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Research Article

Artificial Intelligence-Supported Green Financing Solutions for Sustainable Development: The Case of Turkey

Çetin Ünen[1]

[1]Lecturer Dr., Kayseri University, Pinarbasi Vocational School, Banking and Insurance Department, Hürriyet Mahallesi Mehmet Akif Ersoy Caddesi No: 10 Pinarbasi Kayseri, Email: cetin.unen@kayseri.edu.tr
Orcid: https://orcid.org/0000-0001-9097-9088

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ABSTRACT

This paper attempts to analyze how artificial intelligence supported green financing could help advance the sustainable development goals (SDG) in Turkey. This paper discusses Turkey's current situation on green finance through literature review and secondary data analysis and the implementation of AI in the financing processes. The research demonstrates that AI driven solutions might contribute to less investment risks, data driven decision making processes and the optimization of resource allocation. Still, a lack of awareness, technical infrastructure deficiencies and regulatory gaps limit the process. Recommending enhancing regulatory frameworks, increase public private partnerships, and enhance technological capacity to expand the use of AI supported green finance in Turkey, the study provides recommendations. For literature, and for other developing countries, this is an important contribution to the study in this context.

1. Introduction

Developing green economies in the face of environmental problems has become a necessity in Turkey and around the world. Innovative technologies and practices are now needed more than ever because of new environmental problems that are affecting the entire world. Obviously, this study primarily focuses on analyzing the integration of artificial intelligence (AI) in green financing mechanisms to facilitate sustainable development goals (SDGs) in Turkey. Specifically, this research addresses the following questions: How to optimize financial resource allocation and reduce risks in green financing processes using AI? (ii) What are the current challenges and opportunities for executing AI-based green finance solutions in Turkey? By answering these questions, the study makes two significant contributions to the literature: It identifies how AI improves the efficiency and transparency of green financing first and second and gives actionable policy recommendations tied to Turkey's specific economic and institutional context. In this context, it is vital for countries to discover prospective green financial solutions designed to ease the accomplishment of these practices and strategies. As such, the main objective of this paper is to introduce considerations of how attempts can be made from an alternative perspective to illustrate the interrelationship between these two basic theories in the context of Turkey. This study will initially discuss general strategies that can be viewed from the perspectives of financial and efficiency management for Turkey in terms of green development efforts. It will then provide some strategies for realizing the prospects of these approaches in practice; alternative financial solutions will be depicted for examining investment and structural funds under a separate heading. Given this framework, we will focus on artificial intelligence (AI) supported green financing and sustainable development practices and closely highlight Turkey as a case study. At the international level, the consensus on environmental considerations and allocations is an important opportunity to refer to in terms of establishing the necessity of this required unanimity and creating and disseminating certain basic principles. Given these judgments, according to the exponential advancement of the parties, there has not yet been a deterioration in the global climate condition—since the assurances and harmony set are not being implemented, a comprehensive and universal consensus is needed to create and spread essential conditions and rules (Anser et al., 2021; Gokmenoglu et al., 2021; Raihan & Tuspekova, 2022; Shan et al., 2021; Zhang et al., 2022).

The remainder of this study is organized as follows: Section 2 presents a conceptual framework about definitions and significance of green financing towards sustainable development. Section 3 discusses the integration of artificial intelligence into green financing processes and discusses its applications and benefits.

In the following section (4) we analyze in detail Turkey's contemporary green financing landscape, considering policies, initiatives and major players. Section 5 articulates challenges and opportunities for AI enabled green financing in Turkey. Finally, Section 6 outlines such policy recommendations to deal with these problems and facilitate the adoption of AI driven solutions. Finally in section 7, I conclude the study by summarizing key findings, implications, and future research directions.

1.1. Background and Rationale

Here, at the turn of the third decade of the twenty-first century, it is incumbent on all nations to enter jointly into a time of self-directed change. As the Earth faces colossal environmental risks to which no country is immune by itself, be it climate change, deforestation, or claims by environmentalists on needing more green areas to slow down the pace of anthropogenic climate change, the notion of sustainable development has gotten far more attention than it used to a few decades ago (Al-Shetwi, 2022; Ruggerio, 2021).

Recent statistics on financial flows and stock enhancement patterns confirm the increasing loss suffered by society and, even worse, since 2013, the negative multiplier effects of a downward spiral of lower labor productivity, growing inequality, unemployment, and stagnant wages. As a possible solution, we are looking into progressively innovative financing solutions, with artificial intelligence being one of the latest of these, which uses both intelligent agent-based modeling and natural computing techniques to concisely demonstrate two of the most sophisticated dimensions of efficiency known to date in financing processes. In recent years, positive as well as negative criticisms have been voiced against innovative AI solutions that propose to maximize efficiency in interest by forecasting the state of future financial markets (Balsalobre-Lorente et al., 2023; Khairunnessa et al., 2021).

While the demand for AI-based technologies in financing has intensified the searches in the academic community, there is an overwhelming need for providing comprehensive coverage of the available information and approaches, particularly when it comes to the nature and extent of positive or negative social impact that may result from such green financing practices. Of course, Afghanistan needs many passionate and well-equipped researchers and experts in the finance and technology fields. For instance, Turkey contributes about 1.9% to the European and Central Asian regional economies. The country's achievements in sustainable finance come at a time when at least 1.4 million people in Turkey are at risk of not being able to meet their financial needs. Also, many institutions in the country have not integrated financial technologies into their work. In this context, the out-of-proportion increase in their knowledge and awareness of emerging green financing solutions and related technologies becomes an imperative for Turkey (Pomfret, 2022; Püsküllüoğlu, 2023; Vinokurov et al., 2022).

2. Green Financing and Sustainable Development

Green financing refers to financial instruments used to raise capital for environmentally friendly projects and activities. The paradigm of sustainable development addresses strategies and tactics that can protect the environment and enhance human welfare. Inequality, excessive resource consumption, and environmental degradation emphasize the necessity of changes to ensure sustainable welfare for future generations and meet the current demand of the people. Development strategies and tactics support both economic growth and ecological preservation. The essence of sustainable development lies in reconciling these dual goals. Located at the core of the circular economy and the development paradigm, green financing strategies seek to finance projects that reduce pollution, protect human health, improve natural ecosystems, and accelerate their recovery. Green bonds, green profit-sharing bonds, green lease certificates, sustainable project finance, sustainable mortgage systems, and sustainable consumer credits are some of the financing mechanisms used in the world and Turkey. Green and sustainable investment funds are also gaining an important place in parallel with corporate governance and stakeholders in the financing of projects that prioritize ecological priorities. The green financing mechanism has the potential to make a significant contribution to the environment and society. However, it is a principle that all actors involved in social, environmental, and economic development and stakeholders in terms of sustainable development and green finance can improve their standards by following national green and sustainable institutional and environmental standards in accordance with their principles. Reforming the institutional structuring of countries and conducting pilot studies will raise international awareness about the standardization of green finance projects in developing countries with lower income levels and opportunities (Akomea-Frimpong et al., 2022; Falcone, 2020; Gilchrist et al., 2021; Ozili, 2022; Taghizadeh-hesary & Yoshino, 2020).

2.1. Conceptual Framework

Green financing, in its broadest context, refers to the principle of corporate social governance that eliminates the long-term environmental impacts caused by traditional business operations and improves resource use efficiency while simultaneously reducing costs. It recognizes the complementarity of financial investment and environmental protection and relies on policies and technology for environmental governance to promote the realization of green development. With the combination of the above concepts, the link between financial investments and appropriate environmentally sustainable developments can be maintained, and indicators for economic growth rate, financial development, individual consumption, and sustainable development can

be obtained by formulating these definitions. New mechanisms, such as the flow of financial resources to one of the possible allocations, while other consumer spending, a variety of goods and services (however, especially meeting basic human needs concerning the need to ensure environmental sustainability), will also be provided through the functioning of various financial products and the various characteristics of the financial instruments supported by consumer needs and goals modeling (Liang & Renneboog, 2020; Sadiq et al., 2022; K.-H. Wang et al., 2022).

At institutional, association, industry, and system levels, in particular, there are various models from different policies to financial flows that will ensure the allocation of resources to green applications and highlight the flow dynamics of financial resources to sustainable projects. This article will follow the structure of "green funds," "establishment of green funds," and "green funds in Turkey" through discussions on the concepts, functions, and asset allocation processes of the actors in the stock market and stock market investment. Furthermore, as much as growth models can be implemented, a policymaker who can move and develop finance-technology mechanisms at a time that will be meaningful in terms of resources required to achieve a low-carbon economy in coordination will improve the triple edges like cost-effectiveness from sustainable investments that are thought to be effective and can perform the duties for sustainable investment policymaking (Agrawal et al., 2024; Bolón-Canedo et al., 2024; Lv et al., 2021).

3. Artificial Intelligence in Green Financing

Artificial intelligence, machine learning in particular, is increasingly finding applications in green financing. Better integrating the methodology reduces the scope for value-destructive ethical externalities and promotes stakeholder trust, as, for example, preparing for future-proof automated insurance pricing. While they lack ethical consciousness, AI-powered algorithms trained on ESG data use crowdsourced wisdom to optimize expectations regarding status quo maintenance and are increasingly being used to help winnow noxious emissions, security veil, and other UN SDGs from professionally managed investment funds. Available solutions include natural language processing, gradient boosting machines, Black-Litterman models, conflict event prediction, anti-money-laundering technologies, and big data-based AI for combating terrorism funding (Bolón-Canedo et al., 2024; Debrah, C., Chan, A. P. C., & Darko, 2022; Kumar et al., 2022; Macchiavello & Siri, 2022).

Prominent emerging approaches relate to deep learning, focusing especially on risk assessment and financial regulation and compliance. This enables credit investors and managers to develop more robust financial risk and return forecasts given the relative and often long-term impacts of environmental changes, high-tech offerings, changes in the economy, healthcare, and the social sector. Ever more institutional venture capitalists, natural resources traders, and even banks are already using digital technology to generate machine actionable economic and market insights by mining data, reading legal briefs, and pattern-content sorting thousands of pages in mere seconds to establish bias parameters and likely regulator response functions, thus creaming profits with more insulation from true event risk. Other case uses of AI in green financing include regulatory reporting, high-speed algorithmic trading, investor insights, and entity risk scoring (Hegde & Rokseth, 2020; Z. Ma & Mei, 2021; Shen et al., 2021).

3.1. Applications and Benefits

Artificial intelligence applications have a significant role in green financing. AI can systematically assist in identifying and assessing which projects might fall within the green taxonomy category. The benefits of emerging AI applications are convenience, speed, reliability, and predictive accuracy. As finance is mainly about predicting the expected future outcomes of investments and other impacts, AI can assist financiers in facilitating and increasing the accuracy of their predictive analytics. This may lead to further reductions in finance and insurance solutions and operations costs, as well as reduce the amount of labor that is necessary. Aside from that, AI systems enabled by financial technologies can provide increased traceability and transparency in transactions. This will allow a greater degree of certainty and reliability, along with the related legal assurance to the parties. This is because smart contracts, blockchain, and other relevant fintech can produce tamper-resistant records, which can be used as a legal basis in case of any commercial legal dispute. Another benefit related to AI in financial institutions is the ability to have real-time data and reporting of the environmental, social, and commercial implications of investments. This is particularly important in the area of green finance, where physical and transitional changes that may impact risk management and the value of investments can occur rapidly. In this respect, financial institutions can respond to these changes, mostly in predictive terms, thus forecasting the value rather than relying solely on projected qualitative factors, especially in terms of pandemic-related risks. Yet another advantage of AI applications in finance at the project or investor level is that AI can provide more data-driven predictive findings regarding the qualitative factors of environmental, social, and commercial dimensions of a given investment. This can benefit not only project managers but also financiers in making better strategic or financial decisions (Cao et al., 2021; Debrah, C., Chan, A. P. C., & Darko, 2022; Macchiavello & Siri, 2022; Madaleno et al., 2022; Zhou et al., 2022)

4. The Case of Turkey

When it comes to green finance in Turkey, the most popular form of sustainable investment is environmental, social, and governance investment. Although this concept of sustainable investment has roots back to the 1900s for Western countries, the Turkish context emerged in the early 2000s, and awareness has risen rapidly in the last decade. Individuals with social responsibility and sustainability prioritize ESG criteria, and they do not avoid investing in business processes or projects that are pledged to "do no harm" to the environment and society. Investors use ESG rating services or market data from various companies to search and classify financial institutions and companies using a combination of ESG criteria (Bayram et al., 2022; Sariyer & Taşkın, 2022; Yilmaz et al., 2020; Zehir & Aybars, 2020).

The results of the scope of this study show that the Banking Regulation and Supervision Agency is committed to ESG principles in a circular letter, and many of the top banks in Turkey have a more inclusive classification such as green finance, sustainable finance, sustainable development finance, etc., but no separate institutions or stakeholders are mentioned or explained under these classifications. As a result of the research, it was understood from the practices of certain banks that the Terms of Use are based on the "Green Bond Principles" and "Social Bond Principles" and that social and environmental aspects are explained in detail regarding the allocation of loan and credit transactions conducted through different products under the headings of green finance or sustainability or sustainable finance. The application of algorithms in many other sectors and in the world, literature can be continuously observed in the FinTech world. Turkey's high reputation from public to private sector actors around rapid adaptation to technological innovation offers a great opportunity for the attractiveness of AI-based ESG applications. Again, the actors emphasize that it would be very difficult to keep track of a rapidly growing and changing credit market or financial world without using any AI-based applications (Aras & Hacioglu Kazak, 2022; Aras & Kutlu Furtuna, 2024; Bayram et al., 2022; Güler, E., Seyidoğlu, 2024; Özbek, 2024).

Green finance and ESG (environmental, social, and governance) investments in Turkey have gained significant momentum in recent years. Green Bond Issues in Turkey: Green bond issuances in Turkey have been on the rise since 2016. The amount of environmental and sustainable bonds issued by the banking sector totaled USD 2.7 billion. Turkey Green Fund: The Turkey Green Fund, established in cooperation with the World Bank and the Industrial Development Bank of Turkey (TSKB), is expected to reach a total size of USD 405 million with the mobilization of USD 250 million in private capital. This fund aims to support the green transformation of companies in Turkey. Green Financing Projects of Banks: Banks in Turkey are focusing on green financing projects in many sectors ranging from heavy industry to textiles, from food to energy. Following the signature of the Paris Climate Agreement, sensitivity in this area has increased even more. Green Financing and Loan Market in Turkey: The green financing and loan market in Turkey has grown rapidly in the last 5 years. A remarkable growth was recorded, especially in the period 2022-2023 (*$155 Million World Bank Loan to Expand Equity Finance for the Greening of Turkish Firms*, n.d.; *ESG Issuances - TR Ministry of Treasury and Finance Official Portal*, n.d.; *İşbank Makes Landmark Move with First-Ever Domestic Green Debt Instrument Issuance in Turkish Lira | Türkiye İş Bankası*, n.d.; *TSKB Issues the First Ever Green Bond out of Türkiye | TSKB*, n.d.).

Exit of Banks from Coal Investments: By 2024, the number of banks that have completely exited coal investments in Turkey will have reached 4. In addition, the number of banks committed not to finance new fossil fuel projects increased to 10. Green Bond Issuances and Firm Value in Turkey: When the effect of green bond issuances on the stock returns of companies in Turkey is analyzed, significant positive returns are found in the stocks of companies on the first day following the green bond issuance. These data show that green finance and ESG investments are gaining importance in Turkey, and financial markets are orientated towards this area (Dumlu & Keleş, 2023; Göçmen Yağcilar & Yilmaz, 2022).

4.1. Overview of Turkey's Green Financing Landscape

Turkey's green financing landscape presents a blend of public and private sector actors. As a developing country, the Turkish government and many regional actors have initiated new projects, systems, and platforms towards the generation and financing of green investments. In terms of national bodies, the Green Climate Action Turkey aims to finance and facilitate climate investments and implement projects on agriculture, land use, and sustainable cities. The institution also develops new market and business-enabling mechanisms to engage private companies in climate finance and develop green projects and financial products that fit the market needs. This institution receives its funding from a development bank, and funds are earmarked for Turkey as a priority (Kul et al., 2020; Odugbesan et al., 2021; Özkan et al., 2024)

Several private and commercial banks intend to provide credit or financing with a low or reduced interest rate for green projects. On systemic finance for environmentally friendly investments, also known as green financing, a big proponent is the Turkish state in general. In the past few years, there have been several special plans and other regulatory measures, such as support packages and incentives, to stimulate the use of green financial products. The segment of private banks that provide loans for environmental protection projects in Turkey is growing, and there are special financing activities specific to environmental protection. This involves financing manufacturers of ecological products or of products manufactured through an eco-friendly process, as well as loans for the establishment of all types of plants that comply with emission

standards. The total share of environmental loans in total loans increased from 2.85% to 3.33% in the survey examined (Javadi & Masum, 2019; Li et al., 2024; Y. Ma et al., 2024; Qiu & Yu, 2024; T. Wang et al., 2022).
In Turkey, there are various initiatives in the field of green finance in which both the public and private sectors play an active role. These initiatives offer different financing models and incentives to achieve sustainable development goals and support environmental projects.
Public and Private Sector Initiatives: Public and private sector initiatives play a crucial role in facilitating the implementation of AI-supported green financing solutions. These initiatives can enhance collaboration between stakeholders, drive investment in sustainable projects, and ultimately contribute to the achievement of Turkey's sustainable development goals. Turkey Green Fund (TYF): Managed by the Industrial Development Bank of Turkey (TSKB) with the support of the World Bank, TYF aims to reach a total size of USD 405 million. The fund aims to provide capital financing to companies in the process of strengthening their environmental, social, and governance (ESG) criteria.
Turkey Green Industry Project: Within the scope of this project supported by the World Bank, financing amounting to USD 450 million was provided to support the green transformation processes of industrial companies in Turkey. USD 250 million of this financing was allocated to projects aimed at increasing the resource efficiency of small and medium-sized enterprises (SMEs). Turkey Sustainable Energy Financing Programme (TurSEFF): Supported by the European Bank for Reconstruction and Development (EBRD), TurSEFF provides financing for energy efficiency and renewable energy projects. The program offers loans of up to EUR 250.000 for small-scale projects and up to EUR 5 million for medium-scale projects. Green Financing Products of Private Banks: Private banks in Turkey have developed various financing products to support environmentally friendly projects. İşbank Environmental Loans: İşbank offers renovation and renewable energy support loans for tourism businesses making environmentally friendly investments. Special car loans are also available to encourage the purchase of electric vehicles. Halkbank Environmentalist Vehicle Loan: Halkbank provides environmentally friendly vehicle loans with favorable interest rates and maturity options to support the purchase of electric and hybrid vehicles. Environmental Protection Expenditures: Environmental protection expenditures play a crucial role in promoting sustainable practices by allocating financial resources towards initiatives that mitigate environmental degradation and enhance natural ecosystems. According to the Turkish Statistical Institute (TurkStat), the share of environmental protection expenditures in gross domestic product was 0.9% in 2021. In 2020, this ratio was 0.8 percent, indicating an increase in spending on environmental protection. Green Financing and Sustainability Reports: TSKB Economic Research Unit, in its report titled 'From Carbon to Credit: Restorative Agriculture and Carbon Credits' draws attention to the importance of restorative agriculture practices and the carbon credits that can be obtained from these practices. The report also points to the role that restorative agriculture and carbon credits can play in the recovery of the earthquake zone. Financing Opportunities for Green Transformation: The Scientific and Technological Research Council of Turkey (TÜBİTAK) has published a report titled 'Financing Opportunities for Achieving Green Transformation Goals'. This report provides an important roadmap for Turkey to achieve its green transformation goals (Bakanliği, 2024; *Türkiye'deki Şirketlerin Yeşil Dönüşümü Için Sermaye Finansmanını Arttırmaya Yönelik 155 Milyon ABD$ Dünya Bankası Kredisi*, n.d.).

5. Challenges and Opportunities

Turkey deals with several challenges while it is ready to seize the opportunities in the field. Institutional challenges include limited environmental and social debt policy, weak environmental and social investment awareness, no laws or incentives to promote sustainable and justifiable financing, and limited capacity of international financial institutions. Financial challenges involve the need for equity, including soft loans and grants, high transaction costs, reduced risk, long payback time, lack of liquidity, and profitability that has remained lower than global indicators in the build-out phase. There is limited access to capital in different regions, difficulty in overcoming policy and market price risks, a financing gap, and limited access to long-term project debt constraints. There are also constraints on borrowing hard currency, limited domestic and international secondary markets, and constraints on equity financing. Technical challenges include available data, including a project pipeline, legal mechanisms to build the pipeline, and using standards such as harmonization with the Protection Principles, Performance Standards, and the Equator Principles. Reliability and sufficient trend information are also important, as are environmental and social impact assessment projects. The ecosystem should be holistic and work together, including investment and finance, projects, and transactions. Innovative and scalable solutions should be supported to operate and green the system. Artificial intelligence can contribute effectively to solving technology use and capacity constraints (Dogan et al., 2023; Goel et al., 2021; Özgül et al., 2020).
There is many engineering infrastructures planned in Turkey, such as high-speed trains and transportation mega-projects. Many of these will have significant social and environmental impacts. Through effective green financing, projects with significant long-term benefits can be systematically prioritized with respect to the environment and society. One of the centerpieces of Turkish economic development is the transition to a sustainable economic model. At the heart of a sustainable society is harmonization between people and their environment. It requires social development; economic growth and long-term profitability can all be implemented. This requires integrating social, environmental, and economic sustainability into the project.

In strengthening national development, it is important to put these plans into the National Action Plan for Harmonization with Financial Principles in Turkey, aligning with globally accepted and equivalent financial systems. Although it has begun to mobilize and cooperate on the green financing agenda, such as establishing and leading organizations, the issue of green financing is slightly lower. Stakeholders need to agree on action strategies, network, and adhere to new decision-making mechanisms and preferences. Intergovernmental alignment and harmonization of national and international economic development plans for action are necessary. A synchronized process is needed to align the guiding model and its components. Strategies and instruments should be continuously verified, tested, and adjusted as necessary (Degirmencioglu Aydin & Aydin, 2024; Kayakuş et al., 2023).

5.1. Barriers to Adoption

Although many green financing solutions exist, uptake is relatively low in Turkey. Barriers can be categorized as financial, regulatory, and capacity. Financial barriers include the fact that green financing requires significant upfront investment and long return on investment periods. Regulatory barriers cover the fact that currently innovative products are not explicitly acknowledged by institutions; in practice, this provisionally extends the already burdensome credit application process. This can be changed, if successful, and subsequently also pursue regulatory changes and supporting interventions to secure the market, as Turkey does not yet have a secondary market for green loans. Data limitations restrict the number of potential clients being aware of and engaging in green finance, as both banks argue that the setting where customer engagement in green lines does not require a certain amount of green project financing is also a legal requirement to apply for a green loan, and needs are therefore in fact decreased relative to actual demand for green inputs. An application for a loan can be discouraged, or they can compromise would-be customers' access to green financing. Capacity limitations, both for banks and clients/property owners, have prevented further engagement in green finance in Turkey. The tools that would be seen in this area are recognizing brown redemption and sustainability credentials to increase awareness and understanding of green finance (Anas Et Al., 2024; Citil, 2024; Hossain Et Al., 2024; Nawaz Et Al., 2021; Steffen, 2021).

Challenges with the current regulatory framework that do not directly support innovation and having to adapt to established operating models and processes contribute to this in Turkey. In the absence of an established infrastructure or quality assurance for such projects in the building renovation market in Turkey, adapting the EPC-F to Turkish circumstances is considered a high-risk strategy, and financing is not currently being pursued. In general terms, the main barriers to investment in substantially sustainable solutions are initial capital limitations; the high rate of return on investment, which can make a project less appealing or increase the perceived market risk; and regard to high innovation risk to finance. There are also more specific barriers, like those facing the banking sector. Current practices, particularly in real estate, are noted as barriers because they lack the political and institutional structure and government incentives required to handle the deep renovation of existing residential buildings. This infrastructure extends to financing, with loan funds linked to being provided by, in addition to over the years. It needs to be noted that such investment considerations are different for investors concerned with the value of their investments over a period beyond five years (Özgül et al., 2020; Shan et al., 2021; Xu et al., 2022).

6. Policy Recommendations

To resolve these major challenges, a set of policy recommendations has been developed to enhance the case for green financing in Turkey. The new comprehensive regulatory framework should be expedited for sustainability, given the recent amendments in the field of ESG reporting and disclosure. This new infrastructure should, on the one hand, facilitate the supply side to provide a viable environment for green project development and encourage long-term investment horizons. More specifically, it should include a dedicated chapter for green financing, encompassing clear definitions, principles, and standards about green financing instruments to facilitate sustainable investments. It is essential to refine, polish, and operationalize the economic analyses of green projects and investments based on them (Bayram et al., 2022; Odugbesan et al., 2021; Ozili, 2022).

Yet, for this purpose, the relevant cabinets, which will be newly created after the elections, should be equipped with the expertise to integrate these analyses as performance metrics into the KPI systems of public utilities. The proposed amendments should also address the concerns emanating from the weak legal backgrounds of the investment incentive and feed-in tariff schemes. In other words, they should consider a reform under international law to remove the uncertainties stemming from the operation of the bilateral investment treaties and an overhaul of national law to accommodate the ambitions of the new investment agreements that will take over the existing bilateral investment treaties. This would clarify the grounds under which investors can seek protection and compensation in international arbitration courts. The draft bill needs to put a separate emphasis on phase 2 of the strategy: institutional capacity building for the implementation of the envisioned financial restructuring. First, it is essential for the public and regulatory bodies to establish links to the financial administration for the prioritization of prospective bankable projects. Therefore, career paths should be restructured at the decision-making centers within the ministry and relevant state agencies. Similarly, financial analysis and structuring units should be established at the interface between public

project developers and potential investors. These units should either be assigned to development and investment banks or be run directly under the umbrella of the Ministry of Energy and Natural Resources. Second, the ongoing climate policy studies and workshops need to be deepened for public-private partnerships to start producing tangible, immediately bankable projects attracting bridging finance. For that, Turkey should partner with either project developers possessing a fund portfolio in the development or PPP phase or with fundraising authorities. The likelihood of project realization financed by international financial institutions is higher than that by foreign direct investment, as the former directly contributes capital without expecting additional profits in the future (Ari & Koc, 2021; Baker & Benoit, 2022; Büyükkaraciğan, 2023; *Introduction to Project Finance in Renewable Energy Infrastructure ... - Farid Mohamadi - Google Books*, n.d.).

6.1. Regulatory Frameworks

Not only is the development of a robust legal structure that is in conformity with international standards and commitments, but also the adaptation of existing national regulations is important in order to encourage green financing. Unfortunately, Turkey has had some difficulty in ensuring compliance with environmental standards and the regulations for environmental protection. Although Turkey has established a significant legal structure for environmental protection, the fact that enforcement and compliance are increasing, and the necessary instruments have not been adequately prioritized within the legislation has caused Turkey to have difficulties in this respect. Procurement of compliance with the mentioned and prepared related regulations regarding the ISO 14001 standard, as determined within the agreements, and the consistent compliance with the conditions of the partnership in secondary legislation, as well as compliance with the procedures and principles determined within the Ecological Studies Permit Implementation Regulation, are important with respect to green financing (Acar et al., 2022; Bashir et al., 2024; Shao et al., 2021).

The fact that the laws and regulations that are valid in a country, apart from being appropriate, make valuable contributions to attracting FDI from abroad, mainly by establishing transparency, ensuring reliability, and eliminating equal or divergent treatments. Additional capital inflows through FDI in the form of equity to manufacturing firms in developing countries lead to an increase in the desired outcomes such as output, productivity, and exports. In addition to this, in Turkey, having transparent and predictable government regulations has a positive effect on macroeconomic indicators such as GDP, investment, new employment generation, consumer trust, and price stability. In this respect, it is important for governments to justify the regulatory requirement to set the boundaries of property and to ensure that a proportion of environmental protection and investments are confidential. The obligation meets the cost of compensation for all loss of rights and interests of holders who are affected by the seizure, as well as loss of property rights of holders who were directly affected by the current obligation for public use. This obligation is enacted and is free from the risk of falling to expropriated value insufficiencies. At this point, there may be some problems regarding the valuation of ecological services. If these problems are addressed and if stakeholder agreement can be ensured, important steps towards adaptation to development in a sustainable manner will be possible (Arzova & Sahin, 2024; Bulut, 2020; Cevik & Erduman, 2020; Khudari et al., 2023; Tekin et al., 2023).

7. Conclusion and Future Directions

This article examined the crucial need for artificial intelligence in delivering initiatives for green financing, largely contributing to sustainable development. Turkey, like other developing countries, has strived to provide financing solutions for specific sustainable development economy areas. Nevertheless, the designed approaches depend on unsystematic data screening and systematic solution forms because inefficient optimization tools do not currently exist to support financial institutions. AI is crucial to find optimum green investment points based on individual national plans and country characteristics; the results demonstrate that green finance opportunities will contribute to Turkey's climate goals and environmental landscape in various ways, from the investor's opportunity cost on loan interest to the marginal opportunity costs for CO_2 emissions. In conclusion, this paper has stressed the crucial interrelations between AI, green finance, and sustainable development. Policymakers should concentrate on some possibilities while tackling the related challenges.

Artificial intelligence has become essential for delivering context-dependent green finance initiatives, playing a crucial function in the design of more proactive measures in specific sectors. This study is expected to play a key role in the development of solution maps. Green finance actions should be shaped according to the region or infrastructure where green finance investments will be made. Moreover, to further the research field, there are substantial interactions that may be influenced by policy, technology, and investment priorities. Policymakers have several possible future steps that should be evaluated: the portfolio of incentives in green finance, exploiting potential tax advantages, creating new green financing business models, and furthering capital markets' involvement in green finance investment tools. This study will fill the gap given the abovementioned findings and provide additional innovative finance mechanisms in further research that consider participatory stock market investment tools. The policy prospects described provide a good foundation for stakeholders in various fields to implement the further bright infrastructure possibilities required in Turkey.

7.1. Key Findings and Implications

The focus of this study was to identify the potential role of artificial intelligence (AI) in accelerating green financing to mobilize more resources for the realization of the sustainable development goals (SDGs) and the new sustainable development priorities in the light of the 2030 Agenda in developing countries. Based on the analytical knowledge generated throughout the study, the synthesis of the key findings and the potential implications for different stakeholders are presented below.

This study has highlighted various findings, which might be the starting point for deliberations and actions moving forward. The key findings include the potential influence of using AI down the chain in the decision-making process in green financing by offering reliable, systemic, and holistic insights regarding the stocks to be financed. The main caveat at this juncture in the use of technology in green investment is the low adoption of new technologies due to various reasons. Some critical areas where concerted efforts can open the pathway of adoption or use of artificial intelligence in finance for investment in sustainable projects were identified, such as data quality and quantity, education and capacity development, and market capabilities for technological readiness. The identification of these barriers also suggests possible solutions for the take-up of artificial intelligence tools in green finance. It involves designing training and education programs that could prepare finance functionaries for adopting data management systems. Moreover, coordinated efforts are suggested to develop other necessary capabilities such as technology, society, and policy.

The presentation and interpretation of findings and the building of thematic synthesis led us to the formulation of some initial thoughts regarding what the findings might mean. These are, of course, not answers or prescriptions. They are offered here as perspectives that may stimulate further thinking and consideration. First, we may have provided valuable insights into several facets of green and sustainable finance, more specifically technological dimensions, including some of the barriers that can impede their adoption. Efforts might be initiated to mitigate these barriers, bring clarity, and elevate the necessary competencies in the diverse financial communities of civil societies and developing countries. The findings might inform the design of inclusive and capacity-building programs in technology and finance with the aim of effective utilization of innovative financial instruments on the three bottom lines. This, however, needs the collaborative actions of policymakers, development organizations, and civil society at the global level. A stakeholders' dialogue, therefore, is necessary to validate the findings and, in the process, generate new and transformative knowledge.

It was also apparent that climate change, irresponsible investment activities, and the increasing aversion to the use of natural resources can affect future economic growth in Turkey. If sustainability is considered in growth, the losses can be reduced, and the use of natural resources can be prevented. The possible steps to be taken in preventing these negative impacts have come to the forefront because of technological developments. In the Investors' Roundtable Meeting, it was understood that privately, it becomes essential to think with a sustainable and long-term perspective. The study confirmed that the right investments can make a huge difference, mainly in terms of reducing pollution and thus slowing down global warming. Initiatives, therefore, should continue, particularly on mobilizing finance for green investments, which will help move to a low-carbon economy.

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