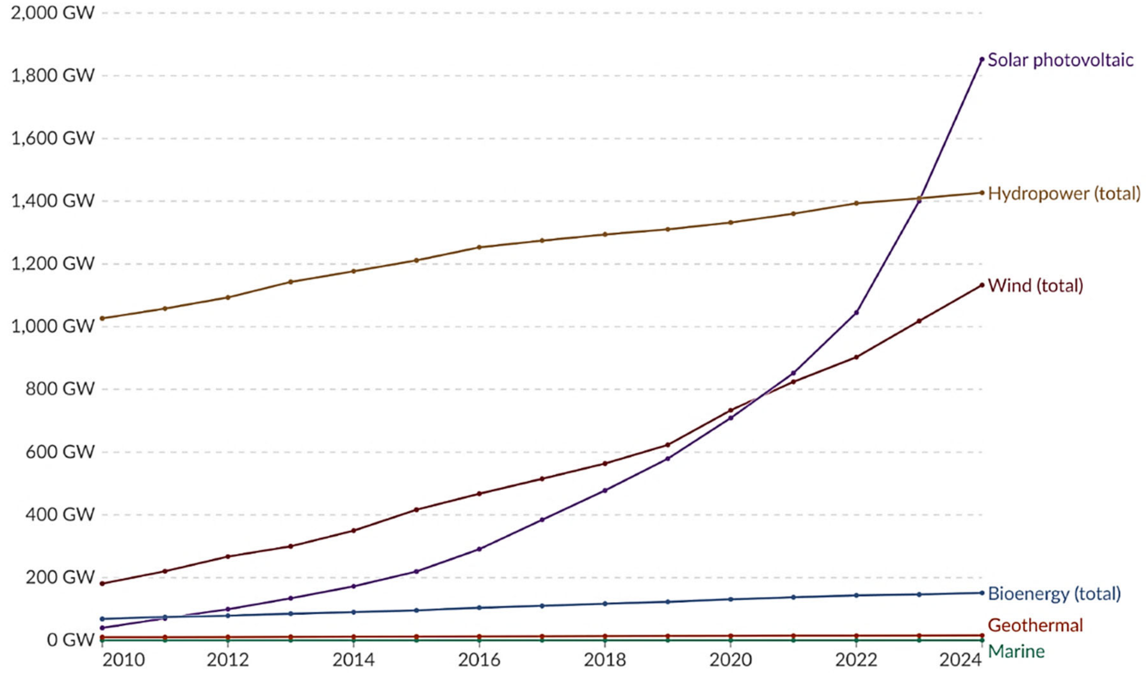


Figure 1.4: Global installed renewable energy capacity by technology in gigawatts (GW) (2010-2023). Adapted from IRENA, (2024). Evolution of global installed capacity (in GW) by renewable energy technology from 2010 to 2024. An exponential growth in solar photovoltaic capacity is observed, surpassing wind energy in 2022 and approaching hydropower, which remains the leading renewable source in absolute terms. Bioenergy and geothermal show more stable growth trends, while marine energy remains marginal.

Hydropower:

The environmental benefits of renewable energy integration come with challenges (Uzondu & Joseph, 2024). While these technologies reduce carbon footprint, they bring along their right share of environmental trade-offs (Sumon et al., 2024). Hydropower plants have a major sociopolitical problem that forces people to shift away from the construction areas of such plants (Sayed et al., 2021). They, of course provide a huge and significant number of jobs for local communities which will eventually and importantly support the economic development of these communities (Kumar, 2020). Like any other renewable energy system, water-based energy systems have some social impacts like public perception and view. Additionally, just like any mechanical based system, water-based energy systems are like wind energy systems; they can cause possible aquatic life threats through collisions and underwater noise (Sayed et al., 2021). A few of the environmental impacts of these projects can be the diversion of river flow, including impact on historical monuments landscapes and sites; cost of lost recreational activities/water sports; and loss of scenic view including the loss of forest land and of home gardens. (Botelho et al., 2017). Hydropower, which contributes to around 16% of global electricity and more than 72% of renewable electricity, is expected to play an important role in the deep decarbonization of the energy sector. However, the idea that hydropower is a carbon-neutral energy alternative on par with solar and wind is controversial (Gemechu & Kumar, 2022).

Marine Energy:

Marine renewable energy (MRE) harnesses energy from the ocean and provides a low-carbon sustainable energy source for national grids and remote uses. However, there're risks an MRE device may pose to marine animals, habitats, and the environment due to the function of the attributes of the MRE devices, including device structure and whether the device is submerged, floating, or surface-piercing (static or dynamic); the type of resource (wind, wave, tidal, or riverine); and the spatial scale of a particular installation (single device or arrays) (Copping et al., 2020). On the environmental side, the anthropogenic sound in the marine environment may affect the way that many marine animals interact with their surroundings and may also affect communication, social interaction, orientation, predation, and evasion (Southall et al., 2019). Risks to marine animals from anthropogenic sounds, including the operation of MRE devices, vary with the amplitude, frequency, and directionality of the noise source, as well as propagation losses, prevailing ambient noise, animals' hearing thresholds, and possible behavioural responses (Copping et al., 2020). Additionally, MRE development can bring social and economic benefits to a region, including the stimulation of economic development, production output, regional development, and tourism, along with the generation of employment and revenue (Regeneris Consulting Ltd., 2013). However, if not carefully and sensitively sited and implemented, MRE development could have adverse social and economic impacts including conflicts with existing marine uses (such as with local fishing and recreation), visual obstruction, and economic effects if the local supply chain is not engaged and leveraged (Copping et al., 2020).

Bioenergy:

Every power generation facility inevitably exerts some environmental and social impact, so does biomass projects. The development of biomass energy systems often relies on intensive land and water use, which can strain local ecosystems. A common issue is the high rate of soil erosion caused by replacing natural forests with croplands, leading to increased surface water run-off and limiting the natural replenishment of groundwater (Sayed et al., 2021). Additionally, energy crops often depend on fertile soils, and to maintain their productivity, synthetic fertilizers are commonly used. This practice can worsen soil degradation and increase the risk of water contamination. The large-scale cultivation of these crops also reduces ecological diversity, as the expansion of biomass plantations displaces natural habitats, forests, and traditional agricultural land, resulting in significant loss of biodiversity (Sayed et al., 2021). The establishment of new forest biomass utilization projects might have multiple social effects on forest-rich regions (Cambero & Sowlati, 2014). These social impacts may encompass alterations to individuals' lifestyles, cultural practices, community dynamics, political structures, environmental conditions, health and wellbeing, as well as personal and property rights, including people's fears and aspirations. However, many of these effects are difficult to measure consistently using quantitative methods (Cambero & Sowlati, 2014). The social impacts of bioenergy projects tended to be more varied and included land-use change, worker health, impacts on traditional communities and food versus fuel debates, among others. Worker safety and land-use change are most frequently cited as potential negative impacts (White, 2016).

Geothermal energy systems:

The different E&S risks associated with geothermal energy systems include the geological hazardous, land use, impacts on biodiversity, release of contaminated wastewater to the environment, gaseous emissions, solid waste, waste heat, noise, sociological impacts (Shortall et al., 2015). The main E&S risks that limit the development and use of the geothermal technologies are related to several points, including removals of steam and mass fluids resulting in land subsidence (Kristmannsdóttir & Ármannsson, 2003). Operational drilling might result in disturbing the land, creating high noise pollutions, threatening and disturbing wildlife, and gaseous emissions like carbon dioxide, hydrogen sulphide, and solid waste, which will all eventually affect workers' health as social impacts (Bošnjaković et al., 2019). Air and water pollutions are huge concerns when it comes to geothermal energy systems as possible ecosystems' degradation causing extra destruction and altering the wildlife and vegetations' habitats (Bayer et al., 2013). Land subsidence is further aggravated by the variable response of subsurface materials to fluid extraction and reinjection, which may also induce landslides or seismic activity due to changes in underground pressure and rock stress (Shortall et al., 2015). Geothermal facility construction and operation can lead to surface disruption, with the degree of impact varying according to the plant's size and capacity. Moreover, persistent noise generated by machinery during both phases, along with changes to the local landscape, may disturb natural habitats and contribute to a decline in biodiversity in nearby areas. Whilst geothermal energy developments tend to stabilize electricity supply and promote economic growth through increased employment or tourism, they may also carry negative social impacts such as loss of local culture resulting from resettlement and land acquisition (Shortall et al., 2015).

Solar Energy:

Solar photovoltaic (PV) technology has become an increasingly important energy supply option globally (Guerin, 2017). Little research has been conducted on the impact of solar farms on biodiversity. The development of utility-scale photovoltaic plants and related infrastructure typically involves clearing vegetation and grading extensive land areas to prepare the site. This can result in habitat loss, degradation, and fragmentation, reducing species richness and density and displacing wildlife populations (Bošnjaković et al., 2023). Shadow effects from solar panels can alter the species composition and diversity of underlying habitats due to changes in air and soil microclimates. Additionally, noise pollution is one of the environmental aspects that must be considered when installing a PV solar power plant. Noise can be generated during the construction, operation, and maintenance phases of a PV system (Bošnjaković et al., 2023). The main problem that the surrounding communities face from the establishment of solar power plants is the change in land use and water usage. Large scale solar plants require significant amount of land which may result in conflict with the surrounding communities. Not involving these communities in development and operation of solar farms is another concern of the communities (Gawande & Chaudhry, 2019)

Wind Energy:

Wind energy, like any other industrial activity, may cause impacts on the environment which should be analysed and mitigated (Jaber, 2014). A primary concern is the potential impact on wildlife, especially birds and bats, due to wind turbines. Collisions with wind turbines can lead to significant mortality rates for these species (Uzondu & Joseph, 2024), an impact that is expected to intensify as turbine units increase in size and wind farms of larger capacity are built (Al Mubarak et al., 2024). There are also potential offshore ecological impacts that require careful evaluation when planning and constructing large offshore wind farms (EERE, 2023). The visual impacts of windfarms destroying the ascetic beauty of the natural environment are also of concern to many residents and tourists, although that is often not considered as substantial environmental damage (Al Mubarak et al., 2024). The construction and maintenance of wind-energy facilities also alter ecosystem structure through vegetation clearing, soil disruption and potential for erosion, and produce noise. Alteration of vegetation, including forest clearing, represents perhaps the most significant potential change through fragmentation and loss of habitat for some species (Jaber, 2014). Additionally, the construction of wind farms cause a land area impact including the construction of access roads that can interfere with ecosystems (Al Mubarak et al., 2024). In contrast, to the extent that wind-energy projects create negative impacts on human health and wellbeing, the impacts are experienced mainly by people living near wind turbines that are affected by noise and shadow flicker. Furthermore, large-scale renewable energy projects can also pose social challenges (Uzondu & Joseph, 2024).

The installation of wind farms, and especially solar PV systems, require significant land use, leading to various ecological issues, including deforestation and impacts on human health, animals, plant life, and the environment (Uwaga & Ogunbiyi, 2025). Their construction can lead to conflict with agricultural activities and the livelihoods of local communities, land disputes and the displacement of local populations (Uzondu & Joseph, 2024). The expansion of RE is a cornerstone of global efforts to combat climate change (Uwaga & Ogunbiyi, 2025). Although the negative environmental impacts from renewable energy installations are much lower in intensity than those produced by conventional energies, they still have to be assessed and mitigated when necessary (Uzondu & Joseph, 2024).

1.3.2 Applying the Environmental and Social Standards to Manage Risks in Renewable Energy Projects

The main reason for the increasing investment and exploitation of renewables is certainly environment preservation and environmental aspect of sustainability (Maradin, 2021). As highlighted earlier (see Section 1.1), risk identification and management are central to project development and decision-making. Therefore, as renewable energy investments gain momentum globally, accurate risk identification and management have become vital to ensuring project viability and investor confidence (Akhigbe et al., 2024). The sector's complexity, scale, and long-term nature introduce distinctive challenges, making structured and anticipatory approaches to risk management essential. Developers of the renewable projects encounter various types of risks, inherent to these projects, and all these risks should be studied in advance and ways of their mitigation developed (Nuriyev et al., 2019). One of the most critical aspects of successful renewable energy investments is risk assessment, which is vital for identifying, analysing, and mitigating uncertainties that could affect project viability and financial returns (Akhigbe et al., 2024). In particular, E&S risks have gained greater attention due to their relevance for project financing, stakeholder acceptance, and reputational concerns (Gibbons et al., 2022).

As explained in Section 1.2.1, several international frameworks such as the IFC Performance Standards have been adopted by FIs to assess and manage E&S risks, serving as reference points during the lending process and requiring borrowers to demonstrate compliance with environmental and social criteria to secure funding. (Otieno & Loosen, 2016). One of the practical approaches used by lenders to operationalise this process is E&S Risk Categorisation, which categorises a client's operation or project to determine the level of E&S risk assessment that the bank should undertake (Jaber, 2013). Projects risk are classified as High (Category A), Medium (Category B) or Low (Category C) depending on the type of activity, the location, sensitivity and scale of the operation or project (Jaber, 2013). These aspects all have a bearing on the nature and magnitude of potential impacts of an operation or project. For example, an operation that involves activities and is of a size that give it a medium risk profile might have its risk profile increased if it is located in an environmentally or socially sensitive area. Based on these categorizations, different assessments have to be made, and different documents have to be filed in order to fulfil the requirements, such as an environmental and social assessment or the implementation of an E&S management system or the demonstration of an effective stakeholder engagement in case of a category A project (Mertens et al., 2023). Thus, an E&S management plan with measurable mitigation measures as well as a consideration of stakeholders interests and opinions, including a grievance mechanism, are compulsory (Mertens et al., 2023).

While this categorisation supports compliance, it also enables early identification of potential project weaknesses, which can inform better planning and reduce approval delays. As sustainability becomes embedded in investment decision-making, developers are increasingly expected to integrate risk governance practices that go beyond basic compliance.

Renewable energy investments are subject to a wide range of risks that span financial, operational, regulatory, and environmental dimensions (Mertens et al., 2023). Since renewable energy is a sector requiring large amount of investment costs, evaluation of investment risks are extremely important to make the best investment decisions (Ilbahar et al., 2022). This relevance is further illustrated in Figure 1.5, which presents investment trends in renewable energy projects by major international financial institutions between 2010 and 2020, highlighting cumulative amounts and top recipient countries. Therefore, a comprehensive approach to risk management is essential for ensuring the success and sustainability of renewable energy investments, contributing to global efforts to combat climate change and achieve sustainable development goals (Akhigbe et al., 2024). By understanding and addressing these risk factors, stakeholders can enhance project resilience, attract financing, and accelerate the deployment of renewable energy infrastructure (Akhigbe et al., 2024). Therefore, an appropriate risk management instruments are undoubtedly essential to financers, developers and investors (Lee Wing, 2014). In conclusion, this rapid expansion of renewable energy investments underscores the pressing need for advanced risk assessment tools that address the unique challenges associated with large-scale projects (Akhigbe et al., 2024).

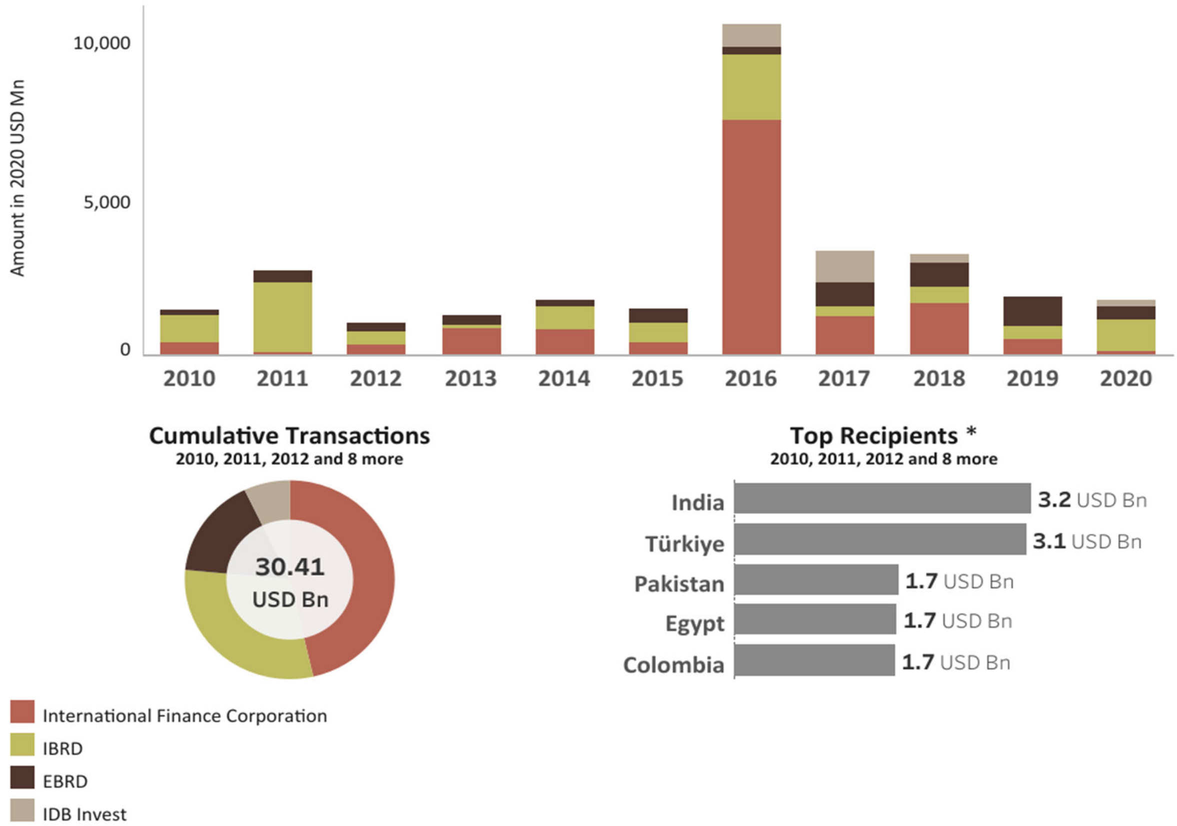


Figure 1.5: Public investment in renewable energy projects by major IFIs between 2010 and 2020, adjusted to 2020 United States dollar (USD) values. Adapted from IRENA (2022) The IFC stands out as the main contributor, with a peak in investment in 2016. The chart also highlights cumulative transaction volumes (USD 30.41 billion) and identifies the top five recipient countries: India, Türkiye, Pakistan, Egypt, and Colombia.

Given the complexity and multidimensional nature of risks in renewable energy projects, relying solely on traditional risk management approaches may not be sufficient. These projects often involve multiple stakeholders, conflicting priorities, and uncertain outcomes. As such, there is a growing need for structured methods that can support decision-makers in navigating these challenges. This is where decision support methods become particularly valuable, offering systematic frameworks to evaluate options, integrate diverse criteria, and justify investment decisions under uncertainty.

1.4 Decision Support Methods

Bardos et al., (2001) define decision support as "the assistance for, substantiation and corroboration of, an act or result of deciding; typically, this deciding will be a determination of an optimal or best approach". It must be noted that decision making, especially group decision making, is a difficult activity because of a heterogeneous spread of expertise (Canco et al., 2021). Risk management of environmental projects requires balancing scientific findings with multi-faceted input from many stakeholders with different values and objectives (Linkov et al., 2006). In these situations, structured decision-making tools offer an effective means of addressing both technical complexities and behavioural considerations. The development of energy projects requires methodological approaches to incorporate social, environmental and economic criteria into decision-making models, including stakeholder participation (Estévez et al., 2021). Identifying an appropriate approach for a particular initiative or case study can be challenging due to the complexity of participatory sustainable decision making in this sector, as well as the complexity and broad range of available methodologies. In response to these challenges, some regulatory agencies and environmental managers have moved toward more integrative decision analytic processes, considering a range of analytical methods designed and employed to facilitate balanced and integrated decision-making in the context of environmental and energy sector projects. Among the commonly used approaches are the Multi-criteria Decision Analysis (MCDA), Cost-benefit Analysis (CBA), Life Cycle Assessment (LCA), and Cost Effectiveness Analysis (CEA) (Bhagtani, 2008). A comprehensive analysis comparing the respective advantages and limitations of these methodological approaches is provided in Section 2.1 of the Methodology chapter. CBA is the assessment of all costs and benefits that are involved in various available options (Onwubuya et al., 2009). CBA quantifies the extent to which benefits from a project exceed its costs over a specified period of time (Chelli et al., 2025). In CBA, difficulties may arise when considering aspects which may not have an immediately obvious or easily quantifiable monetary value (e.g. an ecosystem, social acceptability of a remediation option, etc.) (Onwubuya et al., 2009). Regarding CEA, it is a form of economic analysis that compares the relative expenditure (cost) and output (effectiveness) of two or more courses of action (options) (Angelis-Dimakis et al., 2008). However, CEA application is limited in renewable energy contexts where outputs cannot be easily standardised or expressed through a single common unit of effectiveness. For example, comparing social acceptability with biodiversity loss or land use conflicts cannot be captured through simple ratios, making CEA insufficient to handle the multidimensional nature of E&S risks. The significant difference between CBA and CEA is that the benefits of a project, in the case of CEA, are not monetised. The considerable difference is that CBA monetises all impacts (costs and benefits) to assess overall project worthiness, while CEA only compares costs relative to a non-monetary outcome, and is not designed to assess whether a project is worth doing, only how effectively it achieves a specific goal (Onwubuya et al., 2009). The main purpose of LCA is to identify the environmental impacts of goods and services during the whole life cycle of the product or service (Góralczyk, 2003) However, in LCA, assessing its outcomes is not always easy, especially when decision-making must be carried out in such complex situations (Zanghelini et al., 2018). Nevertheless, LCA offers a valuable framework for evaluating environmental risks across a project's life cycle. However, LCA is primarily focused on quantifiable environmental indicators (e.g., GHG emissions, resource use) and does not account for social or qualitative dimensions such as stakeholder concerns, regulatory uncertainty, or land tenure conflicts. Moreover, the application of LCA requires detailed inventory data, which is typically unavailable or unreliable in early project stages, limiting its applicability to pre-screening scenarios.

On the other hand, MCDA adopts a broader view of what constitutes a gain or loss (Bhagtani, 2008). MCDA consists of a group of approaches which allow to account explicitly for multiple criteria, in order to support individuals or groups to rank, select and/or compare different alternatives (e.g. products, technologies, policies) (Belton & Stewart, 2002). Moreover, MCDA methods are increasingly used due to the complexity of issues and the inadequacy of conventional tools, such as CBA and CEA, and it "allows for participatory analysis and qualitative assessment" (Nalmpantis et al., 2019). Therefore, given its capacity to incorporate multiple criteria, both quantitative and qualitative, and to facilitate stakeholder participation in complex decision contexts, MCDA stands out as the most suitable method for addressing the multifaceted risks and trade-offs inherent to renewable energy project planning. For this reason, it was selected as the methodological basis of this work and will be analysed in detail in the following section.

1.4.1 Multi-criteria Decision Analysis (MCDA)

Making decisions is an integral part of human life. All such decisions are made based on the assessment of individual decision options, usually based on preferences, experience, and other data available to the decision maker (Deveci et al., 2020). Taking into account the systematics of the decision problem itself and the classical paradigm of single criterion optimization, it should be noted that it is now widely accepted to extend the process of decision support beyond the classical model of single goal optimization described on the set of acceptable solutions (Roy, 1996). This extension allows one to tackle multi-criteria problems with a focus on obtaining a solution that meets enough many, often contradictory, goals (Deveci et al., 2020). Almost in every case, the nature of the decision problem makes it a multi-criteria problem. This means that making a "good" decision requires considering many decision options, where each option should be considered in terms of many factors (criteria) that characterize its acceptability (Sałabun et al., 2020). Since decision-makers may assign different levels of importance to each criterion, a degree of subjectivity is inherently present in multi-criteria decision-making. However, once the criteria and their respective weights are defined, the process of ranking the alternatives becomes more objective, as the evaluation is carried out using a specific MCDA method that applies consistent rules and algorithms to all options (Sałabun et al., 2020). In short, there is a need for an improved planning and decision support tool that ensures democratic and cost-effective processes securing qualified decision-making, as the Multi-Criteria Decision Analysis (MCDA) methods, also known as Multi-Criteria decision making (MCDM) (Hanssen et al., 2018). The MCDA methods are used to solve decision problems where there are many criteria (Więckowski & Szyjewski, 2022). MCDA methods enable a comprehensive analysis of decision options to identify the most preferred values. Furthermore, MCDA allows for simultaneous consideration of stakeholder interests and technical evaluations, utilizing rigorous scientific methods to process technical information (Giove et al., 2009). The role of external stakeholders in the various MCDA applications is fundamental.

The application areas of these methods are huge (Mardani et al., 2015). Examples can be found in supplier selection, technical evaluation of tenderers, evaluation of service quality or in renewable energy (Ceballos et al., 2016). In particular, MCDA methods have been widely used throughout the renewable energy literature for several purposes such as evaluation of energy policies, selection of the most suitable renewable energy source for electricity generation, evaluation of renewable energy sources, identification of the optimal site for a renewable energy facility, and selection of the best one among energy alternatives (Ilbahar et al., 2019). For example, Ioannou et al. (2017) used quantitative and semi-quantitative methods to model risks and uncertainties in energy system planning, feasibility studies, and development of optimal energy technology portfolios. According to these authors, "quantitative methods measure risks mainly by means of the variance or probability density distributions of technical and economic parameters; while semi-quantitative methods such as scenario analysis and MCDA can also address non-statistical parameters such as socio-economic factors (e.g. macro-economic trends, lack of public acceptance)". Given its relevance to the objectives of this study, the MCDA method is examined in depth in the 2.1 section.

There are many MCDA methods, and each method has its own definition of best alternative, and it is not determined if using same input data in different MCDA methods will give the same results (Zlaugotne et al., 2020). Some of the methods include weighting and ranking methods, as for example, Multi Attribute Utility Theory (MAUT), Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), Elimination and Choice Expressing Reality (ELECTRE), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Bernabeu et al., 2014).

However, it should be noted that it is difficult to answer the question of which method is the most suitable to solve a specific type of problem (Zanakis et al., 1998). This is related to the apparent universality of MCDA methods, because many methods meet the formal requirements of a given decision-making problem so that they can be selected independently of the specificity of a particular problem (e.g., the existence of a finite set of alternatives may be a determinant for the decision-maker when choosing a method) (Sałabun et al., 2020). In such a condition, it becomes a significant research problem to select a decision support method suitable to answer the question under consideration since only a properly selected method can provide a proper solution that reflects the decision maker's preferences (Brandenburg et al., 2024). The assessment of alternatives performed using MCDA methods requires considering the decision maker's preferences, which means that the final recommendation may change depending on those preferences (Karczmarczyk et al., 2024).

One of the most used methods to support decision-making and include the decision maker's preferences is the Analytic Hierarchy Process (AHP). Developed by Saaty (1980), this method structures the problem in a hierarchy and uses pairwise comparisons to assign weights to the criteria. This method is further examined in the following section.

1.4.2 AHP

The most versatile analysis approach in the energy area for the quantitative analysis of the risks that hides among the whole-life cycle of a renewable energy project is the AHP, as it can convert a complex issue into a simple hierarchy, flexibility and intuition (Zhou & Yang, 2020). The AHP, proposed by Saaty (1980), is a simple mathematically based multicriteria decision-making tool (Alkhalidi et al., 2020). The method mixes qualitative and quantitative criteria and internal and external effects to meet the requirement of the decision maker (Zhou & Yang, 2020). AHP expresses a quantitative analysis of the risks that hides among the whole-life cycle of the wind power project (Jin et al., 2014).

AHP can mathematically assess the risk, and, at the same time, consistency of the judgment is taken into consideration. The ability to capture both actual numerical data and subjective opinion makes it a desirable approach to decision makers (Alkhalidi et al., 2020). In this method, alternatives are listed and then compared pairwise according to their contribution to reaching each objective or criterion (Zlaugotne et al., 2020).

The method also takes into consideration the inconsistencies in human opinions, while mathematically assessing the degree of these inconsistencies (Alkhalidi et al., 2020). This process is designed to deal with complex, unstructured, and multiattribute problems (Çoban, 2020). It generates a weight for each evaluation criterion by assigning a score according to the decision maker's pairwise comparisons of the criteria (Alkhalidi et al., 2020). This is done based on that criterion, the higher the weight, the more important the corresponding criterion, and then synthesizing the results (Saaty, 2004). Such approach can integrates preventing revenue losses and ensures safety into project risk evaluation using a multiattribute decision-making technique (Alkhalidi et al., 2020).

AHP can be summarized into the following six main steps:

1. Identifying the input criteria using actual data and/or subjective opinion;
2. Develop hierarchical structure;
3. Creating the pairwise comparison matrix for all levels;
4. Computing priority vector scores;
5. Checking for consistency;
6. Develop overall ranking of the options.

Regarding the studies using the AHP approach focused on renewable applications, the literature is diverse (Rawat et al., 2022).

Given the versatility and structured nature of the AHP method, its integration into E&S risk evaluation emerges as a valuable approach for complex decision-making scenarios in renewable energy projects. A detailed comparison of the advantages and limitations of the AHP method in relation to other decision-making approaches is presented in Section 2.2 of the Methodology chapter. AHP's ability to combine subjective expert judgment with objective data enables the development of tools that are both analytically robust and practically applicable.

Building upon this methodological foundation, the next section outlines the core objectives of this study, particularly the design and implementation of a practical E&S risk pre-screening tool that leverages AHP to support early-stage project or portfolio evaluation.

1.5 Objectives

Evaluating a project finance proposal for RE is a complex analysis that can be defined as a multi-criteria decision-making problem with a multidimensional space of indicators (Bernabeu et al., 2014). This complexity is due to the interplay of multiple environmental, social, technical, and economic factors. This process can be framed as a multi-criteria decision-making. Moreover, access to international funding increasingly depends on meeting E&S requirements set by institutions such as the IFC, WB, IDB and the EBRD. While these standards share common principles, their structure, terminology, and scope often differ, which complicates and confuses early-stage project assessments.

Given this context, the central objective of this study is guided by the following question:

Can we develop a screening tool that enables a practical, consistent, and analytically robust assessment of E&S risks, applicable to RE projects or portfolios?

Therefore, the goal of this works is to create a decision-support tool that facilitates early-stage project assessments by combining analytical and mathematical rigour with user-friendly design. While tailored to the specific needs of the renewable energy sector, the tool may also offer insights applicable to other project types sharing similar E&S challenges. To achieve this, the study sets out the following specific objectives:

1. Identify key requirements and performance indicators relevant to project or portfolio pre-screening, through the analysis of internationally recognised E&S standards (IFC, WB, IDB, and EBRD).
2. Design a robust framework for the semi-quantitative assessment of E&S risks, based on consistent metrics and standardised criteria.
3. Develop a practical, resource-efficient, and user-friendly tool, that integrates the framework and methodology, supporting consistent and transparent assessments by consultants, analysts, and project developers.
4. Pre-validate the tool by applying it to a real-world case study, comparing the outcomes with actual project results and expert feedback to ensure its reliability, usability, and relevance.

Through meeting these objectives, the study seeks to contribute to a more transparent, efficient, and standardised approach to early-stage E&S risk screening in sustainable project development.

2. Methodology

This chapter depicts the methodological framework implemented for the development of a pre-screening tool aimed at evaluating E&S risks in RE projects. The approach was designed to ensure methodological rigour, efficiency, transparency, and alignment with globally recognised sustainability standards. The entire process was organized into multiple interconnected stages. Initially, a comparative analysis of decision-making techniques was conducted to identify the most appropriate method for the scope and objectives of this research, leading to the adoption of the MCDA method. Following this analysis, the Analytic Hierarchy Process (AHP) was selected. Afterwards, a hierarchical structure of E&S risk factors and their subfactors was established through the review of key international standards. Expert judgements were gathered via structured questionnaires to populate the AHP required pairwise comparison matrices. These matrices were aggregated using the geometric mean, and the priority weights of each criterion were calculated. The consistency of expert inputs was assessed to ensure the trustworthiness of the outcomes. Ultimately, global weights were derived to determine the overall influence and impact of each risk factor in the decision-making model. Each of these methodological steps is described in detail in the subsequent sections.

2.1 Comparative Analysis for selecting an approach.

The informal approach to method selection consists of selecting the method for a given decision problem based on heuristic analysis performed by the analyst/decision-maker (Adil et al., 2014). This analysis is usually based on the author’s thoughts and unstructured description of the decision problem and the characteristics of specific methods. The methodological approach is similar to the semi-formal one, with the difference that the characteristics of individual MCDA methods are, to some extent, formalized here (e.g., table describing the methods) (Sałabun et al., 2020).

To support the development of the screening tool, a comparative analysis of decision-making methodologies was conducted through a targeted review of relevant literature. The analysis focused on identifying methods applicable to the study's objectives, namely, to create a tool that is both analytically rigorous and practical for real-world applications in renewable energy project funding. This comparison was divided into two stages:

1. Assessment of high-level evaluation frameworks involving Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA), and Multi-Criteria Decision Analysis (MCDA). These were evaluated for their capability to accommodate a wide range of E&S indicators, handle non-monetary values, and support early-stage decision-making under uncertainty.
2. Detailed analysis of specific decision-making techniques within the frameworks found to be most suitable. In this stage, several methodological options were considered, including the Multi Attribute Utility Theory (MAUT), Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), Elimination and Choice Expressing Reality (ELECTRE), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

Each method was evaluated for its strengths and limitations in the context of this thesis. The Tables 2.1 and 2.2 provide a summary of the key findings from the comparative analysis:

Step 1: Selection of a Suitable Decision-Making Approach

The first step was to assess general approaches commonly used in project evaluation: Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA), and Multi-Criteria Decision Analysis (MCDA). This analysis is summarised in Table 2.1, which compares the key features, advantages, and limitations of each approach.

Table 2.1:Comparison of General Decision-Making Frameworks.

Method	Advantages	Limitations
CBA	- Quantifies costs and benefits in monetary terms; - Standard tool in economic and financial evaluation.	- Struggles to monetise E&S impacts; - Overlooks non-financial or qualitative criteria.
CEA	- Easier to apply than CBA; - Focuses on efficiency per unit of impact (e.g., €/ton CO_2).	- Not suitable when multiple types of impacts are involved; - Requires clearly defined outcomes.
MCDA	- Integrates quantitative and qualitative factors; - Can handle conflicting and non-monetary criteria; - Adaptable to complex sustainability contexts; - It facilitates multi-disciplinarity and can be adapted to include biophysical, socio-economic and political criteria.	- Requires structured input and scoring; - Subjectivity in assigning weights if not well controlled.

Given the complex, multiscale and multidimensional nature of the topic, where both qualitative and quantitative factors coexist and often compete, MCDA was selected as the most appropriate approach. It offers the flexibility needed to unify multiple E&S criteria from different international standards and apply them consistently at the early screening phase.

Step 2: Selection of the Most Suitable MCDA Method

Once the MCDA framework was identified as the most appropriate for the tool's objectives, the next step was to determine which specific MCDA method would be best suited for its application. This selection considered key aspects such as:

• The ability to structure decision problems hierarchically;
• The integration of expert judgment;
• A balance between analytical rigour and practical usability;
• Smooth implementation within tools such as Excel.

This comparative assessment is presented in Table 2.2.

Table 2.2: Comparative analysis of main MCDA methods. Adapted from Azhar et al., (2021) and Taherdoost & Madanchian, (2023).

Method	Advantages	Limitations	Suitability E&S risk screening in RE projects
AHP	- Clear hierarchical structure - Enables pairwise comparisons -Simple to implement in Excel - Includes consistency check - Minimizes human error and reduces the economic costs of the decision.	- Assumes independence between criteria - Can be time-consuming with many criteria/sub-criteria- - Criteria may change their value in space and time	Very High: Well-suited for transparent and replicable tools with structured decision logic
ANP	- Allows interdependencies between criteria - Realistic structure for complex problems	- More complex structure - Harder to implement in simple tools or with limited resources - Possibility of significant problems due to the measurement error	High: Theoretically robust but less practical for early-stage tools
ELECTRE	- Handles both qualitative and quantitative data - Accepts incomparability between alternatives	- Difficult to understand and time consuming - Requires strong technical expertise	Moderate: Useful in complex trade-off settings, but less intuitive for broader audiences
TOPSIS	- Straightforward ranking based on proximity to an ideal solution - Easy to understand and apply - Takes an infinite number of criteria and attributes as inputs	- Assumes linear trade-offs - Sensitive to scale and normalization - Lacks consistency judgments check	Moderate: Useful for simple ranking of alternatives but may not fully capture qualitative risk factors

PROMETHEE	- Transparent preference modelling - Handles partial rankings and preference thresholds - Easy to use and requires less input	- Requires careful calibration of preference functions - Lacks a clear method for assigning weights - Limited intuitive appeal for non-expert users	Moderate: Strong for preference modelling, but may lack transparency in E&S screening context
MAUT	- Strong theoretical foundation - Captures stakeholder preferences over uncertain outcomes	- Data intensive - Requires clear utility functions, which can be difficult to define	Low: Not ideal for early-stage screening with limited data or qualitative factors

The results of this comparative analysis confirmed that the AHP was the most suitable method. Its hierarchical structure, combined with its ability to process subjective judgments in a transparent and replicable way, aligns well with the goal of creating a decision-support tool that is both robust and user-friendly. The AHP allows for the construction of a clear decision tree aligned with the criteria of international E&S standards, enabling the harmonisation of terminology and structure.

2.2 Applied Method: AHP

The application of AHP in this study involved structuring the decision problem hierarchically, identifying and categorising risk factors and subfactors derived from international E&S standards and conducting pairwise comparisons to quantify their relative importance. These comparisons were gathered through structured expert questionnaires and analysed using established AHP mathematical procedures, including matrix aggregation, weight derivation, and consistency testing.

To ensure practical applicability, the entire process was implemented in Microsoft Excel using structured formulas and logical functions. This decision allowed for transparent calculations, easy replication, and future adaptability by practitioners in the renewable energy sector. This approach ensures that the resulting tool reflects expert knowledge and maintains methodological domain.

The AHP application was developed in six key stages, which are represented in Figure 2.1, and described in the following sub-sections.

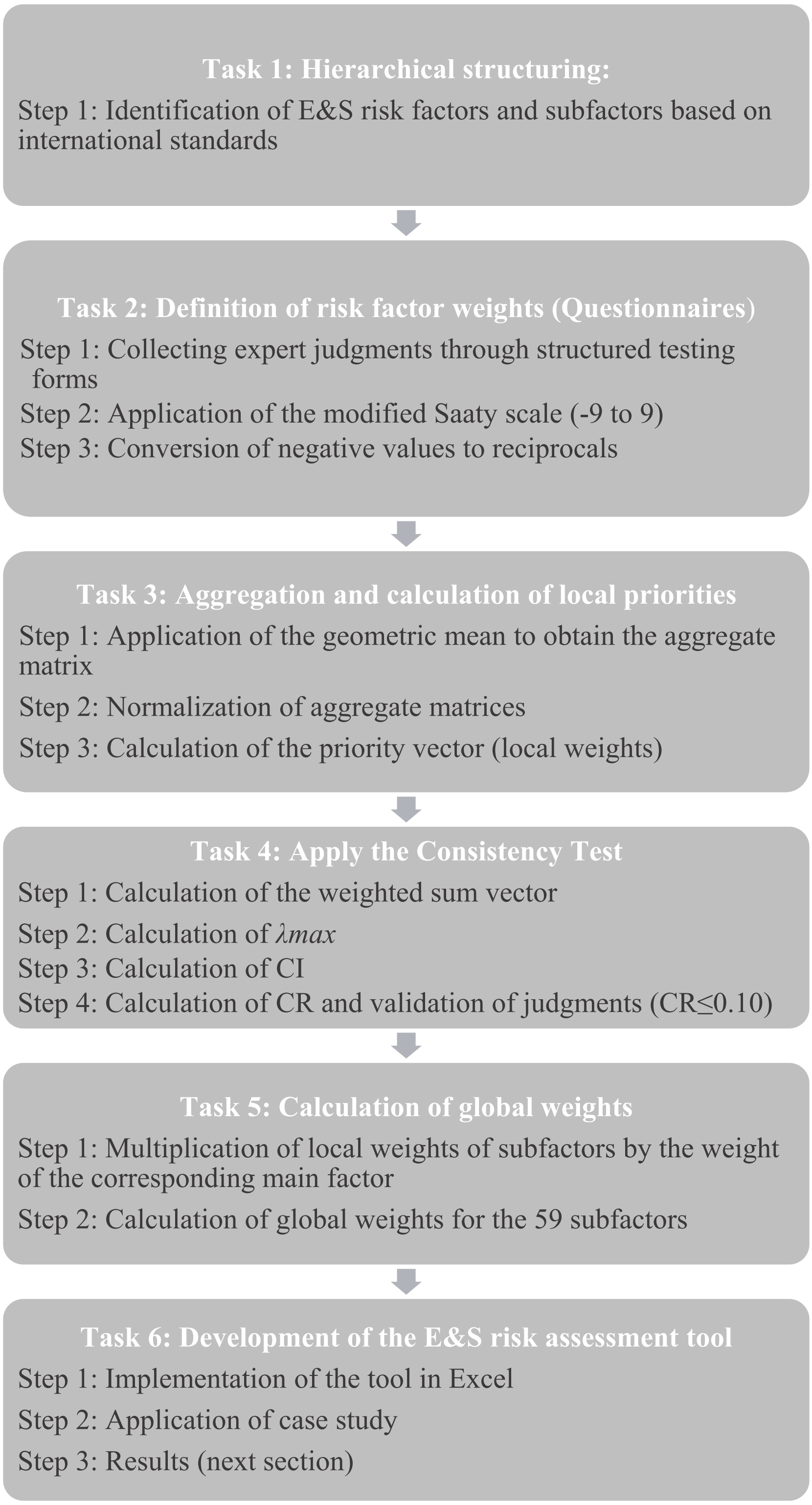


Figure 2.1: Methodology steps for building the E&S risk assessment tool based on AHP.

2.2.1 The Hierarchical tree

The suggested tool hierarchically breaks the problem down into simpler problems. For this reason, each subproblem was examined and analysed separately. Therefore, to allow for a systematic assessment of E&S risks, it was first necessary to define the factors and subfactors that constitute the model. These were identified through a comprehensive review and analysis of the main E&S international standards adopted by the selected multilateral financial institutions, namely IFC, WB, IDB and EBRD.

This analysis led to the consolidation of nine (9) main risk factors that encompass the most relevant dimensions for the screening of projects, particularly within the RE sector. For each of the main factors defined, specific subfactors were specified, capturing the elements necessary for a more granular analysis of potential risks. This hierarchical structure provides a rigorous and organised foundation for the application of the AHP methodology. In total, 59 subfactors were identified and defined (Annex A) based on the risk dimensions typically addressed by the above-mentioned institutions, as presented in Table 2.3.

Table 2.3: Hierarchical Framework of E&S Risk Factors and Subfactors.

Risk Factors	Risk Subfactors
F1. Management Systems	F10: Lack of/Poor Essential Policies F11: Lack of/Poor Mechanisms for Risk Identification F12: Lack of/Poor Organisational Capacity F13: Lack of/Poor Management Programs F14: Lack of/Poor Emergency Preparedness and Response F15: Lack of Monitoring and Review F16: Financial Management Risks F17: Land Requirements Risks
F2. Social-Political	F20: Compliance with National Laws F21: Lack of Stakeholder Analysis F22: Lack of Engagement Plan F23: Poor Grievance Mechanism F24: Lack of Community Reporting F25: Physical Displacement F26: Economic Displacement F27: Poor Resettlement Planning
F3. Labour & Working Conditions	F30: Working Conditions Risks F31: Limited Freedom of Association F32: Risk of Discrimination F33: Retrenchment F34: Poor Worker Grievance Mechanism F35: Risk of Child Labour F36: Risk of Forced Labour F37: Occupational Health and Safety F38: Third-Party Workers F39: Supply Chain Risks

F4. Environmental	F40: Resource Efficiency F41: GHG Emissions F42: Climate-related Impacts F43: Water Risks F44: Waste Impacts F45: Pollution Prevention F46: Hazardous Substances F47: Noise Impacts F48: Biodiversity Sensitivity
F5. Community Health & Safety	F50: Infrastructure and Equipment Safety F51: Hazardous Materials Exposure F52: Ecosystem Services F53: Disease Exposure F54: Emergency Preparedness F55: Presence of Security Personnel
F6. Indigenous Peoples	F60: Presence of Indigenous Peoples F61: Lack of Consent F62: Impacts on Customary Lands F63: Relocation F64: Poor Development Benefits
F7. Cultural Heritage	F70: Lack of Chance Find Procedures F71: Poor Community Access F72: Critical Heritage Sites F73: Project Use of Heritage
F8. Gender Equality	F80: Gender-Based Violence Risks F81: Lack of Gender Inclusion
F9. Technological	F90: Project Duration F91: Project Geometry F92: Project Cost F93: Host Country Technical Capacity F94: Host Country Regulatory Environment F95: Project Technological Level F96: Site-specific Constraints

2.2.2 Determination of risk factor weight based on AHP

This step aimed to determine the relative importance of each E&S risk factor and subfactor through a structured weighting process based on the AHP.

After making the hierarchy shape illustrating the problem and taking into consideration renewables risk-related statistical data limitation, experts' opinion questionnaire approach was chosen as an information collection tool, allowing to generate the pairwise comparison matrices required by the AHP method. Therefore, the structured questionnaire was developed and submitted to six experts with professional experience in environmental and social risk assessment and project finance. The experts were selected based on their experience and competencies. The group included social experts, environmental and sustainability consultants, and nuclear engineers, all of whom had professional experience in renewable energy projects. The experts represented diverse nationalities and held varying levels of seniority, ranging from 3 to over 20 years of professional experience. For confidentiality reasons, their identities are not disclosed, however, their backgrounds ensure that the panel reflects a broad and relevant range of perspectives.

The experts were asked to evaluate these risks through a survey, in which qualitative judgments were translated into numerical scores. Each pair of objectives was compared using pairwise assessments, reflecting their relative importance with respect to the higher level of the hierarchy (Figure 2.2). In the classical AHP approach, expert judgments are expressed using a scale from 1 to 9, where 1 means equal importance between two elements, and 9 indicates extreme importance of one over the other. To represent the reciprocal situation, i.e. when the second element is more important than the first, the traditional AHP method uses reciprocal values (e.g., 1/3, 1/5).

Risk Sub-Factors	**F70**-Absence of/Poor Chance Find Procedures	**F71**-Lack of/Poor Community Access	**F72**-Critical Cultural Heritage	**F73**-Project's Use of Cultural Heritage
F70-Absence of/Poor Chance Find Procedures	1	-5	3	-3
F71-Lack of/Poor Community Access		1	8	2
F72-Critical Cultural Heritage			1	-6
F73-Project's Use of Cultural Heritage				1

Figure 2.2: Illustrative example of the F7 pairwise comparison matrix derived from expert responses in the questionnaire.

To streamline the response process and enhance clarity, this study adopted a modified Saaty scale, ranging from -9 to 9, as presented in Table 2.4, where:

- Positive values (1 to 9) indicate that the row element is more important than the column element.
- Negative values (-1 to -9) indicate that the column element is more important than the row element, thus representing reciprocal judgments without requiring fractional input.

For example, in the pairwise comparison between F70 – Absence of/Poor Chance Find Procedures and F71 – Lack of/Poor Community Access, the expert assigned a value of -5, meaning F71 was judged to be strongly more important than F70 (Figure 2.2). During data processing, the -5 was converted into 1/5 it's standard AHP equivalent, to ensure compatibility with the standard AHP calculation method. This adjustment keeps the method analytically sound while making the questionnaire easier to use.

Table 2.4: Modified Saaty Scale vs. Traditional AHP Scale

Modified Saaty Scale	Standard AHP Equivalent	Interpretation
-9	1/9	Column element is extremely more important
-8	1/8	Intermediate between 1/7 and 1/9
-7	1/7	Column element is very strongly more important
-6	1/6	Intermediate between 1/5 and 1/7
-5	1/5	Column element is strongly more important
-4	1/4	Intermediate between 1/3 and 1/5
-3	1/3	Column element is moderately more important
-2	1/2	Intermediate between 1 and 1/3
1	1	Equal importance
2	2	Intermediate between 1 and 3
3	3	Row element is moderately more important
4	4	Intermediate between 3 and 5
5	5	Row element is strongly more important
6	6	Intermediate between 5 and 7
7	7	Row element is very strongly more important
8	8	Intermediate between 7 and 9
9	9	Row element is extremely more important

In order to ensure consistency in the construction of the judgment matrices and compatibility with the eigenvector-based weight calculation method, during the data processing phase, all negative values were converted into their reciprocal equivalents to align with the standard AHP methodology. For instance, a judgment of -3 was transformed into 1/3, and -7 into 1/7.

The responses obtained from these questionnaires are not considered results of this research. Instead, they represent intermediate inputs used to constitute the AHP judgment matrices. These matrices were then aggregated and processed to support the internal logic of the development of the pre-screening tool.

The use of expert-based inputs at this stage safeguards that the weighting structure of the tool is grounded in real and practical knowledge, while also allowing for further refinement and application in different project contexts during the tool's preliminary validation phase.

2.2.3 Aggregation and Derivation of Local Priorities

After collecting the pairwise comparison matrices from the six experts, the next step was to process these individual assessments in order to obtain a consolidated judgment base for each group of risk subfactors and main factors.

Each expert provided 10 matrices in total, one for each group of risk subfactors (F1 to F9), and one for the main risk factors, resulting in 60 matrices overall. Since AHP requires a single judgment matrix per comparison level, these matrices were aggregated using the geometric mean, which is the standard method in group AHP analyses.

1st step: Aggregation of Pairwise Judgments (Using the Geometric Mean)

The geometric mean preserves the multiplicative relationships between elements, ensures reciprocity, and reduces the influence of extreme values, thus making it a robust approach for combining expert opinions. Within group decision-making, it is common for some experts to have completely different opinions, resulting in the provision of very high or very low values. While the arithmetic mean is sensitive to such outliers, the geometric mean produces more stable and representative results by giving proportionally less weight to extreme deviations.

For example:

- If one expert rates factor A as three times more important than factor B (value = 3), while another expert rates factor B three times more important than factor A (value = 1/3), the geometric mean of these two judgments is 1, indicating equal importance. This accurately maintains the reciprocal nature of the comparison. In contrast, using the arithmetic mean would result in a distorted average of 1.67, that does not account for the balance of opposing viewpoints.

To consolidate expert judgments into a single matrix A=[*aij*] per comparison group, the geometric mean was applied element-wise across all expert matrices:

Equation 2.1: $$a_{ij}^{(group)} = \left(\prod_{k=1}^{m} {a_{ij}}^{k}\right)^{\frac{1}{m}}$$

Where:

- *aij(k)* is the judgment from expert *k* for the comparison between elements ii and jj. The superscript *k* serves as an index identifying the expert and does not denote an exponent.
- *m* is the total number of experts (in this case, *m*= 6),
- *aij(group)* is the aggregated value in the final judgment matrix.

As a result, 10 aggregated judgment matrices were obtained: one for each group of subfactors and one for the main factors (Annex B).

2nd Step: Matrices Normalization

Once the aggregated judgment matrices A=[aij] were obtained via geometric mean, each matrix was normalised to derive the priority weights by dividing each element by the sum of its column:

Equation 2.2: $$a'_{ij} = \frac{a_{ij}}{\sum_{\{i=1\}}^{n} a_{ij}}$$

Where:

- *aij* is the value in the aggregated matrix,
- *a'ij* is the normalized value,

- n is the number of elements being compared (i.e., the size of the matrix).

This resulted in 10 normalized matrices *A'=[aij'],* where the sum of each column is 1, one for each group of subfactors and one for the main factors (Annex C).

3rd step: Priority Vector (Local Weight Calculation)

The priority vector *w=[w1,w2,...,wn]T* is obtained by summing the values in each column, dividing each cell by the corresponding column total, and then computing the average of each row. The resulting row averages represent the relative weight (priority) of each factor or subfactor in the hierarchy.

Equation 2.3: $$w_i = \frac{1}{n}\sum_{j=i}^{n} a'_{ij}$$

Where:

- *wi* is the local weight (or priority) of element *i,*
- n is the number of elements being compared (i.e., the size of the matrix),
- *a'ij* is the normalized value in row *i*, column *j* of the normalized matrix.

The result is the priority weight (wi) assigned to that row's element. The resulting vector w contains the local weights for all elements and reflects their relative importance within the corresponding comparison group. These weights are used in the following steps for consistency assessment and for calculating global weights in the final AHP synthesis.

2.2.4 Consistency Tests

After aggregating the expert responses into ten final judgment matrices, nine for each group of risk subfactors (F1 to F9) and one for the main risk factors, a consistency assessment was conducted. This step ensures the logical coherence of judgments prior to calculating priority weights.

The consistency test is a key component of the AHP framework. Since AHP relies on subjective pairwise comparisons, inconsistencies may arise, especially when comparing many elements. This test serves to:

- Validate the coherence of expert judgments,
- Ensure the reliability of the priority weights,
- Maintain methodological rigour, as proposed in Saaty's (1990) original AHP framework.

The Consistency Ratio (CR) was calculated using the following steps:

1. Calculate the Consistency Index (CI):

Equation 2.4: $$CI = \frac{\lambda_{max} - n}{n - 1}$$

Were:

- $\lambda\ max$ is the maximum eigenvalue of the matrix,
- n is the number of elements being compared.

Where in order to obtain *λ max:*

<u>1st Step: Priority (Weighted) Sum Vector calculation</u>

After computing the priority vector *w=[w1,w2,…,wn]T* (i.e., the vector of weights previously derived through normalization) the weighted sum vector *v=[v1,v2,…,vn]T* is obtained by multiplying the aggregated pairwise comparison matrix *A=[aij]* by the priority vector *w.* This process quantifies how well each criterion aligns with the assigned weights across the entire matrix.

Equation 2.5: $v = A \times w$

Where:

- A is the aggregated pairwise comparison matrix (size $n \times n$),
- w is the priority vector (local weights),
- v is the resulting weighted sum vector.

The vector v measures the alignment of each element's derived weight w_i with the original pairwise judgements in matrix A. It is a necessary step in computing the maximum eigenvalue λ_{max} used in the consistency test.

<u>2nd Step: λ *max* value calculation</u>

The principal eigenvalue λ*max* indicates how closely the judgments in the comparison matrix align with a perfectly consistent matrix. In a perfectly consistent matrix, λ*max*= n, where n is the number of elements being compared.

After computing the weighted sum vector (v=A·w), λ*max* is obtained as the average of the element-wise ratios between v and w. Then:

Equation 2.6: $$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{v_i}{w_i}$$

Were:

- v is the weighted sum vector,
- w is the priority vector,
- n is the number of elements being compared.

This value reflects how consistent the original judgments were. The closer λ_{max} is to *n,* the more consistent the matrix is considered to be. The computed λmax is then used to calculate the Consistency Index (CI) and, subsequently, the Consistency Ratio (CR).

Now,

CI is obtained for all the matrices.

2. Calculate the Consistency Ratio (CR):

$$\text{Equation 2.6: } CR = \frac{CI}{RI}$$

Where:

- CI: was previously calculated,
- Random Index (RI): The RI is a theoretical value that reflects the average consistency index of randomly generated pairwise comparison matrices. Its values, proposed by Saaty (1990), are as follows:

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	N/A[1]	N/A	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Interpretation

- If CR ≤ 0.10, the matrix is considered consistent, and the weights derived are reliable,
- If CR > 0.10, the matrix is inconsistent, suggesting the need to review or revise the judgments,
- If CR = 0, the judgment matrix is a complete consistency matrix.

Each of the 10 aggregated matrices were tested for consistency using the steps described above. All matrices obtained a CR below 0.10, indicating acceptable consistency levels, as shown in Table 2.5. Therefore, the resulting priority weights can be considered methodologically valid and were used in the subsequent phase for the quantitative risk scoring.

Table 2.5: Modified Saaty Scale vs. Traditional AHP Scale

Risk Factors	**CR Value**	**Status**
F1 - Management Systems	0.028	Consistent
F2 - Socio-Political	0.018	Consistent
F3 - Labour and Working Conditions	0.019	Consistent
F4 - Environmental	0.003	Consistent
F5 - Health, Safety, Security	0.014	Consistent
F6 - Indigenous Peoples	0.002	Consistent
F7 - Cultural Heritage	0.008	Consistent
F8 - Gender Equality	0.000	Consistent
F9 - Technological	0.004	Consistent
Main Risk Factors (F1–F9)	0.009	Consistent

[1] *N/A: Not applicable*

2.2.5 Final Calculation of Global Weights

The last step is to calculate the global weight which illustrates the influence level of sub-risk factors in the overall project. Global weight is equal to the local weight of each subfactors multiplied by the local weight of its corresponding criteria of the element. While local weights express the relative importance of subfactors within each main risk factor (e.g., how important F17 is within F1 – Management Systems), global weights measure their overall priority in the full hierarchy, thus enabling a direct comparison across all subfactors regardless of category.

This calculation was performed by multiplying each subfactor's local weight (obtained from its pairwise comparison within the respective main factor) by the local weight of its corresponding main factor (obtained from the pairwise comparison among the nine main factors).

The formula for global weight calculation is:

Equation 2.7: $$GW_{ij} = LW_i \times lW_{ij}$$

Where:

- $GWij$ = Global Weight of subfactor j under main factor i,
- LWi = *Local Weight* of the main factor i (from the AHP comparison of the nine main risk factors),
- $LWij$ = Local Weight of subfactor j (from the AHP matrix for subfactors under main factor i).

This computation was applied to each of the 59 subfactors defined under the nine main Risk factors. The result was a final prioritisation structure, where each subfactor has a unique global weight that integrates both its relevance within the group and the group's overall significance in the decision model. Furthermore, this overall significance can be observed through a worldwide ranking perspective (Annex D).

2.3 Application to a Wind Farm Case Study

Following the development of the E&S risk pre-screening tool, the tool was applied to a real-world case study with the objective of assessing its operational performance and practical relevance. This step involved not only the technical use of the tool but also the implementation of a structured process for its application, designed and executed by the author.

Case Study Selection and Scope

The case study comprises two onshore wind energy projects located in Spain, both part of the same project portfolio and currently under construction. The projects have installed capacities of 30 MW and 50 MW, respectively, and are situated in regions with favourable wind resource potential. Both projects are at comparable stages of development. The methodological decision to include two projects in a single case study is intentional and reflects the tool's intended use, which allows for the simultaneous evaluation and differentiated risk profiles assessment of up to three projects. This allows to support comparative decision-making. The tool operationalises a uniform set of E&S risk factors, weightings, and evaluation criteria, thereby ensuring methodological consistency across, in the case of the present pilot-application, both cases. In addition to providing graphical outputs that highlight the most influential risk factors for each project, the tool also determines which project exhibits the highest overall E&S risk level, thereby enabling experts to make informed, evidence-based decisions regarding project prioritisation and suitability for international financing.

These projects were selected for their methodological relevance, owing to the availability of detailed and diverse E&S documentation, as well as prior assessments conducted by two independent experts according to the IFC PS's. This made it possible to perform a retrospective comparison between expert-based judgment without the tool and the outcomes produced by the tool developed in this research. The documentation provided by the Customer, including Stakeholder Engagement Plans (SEPs), Environmental and Social Management Systems (ESMS), Environmental Impact Assessments (EIA), and project permits, allowed for a robust and realistic application of the tool. The availability of information provided by the client and/or infrastructure developer directly influences the analysis of compliance with international standards, since the absence of certain documentation during a specific project phase may lead to non-compliance or doubt in compliance with international criteria.

Due to confidentiality restrictions, project identifiers and location-specific data are not disclosed. It should be noted that the selected experts were legally authorized to access all the project documentation. Thus, all relevant information required to conduct the assessment was made available.

Implementation Process

The application of the tool to the selected case study followed a structured sequence of methodological steps:

1. Compilation and preparation of project documentation: All available E&S documentation provided by the client was reviewed and organised, including the ESMS, SEP, project-permits, and compliance assessments conducted during the lenders' Technical Due Diligence.
2. Evaluation protocol definition: Based on the structure of the tool, as well as the available documentation, a clear evaluation procedure was established to guide the scoring process for each of the 59 sub-risk factors included in the model.
3. Expert evaluation coordination: The same two experts who had previously analysed the projects under the IFC framework were asked to re-assess the projects using the developed tool. The experts were briefed on the tool's structure, logic, and use of the Excel interface, which was provided in a standardised format to ensure consistency.
4. Input and risk assessments: The two selected experts completed the evaluation of both projects using the Excel-based tool. Each of the 59 sub-risk factors were individually assessed based on their interpretation of the project documentation.
5. Results processing: The experts used the tool's built-in functionalities to automatically apply the global weights (previously determined through the AHP process) and generate risk scores per risk subfactor and risk factor. Subsequently, the technology generated visual outputs that presented the distribution and magnitude of E&S risks in both projects, including bar charts and comparative visuals.
6. Comparative analysis: Based on the outputs generated by the tool, the two experts interpreted the results to identify the most critical risk areas for each project. Additionally, the experts compared the risk exposure between projects in order to provide a realistic confirmation of the tool's ability to structure and synthesise expert judgement in real-world project scenarios.

7. Expert feedback on tool usability and structure: Following the evaluation, both experts were requested to complete a short forms to provide qualitative feedback on the tool's usability, assembly, and relevance value (Annex E). The testing form addressed several dimensions, including ease of use, analytical structure, time efficiency, potential for integration into professional workflows, and limitations encountered during practical application. Both experts had a two-week period to complete the assessment and provide their opinions. In accordance with the established technique, each evaluator used the tool and waited at least 24 hours before responding to the feedback questions, allowing for more contemplative and objective responses. These forms were not designed to collect statistical data, but rather to gather informed opinions and suggestions for tool's enhancement. The input supported additional instructions about clarity, interface usability, and the relevance of the risk structure to real project contexts, supporting further refinement of the tool.

Analytical Dimensions

In order to ensure that the outputs generated by the tool could be usefully evaluated, the analysis centred on the following dimensions, which are directly related to with the tool's design and its intended functionality:

- Identification of critical subfactors with the highest assigned risk levels, i.e. risk level obtained ≥ 4 (high and very high), to highlight priority areas of concern,
- Comparison between evaluators, to test the tool comparison usage functionality, results consistency and assess the robustness of the tool in synthesising potential different expert judgement,
- Comparison between projects (PA and PB), to evaluate whether the tool can differentiate risk profiles in projects with similar characteristics,
- Aggregation by main risk factors, to examine whether results remain consistent when analysed at higher categorical levels, in line with international E&S frameworks,
- Integration of qualitative feedback, to complement the quantitative outputs and assess the tool's usability and potential for professional integration.

The outputs generated during this case study application are further analysed and discussed in the Results chapter.

3. Results

This chapter presents the key results of the research, beginning with the development of the E&S Risk Pre-Screening Tool, followed by its pilot application to the previously described case study. The tool was designed in Microsoft Excel to provide a semi-quantitative, consistent, and comparable assessment of E&S risks across (RE) projects or portfolios. The first section describes the tool's structure, components, and functionalities as implemented in the Excel environment. The second section presents the findings of the pilot application of the tool to the previously presented case study considering two wind energy projects currently under construction. The objective was to test the tool's functionality, consistency, and usability by collecting structured risk scores from two experienced E&S professionals and analysing the resulting outputs. The results are structured around the thesis question: Can we develop a screening tool that enables a practical, consistent, and analytically robust assessment of E&S risks, applicable to RE projects or portfolios?

The results below are based on two expert evaluations of two wind energy projects using the Excel-based tool, and include both quantitative outputs (risk scores, classifications, visuals) and qualitative feedback collected via a structured form.

3.1 E&S Risk Screening Tool

The primary outcome of this research is the E&S Risk Screening Tool, which was created in Microsoft Excel and was designed to operationalise a semi-quantitative approach for the early-stage evaluation of E&S risks in renewable energy projects. The tool accommodates the simultaneous evaluation of up to three projects, applying a consistent set of risk factors, weightings, and scoring criteria with the goal of guaranteeing comparability.

The tool was designed comprising a number of interlinked worksheets, each performing a specific role within the assessment workflow. As the entry interface, the "Dashboard" sheet introduces and contextualizes the tool and its academical purpose. The "Methodology" sheet provides an overview of the analytical procedure, including the successive stages from risk factor characterisation, scoring and weighting to result aggregation. The "Instructions" sheet contains operational instructions that explain how to enter data, navigate between Excel spreadsheets, and interpret the outputs. The complete definitions of the nine Risk Factors (RF) and their corresponding Risk Subfactors (RSF), which together frame the evaluation criteria, are included in the "RF-RSF Definitions" sheet.

For the purposes of this dissertation, the tool was applied to a case study involving two onshore wind energy projects from the same development portfolio and both under construction. These projects were configured in the “Case Study” worksheet, which defines the identifiers, combinations, and parameters for comparative analysis, recording the contextual information relevant to this application.

The worksheet "Assessment_Tool" is where the assessment process is carried out. This begins with a Project Overview, where the user submits baseline information as the number of projects, assigns identifiers, and enters elementary characteristics such as technology type and location. Expert risk classifications are then entered for each subfactor. The embedded calculation modules apply the predefined global weights, compute factor-level and overall risk values, and store these within the underlying dataset. This dataset contains, for each project and subfactor, the global weight, applicability flag (“Applicable? Y/N”), assigned risk level between 1 (very low) and 5 (very high), weighted score, and qualitative and numeric classifications. Within the "Assessment_Tool" sheet, the tool generates a number of outputs, such as:

- Overall E&S risk score calculated for each project,
- Bar charts illustrating the most critical risk factors and subfactors for each project,
- Direct cross-project risk profile analysis through comparative graphs,
- Identification of the project(s) with the highest risk level for each individual subfactor,
- Pie chart displaying the most critical subfactors, based on the cumulative sum of all risk scores assigned.

Ultimately, the Google Forms is available in the tool’s tab “Google forms”, containing the link to the questionnaire used to validate the tool and collect user feedback. For reference, the full set of questions is also provided in Annex E. A complete, functional version of the E&S Risk Screening Tool is provided as a separate accompanying document to this dissertation.

3.2 Tool Application Outcomes

The application of the E&S Risk Screening Tool produced results that identified the most critical E&S risk subfactors for each project. In evaluator 1's assessment, three subfactors emerged with the highest risk scores across both Project PA and Project PB, i.e. risk level obtained ≥ 4 (high and very high) (Figure 3.1). These subfactors obtained the highest risk ratings in the dataset. No variation in scoring was observed between Project PA and Project PB, with identical values assigned to each subfactor in both cases. All the highest-rated subfactors relate to either ecosystem services or gender and social inclusion themes.

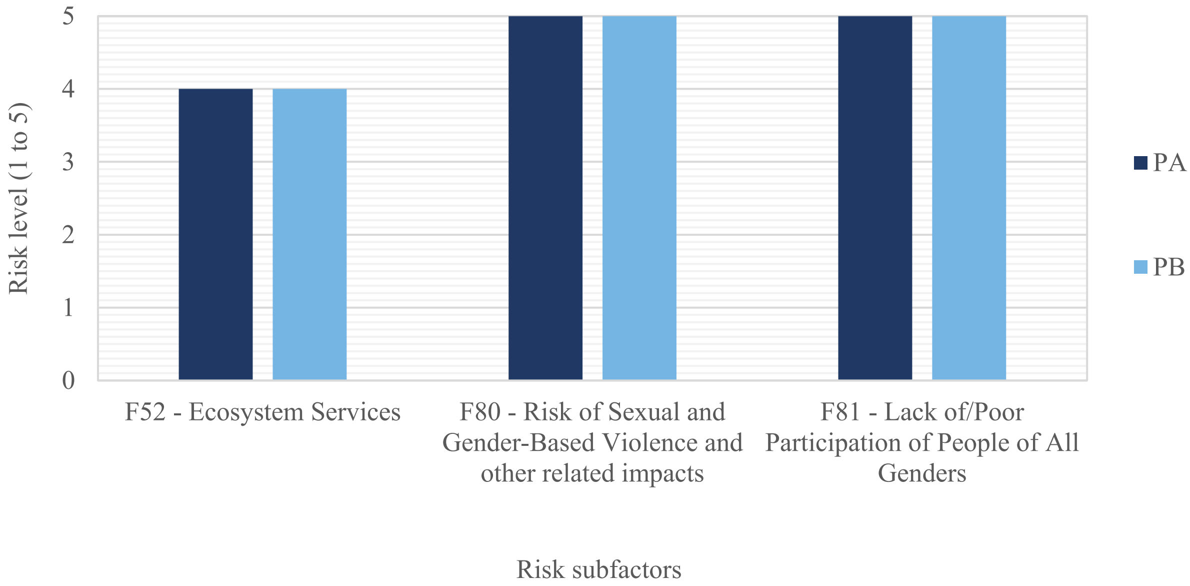


Figure 3.1: Most critical E&S risk subfactors in Projects PA and Project PB, results of evaluator 1's Assessment.

In evaluator 2's assessment two risk subfactors obtained the highest overall risk levels across both projects (Figure 3.2). Both subfactors reached the same final score in Project PA, while only one of them reached that level in Project PB. The subfactors refer to issues related to gender participation and site-specific challenges and were the only ones to stand out from the broader set of 59 evaluated items in this application.

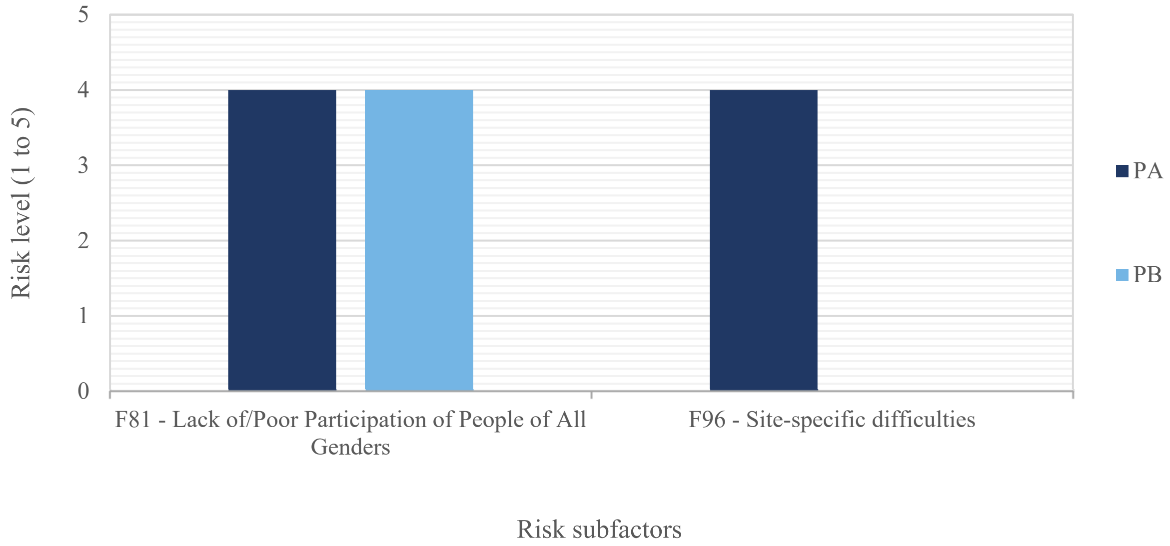


Figure 3.2: Most critical E&S risk subfactors in Projects PA and Project PB, results of evaluator 2's Assessment.

The highest-scoring risk subfactors in Project PA were identified from both expert evaluations (Figure 3.3). While the evaluators reached different conclusions regarding which subfactors were most critical, a common element, F81-Lack of/Poor Participation of People of All Genders, appeared in both assessments, although with a different level of severity. The remaining subfactors highlighted in each case differed, with one set focusing on gender-based violence and ecosystem impacts, and the other on contextual difficulties.

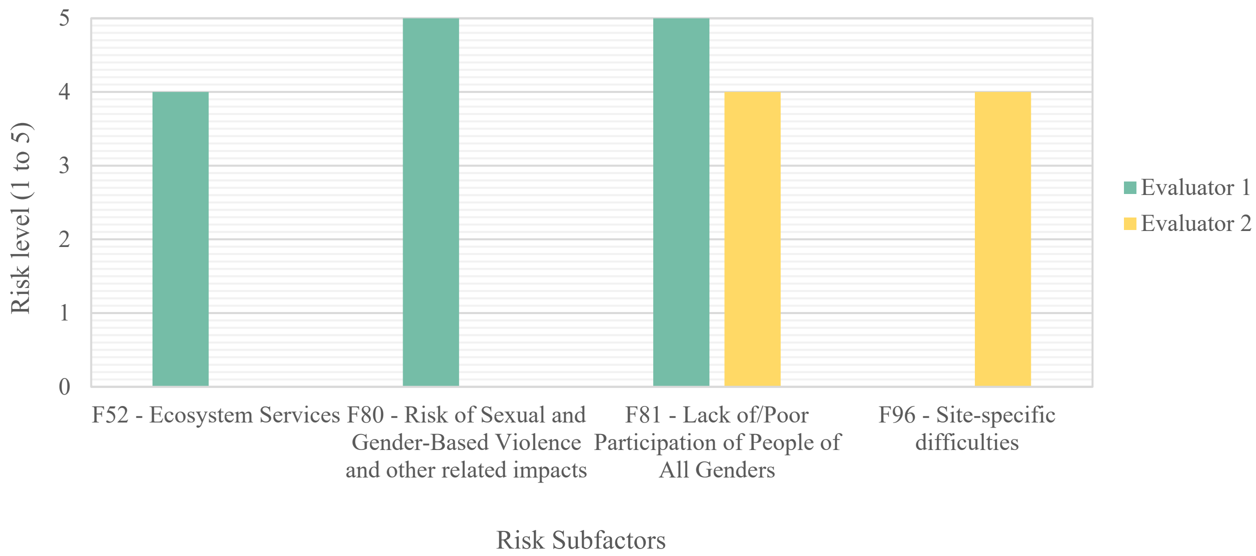


Figure 3.3: Comparison of the highest-scoring risk subfactors in Project PA, based on results obtained from evaluators 1 and 2.

The results obtained for Project PB reveal consistent patterns with those observed in Project PA. The highest-scoring subfactors differ between evaluators, with only one of them appearing in both evaluations (Figure 3.4). Similar to the previous case, F8-Gender-related issues are present in both assessments, but with different final scores.

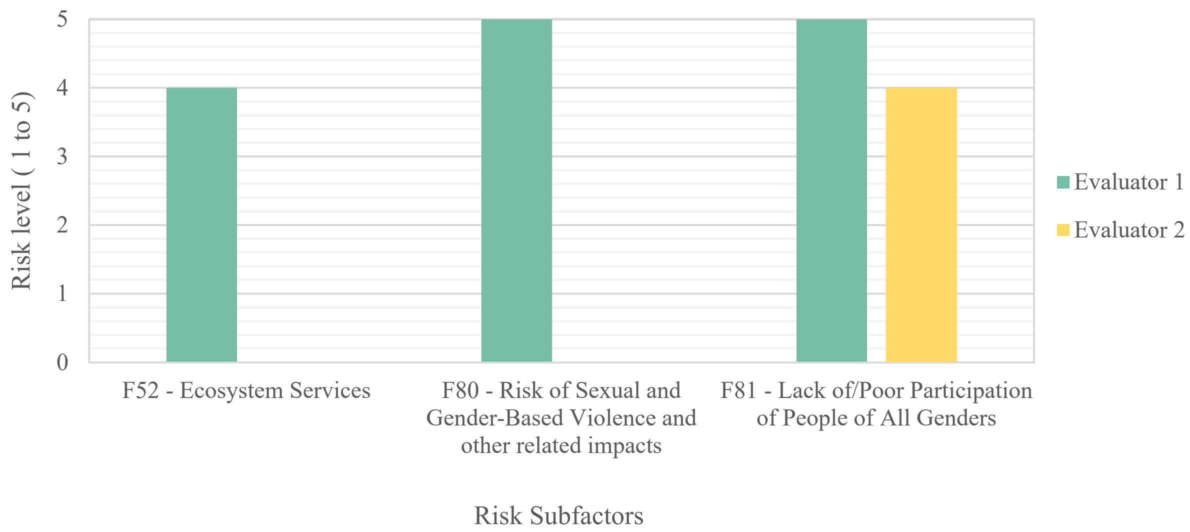


Figure 3.4: Comparison of the highest-scoring risk subfactors in Project PB, based on results obtained from evaluators 1 and 2.

Figure 3.5 and Figure 3.6 reflect the scores considering the sum of weighted subfactor risk levels calculated by the tool, based on the inputs provided by each evaluator. The results obtained by evaluator 1 for both projects showed variation in the cumulative risk scores across the nine main E&S risk factors (Figure 3.5).The grand totals for both projects were highly comparable, suggesting an overall similar level of risk exposure when all factors were aggregated. However, the distribution of scores across individual risk factors revealed meaningful differences. F2-Social-Political risks contributed most significantly to the overall totals, followed closely by factors related to F1-Management Systems, F5-Community Health and Safety, and F3-Labour and Working Conditions. These categories were consistently among the highest-scoring across both projects. Moderate differences were observed in factors such as F7-Cultural Heritage, F8-Gender Equality, and F4-Environment, which also showed relevant contributions to the total score but with small variations between projects. F6-Indigenous People was not included in this assessment, as evaluator 1 considered this factor not applicable to either of the projects during the initial configuration steps of the tool.

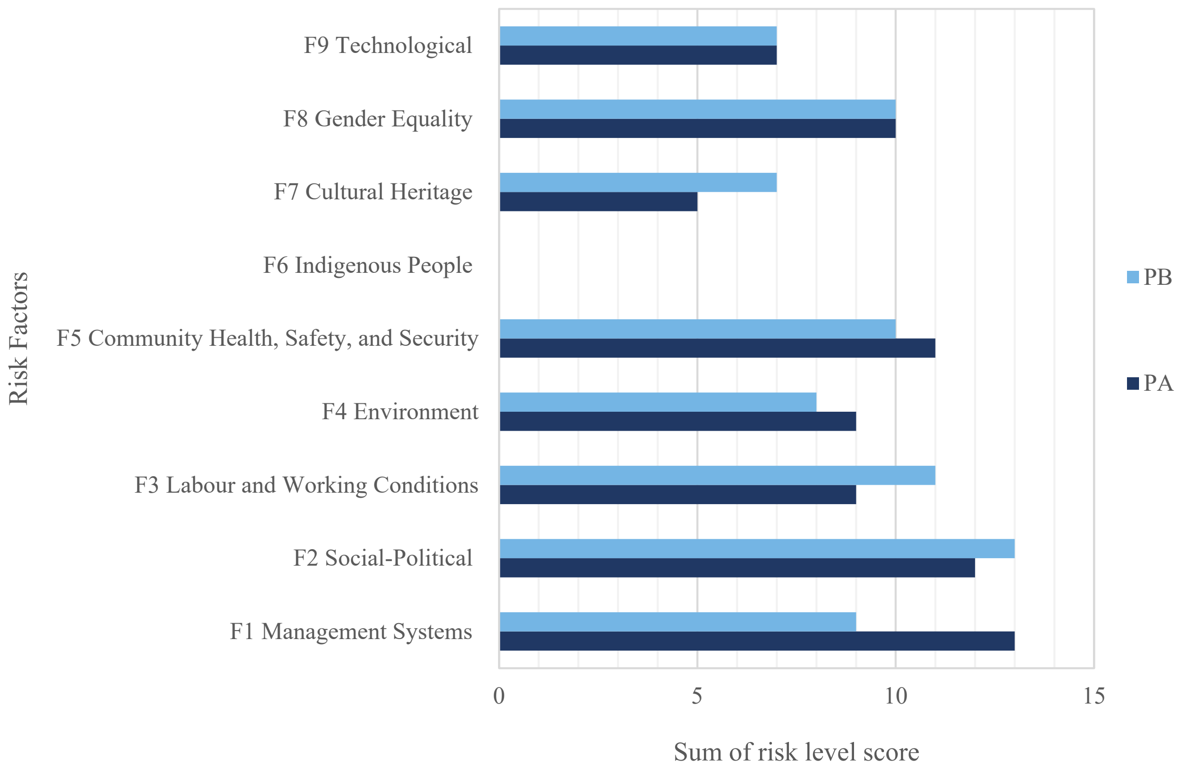


Figure 3.5: Aggregated risk factor scores for Project PA and Project PB based on results obtained by evaluator 1.

Regarding the grand totals for both projects obtained by evaluator 2, Figure 3.6 shows that they were very similar, indicating comparable overall risk exposure. Among the risk factors considered, F2-Social-Political and F1-Management Systems stood out as the most significant contributors. These were followed by F9-Technological, F4-Environmental, and F3-Labour-related factors, which also played a relevant role in the overall risk profile. A difference between projects was observed in the F8-Gender Equality category, with a higher risk score obtained in one of the cases. F5-Community Health, Safety, and Security, F6-Indigenous People, and F7-Cultural Heritage were not included in this assessment, as this evaluator considered these factors not applicable to either of the projects during the initial configuration of the tool.

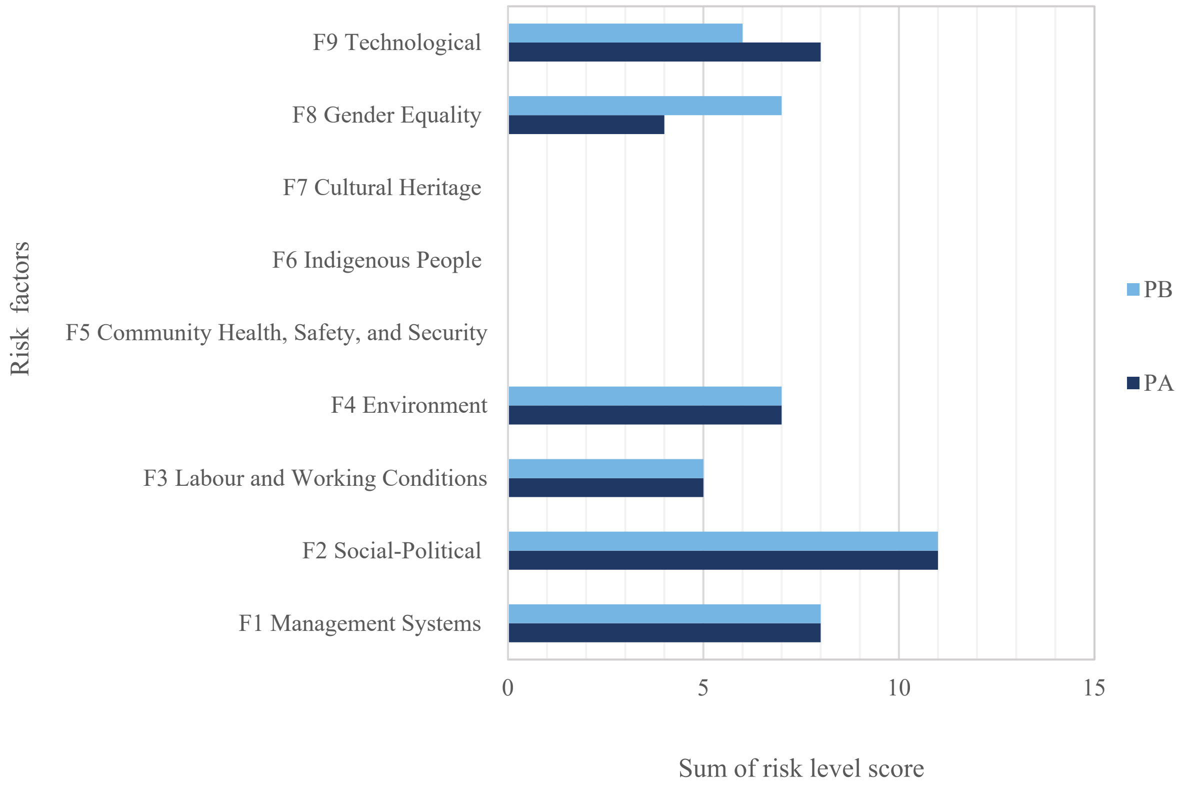


Figure 3.6: Aggregated risk factor scores for Project PA and Project PB based on results obtained by evaluator 2.

The aggregated risk scores obtained per main factor by the two evaluators to Project PA are presented in Figure 3.7. Both assessments identified F2-Social-Political and F1-Management Systems as the highest-scoring factors. Risk levels were also obtained in categories such as F3-Labour and Working Conditions, F4-Environment, F8-Gender Equality, and F9-Technological aspects. Evaluator 1 included additional risk factors not present in evaluator 2's configuration, namely Community Health, Indigenous People, and Cultural Heritage. These factors contributed to a higher grand total in evaluator 1's evaluation. Across the factors shared by both evaluators, higher scores were observed in evaluator 1's evaluation. The differences are reflected in the cumulative score totals obtained through the tool. Despite the variation in absolute scores, both assessments converged on the identification of institutional and social-related risks as central to the project's E&S risk profile.

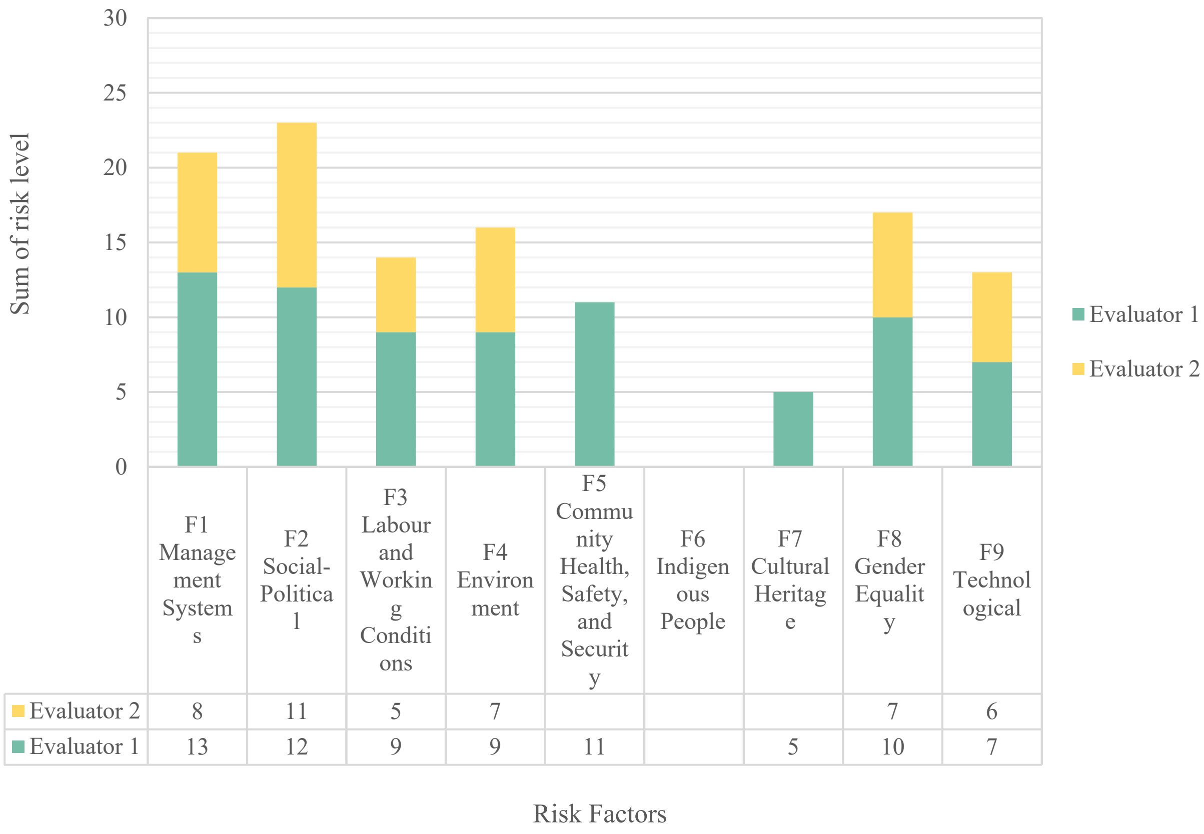
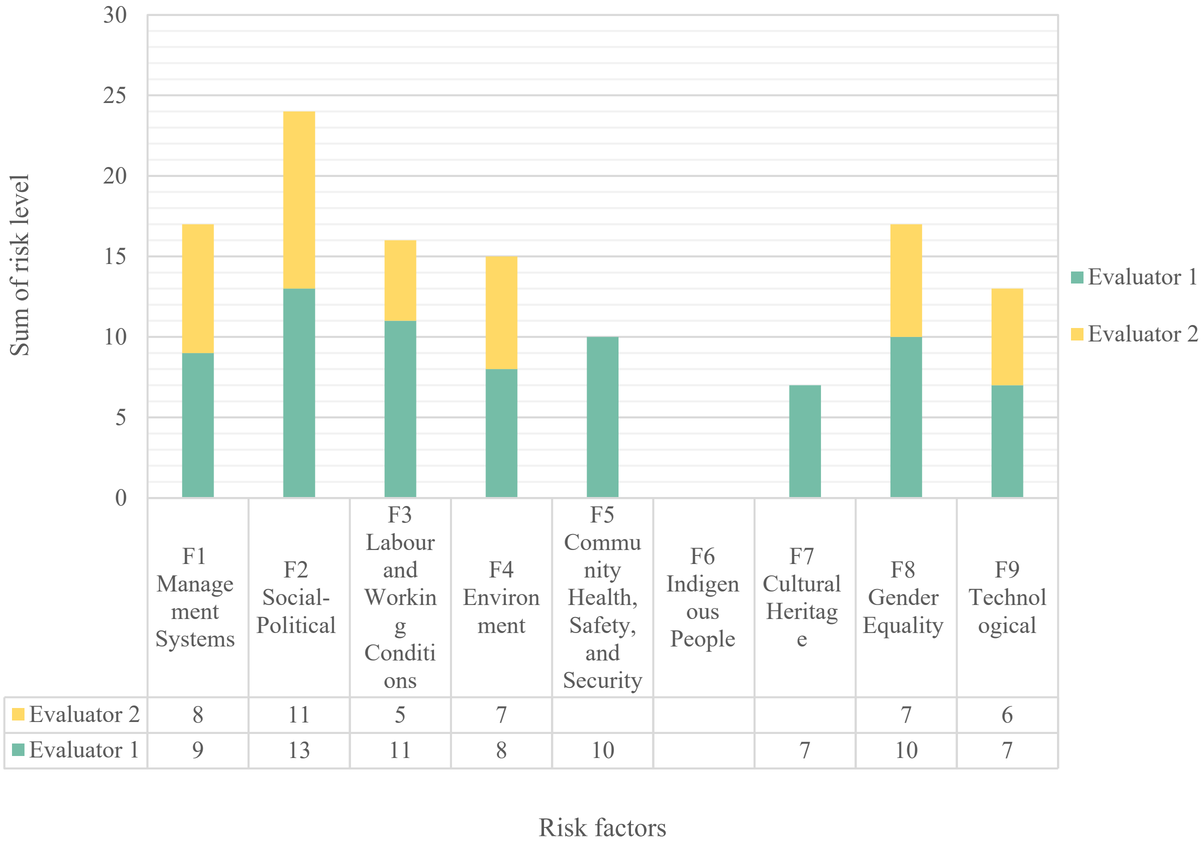


Figure 3.7: Comparison of Aggregated E&S Risk Factor Scores for Project PA Based on Evaluations by evaluator's 1 and 2.

Both evaluators reported the highest scores in the Social-Political and Management Systems categories as presented in Figure 3.8. Other factors with scores in both evaluations include F4-Environment, F3-Labour and Working Conditions, F8-Gender Equality, and F9-Technological aspects. Evaluator 1 also included F5-Community Health, Indigenous People, and F7-Cultural Heritage in the assessment, which were not considered applicable by evaluator 2. As a result, evaluator 1's evaluation resulted in a higher grand total. Among the factors evaluated by both, the scores obtained by evaluator 1 were consistently higher. This difference contributed to variation in the cumulative risk profiles produced by the tool for Project PB.



	F1 Management Systems	F2 Social-Political	F3 Labour and Working Conditions	F4 Environment	F5 Community Health, Safety, and Security	F6 Indigenous People	F7 Cultural Heritage	F8 Gender Equality	F9 Technological
Evaluator 2	8	11	5	7				7	6
Evaluator 1	9	13	11	8	10		7	10	7

Figure 3.8: Comparison of Aggregated E&S Risk Factor Scores for Project PB Based on Evaluations by evaluator's 1 and 2.

The Figure 3.9 shows the percentage of the risk score attributed to each project by each evaluator. These values were calculated by summing the weighted risk levels of all applicable subfactors and then converting the result into a percentage relative to the maximum possible score. The purpose of this comparison is to identify which of the two projects (PA or PB) presents a higher overall risk profile. Results indicate that the two projects achieved very similar final scores in each evaluator's evaluation, suggesting a comparable risk profile. Project PA received 42.9% and 24.3% of the maximum score from evaluator 1 and evaluator 2, respectively. Similarly, Project PB recorded 42.4% and 24.9% of the maximum score, as assessed by evaluator 1 and evaluator 2, respectively. In both cases, evaluator 1 assigned higher total scores, while the final values attributed to each project remained relatively similar within each evaluator's evaluation.

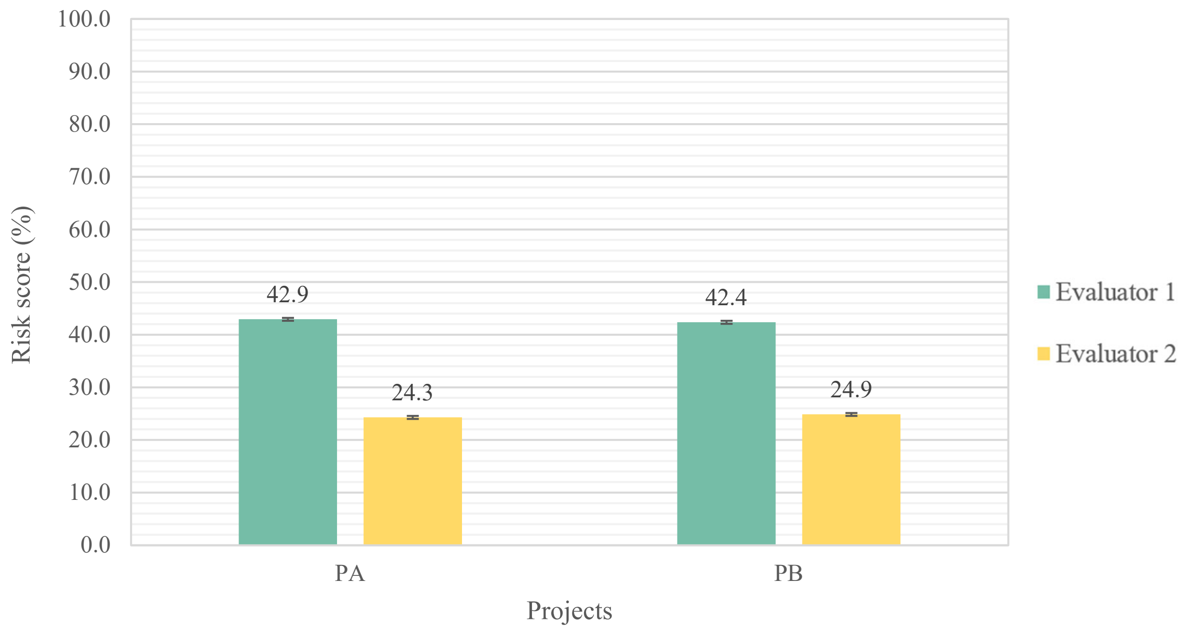


Figure 3.9: Percentage-Based Risk Scores by Project and evaluator.

3.3 Qualitative feedback on Tool performance

To complement the quantitative results, feedback was collected from both evaluators through a structured form consisting of 17 questions. The objective was to assess the usability, utility, and perceived robustness of the E&S Risk Screening Tool when applied to early-stage risk assessments in renewable energy projects.

Both evaluators agreed that the tool was easy to understand and user-friendly. In terms of time efficiency, one evaluator found it significantly more efficient than conventional approaches, while the other partially agreed. The tool was described as well-structured and visually effective, enabling clarity in both input and output. According to evaluator 1, the tool is particularly useful for screening large portfolios of projects, where time constraints may preclude in-depth project-by-project assessments.

The design of the risk factor structure and the clarity of visual outputs were also positively evaluated. The summarised scoring and graphical presentation of risk levels were considered particularly valuable for comparing E&S risks across projects. Both evaluators confirmed the tool's utility in enabling comparative analysis of project risks and supported its potential integration into routine environmental and social assessment workflows. The usefulness of the tool was positively noted for both risk identification and project comparison. Both evaluators selected multiple valuable features, as presented in the Figure 3.10.

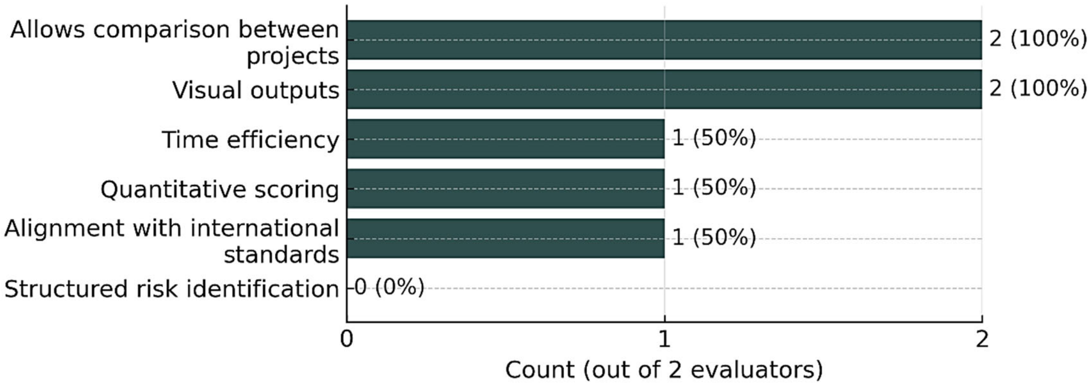


Figure 3.10: Aspects of the Tool Identified as Most Valuable by evaluators.

In parallel with these positive observations, the evaluators identified some limitations of the tool based on practical application experience. These are summarised in Table 3.1.

Table 3.1: Reported Limitations and Recommendations for Tool Enhancement

Feedback Theme	Evaluators' observations	Suggested Improvement
Applicability in Early Stages	Concern about assigning risk levels without full project documentation, especially in early-stage projects.	Clarify use cases, distinguishing between pre-screening and detailed evaluation.
"Not Applicable" Classification	Ambiguity in interpreting the "Not Applicable" option. For example, uncertainty arose whether to exclude certain aspects (e.g., hazardous waste, GHG emissions) because they are genuinely irrelevant, or because their risk is negligible at a given project stage.	Introduce a standardised guideline for defining applicability.
Preset Risk Classifications	Automated risk category assignments (e.g., scoring an impact as "Low" despite high perceived severity) were sometimes inconsistent with expert judgment. Particularly, differences by project type, size, or context may not be fully captured by default thresholds.	Enable confidence levels or comment fields to justify evaluator's interpretation.
Portfolio Homogeneity	Limitation due to projects being in the same region and development phase.	Enable input flexibility for geographic and temporal differentiation.
Framework Referencing	Overlap was noted between frameworks. While broadly aligned, specific institutional requirements may require greater flexibility or specificity in assessments.	Allow for framework selection (e.g., IFC, EBRD, WB, EPs, GLPs) during configuration.

When asked whether the tool's outputs aligned with prior internal assessments, feedback varied. One evaluator agreed that the results were consistent, while the other expressed neutrality. Regarding the tool's ability to identify additional or overlooked risks, one evaluator partially agreed, citing the explicit visibility of gender-based violence risks as an added value that had not been systematically addressed before using the tool. On the robustness of the tool's methodology, one evaluator viewed it as a reliable early-stage screening solution, whereas the other remained neutral. Both agreed that the structure aligns with key environmental and social standards, including those of the IFC, WB, IDB and EBRD. However, suggestions were made to incorporate references to the Equator Principles (EPs) and Green Loan Principles (GLPs), which are currently underrepresented. Furthermore, both evaluators expressed confidence that the tool could be realistically integrated into their professional assessment routines. One evaluator noted its usefulness as a solid starting point to be followed by more detailed evaluation and team discussions.

4. Discussion

The following chapter interprets and contextualises the results presented in Chapter 3, drawing connections between the outputs of the tool's pilot application and the broader research objectives previously described. The discussion is organised around the key elements of the tool's performance: its analytical consistency, practical usability, and potential applicability across different types of RE projects to critically evaluate whether the E&S Risk Screening Tool successfully addresses the complexity of project assessments, as outlined in the thesis objectives.

Alignment with International Standards and Tool Design

One of the most relevant findings from the present pilot application is the alignment between the tool's structure and the internationally recognised E&S standards used during its development. Evaluators confirmed that the tool effectively compiles and operationalises key requirements and performance indicators drawn from these frameworks, which reinforces its relevance and credibility as a project screening instrument, that can serve both technical and institutional needs. This directly contributes to the achievement of objective nº 1: "Identify key requirements and performance indicators relevant to project or portfolio pre-screening based on internationally accepted E&S benchmarks". Nonetheless, the feedback also highlighted opportunities to expand the tool's coverage. The absence of explicit references to the EPs and GLPs was noted as a limitation, particularly for projects that are structured around these frameworks to further align the tool with current financial market expectations. According to evaluator 2, although overlaps exist among the institutional standards, the ability to tailor assessments to specific frameworks would enhance the tool's flexibility. This feedback highlights the importance of expanding the tool's configurability to meet the specific requirements of different financiers or costumers, especially as E&S expectations become increasingly nuanced. However, it is important to recognise that the tool was intentionally designed using international E&S standards that already present a high degree of convergence. As more frameworks such as the EPs or GLPs are integrated, it may become increasingly difficult to preserve an accurate and functional synthesis across all requirements, particularly given that individual assessments often demand distinct technical details and documentation. Considering the tool's purpose as a first-step screening mechanism, its role is not to provide an exhaustive compliance check, but rather to help identify key areas of E&S risk that may justify (or not) further investment of time and resources. In this context, results show the potential of the tool to support preliminary strategic decisions, such as determining whether a project is suitable for financing applications or which among several options should be prioritised. Furthermore, the perspectives provided by the evaluators may be partially influenced by their consulting roles, which tend to favour detailed framework-by-framework evaluations. While this perspective is valid, it may differ from the operational needs of project developers or portfolio analysts, who often require agile and resource-efficient tools to support early-stage prioritisation. Despite this, the overall structure was seen by the evaluators, as a first approach to guide early E&S risk screening.

Usability, Clarity, and Integration into Practice

Feedback on usability and interface clarity was notably positive. Both evaluators considered the tool easy to use and visually effective, with potential for integration into their consultancy workflows. The clarity of inputs, the stepwise organisation of criteria, and the automatic generation of comparative visuals were noted as strengths. This directly contributes to objective nº 3: "developing a practical and user-friendly tool". The capacity to generate comparative visuals automatically and to present scoring in a clear, logical format was considered particularly advantageous for the evaluators. This reinforces the value of the tool as a support system for risk assessment in a pre-screening phase. Despite its strengths, the tool's limitations were highlighted as key areas for refinement. Ambiguity around the "Not Applicable" classification of risk subfactors emerged as a critical point. Evaluator 1 raised concerns about whether this designation reflected irrelevance or simply a low-risk phase. This reinforces the importance of clearly operationalising what constitutes "applicability" within the tool's methodology. For a screening-level instrument designed to be used in early stages, often before complete documentation is available, it is expected that some dimensions of risk will remain partially unknown or context-dependent. However, the absence of a standardised rationale for applying the "Not Applicable" label may introduce the risk of inconsistency across users and projects. Establishing guidance that distinguishes between truly irrelevant risk factors and those with negligible impact in a specific project phase would strengthen the methodological robustness of the tool. Moreover, in the context of renewable energy, certain impacts such as GHG emissions, may not be "negative" per se, but their inclusion could be reframed as an opportunity for positive differentiation (e.g., decarbonisation potential). Thus, rather than omitting these aspects altogether, a revised framework could encourage evaluators to register these under a 'positive screening' dimension or mitigation potential. This could translate into a positive effect, lowering the overall risk sum score of the projects.

Variation in Risk Perception and Professional Judgment

The tool, nevertheless, effectively differentiated between E&S risk factors across projects. Despite minor variations in project-specific risk scores, particularly a general tendency for evaluator 1 to assign higher scores, both Project PA and Project PB exhibited highly comparable overall risk profiles, as indicated by similar grand totals and percentage-based scores. This suggests the tool's capacity to support relative risk comparison in screening phases, which is a crucial functionality when dealing with large portfolios under time constraints. Moreover, the variation in risk perception observed between evaluators aligns with known subjectivities inherent in E&S assessments, particularly when qualitative criteria concerning people's judgment and perception of risks are involved. Despite sharing a similar professional background and having worked together in the same team for the past five years, the divergence in risk scores, most notably evaluator 1's assignment of higher ratings, highlights the influence of individual judgment and interpretative nuances as subtle differences in risk perception, individual judgment style, or interpretation of the tool's guidance framework, even within aligned expert profiles. Rather than undermining the tool's robustness, this variation shows the importance of designing structured tools that accommodate professional judgment while still enabling comparability supported by clear guidance and training. This flexibility can be considered a design strength rather than a shortcoming when the methodology offers enough transparency and documentation to trace decision-making pathways. Importantly, both evaluators agreed on the tool's potential for integration into their workflows, suggesting that despite interpretative differences, the tool provides a solid platform for structured discussion and prioritisation.

Analytical Robustness and Validation Across Cases

The visual and quantitative outputs offer a replicable structure that aligns with international standards such as IFC and EBRD, validating the tool's potential for practical use in alignment with objective nº4: "Validate the tool by applying it to a real-world case study, comparing the outcomes with actual project results and expert feedback to ensure its reliability, usability, and relevance". Regarding the retroactive comparison, although one evaluator agreed that the tool's outputs aligned with prior internal assessments, the other remained neutral. This variation may be attributed to differences in project familiarity, methodological expectations, or the level of detail available. Still, the evaluators recognised the value of the tool in making certain risks, such as gender-based violence, more visible than in prior assessments without the tool. This suggests the tool has added value in supporting systematic and comprehensive identification of E&S risks.

The results also indicated a pattern in which Social-Political and Management Systems factors emerged as the most critical across assessments. This consistency in aggregated risk factor scores indicates that the tool is capable of guiding users toward similar conclusions, even when applied by different experts. This supports objective nº 2 of the study, which focused on "developing a robust and standardised assessment framework". Moreover, this consistency across assessments demonstrates that the underlying structure of the tool is not only methodologically sound but also aligned with broader sectoral trends and governance priorities. The recurring visibility of gender and inclusion-related risks suggests that the tool may enhance the identification of under-assessed social factors, which are often neglected in early-stage evaluations. Such visibility is particularly valuable, as it promotes a more balanced approach to E&S risk screening that extends beyond traditional biophysical or technical issues. Another dimension to consider is the influence of the global weights derived from the initial AHP-based expert judgment process. While the use of the geometric mean helped to mitigate the influence of outlier judgments within the expert group, the composition of the expert pool inevitably shaped the outcome. Characteristics such as the experts' familiarity with the type of renewable energy technologies assessed, their experience with host country legal and permitting frameworks, and the extent of their involvement in E&S reviews, whether high-level or detailed, likely introduced a collective bias that reflects a particular "risk appetite". This, in turn, influenced the final global weights assigned to each risk subfactor, and consequently shaped the results observed in the evaluations carried out by the two evaluators. The findings should therefore be interpreted not only as a reflection of the specific project risks, but also as a manifestation of the expert group's perception and weighting of those risks. This also resonates with the limitation raised by evaluator 1, who noted that the automatic assignment of risk categories may oversimplify certain contextual realities, such as technology type, geographic conditions, or project maturity. This observation points to the need for further calibration of scoring thresholds, or alternatively, the introduction of qualitative justifications to preserve context-specific accuracy. More broadly, it suggests that the AHP-derived weights should not be viewed as static, but rather as a dynamic component that may benefit from periodic reassessment as the user base, technology types, and geographies evolve. Similarly, the tool's scoring architecture might benefit from sensitivity to project phases and regional frameworks. While such features could improve contextual precision, they must be carefully balanced against the aim of standardisation, a trade-off that reinforces the view that this tool is designed to complement, not replace, detailed due diligence processes. Another element that reinforces the complementary role of the tool is the observation that, although the specific subfactors flagged as most critical varied between evaluators, certain themes consistently emerged as high risk. This convergence suggests that the tool is successful in structuring expert analysis and directing attention to priority areas, without overriding the evaluators' individual expertise. In fact, this divergence in specific results, particularly in qualitative domains, further underlines the importance of professional judgment in any E&S risk evaluation. Rather than diminishing the tool's utility, this variability confirms its value as a structured support mechanism that enables comparability and transparency, while leaving room for contextual interpretation. This outcome directly supports the central design intention: to provide a screening tool that facilitates, but does not substitute, expert-driven analysis.

Scope, Limitations, and the Tool's Complementary Role

One of the additional strengths highlighted during tool's preliminary validation was its value in comparing multiple projects under time constraints. Evaluator 1 specifically noted that the tool offers clear advantages in screening large portfolios, where comprehensive, project-specific due diligence may not be feasible at initial stages. This is a key achievement in fulfilling the central research question, i.e. developing a screening tool that enables preliminary risk assessments across project types. However, limitations were noted regarding applicability in projects at very early stages, where documentation may be lacking. While this concern is valid, it is important to distinguish between the concept of "early-stage" in terms of project development and the intended purpose of the tool as a screening mechanism. In this context, screening refers to a preliminary, high-level assessment of E&S risks that can be conducted independently of the project's maturity stage. The objective is not to deliver a definitive diagnosis, but to provide a structured overview that helps identify potential red flags, support prioritisation, and inform subsequent assessment needs. If documentation is lacking due to the project's immaturity, the difficulty in performing the assessment is not a shortcoming of the tool per se, but a constraint inherent to the assessment process itself. In such cases, any effort to conduct E&S due diligence, whether supported by the tool or not, would face similar limitations. Nevertheless, acknowledging the evaluator's feedback, it is fair to recognise that the tool's utility is inherently linked to the availability of a minimum level of project information. As such, although this constraint is not exclusive to the tool, it should be considered a contextual limitation that may affect its effectiveness in very early-stage applications. This nuance is critical, and it matches its first intention which is: while the tool is not intended to replace full-scale due diligence, it serves as a resource-efficient first step that can streamline subsequent assessment stages. This finding supports the tool's intended use as a complement to traditional E&S evaluation processes rather than a standalone diagnostic. Another recognized advantage, as reported by the evaluators, was its visual clarity and capacity to synthesise complex information into actionable outputs. This feature is particularly valuable for early-stage screening, where decision-makers may require simplified summaries to prioritise risk mitigation actions.

The pilot application confirms that the E&S Risk Screening Tool provides a practical and structured method for early risk identification and comparison. Its visual outputs and logical structure make it especially suitable for consultancy firms, financial institutions, and developers seeking to pre-screen projects before entering deeper phases of analysis. However, it should be seen as a complementary, not standalone, instrument. Its strength lies in early-stage screening, but its use must be accompanied by contextual expertise and follow-up validation. In this regard, the tool supports but does not replace in-depth due diligence, as expected.

5. Final Considerations and Recommendations

The development of the E&S Risk Screening Tool represents a meaningful step toward professionalising and systematising E&S risk assessment in RE project planning. This thesis demonstrated that it is possible to construct a semi-quantitative tool that strikes a balance between analytical rigour, through weighted scoring, expert input, AHP-derived structure, and practical usability. By drawing on internationally recognised standards and incorporating expert-informed criteria, the tool responds to a well-recognised gap in early-stage E&S evaluation: the need for consistent, resource-efficient methods that support initial decision-making.

The pilot application pre-validated the tool's core utility. Despite the small-scale scope of the case study, the results illustrate the tool's capacity to structure expert analysis, enhance comparability across projects, and flag critical risk dimensions in a transparent and methodologically sound manner. The visual outputs, user-friendly layout, and standardised scoring mechanisms were found to be particularly valuable for users operating across jurisdictions or managing large portfolios. Importantly, the tool also helped elevate less visible social themes, such as gender inclusion, demonstrating its potential to surface issues often underrepresented in traditional assessments.

It is important to emphasise that this tool is not intended to replace in-depth ESDDs, but rather to function as a decision-support mechanism, one that assists stakeholders in identifying where further attention and resources are most warranted. Its value lies in enabling structured dialogue, promoting internal alignment on risk priorities, and providing a replicable first pass at identifying E&S concerns. The feedback gathered from expert users confirmed this intended function while also surfacing opportunities for refinement and further development. Based on the insights generated throughout this research, the following recommendations are proposed for future iterations and applications of the tool:

1. Enhance contextual adaptability: Incorporate more dynamic parameters to adjust risk sensitivity depending on project type, location, or maturity. This would allow the tool to better reflect site-specific or technology-specific nuances without compromising its standardised nature.
2. Broaden the sample base for validation: This study was limited to two evaluators and one case study with two projects. Expanding the sample, both in terms of the number of users and the diversity of project types, would be essential to evaluate the tool's generalisability and performance across different use cases.
3. Diversify project types in future applications: Both case studies focused on wind energy projects within similar geographic and regulatory contexts. Testing the tool on other renewable technologies such as solar PV, biogas or hybrid systems would provide valuable insights into its applicability across the broader renewable energy landscape.
4. Clarify ambiguous classifications: Provide clearer internal guidance for borderline or ambiguous designations, such as "Not Applicable", to minimise variability in user interpretation and maintain scoring consistency across different applications.
5. Create modular framework options: Allow the tool to operate in a modular fashion, where users can select specific frameworks (e.g., IFC, EBRD, EPs, GLPs) depending on client or investor needs. This balances standardisation with necessary flexibility and may increase the tool's adoption among finance-driven stakeholders.
6. Update weighting structures periodically: The risk weighting model, based on expert judgment, should be treated as a living component of the tool. Regular recalibration, through the engagement of new expert panels or feedback from users, will help the tool remain relevant across changing regulatory, market, and technological contexts.
7. Enable positive impact recognition: Introduce a "positive screening" or opportunity-scoring dimension to capture potential project benefits such as carbon mitigation, biodiversity restoration, or social inclusion measures. This evolution would allow the tool to align more closely with impact-oriented financing mechanisms.
8. Invest in user training and calibration: To enhance comparability across users, especially in multi-analyst or cross-organisational settings, it is recommended to pair tool deployment with

short training modules or calibration sessions, particularly around the more interpretative aspects of risk classification.

In an increasingly complex project finance landscape, early-stage risk screening tools have the potential to enhance both efficiency and accountability. This thesis presents a first step toward operationalising such a tool for renewable energy projects. While refinements will be necessary, the underlying structure demonstrates clear utility in guiding structured and transparent E&S prioritisation. With further development, this approach could form part of a broader strategy to align project development practices with sustainability targets and financing expectations.

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Annex A

Table A.1: Definitions of the 9 Risk Factors (F1 to F9).

Risk sub factors	Definition
F1	**F1 Management Systems Factor:** Underscores the importance of managing environmental and social performance throughout the life of a project. An effective Environmental and Social Management System (ESMS) is a dynamic and continuous process initiated and supported by management, and involves engagement between the client, its workers, local communities directly affected by the project (the Affected Communities) and, where appropriate, other stakeholders. A good ESMS appropriate to the nature and scale of the project promotes sound and sustainable environmental and social performance, and can lead to improved financial, social, and environmental outcomes. (IFC, 2012).
F2	**F2 Social-Political Factor: R**efers to the potential risks and uncertainties associated with the social and political environment in which a project or business operation is undertaken. It encompasses the social dynamics, community relations, governance structures, and political stability of the host country or region.
F3	**F3 Labour and Working Conditions Factor:** Recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental1 rights of workers. For any business, the workforce is a valuable asset, and a sound worker-management relationship is a key ingredient in the sustainability of a company. Failure to establish and foster a sound worker-management relationship can undermine worker commitment and retention and can jeopardize a project. Conversely, through a constructive worker-management relationship, and by treating the workers fairly and providing them with safe and healthy working conditions, clients may create tangible benefits, such as enhancement of the efficiency and productivity of their operations (IFC, 2012).
F4	**F4 Environmental Factor:** Refers to the potential risks and impacts on the natural environment associated with a project or business operation. It encompasses the ecological, biodiversity, and resource-related aspects that may be affected by the project's activities**.**
F5	**F5 Community Health, Safety, and Security Factor:** Recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration and/or intensification of impacts due to project activities. While acknowledging the public authorities' role in promoting the health, safety, and security of the public, this Factor addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups (IFC, 2012).
F6	**F6 Indigenous People Factor:** Recognizes that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. In many cases, their economic, social, and legal status limits their capacity to defend their rights to, and interests in, lands and natural and cultural resources, and may restrict their ability to participate in and benefit from development. Indigenous Peoples are particularly vulnerable if their lands and resources are transformed, encroached upon, or significantly degraded. Their languages, cultures, religions, spiritual beliefs, and institutions may also come under threat. As a consequence, Indigenous Peoples may be more vulnerable to the adverse impacts associated with project development than non-indigenous communities. This vulnerability may include loss of identity, culture, and natural resource-based livelihoods, as well as exposure to impoverishment and diseases.

F7	**F7 Cultural Heritage Factor:** Recognizes the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that clients protect cultural heritage in the course of their project activities. In addition, the requirements of this Performance Standard on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity (IFC, 2012).
F8	**F8 Gender Equality Factor**: Recognizes, regardless of the cultural or ethnic context, the right to equality among genders as established in applicable international agreements. The pursuit of equality requires actions aimed at equity, which implies providing and distributing benefits and/or resources in a way that narrows existing gaps, recognizing that the existence of these gaps can harm people of all genders (IBD, 2020).
F9	**F9 Technological Factor:** Refers to the potential risks and uncertainties associated with the use and implementation of technology within a project or business operation. It encompasses the challenges and impacts related to technological systems, equipment, processes, and innovation.

Table A.2: Definitions of Subfactors under F1: Management Systems Risk Factor.

Risk Subfactors	Definitions
F10	**F10-Lack of/Poor Essential Policies**: The Essential Policies cover all relevant Environmental, Social, Health & Safety (ESHS) aspects.
F11	**F11-Lack of/Poor mechanisms for risks/impacts identification:** It is the establishment and maintained of a process for identifying the environmental and social risks and impacts of the project. Presence of appropriate and relevant methods and assessment tools.
F12	**F12-Lack of/Poor Organizational Capacity:** The Project Sponsor or other responsible entity's internal organization and its capability to mitigate risks and impacts effectively and efficiently, providing an ongoing basis to achieve continuous ESHS progress/goals and an overall successful Project implementation.
F13	**F13-Lack of/Poor Management Programs:** The presence of MPs, that describe " mitigation and performance improvement measures and actions that address the identified environmental and social risks and impacts of the project" (IFC 2012).
F14	**F14-Lack of/Poor EPR:** The EPR must include "identification of areas where accidents and emergency situations may occur, communities and individuals that may be impacted, response procedures, provision of equipment and resources, designation of responsibilities, communication, including that with potentially Affected Communities and periodic training to ensure an effective response." (IFC, 2012)
F15	**F15-Lack of/Poor Monitoring and Reviewing Capacity:** "The client establishes procedures to monitor and measure the effectiveness of the management program, as well as compliance with any related legal and/or contractual obligations and regulatory requirements." (IFC,2012). Tracking changes in capacities.
F16	**F16-Risks linked to management and control of Funds.** *Examples include but are not limited to* Missing a deadline for the investment.
F17	**F17-Land Requirements Related Risks:** Ownership and management of the permitting process are in place.

Table A.3: Definitions of Subfactors under F2 Social-Political Risk Factor.

Risk Subfactors	Definitions
F20	**F20-Compliance with National Policies and Law:** Conformity with laws, regulations, and guidelines created by government legislations and regulatory bodies.
F21	**F21-Absence of/Poor Stakeholder Analysis:** The process of collecting information from a strategic perspective and different sources to outline the key stakeholders (both Affected and Interested Parties) and their needs that could be impacted by (or could impact) the project.
F22	**F22-Absence of/Lacking Stakeholder Engagement Plan:** Communication strategy to inform the stakeholders about the scope of their projects, increasing the likelihood of positive project outcomes. Must include**:** Stakeholder identification; stakeholders' interests and their influence; identification of tools to be used to execute stakeholder engagement.
F23	**F23-Poor Grievance Management for Affected Communities:** "It should seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate and readily accessible, and at no cost and without retribution to the party that originated the issue or concern." (IFC, 2012).
F24	**F24-Lack of/Poor Ongoing Reporting to Affected Communities:** "Provide periodic reports to the Affected Communities that describe progress with implementation of the project Action Plans on issues that involve ongoing risk to or impacts on Affected Communities and on issues that the consultation process or grievance mechanism have identified as a concern to those Communities. The updated relevant mitigation measures or actions will be communicated to them. The frequency of these reports will be proportionate to the concerns of Affected Communities but not less than annually." (IFC, 2012).
F25	**F25-Physical Displacement: "**An involuntary resettlement (relocation or loss of shelter) as a result of project-related land acquisition or restriction of access to natural resources." (EBRD, 2019)
F26	**F26-Economic Displacement-** "An involuntary resettlement (loss of assets or access to assets that leads to loss of income sources or means of livelihood as a result of project-related land acquisition or restriction of access to natural resources." (EBRD, 2019)
F27	**F27-Absence of/Poor Resettlement Plan. "**The document in which a project sponsor or other responsible entity specifies the procedures that it will follow and the actions that it will take to mitigate adverse effects, compensate losses, and provide development benefits to persons and communities affected by an investment project." (IFC, 2002).

Table A.4: Definitions of Subfactors under F3 Labour and Working Conditions Risk Factor.

Risk Subfactors	Definitions
F30	**F30-Risks related to workers' working conditions and terms of employment.** "Project workers are provided with information and documentation that is clear and understandable regarding their terms and conditions of employment. The information and documentation will set out their rights under national labor and employment law (incl. any applicable collective agreements), including their rights related to hours of work, wages, overtime, compensation, and benefits, as well as those arising from the requirements of this ESS. This information and documentation will be provided at the beginning of the working relationship, and when any material changes, to the terms or

	conditions of employment, occur. deductions; hours of work; overtime arrangements and overtime compensation; breaks; rest days; and leave for illness, maternity, vacation or holiday". (WB, 2018)
F31	**F31-Absence of /Limited opportunities to join workers' organizations:** Labor Organization is any union or association of employees in the private sector which exists in whole or in part for the purpose of collective bargaining or of dealing with employers concerning terms and conditions of employment.
F32	**F32-Risks of discrimination and lack of/poor access of equal opportunities:** "The client takes measures to prevent and address harassment, intimidation, and/or exploitation" (IFC, 2012). The principles of non-discrimination apply to women, migrant workers, people with disabilities and other disadvantaged/minority groups.
F33	**F33-Retrenchment:** "Collective dismissals cover all multiple dismissals that are a result of an economic, technical, or organizational reason; or other reasons that are not related to performance or other personal reasons." (IFC, 2012).
F34	**F34-Lack of/Poor Workers Grievence Mechanism: "**The mechanism should involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides timely feedback to those concerned, without any retribution. The mechanism should also allow for anonymous complaints to be raised and addressed. The mechanism should not impede access to other judicial or administrative remedies that might be available under the law or through existing arbitration procedures, or substitute for grievance mechanisms provided through collective agreements." (IFC,2012)
F35	**F35-Risk of Child labor:** "The client doesn't employ children in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development**.** Persons under the age of 18 will be subject to an appropriate risk assessment and regular monitoring of health, working conditions, and hours of work." (IFC, 2012).
F36	**F36-Risk of Forced labor:** Consists of "any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labor, such as indentured labor, bonded labor, or similar labor-contracting arrangements. The client will not employ trafficked persons." (IFC, 2012)
F37	**F37-Occupational Health and Safety Risks of direct workers:** Probability of a person may suffer "harm or an adverse health effect if/when exposed to a hazard. Areas that should be addressed i) identification of potential hazards to workers; (ii) provision of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances; (iii) training of workers; (iv) documentation and reporting of occupational accidents, diseases, and incidents; and (v) emergency prevention, preparedness, and response arrangements". (IFC, 2012)
F38	**F38-Risks related to Workers Engaged by Third Parties:** Regrading contracted workers "the client will take commercially reasonable efforts to ascertain that the third parties who engage these workers are reputable and legitimate enterprises and have an appropriate ESMS" (IFC, 2012)
F39	**F39-Supply Chain Sensitivity:** The volatility in the sequences of processes involved in the production from the origin to the final destination. Example: Presence of child labor or forced labor in the primary supply chain.

Table A.5: Definitions of Subfactors under F4 Environmental Factor Risk Factor.

Risk Subfactors	Definition
F40	**F40-Resource Efficiency related issues/risks:** Resource efficiency includes "technically and financially feasible and cost-effective measures for improving efficiency in a company's consumption of energy, water, as well as other resources and material inputs, with a focus on areas that are considered core business activities. Such measures integrate the principles of cleaner production into product design and production processes with the objective of conserving raw materials, energy, and water." (IFC, 2012). Examples include but are not limited to: supply material in geographically conflicting areas; Company difficulty in managing systems.
F41	**F41-GHG emissions associated with Project:** Gaseous constituents of the atmosphere, both natural and anthropogenic, absorb and re-emit infrared radiation. (International Encyclopedia of the Social & Behavioral Sciences, 2001) "Quantification of GHG emissions is conducted by the client annually in accordance with internationally recognized methodologies and good practice**"** (IFC,2012)
F42	**F42-Other Climate-related Risks and Impacts:** (i) Climate Vulnerability / (ii) Physical: those related to the physical impacts of climate change, such as extreme weather events, chronic heat waves, sea-level rise, erosion, and biodiversity loss. (iii) Transitional: those related to the transition to a lower-carbon economy which could entail policy, legal, technology, and market changes. As well as inflation, economic growth, financial stability, and monetary policy transmission. They also affect the value and risk profile of the assets on the Eurosystem balance sheet.
F43	**F43-Water Consumption Related Risks:** "A potentially significant consumption of water, where measures that avoid or reduce water usage so that the project's water consumption does not have significant adverse impacts on others. These measures include but are not limited to, the use of alternative water supplies, water consumption offsets to reduce total demand for water resources within the available supply, and evaluation of alternative project locations" (IFC, 2012). Examples include but are not limited to: project located in water stressed regions, on-site inefficient water management practices.
F44	**F44-Likely Waste-related Impacts:** Examples include, but are not limited to: Debris from construction and demolition; contaminate land, air (emissions of methane and hazardous leachate), and water and negatively affect human health and environmental conditions
F45	**F45-Risks linked to the Lack/Poor Pollution Prevention & Control.** Pollution prevention can reduce environmental damage from the extraction, processing, transport, and combustion of fuels. Reduces the use of toxic materials. Promotes more efficient use of raw materials, staff resources, equipment, energy, and water. Improves worker health and safety through improved air quality, decreased use of toxic substances, and fewer personnel protective equipment requirements. Examples of lack of pollution include but are not limited to: Air pollution can directly contaminate the surface of bodies of water and soil.
F46	**F46-Environmental risks linked to hazardous substances:** Hazardous materials are sometimes used as raw materials or produced as products by the project. (IFC, 2012).Acute and/or chronic toxicity, Biological hazards (ex: deterioration of ecossystems); Chemical hazards, Ergonomic hazards.
F47	**F47-Likely Noise Impacts**: Examples include, but are not limited to: Increased stress levels, sleep disturbance, and hearing damage. Regarding wildlife/biodiversity interferes with breeding cycles, increased mortality risk, and emigration. (EEA, 2019)

F48	**F48-Presence of relevant Ecological and Biodiversity Features:** Examples include, but are not limited to: Key Biodiversity Areas (KBA's); Important Bird Areas (IBRD); RAMSAR sites; Wetlands, Protected Areas,

Table A.6: Definitions of Subfactors under F5 Community Health, Safety, and Security Risk Factor.

Risk Subfactors	Definition
F50	**F50-Risks linked to Infrastructure and Equipment Design and Safety: "**The Borrower design, construct, operate, and decommissions the structural elements of the project in accordance with national legal requirements, the EHSGs, and other GIIP, taking into consideration safety risks to third parties and affected communities. Structural elements of a project are designed and constructed by competent professionals and certified or approved by competent authorities or professionals. Structural design will consider climate change considerations, as appropriate" (WorldBank, 2018).
F51	**F51-Community Health and safety linked to hazardous materials management:** Avoidance or minimization of the potential for community exposure to hazardous materials and substances that may be released by the project. Where there are potential hazards, particularly life-threatening ones, there must avoid or minimize their exposure by modifying, substituting, or eliminating the condition or material causing the potential hazards. Where hazardous materials are part of existing project infrastructure or components, it must conduct decommissioning activities in order to avoid exposure to the community. Adapted from IFC (2012).
F52	**F52-Ecosystem Services:** "The benefits people derive from ecosystems" (Millennium Ecosystem Assessment, 2006). Services and goods provided by biodiversity and the regular functioning of ecosystems that benefit humans – including human management to enhance ES delivery (De la Notte et al. 2017). Provision Services; Regulatory Services, Supportive Services, and Cultural Services. Examples: Food, pollination, decomposition, water purification, erosion and flood control, and carbon storage and climate regulation.
F53	**F53-Exposure to disease:** Examples include, but are not limited to**:** Water-borne, water-based, water-related, and vector-borne diseases, and communicable diseases that could result from project activities, considering the differentiated exposure to and high er sensitivity of vulnerable groups (IFC, 2012).
F54	**F54-Community Health and Safety Emergency Preparedness and Response:** ***Definition of F14 on EPR plus:*** the Client assistance and collaboration with the Affected Communities, local government agencies, and other relevant parties, in their preparations to respond effectively to emergency situations, especially when their participation and collaboration are necessary to respond to such emergency situations. Adapted from IFC (2012).
F55	**F55-Presence of Security Personnel:** Directed or contracted, provide security to safeguard other personnel and property; they may be armed; presence of a comprehensive Memorandum of Understanding or other written agreement; Project Sponsor's management and control capacity

Table A.7: Definitions of Subfactors under F6 Indigenous People Risk Factor.

Risk Subfactors	Definition
F60	**F60-Presence of Indigenous people:** Indigenous Peoples (IPs) are distinct social and cultural groups that share collective ancestral ties to the lands and natural resources where they live, occupy, or from which they have been displaced. The land and natural resources on which they depend are inextricably linked to their identities, cultures, livelihoods, as well as their physical and spiritual well-being (World Bank, 2023).
F61	**F61-Lack of/Poor Participation and Consent:** The engagement process includes stakeholder analysis and engagement planning, disclosure of information, consultation, and participation, in a culturally appropriate manner. Involve Indigenous Peoples' representative bodies and organizations (e.g., councils of elders or village councils), as well as members of the Affected Communities of Indigenous Peoples; and provide sufficient time for Indigenous Peoples' decision-making processes (IFC, 2012)
F62	**F63-Impacts on Lands/Resources Subject to Traditional Ownership/Customary Use:** Project situations where involuntary restrictions on land use and access to natural resources cause a community or groups within a community to lose access to resource usage where they have traditional or recognizable usage rights (IFC, 2012).
F63	**F63- Relocation of Indigenous Peoples:** Is a form of physical displacement, IPs are required to move from their traditional land to another location due to the development of a project.
F64	**F64-Absence of/Poor Mitigations and Development Benefits**: When there's an Identification of mitigation measures in alignment with the mitigation hierarchy as well as opportunities for culturally appropriate and sustainable development benefits (IFC, 2012).

Table A.8: Definitions of Subfactors under F7 Cultural Heritage Risk Factor.

Risk Subfactors	Definition
F70	**F70-Absence of/Poor Chance Find Procedures:** A chance find the procedure is a project-specific procedure that outlines the actions to be taken if previously unknown cultural heritage is encountered (IFC, 2012).
F71	**F71-Lack of/Poor Community Access:** If the client's project site "contains cultural heritage or prevents access to previously accessible cultural heritage sites being used by, or that have been used by, Affected Communities within living memory for long-standing cultural purposes, the client will, allow continued access to the cultural site or will provide an alternative access route, subject to overriding health, safety, and security considerations" (IFC, 2012).
F72	**F72-Critical Cultural Heritage:** consists of one or both of the following types of cultural heritage: (i) the internationally recognized heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes; or (ii) legally protected cultural heritage areas, including those proposed by host governments for such designation (IFC, 2012)
F73	**F73-Project's Use of Cultural Heritage:** Examples include, but are not limited to "The use the cultural heritage can be knowledge, innovations, practices of local communities for commercial purposes, commercialization of traditional medicinal knowledge or other sacred or traditional technique for processing plants, fibers, or metals" (IFC, 2012).

Table A.9: Definitions of Subfactors under F8 Gender Equality Risk Factor.

Risk Subfactors	Definition
F80	**F80-Risk of Sexual and Gender-Based Violence (SGBV) and other related impacts: "**Disproportionate impacts may be caused directly by project activities, and/ or by excluding people from project benefits due to their gender, and what resources they can access to recover from the negative impacts and benefit from the positive ones" (IFC, 2012). Examples include, but are not limited to risk of physical, sexual and psychological violence, such as rape, sexual abuse, trafficking, and forced prostitution, humiliation, discrimination
F81	**F81-Lack of/Poor Participation of People of All Genders:** Ensure equal and respectful consultation, full and effective participation, and equal opportunities for leadership and representation of both women and men within Project activities. Adapted from WHC (2019).

Table A.10: Definitions of Subfactors under F9 Technological Risk Factor.

Risk Subfactors	Definition
F90	**F90-Critical duration of Project:** Refers to the minimum amount of time required to complete all essential tasks and activities within the project, without causing any loss or delay to the overall project schedule.
F91	**F91-Complexity of project geometry:** The complexity of project geometry refers to the level of intricacy and sophistication involved in the spatial aspects and configuration of a project. It encompasses the various dimensions, shapes, boundaries, and relationships between project elements within a given geographical context.
F92	**F92-Project Costs:** Project costs refer to the financial expenditures incurred during the planning, execution, and completion of a specific project. It encompasses all the resources, materials, labor, equipment, and services necessary to deliver the desired project outcomes.
F93	**F93-Technological/industrial background of the host country:** The technological/industrial background of the host country refers to the existing technological and industrial infrastructure, skills and capabilities, and expertise within a specific country or region where a project or business operation is planned or being conducted.
F94	**F94-Regulatory background of the host country:** Established by the government to govern various aspects of business operations, projects, and industries within its jurisdiction. It encompasses the laws, regulations, policies, and administrative procedures that guide and control the activities of businesses and individuals operating in the country.
F95	**F95-Technological level of the project:** Refers to the degree of sophistication, complexity, and advancement of the technologies utilized or developed within the project. It assesses the level of innovation, technical expertise, and technological capabilities required or employed to achieve the project's objectives.
F96	**F96-Site-specific difficulties:** Refer to the unique challenges and obstacles encountered during a project due to the specific characteristics, conditions, or circumstances of the project site. These difficulties arise from the site's physical, environmental, geological, logistical, or regulatory factors, which may present unexpected or demanding conditions that require special attention and mitigation strategies. Examples include but are not limited to: The project site is directly connected or not to existing transport infrastructures.

Annex B

Table B.1: F1 geometric mean calculation.

Risk Subfactors	F10	F11	F12	F13	F14	F15	F16	F17
F10 - Lack of/Poor Essential Policies	1.00	1.12	0.97	0.61	1.27	0.50	1.37	0.68
F11 - Lack of/Poor mechanisms for risks/impacts identification	0.93	1.00	0.89	1.15	1.52	0.83	1.91	1.25
F12 - Lack of/Poor Organizational Capacity	1.03	1.12	1.00	0.52	1.50	1.12	2.15	1.70
F13 - Lack of/Poor Management Programs	1.65	0.87	1.92	1.00	2.04	0.44	1.61	1.60
F14 - Lack of/Poor EPR	0.79	0.66	0.67	0.49	1.00	0.47	1.31	2.00
F15 - Lack of/Poor Monitoring and Reviewing Capacity	1.98	1.00	0.89	2.29	2.11	1.00	2.20	3.42
F16 - Risks linked to management and control of Funds	0.73	0.52	0.46	0.62	0.76	0.46	1.00	0.86
F17 - Land Requirements Related Risks	1.47	0.80	0.58	0.62	0.50	0.29	1.15	1.00
Total	9.58	7.08	7.39	7.30	10.70	5.12	12.70	12.52

Table B.2: F2 geometric mean calculation.

Risk Subfactors	F20	F21	F22	F23	F24	F25	F26	F27
F20 - Compliance with National Policies and Law	1.00	0.79	0.71	0.64	0.79	0.71	0.70	0.46
F21 - Absence of/Poor Stakeholder Analysis	1.27	1.00	1.35	1.12	1.62	1.19	1.90	1.09
F22 - Absence of/Lacking Stakeholder Engagement Plan	1.41	0.74	1.00	0.45	1.12	0.86	1.41	0.75
F23 - Poor Grievance Management for Affected Communities	1.58	0.89	2.22	1.00	1.46	1.43	1.68	0.74
F24 - Lack of/Poor Ongoing Reporting to Affected Communities	1.27	0.62	0.89	0.68	1.00	1.00	1.39	0.64
F25 - Physical Displacement	1.42	0.84	1.17	0.70	0.99	1.00	1.64	1.71
F26 - Economic Displacement	1.42	0.52	0.71	0.59	0.72	0.61	1.00	0.94
F27 - Absence of/Poor Resettlement Plan	2.15	0.92	1.33	1.36	1.58	0.58	1.07	1.00
Total	11.52	6.31	9.38	6.54	9.28	7.38	10.80	7.31

Table B.3: F3 geometric mean calculation

Risk Subfactors	F30	F31	F32	F33	F34	F35	F36	F37	F38	F39
F30 - Risks related to workers' working conditions and terms of employment	1.00	2.08	1.10	1.42	1.31	1.00	0.83	0.56	0.68	1.35
F31 - Absence of/Limited opportunities to join workers' organizations	0.48	1.00	0.47	0.82	0.71	0.66	0.68	0.46	0.75	1.46
F32 - Risks of discrimination and lack of/poor access to equal opportunities	0.91	2.11	1.00	0.83	1.59	1.13	1.01	0.78	1.94	1.64
F33 - Retrenchment	0.71	1.22	1.20	1.00	1.39	0.72	0.72	0.73	1.70	1.58
F34 - Lack of/Poor Workers Grievance Mechanism	0.79	1.40	0.63	0.72	1.00	0.91	0.91	0.78	1.37	1.53
F35 - Risk of Child labor	1.00	1.53	0.89	1.39	1.11	1.00	1.94	1.36	2.24	2.63
F36 - Risk of Forced labor	1.20	1.49	0.99	1.39	1.11	0.51	1.00	1.09	1.64	1.64
F37 - Occupational Health and Safety Risks of direct workers	1.79	2.19	1.29	1.36	1.29	0.74	0.92	1.00	1.54	1.74
F38 - Risks related to Workers Engaged by Third Parties	1.46	1.34	0.52	0.59	0.73	0.45	0.61	0.65	1.00	0.89
F39 - Supply Chain Sensitivity	0.75	0.69	0.61	0.63	0.66	0.38	0.61	0.57	1.12	1.00
Total	10.07	15.04	8.71	10.16	10.89	7.49	9.22	7.98	13.99	15.47

Table B.4: F4 geometric mean calculation.

Risk Subfactors	F40	F41	F42	F43	F44	F45	F46	F47	F48
F40 - Resource Efficiency related issues/risks	1.00	0.65	1.12	1.11	1.86	0.96	0.93	1.30	1.02
F41 - GHG emission associated with Project	1.54	1.00	0.97	1.00	0.93	0.80	1.07	1.47	0.86
F42 - Other Climate-related Risks and Impacts	0.89	1.02	1.00	2.02	1.37	0.93	1.03	1.00	0.86
F43 - Water Consumption Related Risks	0.90	1.00	0.49	1.00	1.19	0.99	0.54	1.26	1.35
F44 - Likely Waste-related Impacts	0.54	1.07	0.73	0.84	1.00	1.06	1.15	1.48	1.05
F45 - Risks linked to the Lack/Poor Pollution Prevention & Control	1.04	1.24	1.07	1.01	0.94	1.00	0.84	0.95	1.70

F46 - Environmental risks linked to hazardous substances	1.07	0.94	0.97	1.86	0.88	1.19	1.00	1.28	0.37
F47 - Likely Noise Impacts	0.77	0.68	1.00	0.79	0.67	1.05	0.78	1.00	0.74
F48 - Presence of relevant Ecological and Biodiversity Features	0.97	1.17	1.17	0.74	0.96	0.59	2.71	1.35	1.00
Total	8.72	8.77	8.53	10.37	9.79	8.56	10.05	11.08	8.95

Table B.5: F5 geometric mean calculation.

Risk Subfactors	F50	F51	F52	F53	F54	F55
F50 - Risks linked to Infrastructure and Equipment Design and Safety	1.00	0.71	0.57	0.97	0.78	0.94
F51 - Community Health and Safety linked to hazardous materials management	1.41	1.00	0.64	1.39	0.92	1.01
F52 - Ecosystem Services	1.76	1.57	1.00	1.39	1.26	2.36
F53 - Exposure to Disease	1.02	0.72	0.72	1.00	0.69	1.59
F54 - Community Health and Safety Emergency Preparedness and Response	1.28	1.09	0.79	1.44	1.00	2.71
F55 - Presence of Security Personnel	1.06	0.99	0.42	0.62	0.37	1.00
Total	7.53	6.08	4.14	6.81	5.03	9.60

Table B.6: F6 geometric mean calculation.

Risk Subfactors	F60	F61	F62	F63	F64
F60 - Presence of Indigenous people	1.00	3.16	1.57	1.01	2.35
F61 - Lack of/Poor Participation and Consent	0.32	1.00	0.35	0.34	0.67
F62 - Impacts on Lands/Resources Subject to Traditional Ownership/Customary Use	0.64	2.90	1.00	0.52	1.68
F63 - Relocation of Indigenous Peoples	1.01	2.20	1.09	1.00	5.62
F64 - Absence of/Poor Mitigations and Development Benefits	0.42	1.50	0.60	0.18	1.00
Total	3.38	10.76	4.61	3.04	11.31

Table B.7: F7 geometric mean calculation.

Risk Subfactors	F70	F71	F72	F73
F70 - Absence of/Poor Chance Find Procedures	1.00	0.37	0.57	0.42
F71 - Lack of/Poor Community Access	2.69	1.00	0.96	1.07
F72 - Critical Cultural Heritage	1.76	1.04	1.00	1.03
F73 - Project's Use of Cultural Heritage	2.38	0.93	0.97	1.00
Total	7.82	3.35	3.50	3.52

Table B.8: F8 geometric mean calculation.

Risk Subfactors	F80	F81
F80 - Risk of Sexual and Gender-Based Violence and other related impacts	1.00	1.19
F81 - Lack of/Poor Participation of People of All Genders	0.84	1.00
Total	1.84	2.19

Table B.9: F9 geometric mean calculation.

Risk Subfactors	F90	F91	F92	F93	F94	F95	F96
F90 - Critical duration of Project	1.00	0.64	1.98	0.32	0.55	0.40	0.45
F91 - Complexity of project geometry	1.56	1.00	1.75	0.63	0.91	0.95	0.56
F92 - Project Costs	0.50	0.58	1.00	0.45	0.35	0.47	0.45
F93 - Technological/industrial background of the host country	3.10	1.58	2.20	1.00	1.07	0.62	0.45
F94 - Regulatory background of the host country	1.85	1.43	2.22	1.35	1.00	0.56	0.37
F95 - Technological level of the project	2.51	1.05	2.09	1.62	1.78	1.00	0.48
F96 - Site-specific difficulties	2.25	1.80	2.24	2.20	2.71	2.08	1.00
Total	12.78	8.07	13.48	7.56	8.37	6.08	3.75

Table B.10: Risk main factors (F1 to F9) geometric mean calculation.

Risk Subfactors	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1 - Management Systems Factor	1.00	0.55	0.53	2.04	0.71	0.48	1.03	0.61	1.77
F2 - Social-Political Factor	1.82	1.00	2.62	1.52	0.81	1.89	0.59	2.96	0.89
F3 - Labour and Working Conditions Factor	1.86	0.38	1.00	2.94	1.29	1.21	0.61	1.40	1.07
F4 - Environmental Factor	0.49	0.95	0.49	1.00	0.72	0.41	0.78	0.46	2.23
F5 - Community Health, Safety, and Security Factor	1.40	1.85	1.22	2.01	1.00	1.82	0.65	0.72	1.28
F6 - Indigenous People Factor	2.08	0.67	1.09	1.40	0.94	1.00	0.71	0.83	0.58
F7 - Cultural Heritage Factor	0.90	0.82	0.46	1.01	0.61	1.53	1.00	0.39	1.21
F8 - Gender Equality Factor	1.03	0.43	0.71	1.27	0.84	1.19	2.58	1.00	1.03
F9 - Technological Factor	0.56	0.43	0.49	0.59	0.49	0.75	0.90	1.34	1.00
Total	11.15	7.07	8.62	13.79	7.41	10.28	8.84	9.71	11.07

Annex C

Table C.1: Normalized matrix obtained for F1 and the wi (local weight/priority vector).

Risk Subfactors	F10	F11	F12	F13	F14	F15	F16	F17	*wi*
F10 - Lack of/Poor Essential Policies	0.10	0.16	0.13	0.08	0.12	0.10	0.11	0.05	0.11
F11 - Lack of/Poor mechanisms for risks/impacts identification	0.10	0.14	0.12	0.16	0.14	0.16	0.15	0.10	0.13
F12 - Lack of/Poor Organizational Capacity	0.11	0.16	0.14	0.07	0.14	0.22	0.17	0.14	0.14
F13 - Lack of/Poor Management Programs	0.17	0.12	0.26	0.14	0.19	0.09	0.13	0.13	0.15
F14 - Lack of/Poor EPR	0.08	0.09	0.09	0.07	0.09	0.09	0.10	0.16	0.10

F15 - Lack of/Poor Monitoring and Reviewing Capacity	0.21	0.14	0.12	0.31	0.20	0.20	0.17	0.27	0.20
F16 - Risks linked to management and control of Funds	0.08	0.07	0.06	0.08	0.07	0.09	0.08	0.07	0.08
F17 - Land Requirements Related Risks	0.15	0.11	0.08	0.09	0.05	0.06	0.09	0.08	0.09
Total	1	1	1	1	1	1	1	1	100

Table C.2: Normalized matrix obtained for F2 and the wi (local weight/priority vector).

Risk Subfactors	**F20**	**F21**	**F22**	**F23**	**F24**	**F25**	**F26**	**F27**	***wi***
F20 - Compliance with National Policies and Law	0.09	0.12	0.08	0.10	0.09	0.10	0.06	0.06	0.09
F21 - Absence of/Poor Stakeholder Analysis	0.11	0.16	0.14	0.17	0.17	0.16	0.18	0.15	0.16
F22 - Absence of/Lacking Stakeholder Engagement Plan	0.12	0.12	0.11	0.07	0.12	0.12	0.13	0.10	0.11
F23 - Poor Grievance Management for Affected Communities	0.14	0.14	0.24	0.15	0.16	0.19	0.16	0.10	0.16
F24 - Lack of/Poor Ongoing Reporting to Affected Communities	0.11	0.10	0.09	0.10	0.11	0.14	0.13	0.09	0.11
F25 - Physical Displacement	0.12	0.13	0.12	0.11	0.11	0.14	0.15	0.23	0.14
F26 - Economic Displacement	0.12	0.08	0.08	0.09	0.08	0.08	0.09	0.13	0.09
F27 - Absence of/Poor Resettlement Plan	0.19	0.15	0.14	0.21	0.17	0.08	0.10	0.14	0.15
Total	1	1	1	1	1	1	1	1	100

Table C.3: Normalized matrix obtained for F3 and the wi (local weight/priority vector).

Risk Subfactors	**F30**	**F31**	**F32**	**F33**	**F34**	**F35**	**F36**	**F37**	**F38**	**F39**	***wi***
F30 - Risks related to workers' working conditions and terms of employment	0.10	0.14	0.13	0.14	0.12	0.13	0.09	0.07	0.05	0.09	0.11
F31 - Absence of/Limited opportunities to join workers' organizations	0.05	0.07	0.05	0.08	0.07	0.09	0.07	0.06	0.05	0.09	0.07
F32 - Risks of discrimination and lack of/poor access to equal opportunities	0.09	0.14	0.11	0.08	0.15	0.15	0.11	0.10	0.14	0.11	0.12
F33 - Retrenchment	0.07	0.08	0.14	0.10	0.13	0.10	0.08	0.09	0.12	0.10	0.10
F34 - Lack of/Poor Workers Grievance Mechanism	0.08	0.09	0.07	0.07	0.09	0.12	0.10	0.10	0.10	0.10	0.09
F35 - Risk of Child labor	0.10	0.10	0.10	0.14	0.10	0.13	0.21	0.17	0.16	0.17	0.14
F36 - Risk of Forced labor	0.12	0.10	0.11	0.14	0.10	0.07	0.11	0.14	0.12	0.11	0.11

F37 - Occupational Health and Safety Risks of direct workers	0.18	0.15	0.15	0.13	0.12	0.10	0.10	0.13	0.11	0.11	0.13
F38 - Risks related to Workers Engaged by Third Parties	0.14	0.09	0.06	0.06	0.07	0.06	0.07	0.08	0.07	0.06	0.08
F39 - Supply Chain Sensitivity	0.07	0.05	0.07	0.06	0.06	0.05	0.07	0.07	0.08	0.06	0.06
Total	1	1	1	1	1	1	1	1	1	1	100

Table C.3: Normalized matrix obtained for F4 and the wi (local weight/priority vector).

Risk Subfactors	F40	F41	F42	F43	F44	F45	F46	F47	F48	*wi*
F40 - Resource Efficiency related issues/risks	0.11	0.07	0.13	0.11	0.19	0.11	0.09	0.12	0.11	0.12
F41 - GHG emission associated with Project	0.18	0.11	0.11	0.10	0.10	0.09	0.11	0.13	0.10	0.11
F42 - Other Climate-related Risks and Impacts	0.10	0.12	0.12	0.19	0.14	0.11	0.10	0.09	0.10	0.12
F43 - Water Consumption Related Risks	0.10	0.11	0.06	0.10	0.12	0.12	0.05	0.11	0.15	0.10
F44 - Likely Waste-related Impacts	0.06	0.12	0.09	0.08	0.10	0.12	0.11	0.13	0.12	0.10
F45 - Risks linked to the Lack/Poor Pollution Prevention & Control	0.12	0.14	0.13	0.10	0.10	0.12	0.08	0.09	0.19	0.12
F46 - Environmental risks linked to hazardous substances	0.12	0.11	0.11	0.18	0.09	0.14	0.10	0.12	0.04	0.11
F47 - Likely Noise Impacts	0.09	0.08	0.12	0.08	0.07	0.12	0.08	0.09	0.08	0.09
F48 - Presence of relevant Ecological and Biodiversity Features	0.11	0.13	0.14	0.07	0.10	0.07	0.27	0.12	0.11	0.12
Total	1	1	1	1	1	1	1	1	1	100

Table C.4: Normalized matrix obtained for F5 and the wi (local weight/priority vector).

Risk Subfactors	F50	F51	F52	F53	F54	F55	*wi*
F50 - Risks linked to Infrastructure and Equipment Design and Safety	0.13	0.12	0.14	0.14	0.16	0.10	0.13
F51 - Community Health and Safety linked to hazardous materials management	0.19	0.16	0.15	0.20	0.18	0.10	0.17
F52 - Ecosystem Services	0.23	0.26	0.24	0.20	0.25	0.25	0.24
F53 - Exposure to Disease	0.14	0.12	0.17	0.15	0.14	0.17	0.15
F54 - Community Health and Safety Emergency Preparedness and Response	0.17	0.18	0.19	0.21	0.20	0.28	0.21
F55 - Presence of Security Personnel	0.14	0.16	0.10	0.09	0.07	0.10	0.11
Total	1	1	1	1	1	1	100

Table C.5: Normalized matrix obtained for F6 and the wi (local weight/priority vector).

Risk Subfactors	F60	F61	F62	F63	F64	*wi*
F60 - Presence of Indigenous people	0.30	0.29	0.34	0.33	0.21	0.29
F61 - Lack of/Poor Participation and Consent	0.09	0.09	0.08	0.11	0.06	0.09
F62 - Impacts on Lands/Resources Subject to Traditional Ownership/Customary Use	0.19	0.27	0.22	0.17	0.15	0.20
F63 - Relocation of Indigenous Peoples	0.30	0.20	0.24	0.33	0.50	0.31
F64 - Absence of/Poor Mitigations and Development Benefits	0.13	0.14	0.13	0.06	0.09	0.11
Total	1	1	1	1	1	100

Table C.6: Normalized matrix obtained for F7 and the wi (local weight/priority vector).

Risk Subfactors	F70	F71	F72	F73	*wi*
F70 - Absence of/Poor Chance Find Procedures	0.13	0.11	0.16	0.12	0.13
F71 - Lack of/Poor Community Access	0.34	0.30	0.28	0.30	0.31
F72 - Critical Cultural Heritage	0.22	0.31	0.29	0.29	0.28
F73 - Project's Use of Cultural Heritage	0.30	0.28	0.28	0.28	0.29
Total	1	1	1	1	100

Table C.7: Normalized matrix obtained for F8 and the wi (local weight/priority vector).

Risk Subfactors	F80	F81	*wi*
F80 - Risk of Sexual and Gender-Based Violence and other related impacts	0.54	0.54	0.54
F81 - Lack of/Poor Participation of People of All Genders	0.46	0.46	0.46
Total	1	1	100

Table C.8: Normalized matrix obtained for F9 and the wi (local weight/priority vector).

Risk Subfactors	F90	F91	F92	F93	F94	F95	F96	*wi*
F90 - Critical duration of Project	0.08	0.08	0.15	0.04	0.07	0.07	0.12	0.09
F91 - Complexity of project geometry	0.12	0.12	0.13	0.08	0.11	0.16	0.15	0.12
F92 - Project Costs	0.04	0.07	0.07	0.06	0.04	0.08	0.12	0.07
F93 - Technological/industrial background of the host country	0.24	0.20	0.16	0.13	0.13	0.10	0.12	0.15
F94 - Regulatory background of the host country	0.14	0.18	0.16	0.18	0.12	0.09	0.10	0.14
F95 - Technological level of the project	0.20	0.13	0.16	0.21	0.21	0.16	0.13	0.17
F96 - Site-specific difficulties	0.18	0.22	0.17	0.29	0.32	0.34	0.27	0.26
Total	1	1	1	1	1	1	1	100

Table C.9: Normalized matrix obtained for the main Risk factors (F1-F9) and the wi (local weight/priority vector).

Risk Subfactors	F1	F2	F3	F4	F5	F6	F7	F8	F9	*wi*

F1 - Management Systems Factor	0.09	0.08	0.06	0.15	0.10	0.05	0.12	0.06	0.16	0.10
F2 - Social-Political Factor	0.16	0.14	0.30	0.11	0.11	0.18	0.07	0.30	0.08	0.16
F3 - Labour and Working Conditions Factor	0.17	0.05	0.12	0.21	0.17	0.12	0.07	0.14	0.10	0.13
F4 - Environmental Factor	0.04	0.13	0.06	0.07	0.10	0.04	0.09	0.05	0.20	0.09
F5 - Community Health, Safety, and Security Factor	0.13	0.26	0.14	0.15	0.13	0.18	0.07	0.07	0.12	0.14
F6 - Indigenous People Factor	0.19	0.09	0.13	0.10	0.13	0.10	0.08	0.09	0.05	0.11
F7 - Cultural Heritage Factor	0.08	0.12	0.05	0.07	0.08	0.15	0.11	0.04	0.11	0.09
F8 - Gender Equality Factor	0.09	0.06	0.08	0.09	0.11	0.12	0.29	0.10	0.09	0.12
F9 - Technological Factor	0.05	0.06	0.06	0.04	0.07	0.07	0.10	0.14	0.09	0.08
Total	1	1	1	1	1	1	1	1	1	100

Annex D

Table D.1: Coloured Code Ranked List of E&S Risk Subfactors Based on the Global Weights. Lower rank values (e.g., 1, 2, 3) indicate subfactors perceived by experts as more important within the E&S risk framework.

Risk Subfactors	Global ranking
F80 - Risk of Sexual and Gender-Based Violence and other related impacts	1
F81 - Lack of/Poor Participation of People of All Genders	2
F52 - Ecosystem Services	3
F63 - Relocation of Indigenous Peoples	4
F60 - Presence of Indigenous people	5
F54 - Community Health and Safety Emergency Preparedness and Response	6
F71 - Lack of/Poor Community Access	7
F73 - Project's Use of Cultural Heritage	8
F23 - Poor Grievance Management for Affected Communities	9
F72 - Critical Cultural Heritage	10
F21 - Absence of/Poor Stakeholder Analysis	11
F27 - Absence of/Poor Resettlement Plan	12
F51 - Community Health and Safety linked to hazardous materials management	13
F25 - Physical Displacement	14
F62 - Impacts on Lands/Resources Subject to Traditional Ownership/Customary Use	15
F53 - Exposure to Disease	16
F15 - Lack of/Poor Monitoring and Reviewing Capacity	17
F96 - Site-specific difficulties	18
F50 - Risks linked to Infrastructure and Equipment Design and Safety	19
F22 - Absence of/Lacking Stakeholder Engagement Plan	20
F35 - Risk of Child labor	21
F24 - Lack of/Poor Ongoing Reporting to Affected Communities	22
F37 - Occupational Health and Safety Risks of direct workers	23
F55 - Presence of Security Personnel	24
F26 - Economic Displacement	25
F32 - Risks of discrimination and lack of/poor access to equal opportunities	26
F13 - Lack of/Poor Management Programs	27
F36 - Risk of Forced labor	28
F20 - Compliance with National Policies and Law	29
F12 - Lack of/Poor Organizational Capacity	30

F30 - Risks related to workers' working conditions and terms of employment	31
F95 - Technological level of the project	32
F33 - Retrenchment	33
F11 - Lack of/Poor mechanisms for risks/impacts identification	34
F70 - Absence of/Poor Chance Find Procedures	35
F34 - Lack of/Poor Workers Grievance Mechanism	36
F93 - Technological/industrial background of the host country	37
F64 - Absence of/Poor Mitigations and Development Benefits	38
F48 - Presence of relevant Ecological and Biodiversity Features	39
F94 - Regulatory background of the host country	40
F42 - Other Climate-related Risks and Impacts	41
F10 - Lack of/Poor Essential Policies	42
F45 - Risks linked to the Lack/Poor Pollution Prevention & Control	43

F40 - Resource Efficiency related issues/risks	44
F41 - GHG emission associated with Project	45
F46 - Environmental risks linked to hazardous substances	46
F38 - Risks related to Workers Engaged by Third Parties	47
F91 - Complexity of project geometry	48
F14 - Lack of/Poor EPR	49
F61 - Lack of/Poor Participation and Consent	50
F44 - Likely Waste-related Impacts	51
F43 - Water Consumption Related Risks	52
F31 - Absence of/Limited opportunities to join workers' organizations	53
F17 - Land Requirements Related Risks	54
F39 - Supply Chain Sensitivity	55
F47 - Likely Noise Impacts	56
F16 - Risks linked to management and control of Funds	57
F90 - Critical duration of Project	58
F92 - Project Costs	59

Table D.2: Coloured Code Ranked List of E&S Risk Factors Based on the Global Weights. Lower rank values (e.g., 1, 2, indicates the risk factors perceived as the most important across all dimensions; rank 9 indicates the least important according to the aggregated global weight.

Risk Factors	Global ranking
F2 - Social-Political Factor	1
F5 - Community Health, Safety, and Security Factor	2
F3 - Labour and Working Conditions Factor	3
F8 - Gender Equality Factor	4
F6 - Indigenous People Factor	5
F1 - Management Systems Factor	6
F7 - Cultural Heritage Factor	7
F4 - Environmental Factor	8
F9 - Technological Factor	9

Annex E

Validation & User Feedback – Environmental & Social Risk Screening Tool

This questionnaire supports the validation of a pre-screening tool developed as part of a Master's thesis in Ecology and Environmental Management, focused on Environmental and Social (E&S) Risk Assessment of renewable energy projects. Your feedback is highly valued and will contribute to improving both the academic rigour and practical applicability of the tool.

* Indicates required question

1. 1. Name *

____

Tool Usability

2. 2. The tool was easy to understand and user-friendly. *

Mark only one oval.

- ⬭ Strongly agree
- ⬭ Agree
- ⬭ Somewhat agree
- ⬭ Neutral
- ⬭ Somewhat disagree
- ⬭ Disagree
- ⬭ Strongly disagree

Figure E.1: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 1

18/08/2025, 15:05 Validation & User Feedback – Environmental & Social Risk Screening Tool

3. 3. The tool allows for a more time-efficient assessment process compared to the usual approach without its use. *

Mark only one oval.

- ⬭ Strongly agree
- ⬭ Agree
- ⬭ Somewhat agree
- ⬭ Neutral
- ⬭ Somewhat disagree
- ⬭ Disagree
- ⬭ Strongly disagree

Functionality and Value

4. 4. The tool is useful for identifying E&S risks in a pre-screening phase. *

Mark only one oval.

- ⬭ Strongly agree
- ⬭ Agree
- ⬭ Somwhat agree
- ⬭ Neutral
- ⬭ Somwhat disagree
- ⬭ Disagree
- ⬭ Strongly disagree

https://docs.google.com/forms/d/1sEA5kP9bb3gOMTAWN1HTQgkVKer37oITiJcqPSo79jo/edit 2/8

Figure E.2: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 2

5. 5. The tool is useful for comparing E&S risks between projects. *

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Neutral
- Somewhat disagree
- Disagree
- Strongly disagree

6. 6. Which aspects do you consider most valuable in the tool? *(Select all that apply)* *

Check all that apply.

- [ ] Structured risk identification
- [ ] Alignment with international standards
- [ ] Quantitative scoring
- [ ] Time efficiency
- [ ] Visual outputs
- [ ] Allows comparison between projects
- [ ] Other: ____________________

7. 7. What do you see as the main limitations or downsides of the tool? *

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Testing the Tool

Figure E.3: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 3.

8. 8. The results of the tool are consistent with the conclusions of the previous assessment. *

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Neutral
- Somewhat disagree
- Disagree
- Strongly disagree

9. 9. If not, please explain the differences you noticed *(optional)*

10. 10. The tool helped highlight *additional* issues not addressed in the original review. *

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Neutral
- Somewhat disagree
- Disagree
- Strongly disagree

Figure E.4: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 4.

11. 11. If yes, which ones specifically? *(optional)*

Validation of the Research Objectives

12. 12. In your opinion, do you consider the tool practical, consistent, and analytically robust in making an assessment of E&S risks for RE projects? *

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Neutral
- Somewhat disagree
- Disagre
- Strongly disagree

13. 13. The tool effectively compiles and reflects key E&S requirements and indicators from international standards (IFC, WB, IDB and EBRD). *

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Neutral
- Somewhat disagree
- Disagree
- Strongly disagree

Figure E.5: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 5

14. 14. Are there any key E&S aspects from international standards you feel are missing or underrepresented in the tool? *

Mark only one oval.

- Yes
- Not sure
- No

15. 15. If yes, which ones? *(optional)*

____

____

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____

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16. 16. The tool can realistically be integrated into my current E&S assessment workflow. *

Mark only one oval.

- Strongly agree
- Agree
- Somewhat agree
- Neutral
- Somewhat disagree
- Disagree
- Strongly Disagree

Figure E.6: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 6.

17. 17. Please explain your reasoning

18. Any other suggestions or feedback? *(optional)*

Figure E.7: E&S Risk Screening Tool Validation and User Feedback Form (Google Forms) – Page 7.