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# Rule-based systems in balancing the ripple effects of financial services on environmentally impactful sectors

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**Abstract.** This paper investigates the ripple effects of financial services granted to environmentally impactful sectors such as Oil & Gas, Construction, and Agriculture, focusing on how rule-based systems can influence financial decisions to reduce environmental harm. The objective is to create a framework based on the proposed rule-based system by analyzing existing governmental programs, Environmental, Social, and Governance (ESG) criteria, and green loan criteria that serve as economic mechanisms, guiding financial products toward or away from investments in high-emission industries. The methodology combines theoretical analysis with a proposed rule-based framework that links business rules to credit allocation outcomes. Results from the study suggest that financial institutions, through the implementation of rule-based systems, can effectively balance the need to finance essential sectors without exacerbating environmental damage. The proposed framework allows for more informed lending decisions, mitigating the long-term environmental impacts of financial services on high-emission industries. By aligning economic incentives with sustainability, this paper contributes to the discourse on sustainable finance and environmental risk management.
**Keywords:** *ESG, Green loans, Sustainable finance, Rule-based systems, Environmental risk*

## Introduction

The global push towards environmental sustainability has underscored the critical need to reconsider the relationship between financial services and industries that have a substantial impact on the environment. Among the most environmentally impactful sectors are Oil & Gas, Agriculture, and Construction, which collectively contribute significantly to carbon emissions and ecological degradation. As global carbon dioxide ($CO_2$) levels continue to rise, driven primarily by these sectors, the role of financial services in either mitigating or exacerbating this crisis cannot be overstated. Financial institutions, through credit allocations, investments, and loan structures, wield tremendous influence over the direction and sustainability of these industries. Consequently, there is an increasing call for the integration of sustainable finance principles into financial decision-making processes, especially for industries that are environmentally detrimental.

In recent years, the conversation around sustainable finance has gained momentum, with various studies highlighting the potential for financial institutions to promote environmental sustainability. For instance, research has indicated that aligning financial flows with sustainability goals can substantially reduce carbon emissions and minimize ecological harm [1]. Financial services, such as credit allocations and investments, have traditionally been driven by profitability and economic growth, often at the

expense of environmental considerations. However, as climate risks become more apparent, the need to integrate environmental, social, and governance (ESG) criteria into financial decision-making has become more pronounced [2].

The central research problem addressed in this paper is the challenge of balancing the need for economic growth in essential sectors with the urgent requirement to limit environmental damage. Sectors like Oil & Gas are not only vital for energy security but are also major contributors to global emissions. Similarly, agriculture and construction are integral to feeding and housing growing populations but are responsible for significant environmental degradation through deforestation, land-use changes, and greenhouse gas emissions [3]. Financial services, by funding these sectors, indirectly contribute to the environmental challenges they pose. Therefore, the need for a structured approach that guides financial decisions in a more sustainable direction is clear.

This paper seeks to explore the ripple effects of financial services on environmentally impactful sectors and propose a rule-based framework to guide financial institutions toward more sustainable practices. The main objective is to develop a structured model that links business rules to measurable financial decisions, particularly credit allocations, using ESG and green loan criteria as guiding mechanisms. By examining existing governmental programs and their role in regulating capital flows, the paper provides a detailed analysis of how financial services can be directed towards or away from high-emission industries. In doing so, it highlights the potential for rule-based systems to enhance the transparency of financial decisions in sectors with significant environmental risks [4].

In recent years, the adoption of ESG and green loan frameworks has gained traction as a mechanism to incentivize investments in sustainable projects. Green loans, for example, have become an increasingly popular tool in guiding capital towards initiatives that have a positive environmental impact. These loans are structured in a way that rewards companies for achieving predefined sustainability targets, thus aligning financial returns with ecological benefits [5]. Moreover, the integration of ESG criteria into corporate decision-making has encouraged investors to prioritize sustainability alongside profitability. This dual focus on financial and environmental performance represents a significant shift in the landscape of global finance, moving towards a more balanced approach that recognizes the importance of ecological sustainability in long-term economic growth. The personal contribution of the author to this research lies in the development of a novel, rule-based framework that can be used by financial institutions to help mitigate the negative externalities associated with financing high-emission sectors while promoting more informed and responsible lending practices.

This paper is structured as follows: First, the literature review will cover existing research on financial services and environmental sustainability, focusing on governmental programs, ESG criteria, and green loan frameworks. Following that, the methodology will outline the development of the proposed rule-based system. The results and discussions section will showcase the business rules within the rule-based system, examining its contents and potential usage. Finally, the paper will conclude with areas for future research in sustainable finance and the limitations of the study.

## 1. Literature review

### *1.1 Environmentally impactful sectors*

Environmentally impactful sectors, such as Oil & Gas, Agriculture, and Construction, have long been recognised for their significant contributions to economic development, but their activities also present considerable challenges for environmental sustainability. These industries are responsible for a large proportion of global greenhouse gas emissions, deforestation, resource depletion, and ecosystem degradation. The ripple effects of financial services directed toward these sectors play a crucial role in determining their environmental footprint, as funding decisions either encourage unsustainable practices or foster the adoption of more sustainable methods.

The Oil & Gas sector is one of the most impactful industries on the environment due to its role in fossil fuel extraction, refining, and distribution. The sector is a major contributor to global carbon dioxide emissions, which are a primary driver of climate change. Additionally, oil spills, habitat destruction, and pollution from refining processes further exacerbate its environmental effects. The

financial services provided to this sector have historically been driven by profit motives, with little regard for the environmental consequences. A study [6] highlights that global investments in fossil fuel infrastructure continue to rise, despite international agreements to reduce emissions, largely due to financial institutions' prioritisation of short-term returns over long-term sustainability. However, there has been a growing push for divestment from fossil fuels, with many financial institutions now focusing on renewable energy investments as part of broader sustainability strategies [7]. This shift demonstrates the potential for financial services to influence the environmental impact of the Oil & Gas sector, steering it toward greener alternatives.

In contrast, the Agriculture sector presents a complex challenge. While essential for food production and global food security, agriculture is also a leading cause of deforestation, biodiversity loss, and water pollution. The environmental impact of agriculture is not limited to the direct effects of farming practices but extends to associated activities such as land-use change and water management. Financial services in this sector often support industrial-scale farming, which relies on high inputs of chemical fertilisers and pesticides, contributing to soil degradation and water contamination. According to a study [8], the demand for increased agricultural output has led to the expansion of agricultural land at the expense of forests and wetlands, intensifying environmental pressures. However, there is also an emerging trend of financing sustainable agricultural practices, such as agroecology and organic farming. The role of financial services in this shift is significant, as banks and investors are increasingly supporting loans and investments in sustainable farming practices, which can reduce the environmental impact while still addressing the need for food production [9].

The Construction sector is another key industry with substantial environmental implications. Construction activities contribute to high levels of carbon emissions, waste generation, and resource depletion, particularly in terms of energy use and raw materials such as steel, cement, and timber. The production of cement alone accounts for approximately 8% of global carbon dioxide emissions [10]. Traditional financial services have often facilitated the expansion of construction projects without considering their environmental costs. For example, investments in large-scale urban developments or infrastructure projects have typically prioritised economic growth over sustainability. However, in recent years, there has been a notable shift toward green building practices, which aim to reduce the environmental footprint of construction projects. Financial institutions are increasingly offering green loans and sustainability-linked bonds that incentivise developers to adopt energy-efficient technologies and sustainable building materials [11]. This shift in financial services is gradually encouraging more environmentally responsible practices within the sector.

From a broader perspective, the role of financial services in these sectors is multifaceted. On one hand, traditional financial models, focused on profit maximisation, have often overlooked the long-term environmental consequences of supporting industries with significant ecological impacts. On the other hand, the rise of sustainable finance demonstrates the potential for financial services to become a driving force for environmental stewardship. By directing capital towards industries and projects that prioritise sustainability, financial institutions can mitigate the adverse environmental effects associated with sectors such as Oil & Gas, Agriculture, and Construction. However, achieving this requires a concerted effort to align financial incentives with environmental goals, something that is only beginning to gain traction within the financial industry.

### *1.2 Governmental programs directing investments towards sustainable initiatives*

In response to the growing awareness of environmental degradation and the pressing need to address climate change, governments around the world have implemented various programs and initiatives designed to steer investments towards sustainable projects. These initiatives aim to facilitate the transition to a low-carbon economy by incentivising businesses and financial institutions to focus on environmentally responsible investments. A key element of these programs is the establishment of criteria to allocate funding for green projects, ensuring that public money is directed toward activities that contribute to sustainability goals.

One of the most prominent examples of governmental support for sustainable investments is the European Union's Green Deal. The European Green Deal, launched in 2019, seeks to make Europe the first climate-neutral continent by 2050. As part of this ambitious plan, the EU has developed various financing mechanisms, such as the InvestEU programme and the European Green Bond Standard, to mobilise public and private funds for green projects. The InvestEU programme focuses on funding investments that contribute to the European Green Deal's objectives, particularly in areas such as renewable energy, sustainable infrastructure, and energy efficiency [12]. To qualify for financing, projects must adhere to strict sustainability criteria, which assess their potential contribution to reducing carbon emissions, promoting circular economy principles, and enhancing biodiversity.

Another significant governmental initiative is the Clean Energy Finance Corporation (CEFC) in Australia. Established in 2012, the CEFC provides financial support for projects that reduce greenhouse gas emissions or increase the efficiency of energy use in key sectors. The CEFC's investment decisions are based on a set of green investment criteria, which evaluate projects according to their potential to deliver measurable environmental outcomes. Projects funded by the CEFC include large-scale solar and wind energy developments, energy-efficient property projects, and investments in sustainable agriculture [13]. In addition to these environmental criteria, the CEFC also considers the financial viability of projects, ensuring that public funds are invested in initiatives that deliver both environmental and economic returns.

In the United States, the Green Climate Fund (GCF) plays a similar role in directing investments towards sustainable projects, particularly in developing countries. Established under the United Nations Framework Convention on Climate Change (UNFCCC), the GCF provides grants and loans for projects that contribute to climate mitigation and adaptation. The GCF's funding criteria include requirements for projects to demonstrate a clear reduction in greenhouse gas emissions, the adoption of climate-resilient technologies, and the promotion of sustainable land use practices [14]. The GCF's approach is particularly focused on ensuring that developing countries can access financing for green projects, with an emphasis on equity and inclusiveness in its funding allocations.

In addition to these examples, various national governments have developed their own criteria for financing green projects. For example, the UK's Green Finance Strategy, launched in 2019, focuses on mobilising private sector investment in sustainable projects through government-backed schemes. The UK government's Green Investment Bank was initially established to finance offshore wind and energy efficiency projects, using criteria that assess environmental sustainability, financial viability, and alignment with the government's climate change commitments [15]. These criteria ensure that public investments are directed towards projects that have a meaningful impact on reducing the country's carbon footprint, while also ensuring that such investments contribute to long-term economic stability.

As mentioned above, governmental programs that provide funding for green and sustainable projects often establish specific criteria to ensure that investments are directed towards initiatives aligned with environmental and sustainability goals. These criteria cover a range of aspects, including sector-specific eligibility, project location, scale, innovation, and environmental impact.

One common criterion is sector-specific eligibility, where governmental programs focus on industries most capable of driving environmental improvements. For example, energy-related projects in sectors such as renewable energy (solar, wind, hydroelectric, bioenergy) are frequently prioritised. In the transport sector, sustainable initiatives like electric vehicle infrastructure and public transport upgrades may be considered for support. In agriculture, projects promoting sustainable farming practices, such as reduced pesticide use or better water management, are prioritised, while in construction, green building projects that use sustainable materials and reduce energy consumption are often eligible [16]. Circular economy initiatives, such as those focused on recycling and resource recovery, also receive significant attention in funding programs designed to reduce resource use and promote material reuse [17].

Location-based criteria are also commonly used by governmental programs. For example, the World Bank's Climate Investment Funds (CIF) specifically targets low and middle-income countries, prioritising regions that are most vulnerable to climate change [18]. Similarly, the Adaptation Fund,

established under the Kyoto Protocol, provides financial assistance to developing countries that are particularly affected by climate change. This fund helps communities build resilience against climate impacts, such as droughts and floods, which are common in regions like sub-Saharan Africa and Southeast Asia [19].

Project scale and financing amount play a significant role in determining eligibility for government funding. Programs often set minimum and maximum funding amounts to ensure that resources are allocated efficiently. The Green Infrastructure Fund in the UK, for example, finances large-scale infrastructure projects, typically requiring investments in excess of £5 million. These projects focus on significant environmental benefits, such as large-scale urban greening or the development of sustainable transportation networks [20]. On the other hand, smaller, localised projects might be funded by regional programs, such as the Local Energy Scotland CARES Fund, which provides small-scale grants for community-owned renewable energy projects [21]. Additionally, many programs require co-financing or private investment to complement public funds, encouraging partnerships between public and private sectors.

Environmental impact is a central criterion for most government funding programs. Projects are typically required to show a significant reduction in carbon emissions or improvements in environmental sustainability. For example, the Low Carbon Contracts Company (LCCC) in the UK funds projects that contribute to national carbon reduction goals by supporting low-carbon energy generation, such as offshore wind or carbon capture and storage technologies [22]. Projects funded by the Climate Bonds Initiative are evaluated based on their alignment with global carbon reduction targets, with a particular focus on reducing greenhouse gas emissions [23]. These projects must provide data on their expected environmental outcomes, including carbon savings and resource efficiency improvements.

The financial health and seniority of the applicant are also considered. Established companies applying for funding must typically demonstrate a strong track record of financial stability and a proven ability to manage large-scale projects. The European Investment Fund (EIF), for example, requires a thorough assessment of the financial history of applicants, including their previous projects and the stability of their revenue streams [24]. Start-ups, on the other hand, may need to demonstrate the scalability of their proposed innovations, as well as the potential for long-term sustainability. Many government programs conduct due diligence to ensure that projects have the financial and organisational capacity to deliver on both environmental and economic goals.

Compliance with national or international environmental standards is another crucial factor. Projects must often align with major international agreements, such as the Paris Agreement, and adhere to national laws regarding environmental protection. The Green Climate Fund requires projects to meet rigorous environmental and social safeguards, ensuring that investments do not harm vulnerable communities or ecosystems [25]. Projects seeking certification under programs such as LEED (Leadership in Energy and Environmental Design) or the Global Reporting Initiative (GRI) are viewed favourably, as these certifications demonstrate a commitment to high environmental standards [26].

Additionally, many governmental programs consider the social and economic co-benefits of the projects they fund. Initiatives that offer significant job creation in green industries, promote social inclusion, or improve public health outcomes often receive preferential treatment. For instance, the Just Transition Fund under the European Green Deal supports projects that help communities transition from fossil fuel-based industries to more sustainable alternatives [27].

### *1.3 Environmental, social, and governance (ESG) criteria for investments*

Environmental, Social, and Governance (ESG) criteria are a set of standards for evaluating a company's behaviour in areas that affect its long-term sustainability and societal impact [28]. These criteria help investors assess the ethical and sustainability risks associated with a company's operations. ESG is increasingly central to investment decision-making, as it allows investors to consider factors beyond purely financial performance. While financial returns remain important, ESG criteria provide a holistic view of how a company operates in relation to environmental conservation, social responsibility, and governance transparency. The Environmental component focuses on how a company’s activities impact

the natural world, such as its carbon emissions, resource use, and waste management practices. Social criteria examine how the company manages relationships with employees, suppliers, customers, and the communities in which it operates. The Governance aspect evaluates the quality and structure of a company's leadership, including executive compensation, shareholder rights, and internal controls [29].

To be considered ESG ethical, a company must demonstrate its commitment to sustainable practices, social responsibility, and transparent governance. One key element of being ESG ethical is alignment with international sustainability standards. For instance, companies that adhere to the United Nations' Sustainable Development Goals (SDGs) or the Paris Agreement on climate change show a commitment to reducing their environmental impact and promoting social equity. Another important factor is transparency and disclosure. Investors expect companies to disclose data on their environmental impact, such as greenhouse gas emissions, water usage, and waste management. Reporting standards such as the Global Reporting Initiative (GRI) or the Task Force on Climate-related Financial Disclosures (TCFD) offer frameworks for companies to report on their ESG performance in a way that investors can assess. Additionally, being ESG ethical involves taking proactive steps to address environmental and social risks, such as committing to carbon neutrality or developing supply chains that support fair trade practices [30]. A company that is considered ethical in ESG terms must also demonstrate strong governance structures, including a transparent leadership team and clear channels for accountability. This can include factors such as gender diversity on boards, fair executive compensation, and the presence of anti-corruption policies. Poor governance practices, such as a lack of oversight or conflicts of interest, can indicate higher risks for investors, making good governance a critical part of ESG considerations.

Environmental considerations under ESG encompass how a company's activities affect the planet. Investors typically scrutinise a company's efforts to reduce greenhouse gas emissions, use resources efficiently, and manage waste responsibly. For example, companies are assessed on their carbon footprint and their commitment to transitioning toward a low-carbon economy. Companies that set clear targets for carbon reduction or participate in initiatives such as the Science-Based Targets initiative (SBTi) are often favoured by investors. Carbon emissions, as a core element of environmental impact, are not just about a company's direct emissions but also its supply chain's carbon intensity and the long-term risks of climate-related regulations [31]. Another environmental factor worth mentioning is resource efficiency, which examines how well a company manages its consumption of water, energy, and raw materials. Companies that implement energy-saving technologies, use renewable energy sources, or apply water conservation techniques are seen as better aligned with ESG goals. Responsible sourcing of materials, particularly in industries such as construction and manufacturing, is important for ensuring that companies reduce their overall environmental impact. Pollution control and waste management also play a significant role.

The social dimension of ESG revolves around how companies interact with their employees, customers, and the communities in which they operate. Labour practices are central to the social assessment. Investors evaluate whether companies provide safe working conditions, fair wages, and opportunities for professional growth. Diversity and inclusion initiatives are crucial indicators of a company's commitment to equality. Companies that actively promote gender equality and diversity within their workforce are more attractive to socially conscious investors [32]. Community engagement is another aspect that falls under social criteria. Companies are increasingly expected to contribute positively to the communities where they operate, whether through corporate social responsibility (CSR) initiatives or sustainable supply chain practices. This includes efforts to respect human rights and ensure ethical treatment of workers throughout global supply chains, especially in industries where exploitative labour practices have been prevalent [33].

Governance addresses how well a company is run, with particular focus on transparency, accountability, and ethical leadership. A diverse and independent board of directors is an essential marker of strong governance. Investors look for companies where leadership is transparent, and decision-making processes are designed to prevent conflicts of interest. Boards that include a mix of genders, ethnicities, and professional backgrounds tend to foster more balanced and responsible

corporate governance [34]. The independence of board members from management is also important, as it promotes accountability and prevents undue influence over key decisions. Executive compensation is one more aspect that investors consider. Pay structures that are tied to long-term company performance, rather than short-term financial gains, are viewed more positively. In particular, companies that link executive pay to the achievement of ESG goals, such as reducing emissions or improving diversity, are often seen as more aligned with sustainable practices [35]. Furthermore, investors look for strong policies that prevent corruption and ensure that companies have effective mechanisms in place to manage risks, including ESG-related risks [36].

*1.4 Green loans*

Green loans are financial instruments specifically intended to fund projects that have a clear environmental benefit [37]. These loans are part of the broader trend of sustainable finance, which focuses on encouraging environmentally responsible investments. Unlike traditional loans, green loans come with stipulations that the capital must be used exclusively for projects contributing to environmental sustainability, such as renewable energy, energy efficiency, sustainable agriculture, or green infrastructure. The key distinction of green loans lies in the borrower's commitment to ensure that the funds are utilised for specific, environmentally beneficial purposes, and this use must typically be verified by external audits or evaluations to maintain transparency.

One of the fundamental criteria for granting green loans is the clear and defined use of proceeds. Banks require that the loan be directed solely towards projects that demonstrate significant environmental benefits. Then, banks and financial institutions must establish a robust process for evaluating and selecting eligible projects. The criteria often require borrowers to provide detailed environmental impact assessments, specifying how their projects contribute to sustainability. In some cases, the assessment is conducted with the assistance of third-party certification bodies that verify the environmental credentials of the project. These certification bodies might include global organisations like the Climate Bonds Initiative (CBI) or the Carbon Trust. The evaluation process also considers whether the project aligns with regional or international environmental goals, such as the Paris Agreement or the United Nations Sustainable Development Goals (SDGs). Projects that have the potential to significantly reduce carbon emissions or promote long-term environmental sustainability are more likely to receive approval. The bank's internal sustainability team or a third-party verifier usually oversees the project's alignment with these objectives [38].

Once the green loan has been granted, banks require clear tracking of how the funds are being used to ensure compliance with the loan agreement. To maintain transparency, borrowers must segregate the green loan proceeds from other funds, allowing financial institutions to monitor their use more easily. Regular reports or audits are commonly required to ensure that the funds are being used appropriately for the intended environmental projects. These reports might include details on how the funds have been allocated, the current status of the project, and any environmental benefits that have been realised to date [39]. Transparency is critical in the green loan market, and as such, financial institutions often require borrowers to submit regular updates on the environmental impact of the funded projects. These updates, typically required on an annual basis, are meant to measure the project's ongoing environmental performance. They include metrics such as carbon emissions reduced, energy savings achieved, or renewable energy generated. Banks expect these reports to be detailed and often require independent verification of the environmental benefits claimed. This ensures that the projects continue to align with the green loan's objectives throughout its lifecycle. In some cases, failure to meet the agreed-upon environmental benchmarks may lead to penalties, such as higher interest rates or the withdrawal of green loan status [40].

Borrowers must also meet certain eligibility criteria to qualify for green loans. Financial institutions evaluate the borrower's environmental track record, considering whether they have previously undertaken sustainable initiatives. For companies or organisations, strong governance structures that ensure environmental responsibility are often a prerequisite. In addition, financial institutions may look for companies that have adopted ESG (Environmental, Social, and Governance) practices or that are

listed on recognised sustainability indices. In some cases, borrowers may be required to show that they have a sustainability strategy in place, including long-term environmental goals and targets. This strategy must demonstrate the company's ongoing commitment to sustainability beyond the specific project being funded by the green loan [41].

1.5 Rule-based systems

Rule-based systems refer to a form of artificial intelligence (AI) or decision-making framework in which a set of predefined rules guides the system's operations or responses. These rules are typically expressed as "if-then" statements, meaning that if a certain condition is met, then a specific action or outcome is triggered. The rules within the system are often derived from expert knowledge in the relevant field and are encoded to solve specific problems or automate decision-making. Rule-based systems operate by comparing input data against these predefined rules and executing the corresponding actions when conditions are satisfied [42]. This approach has been extensively applied in fields such as medical diagnosis, fraud detection, financial systems. The novelty of this study lies in applying these principles to sustainable finance, where such systems could help streamline processes like credit allocation based on sustainability criteria.

A classic example of a rule-based system can be found in tax preparation software, which guides users through filing their taxes by asking a series of questions (the input). Based on the answers, the software applies tax rules (the "if-then" statements) to compute the user's tax liability. The ability of rule-based systems to automate decisions based on consistent rules makes them a useful tool in complex environments requiring adherence to strict regulations or predefined standards.

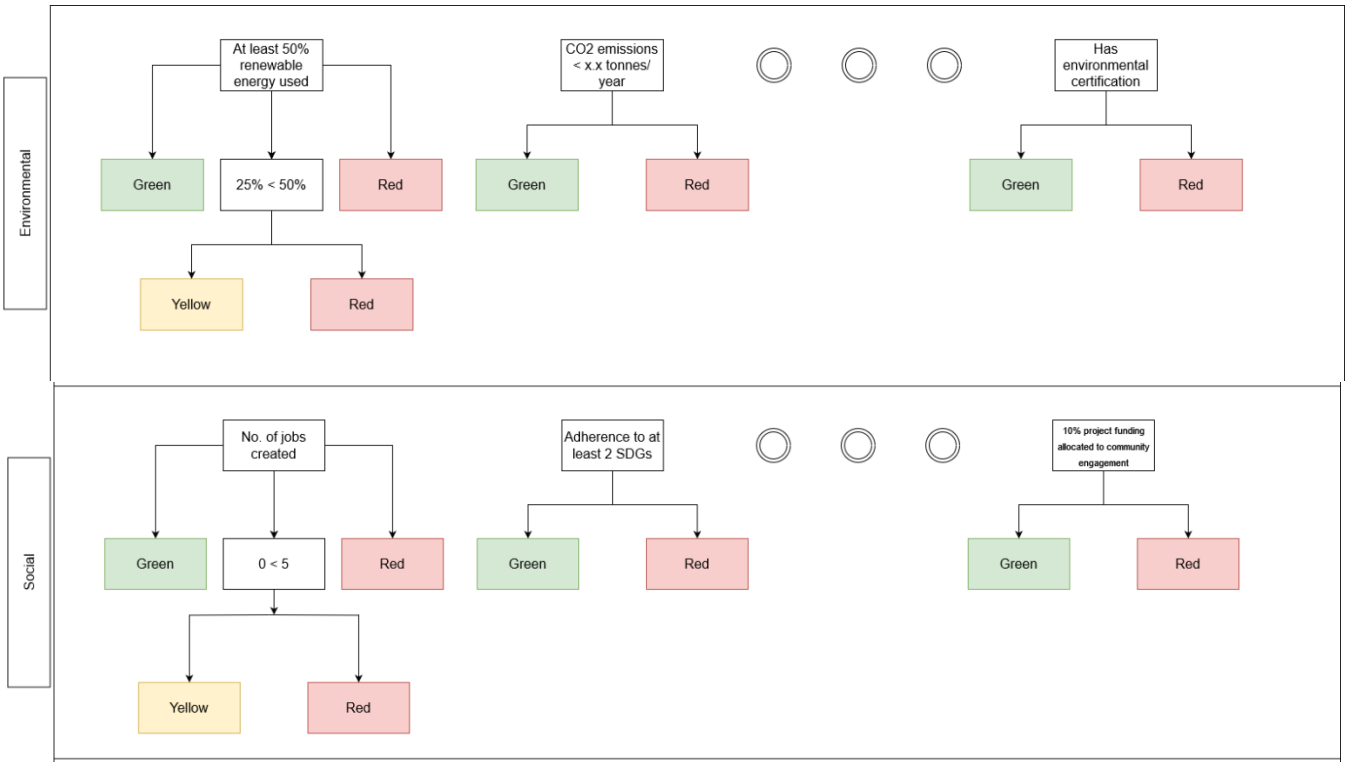
In the context of this study, a rule-based system can help standardise the evaluation process [43] for determining whether a loan applicant meets the necessary environmental, social, and governance (ESG) criteria. By encoding the bank's ESG standards into a set of rules, a rule-based system can automatically assess whether a project qualifies for green financing, based on specific indicators such as carbon emissions, energy efficiency, and resource use. This ensures that lending decisions are consistent and aligned with sustainability goals. For financial institutions, especially those that are mandated to adhere to strict sustainability guidelines, a rule-based system ensures that every decision is made according to pre-established rules, leaving little room for bias or arbitrary decision-making. This can be particularly useful when working with a large number of loan applications, as it ensures that each application is processed according to the same environmental criteria, reducing the risk of inconsistency. For borrowers, knowing that lending criteria are consistently applied builds trust in the loan approval process and fosters confidence that their projects will be assessed fairly.

Rule-based systems allow for the continuous updating and optimisation of decision-making frameworks [44] as regulatory requirements or sustainability goals evolve. As new green finance initiatives emerge or as governments tighten their environmental regulations, financial institutions can easily update the rules within the system to reflect these changes. This adaptability ensures that the bank remains compliant with current standards without needing to overhaul the entire decision-making process. For instance, if a country strengthens its renewable energy targets, the rule-based system can be programmed to favour projects that generate higher renewable energy outputs or are more energy efficient. Another significant implication for the study is the potential for rule-based systems to simplify auditing and reporting [45]. Since all decisions are made based on encoded rules, it is easy for financial institutions to track how each decision was made, which facilitates internal audits and reporting to external regulatory bodies. This is particularly crucial for green loans, where financial institutions are often required to demonstrate that the funds are being used in environmentally beneficial ways. With a rule-based system, these institutions can more easily produce the necessary documentation showing how loan decisions aligned with ESG criteria. By integrating continuous monitoring criteria into the system, such as periodic reporting requirements from the borrower on the environmental impact of their project, financial institutions can automate the ongoing assessment of whether a project continues to meet green loan conditions. This ensures that funds are being used as intended and that any deviations from the project's sustainability commitments can be addressed promptly.

## 2. Methodology

The analysis in this study is a proposal of how rule-based systems can be used to influence financial decisions toward more sustainable outcomes. Specifically, the study evaluates how integrating Environmental, Social, and Governance (ESG) criteria into decision tables can support financial institutions in making green loan approval decisions that promote sustainability and reduce environmental impact.

The decision tables in figure 1 were constructed to break down each category into measurable components under Environmental, Social, and Governance pillars. These components were carefully selected to reflect the most relevant criteria that affect green loan decisions. The decision table is made up of business rules that all fall under the characteristics or quality of condition. Each business rule in part will have a separate outputted decision (green/red, true/false, etc.), depending on the condition the specific business rule encapsulates. The result of the overarching decision table can be similar to that of a voting mechanism, in which a passing vote can be set to require unanimity, two thirds, simple majority, etc. The way the voting mechanism is chosen depends, just like with the business rules, on the subject matter expert designing the rules and/or tables. Similarly, the decision tables compose another layer of voting, which depends once again on the subject matter expert to define and refine in order to achieve a controlled output decision. Each business rule can be categorical, numerical, boolean and the exact values/thresholds, as well as the decision based therein, will be the result of subject matter experts' analysis and stakeholder discretion. These values have to be periodically updated, especially the numerical values that are in connection with financial/economical/demographic business rules.



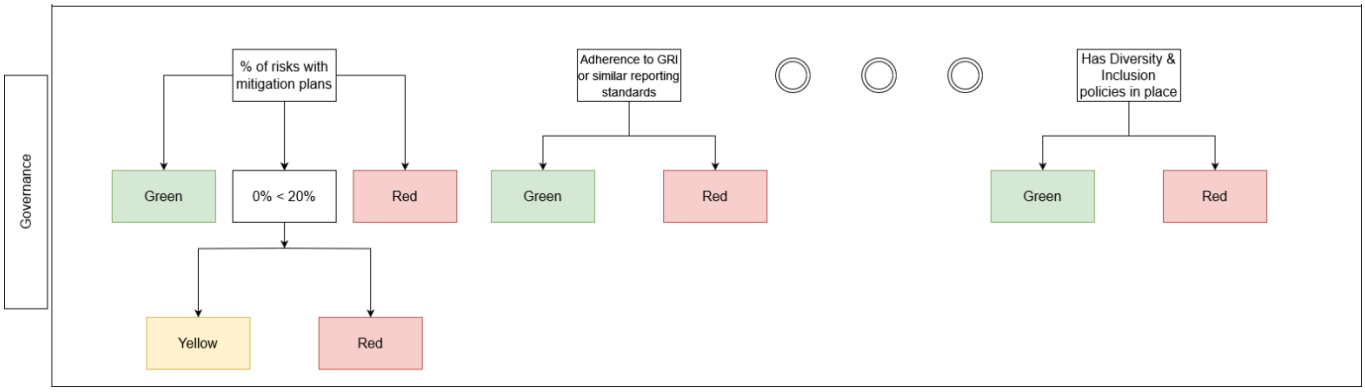



**Figure 1.** Decision tables

For each project/company in part relevant information (data) has to be inserted into a system through what is typically a data entry interface. This can also be done automatically, depending on the organization's level of technical maturity and available infrastructure. For example, a company profile can be created automatically using internal and external sources/processes such as an internal onboarding of a customer in a financial institution as an internal example, and publically released records of the companies' performance as an external source.

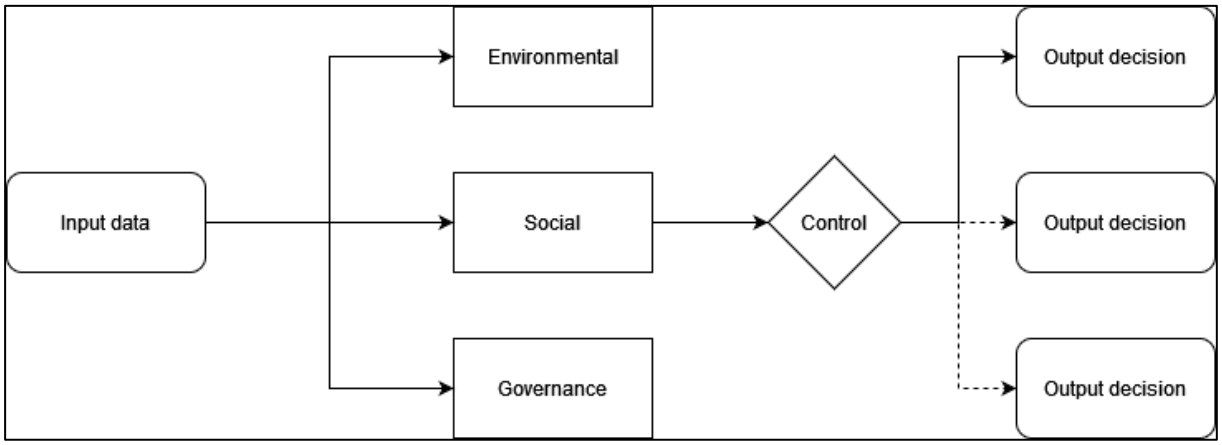



**Figure 2.** Rule-based system

## 3. Results and discussions

*3.1 Selection of business rules*

The process of selecting the business rules presented in the decision tables and diagrams involved a rigorous assessment of relevant Environmental, Social, and Governance (ESG) factors, of governmental programs directing investments towards sustainable initiatives, and of typical green loan criteria that are integral to sustainable finance. The aim was to create a set of business rules that would allow financial institutions to make data-driven, transparent decisions about whether to approve or deny green loans. By focusing on measurable criteria within the three ESG pillars, the business rules are designed to ensure that financing decisions promote sustainability, mitigate environmental harm, and encourage social and governance improvements within borrowing companies.

In the Environmental pillar, the chosen business rules reflect critical factors that contribute to a company's or project's environmental impact. One of the most important rules chosen is related to the use of renewable energy, where the system evaluates whether at least 50% of the energy used in the project is derived from renewable sources. This threshold serves as a key indicator of a company's commitment to reducing its reliance on fossil fuels. A project that uses 50% or more renewable energy is classified as "Green," signifying that it meets the high standards required for green loan approval.

Projects that fall below this threshold but still demonstrate some level of renewable energy use (between 25% and 50%) are categorized as "Yellow," indicating that they show potential but require further improvement. Projects using less than 25% renewable energy are classified as "Red," making them ineligible for approval without significant changes. This rule was chosen because of the well-established link between renewable energy usage and reduced greenhouse gas emissions, which is a core goal of green finance.

Another environmental rule focuses on CO2 emissions. The decision table evaluates whether the project's emissions fall below a certain threshold, which is typically industry-specific and aligned with regulatory standards. This rule was selected because carbon emissions are a widely recognized contributor to climate change, and reducing these emissions is central to most sustainability goals, including the Paris Agreement. A project with CO2 emissions below the acceptable limit is classified as "Green," while those that exceed the threshold are classified as "Red," triggering a requirement for an emissions reduction plan before the project can be reconsidered for financing.

The environmental certification rule was included to account for third-party verification of a project's environmental sustainability. Certifications such as LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method) provide independent assurance that a project adheres to specific sustainability criteria. Projects with such certifications are automatically classified as "Green" in the decision table, as these certifications are widely recognized as benchmarks of environmental performance. The presence of this rule ensures that projects meeting these recognized standards can easily qualify for green loans.

Within the Social pillar, the business rules are designed to capture a project's contribution to society beyond its environmental impact. One such rule focuses on job creation, a tangible and measurable aspect of a project's social impact. The decision table evaluates the number of jobs created by the project, with thresholds set to classify projects into Green, Yellow, or Red categories. Projects that create a significant number of jobs, typically more than five, are considered "Green," reflecting their positive contribution to local economies. Those creating fewer than five jobs are classified as "Red," signaling that the project may not provide sufficient social benefits to justify financing. This rule was chosen to ensure that the financial institution supports projects that contribute to local development and societal well-being, particularly in underdeveloped regions.

Another important rule in the Social pillar is adherence to Sustainable Development Goals (SDGs). Specifically, the system assesses whether the project contributes to at least two SDGs, such as reducing inequality, promoting gender equality, or supporting decent work and economic growth. Projects that align with multiple SDGs are classified as "Green," as this demonstrates a broader commitment to sustainability across multiple dimensions. This rule was included to ensure that the financial institution's investments support projects that have a holistic approach to sustainability, not only focusing on environmental goals but also promoting social development.

The third Social rule evaluates the percentage of the project's funding allocated to community engagement. This rule was selected to ensure that financed projects have a direct and positive impact on local communities. Projects that allocate at least 10% of their budget to community development initiatives, such as local partnerships or educational programs, are classified as "Green." Those that fail to meet this threshold are classified as "Red." This rule helps ensure that green loans contribute not only to environmental sustainability but also to enhancing social capital in the areas where projects operate.

In the Governance pillar, the business rules were designed to ensure that borrowing companies have strong governance practices in place. One key rule evaluates whether the company adheres to Global Reporting Initiative (GRI) or similar reporting standards. Transparent ESG reporting is essential for maintaining accountability and ensuring that companies are acting in accordance with sustainability commitments. Projects that adhere to such standards are classified as "Green," signaling that they are likely to manage funds responsibly and align with the green loan's objectives.

The second Governance rule focuses on the diversity and inclusion policies of the borrowing company. Companies with established diversity and inclusion policies, particularly in leadership positions, are classified as "Green," as these practices are closely linked to better decision-making and

stronger governance overall. This rule was chosen to promote social equity and ensure that the financial institution supports companies that value inclusivity and diverse perspectives.

The third Governance rule assesses the percentage of risks with mitigation plans. This rule was selected to ensure that projects financed by green loans have robust risk management strategies in place. Projects that have addressed more than 20% of identified risks with formal mitigation plans are classified as "Green." Those that have not are classified as "Red" or "Yellow," depending on the extent of the shortcomings. This rule ensures that projects are financially and operationally resilient, reducing the likelihood of failure or non-compliance with loan conditions.

It is important to note that the rules selected for this study are not exhaustive. These rules represent the key ESG factors deemed most relevant for evaluating green loans. However, additional business rules can be introduced based on the analysis of subject matter experts or as specific industries and environmental concerns evolve. This flexibility allows financial institutions to continuously refine their decision-making processes and adapt to emerging trends in sustainability.

*3.2 Simulation of the proposed rule-based system*

In order to exemplify how the proposed rule-based system should work, we will conduct a simulation. The company in question, referred to as Company A, operates in the manufacturing sector and has implemented several sustainability initiatives. For the environmental criteria, it was found that Company A currently sources 40% of its energy from renewable resources, such as solar and wind. While this demonstrates a commitment to sustainability, the percentage falls between 25% and 50%, placing the company in the “Yellow” category. Although the company is on the right track, further efforts to increase renewable energy usage would be needed to meet the higher "Green" classification. On the other hand, Company A's CO2 emissions are reported to be below industry benchmarks, registering at 40,000 tonnes per year. This places the company in the “Green” category for CO2 emissions, as they are below the required threshold. Additionally, the project holds a LEED Gold certification, which confirms the company’s strong environmental credentials and further classifies the project as "Green" for environmental certification.

Moving to the social criteria, the project is expected to create 20 new jobs in the local community, a significant number that comfortably exceeds the required threshold for this aspect. This classifies the project as "Green," as it demonstrates a positive impact on job creation and local economic growth. The project also aligns with three Sustainable Development Goals (SDGs): Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8), and Responsible Consumption and Production (SDG 12). By contributing to at least two SDGs, the project is classified as "Green" in this respect. However, for community engagement, Company A has allocated only 5% of the project’s funding to initiatives such as education and skills development programs. This places the company in the “Yellow” category for community engagement, as it falls short of the 10% threshold, indicating that there is room for improvement in this area.

The governance criteria revealed that Company A has formal mitigation plans for 25% of the risks identified within the project. This positions the company in the “Green” category for risk management, as it exceeds the requirement of addressing 20% of project risks with mitigation strategies. Furthermore, the company adheres to Global Reporting Initiative (GRI) standards and produces transparent ESG reports annually, ensuring that they meet recognized international reporting standards. This adherence places Company A in the “Green” category for ESG reporting. Additionally, the company demonstrates strong governance practices by maintaining established diversity and inclusion policies, with 40% of leadership positions held by women or minorities. This commitment to diversity also earns the company a "Green" classification in this governance category.

Overall, Company A’s performance across the environmental, social, and governance pillars indicates a strong commitment to sustainability. While the company performs exceptionally well in several areas, such as CO2 emissions, environmental certification, job creation, adherence to SDGs, and governance, there are areas—specifically renewable energy usage and community engagement—where improvements can be made. These areas are classified as "Yellow," reflecting their potential but

signaling a need for further progress. Despite these minor shortcomings, the project is likely to receive approval for the green loan. Recommendations would include increasing renewable energy use to surpass the 50% threshold and enhancing community engagement efforts to allocate a larger share of the project's funding to social initiatives.

## 4. Conclusions

The conclusions drawn from this study highlight the importance of a structured, rule-based system for guiding financial institutions in their green loan decisions. By integrating Environmental, Social, and Governance (ESG) criteria into the loan approval process, financial institutions can ensure that their lending practices promote sustainability and contribute to reducing environmental harm. The decision tables constructed in this study provided a clear framework for assessing the eligibility of borrowers based on measurable and objective criteria, allowing for data-driven, transparent decisions.

However, this study also revealed some limitations. The decision tables used are not exhaustive and may not cover the full range of ESG criteria relevant to all sectors or regions. As such, this system is adaptable, and business rules can be added or modified based on insights from subject matter experts or specific industry requirements. Another limitation is the reliance on data availability and the accuracy of reporting from the borrowing companies. If data is incomplete or not up to date, it could lead to misclassifications, affecting the final loan approval decision. Furthermore, the analysis primarily focused on static, measurable criteria, while the dynamic and evolving nature of sustainability practices might require more flexible evaluation systems in the future.

Recommendations for future research include developing more comprehensive decision tables that account for sector-specific ESG criteria, allowing for more tailored evaluations. There is also a need to explore the use of advanced technologies, such as machine learning, to predict long-term sustainability outcomes based on historical data and trends. Future studies could explore the application of real-time data integrations through third-party APIs or external databases to enhance the accuracy and timeliness of the data used in these decision systems. Future research could also investigate how the financial institution's technical infrastructure influences the effectiveness of automated decision-making processes. Given the rapid advancement of artificial intelligence (AI) and machine learning, future systems could benefit from predictive models that learn from previous lending decisions and ESG performance, thus offering more adaptive and forward-looking green loan assessments. Moreover, research into how financial institutions can support companies with contingency measures, such as developing roadmaps for meeting renewable energy targets or improving governance practices, would be beneficial for enabling companies that fall into the "Yellow" category to eventually qualify for green loans.

In conclusion, the rule-based system developed in this study provides a robust and adaptable framework for green loan decision-making, promoting both sustainability and responsible lending. Nevertheless, ongoing refinement, technological advancements, and broader industry involvement is important to ensuring that these systems evolve alongside the changing landscape of sustainable finance. By continuously updating the decision criteria and exploring more dynamic, predictive models, financial institutions can better support the transition to a greener, more sustainable economy.

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