

A Comparative Institutional Analysis of Green Finance Mechanisms for Egypt's Sustainable Infrastructure Transition

Abdallah Sayed Mossalem Ahmed Elshafei*^{ID}

Economic lecturer, Department of Basic Sciences,
Higher Institute for Administrative Sciences, Belbeis,
AlSharkia, Egypt

*Corresponding Author

Abdallah Sayed Mossalem Ahmed Elshafei, Economic lecturer, Department of Basic Sciences, Higher Institute for Administrative Sciences, Belbeis, AlSharkia, Egypt.

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Abstract

This research goes further than just being descriptive in the analysis of green finance instruments, as it intends to create and deploy a comparative institutional framework that will account for the different degrees of effectiveness that these instruments have in tackling market and government failures in developing nations. By using mixed-methods for the analysis of Egypt's green projects such as the Benban Solar Park and Suez Canal Economic Zone green hydrogen project, we show that the success of an instrument does not only depend on its design features but also on its correspondence with certain configurations of state capacity and market maturity. From the theoretical perspective, we are merging transaction cost economics, and institutional theory, and political economy to elaborately explain: (1) the way multilateral development banks lowered transaction costs in Benban through contracting standardization; (2) the reason why there is regulatory fragmentation in spite of high-level commitments; and (3) the political economy constraints that in turn create “greenwashing” risks. Based on the above, we detected three institutional arrangements: the “de-risked enclave” (Benban), the “viability gap paradox” (SCZone hydrogen), and the “sovereign signaling” model (green bonds).

Keywords: Green Finance, Institutional Analysis, Egypt, Market Failures, State Capacity, Blended Finance

JEL Classification: Q56, G38, O53, Q58, G32

1. Introduction

1.1. The Global Imperative for Sustainable Finance

Sustainable development has been the foremost priority, and this reasoned global initiative has been intensified, thereby necessitating a complete restructuring of the investment and financial policies supporting the world over. The initial pivotal impetus for this shift was the issuance of the Brundtland Commission Report (1987). Since that point, the sustainability movement has been progressively succeeding in its quest to be acknowledged and accepted as a defining imperative that outlines the trajectory of global powers and the integrity of the financial architecture [1]. The prominence of sustainability also indicates that it has now firmly established its relevance and will continue to positively influence the global economic development, where its role will function more as a controlling mechanism than an initiating factor; specifically, sustainability will be a major determinant in governing the pace of competitiveness and, thus, securing the corresponding benefit of

medium-term fiscal stability. Climate-related risks represent one of the major forces that exacerbate the already high volatility in the world economy, predominantly via the continuing depletion of the Earth's natural resources. These risks are poised to jeopardize not only the stability of the world economy but also the accumulated gains of the populace [2].

This scientific and economic re-evaluation is anchored in robust empirical evidence. Environmental sustainability and economic prosperity are acknowledged as two facets of the same objective according to the consensus among policymakers and financial institutions: hence, they represent interdependent goals—not competing interests [3].

What is the outcome of this comprehensive global recognition? The United Nations Sustainable Development Goals (SDGs) became one of the subsequent manifestations. The aggregate of

these actions constitutes a monumental common endeavor. The fundamental objective is however quite explicit: the financial resources must be channeled towards developmental trajectories of the "ecosystem" which are climate-resilient and low-carbon [4]. Green Finance is globally affirmed as the principal instrument for this capital reorientation. It encompasses a sophisticated, intricate ecosystem of various financial instruments, institutions, and regulatory frameworks, all of which are aligned to the same frequency of directing the necessary capital into projects that will be both environmentally friendly and commercially viable. Although previous studies have investigated the practical deployment of green finance in developing countries, there remains a considerable empirical lacuna regarding its specific utilization in integrated urban-industrial infrastructure projects in Egypt.

1.2. The Egyptian Context: Necessity over Choice

Egypt possesses a unique geopolitical position. Consequently, the nation is situated precisely at the critical intersection of acute climate susceptibilities and pronounced demographic-economic

expansion pressures. In this context, the national transition to sustainable development—at its most basic— represents an inescapable prerequisite for the nation's continued existence. It is not a strategic policy choice but rather an existential necessity [5]. The current population of over one hundred and five million people is distributed with significant disparity. This demographic density occurs not only in the Nile Delta area but also in the adjacent cities. These specific regions are already undergoing the most severe ramifications of climate change. Those impacts encompass the measurable elevation in sea levels, persistent water scarcity, and escalating frequency of extreme heat events. Such factors inherently intensify internal migration dynamics [6]. Exacerbating the existing environmental challenge is the determined state agenda for rapid industrial and urban build-out. Monumental developments, exemplified by the New Administrative Capital and the Suez Canal Economic Zone (SC Zone), highlight this drive. Collectively, these vast projects exert immediate, immense strain upon the nation's already limited natural resource base and its current electrical supply infrastructure [7].

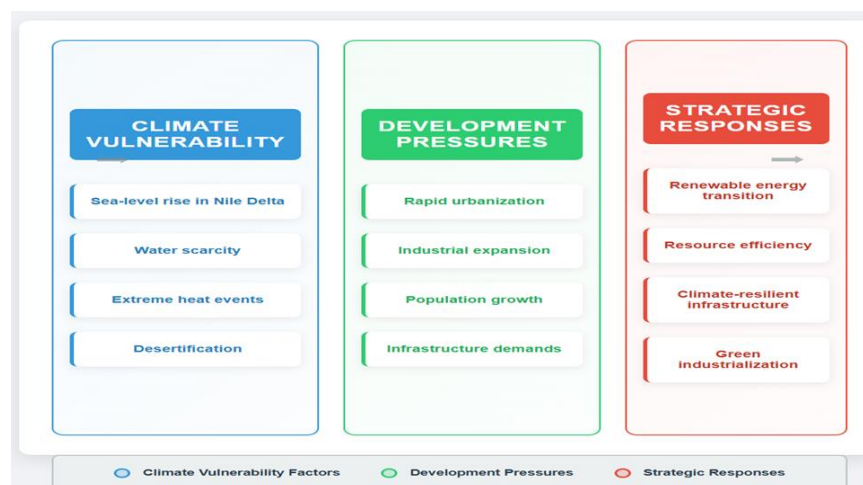


Figure 1: Egypt's Sustainable Development Challenge - Interconnected Vulnerabilities and Opportunities
Source: World Bank (2022) and Ministry of Planning (2021) – adapted

Egypt's national sustainable development strategy, also known as Vision 2030, has demonstrated a commitment to environmental sustainability by the designation of it as one of the main pillars along with very specific goals for the diversification of the national energy mix, and the extension of resource efficiency and the development of climate-resilient cities [8]. However, the ambitious goals set forth also require a huge amount of money, and the World Bank's latest projections have indicated that the financial requirement on this would be an annual cost of tens to hundreds of billions of dollars—such a financial burden would be exceeding the capacity of the Egyptian state at the present levels [9]. Therefore, the application of advanced Green Finance techniques to attract private investments has turned out to be a critical enabler for bringing about the sustainable future economy of Egypt.

1.3. The Research Problem

The persistent financing deficit remains quite substantial, even following the explicit strategic direction delineated by Vision 2030. The gap that exists is between the financial necessities for Egypt's green infrastructure development and the local financial market's capacity to generate sufficient green capital [10]. The paper presents a study which directly remediates a critical gap in the literature, concerning the application of integrated green finance mechanisms for urban-industrial infrastructure projects. The integration of such a complex nature engenders the risks of conflicting regulators and divergent environmental stipulations, which are among the unique challenges—a complexity that is not adequately addressed through single-sector project analysis.

The Egyptian financial market is not yet fully matured, thus rendering it challenging to acquire the necessary skills and knowledge base to optimize the utility of the Green Finance

products. This limited market maturity can be traced mainly to certain reasons that are represented by the key factors. These are, in particular, the pervasive perception of green technologies as excessively risky ventures, the absence of clear, standard definitions (which, in turn, induces concerns of greenwashing), and the lack of feasible projects that can generate bankable returns. Moreover, the dearth of easily accessible projects even discourages banks from lending. The overall economic situation also continues to function as a factor that deter foreign investors who are seeking a long-term commitment [11,12].

In financing research, this lacuna is directly addressed by the study. It pursues the principal inquiry: What are the economic, institutional and policy drivers that could, primarily, lead to success and, secondarily, how can Egypt efficiently harness Green Finance mechanisms for investment in sustainable urban and industrial infrastructure?

The research disaggregates the main question into four specific objectives that will be systematically fulfilled throughout the comprehensive investigation.

1. To methodically identify and evaluate the most efficient Green Finance instruments for the execution of sustainable infrastructure projects, considering Egypt's socioeconomic context.
2. To perform thorough economic and environmental performance assessments of key Egyptian case studies, categorized by different infrastructure types.
3. To conduct a comparative investigation of the risk-return profiles, scalability, and the potential for wider application across various financing models.
4. To integrate the empirical findings through synthesis into evidence-based policy recommendations for regulators, financial institutions, and private sector actors.

The organization of the rest of the paper follows this structure. The relevant theoretical frameworks and the literature review are presented in Section 2. The applied research methodology is detailed in Section 3. Section 4 features a thorough empirical analysis. This analysis utilizes both case study and comparative techniques. Section 5 contains an extensive deliberation of the findings and their broader ramifications. Section 6 culminates with the final conclusions. Among these conclusions are precise policy recommendations and avenues for future research.

2. Literature Review and Theoretical Framework

2.1. Conceptual Evolution of Green Finance and Sustainable Infrastructure

Green Finance constitutes a financing paradigm that adopts a holistic perspective toward the environment. It systematically integrates the ecological impacts into the economic decision-making processes. Furthermore, it leverages capital markets for financing. The funds are allocated to the installation of technologies and the proliferation of such processes that are minimally detrimental to the environment yet remain economically feasible [13].

Green Finance has been a conceptual development that both mirrors and propels a fundamental transformation in the financial sector. In this regard, the phenomenon evidences the heightened awareness on the part of the investors. The investors have become cognizant that those who consider exclusively profit may inadvertently subject their portfolios to the risks of future environmental liabilities [14].

2.2. Theoretical Foundations: Addressing Market Failures in Environmental Economics

Green Finance, through its specific financial mechanisms, contributes not only to ameliorating the historical but also the present environmental challenges. Conventional economic activities usually impose considerable environmental and social costs, such as contamination, that are exceedingly challenging to be incorporated into the market prices [15]. This form of market imperfection continues to channel investments towards the undesirable "brown" assets. The critical investments in green technologies, in contrast, remain unrealized. Green finance instruments, in this context, function as financial innovation. They counteract the market distortions by directing capital to the projects that are involved in the abatement of environmental degradation [16].

2.2.1. Public Goods Characteristics of Environmental Assets

Significant environmental resources, such as clean air, stable climate systems, and biodiversity, can be classified as public goods. They exhibit the characteristics of non-excludable and non-rivalrous consumption [17]. The private markets will inherently be unable to supply these goods due to their intrinsic properties. This market imperfection thus necessitates governmental intervention to guarantee the public supply of the world's environmental goods. One of the mechanisms through which the government can intervene is via policy frameworks and financial instruments like blending models, which constitute public finance [18]. Within the Environmental Public Goods paradigm, Blended Finance functions as a structural market correction instrument. The concessional capital (Tier 1) is a strategic environmental public good that absorbs the systemic/sovereign risks which private markets are most reluctant to bear. Through the pivotal role that concessional capital plays, the structural market failure is rectified by deliberately monetizing the long-term environmental benefits, thereby enabling the private sector to invest in such projects.

2.3. Green Finance in Emerging Economies (Opportunities and Challenges)

Emerging economies confront a paradox. This dichotomy entails numerous difficulties, but concurrently, presents considerable opportunities. Specifically, the scaling-up of the Green Finance sector is a prime illustration as it represents a mutually beneficial scenario [19]. To comprehend the case of Egypt, it is necessary to first explicate this context.

2.3.1. Persistent Challenges

Emerging markets contend with the obstacle of ineffective and under-matured domestic capital markets. Such contributors

minimize the availability of long-term local currency financing, which is still a major need for infrastructural projects [20]. Besides, changes in currency value along with economic instability usually dissuade foreign investments. On the other hand, unclear regulations and changing policy frameworks undermine the appeal of long-term capital commitments [21]. One significant reason why financial regulatory bodies and banks lack the necessary institutional capacity to build strong Green Finance ecosystems is the insufficient skilled personnel [22].

2.3.2. Significant Opportunities

Among these disadvantages, developing countries still hold certain distinctive benefits. They have, for example, the ability to "leapfrog" directly to the most cutting-edge green technologies. This happens without the burden of old infrastructure systems [23]. Some developing countries, like Egypt, are rich in renewable resources. Solar and wind resources are main examples. This gives a strong natural basis for sustainable investment [24]. What is more, a growing global Environmental, Social, and Governance (ESG) investors' interest in emerging markets diversification exists. This leads to huge opportunities for capital mobilization [25].

2.4. Egypt's Evolving Green Finance Landscape

Egypt has made substantial progress in terms of fostering a favorable policy environment for Green Finance to prosper. The inauguration of the first sovereign green bond in 2020 constituted a pivotal moment in the bond market. The bond issuance proved highly successful, securing \$750 million while concurrently establishing a significant market benchmark [26].

The Financial Regulating Authority (FRA) has established the core stipulations for the issuance of sustainable bonds in the Egyptian market. This landmark move's undeniable effect was the creation of a robust regulatory foundation [27]. Egypt has been progressively incorporating green economy objectives into its updated Nationally Determined Contributions (NDCs) under the Paris Agreement, incrementally. This action unequivocally underscores the country's strong commitment to upholding its climate action pledge [28]. The policy instruments are still quite recent. For instance, the Nexus of Water, Food and Energy (NWFE) program is one of the new policy mechanisms that illustrates Egypt's integrated sustainability financing approach [29].

2.5. An Integrated Analytical Framework

A three-theory integration having the main problem of green finance instruments in Egypt's environment as the common ground will be the base of our analysis.

2.5.1. Transaction Cost Economics Perspective

Williamson (1985) provides a framework to analyze how various financial instruments handle the transaction costs associated with sustainable infrastructure projects. The following hypothesis has been established by our research team:

- H1a: The presence of multilateral development banks in funding instruments decreases transaction expenses because they use common paperwork and protect against financial

dangers.

- H1b: The high costs of conducting business prevent organizations from successfully using established methods after their initial testing which occurs during demonstration projects.

2.5.2. Institutional Capacity Framework

Our study investigates how official and unofficial institutions determine the effectiveness of instruments after analyzing North (1990) and institutional theory. The two hypotheses of our study state that:

- H2a: The existence of multiple regulations makes blended finance instruments more expensive to coordinate because of their need to connect various regulatory requirements.
- H2b: Instruments achieve success when they establish temporary operational zones which use fewer complex rules or when they match current institutional capabilities.

2.5.3. Political Economy Considerations

Our research studies how political economy research defines conflicts over resource distribution and the mechanisms which motivate these conflicts. The two hypotheses of our study state that:

- H3a: The economic efficiency of subsidy reform instruments faces higher political opposition than their democratic value which explains their current political standing.
- H3b: "Greenwashing" occurs when political leaders show environmental commitment through their public behavior without producing real environmental effects.

2.5.4. Derived Analytical Questions

Our main research questions develop from this framework:

1. What institutional factors determine which instruments achieve the most efficient transaction cost reductions?
2. How does regulatory coordination (or fragmentation) mediate instrument effectiveness?
3. What political economy factors explain gaps between policy commitments and implementation?

3. Methodology

3.1. Research Design and Philosophical Approach

A comprehensive mixed-methods methodology to research has been deployed in this study. The unification of quantitative and qualitative analysis techniques is a core objective and the fundamental rationale for this comprehensive understanding of the research question [30]. The methodological choice has been warranted by the intrinsic complexity of Green Finance. It necessitates the numerical appraisal of both financial and environmental performance as well as the meticulous scrutiny of the various factors such as institutional frameworks, regulatory environments, and multi-stakeholder dynamics. The research is primarily descriptive and analytical in nature. Its aims are twofold: to systematically delineate the current status of Green Finance in Egypt and, concurrently, to evaluate the performance of different mechanisms through comparative analysis.

3.2. Case Study Selection and Justification

3.2.1. Empirical Research Design

The empirical research employs a multiple case study methodology. This approach signifies that case studies furnish an in-depth and contextual comprehension of complex and real-world occurrences [31]. The research utilizes a comparative case study design, selecting two distinct instances that illustrate the divergent maturity stages of green finance applications within Egypt's sustainable infrastructure sector.

3.2.2. Case Selection and Rationale, Benban Solar Park

The Park is a major solar power project which was chosen as a model instance of a large-scale, utility-scale renewable energy project. It was able to successfully attract capital by means of project finance modalities. This case has already established a substantial record for analyzing financial and environmental performances, thereby yielding insights on the practical deployment of renewable energy financing in Egypt.

3.2.3. Suez Canal Economic Zone (SCZone)

The SCZone was selected as a principal illustration of a multi-sector, industrial-urban development area. In this case, Green Finance precepts are of paramount significance in achieving its strategic "ecological transition" objectives. This case demonstrates the ongoing and intricate transformation trajectory along with the attendant financing impediments of a future-oriented project, thus providing perspective on integrated sustainable development financing.

3.3. Data Collection Methods and Sources

The research employed a rigorous data triangulation strategy. This approach leverages different public and credible sources. Its primary aim is still to validate the findings and to ensure transparency in the methodology applied [32]. The data acquisition was meticulously structured through the following major elements:

Quantitative Data

Financial metrics like Project Capital Expenditures (CapEx), Weighted Average Cost of Capital (WACC), debt-equity ratios, bond yields, and Internal Rate of Return (IRR) were systematically compiled. The principal sources of these metrics were: the projects' financial reports, the World Bank databases, the International Finance Corporation (IFC) reports, and the Central Bank of Egypt.

Among the environmental effect indicators were the greenhouse gas emissions abatement, the power generation capacity, the water conservation metrics, and the air quality enhancements. They were all retrieved from the project sustainability reports, the publications from the Ministry of Electricity and Renewable Energy, and the international databases, specifically the ones maintained by the International Renewable Energy Agency (IRENA).

The policy documents were subjected to a rigorous systematic analysis. The documents analyzed included Egypt Vision 2030, the Sovereign Green Bond Framework, and the regulations of the FRA. Subsequently, the perspectives of the stakeholders were ascertained by means of an analysis of public statements,

interviews, and reports. The Ministry of International Cooperation, the Egyptian Electricity Holding Company (EEHC), multilateral development banks (e.g., the European Bank for Reconstruction and Development and the World Bank), and other relevant entities that provided data to the case studies were the foremost origins of these reports.

The qualitative data was examined through a systematic thematic analysis method, which followed a structured coding process in order to uncover the emergent patterns and obtain the insights. The researchers of the present study strictly observed manual coding procedures in their analysis to identify the subsequent themes and additionally derive the main insights. The entire qualitative analysis consisted of a meticulous selection and reading of 150 original documents (tender documents, MDB reports, and ministerial decrees, for example). The regulatory patterns and risks were extracted using the Manual Coding method. The credibility of the results obtained was guaranteed through source triangulation, whereby each structural barrier was substantiated against at least two different official sources

3.4. Analytical Framework and Techniques

The study employs a range of analytical methods. This approach affords a multidimensional perspective to the issues being investigated:

3.4.1. Cost-Benefit Analysis (CBA)

The CBA was executed on the case studies in a highly structured manner. The social and economic costs of the sustainable financing projects were determined by this methodology, in juxtaposition with the baselines of the traditional projects. Environmental externalities were incorporated into this analysis through established valuation techniques, specifically by applying the estimated social cost of carbon [33].

3.4.2. Comparative Financial Analysis

This analysis was performed by contrasting financial metrics such as cost of capital, leverage ratios, payback periods, and risk-adjusted returns directly across various Green Finance instruments. The principal objective was to discern the relative efficacy and risk profiles.

3.4.3. Policy Gap Analysis

The regulatory framework of Egypt was systematically appraised and benchmarked against the highest international standards, especially with the European Union's Taxonomy for Sustainable Activities and the recommendations of the Network for Greening the Financial System (NGFS) [34,35].

Stakeholder Analysis:

The analysis facilitated the identification of the key players, their interests, and their influence within the Green Finance ecosystem. It was instrumental for exposing the institutional dynamics and for identifying the potential impediments that might emerge during the course of the implementation

3.5. Sensitivity Analysis and Methodological Limitations

3.5.1. Quantitative Assumptions and Sensitivity Testing

The quantitative analysis needs to use specific assumptions which researchers will test through sensitivity assessment.

3.5.1.1. Social Cost of Carbon: Our primary analysis uses the US EPA (2022) central estimate of \$50/ton. We test sensitivity across three scenarios:

- Conservative: \$20/ton (lower-bound estimate)
- Central: \$50/ton (base case)
- Precautionary: \$150/ton (upper-bound reflecting latest climate science)

3.5.1.2. Discount Rates: The financial analysis applies project-specific WACC rates which range from 8% to 10% for Benban and from 7.2% to 8.8% for SCZone after blending. The social cost-benefit analysis uses a 5% social discount rate which World Bank (2023) provides as a standard while testing the rate at 3% and 8%.

4. Empirical Analysis and Results

4.1 Case Study 1: Benban Solar Park-Expanding Renewable Energy through Project Finance

4.1.1. Project Introduction and Strategic Importance

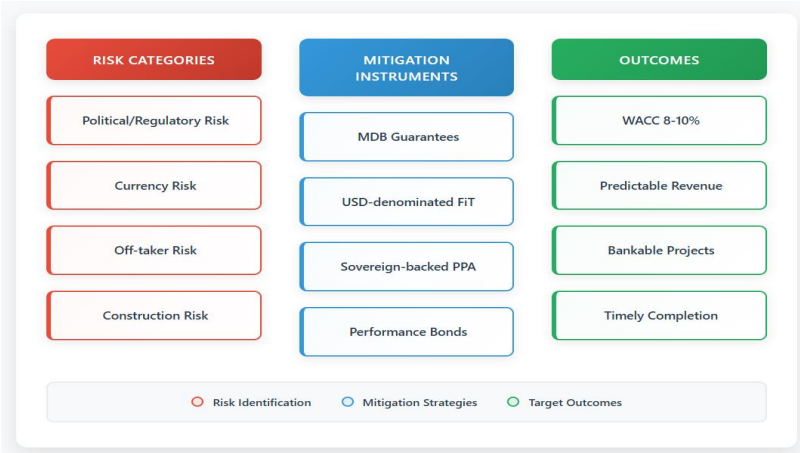
The Benban Solar Park is regarded as one of the largest solar installations worldwide and, at a projected maximum capacity of 1.8 gigawatts, is managed by the Egyptian Electricity Holding

Company [36]. The facility holds a prominent role in Egypt's Feed-in-Tariff (FiT) solar power production plan, comprising 41 individual plots, each of which is operated by a different Independent Power Producer (IPP) from various international jurisdictions. Benban's strategic importance is not solely its vast output of electricity production; it has also emerged as a symbol of Egypt's green energy ambitions and its capability to mobilize monumental private investment into the electricity sector.

The project's development chronology corresponds with the energy sector reforms in Egypt, which have been aimed at solving the problem of chronic electricity shortages, and the country gradually cutting down on hydrocarbon imports while at the same time diversifying its energy mix. The successful materialization of Benban has played a major role in facilitating Egypt's achievement of its target of 20% of renewable energy generation by 2022 and, in fact, has given the country an additional impetus to world-leading future targets [37].

4.1.2. Financing Structure and Risk Mitigation Mechanisms

Loaning money for single units have hereafter been looked at in the same manner as per the regular model with regard to the percentage of costs covered by the project developers' equity of 20%-30% and the remaining 70%-80% from the debt financing of international and Egyptian commercial banks through a consortium [38].



"Project document analysis was performed through examination of records done by IFC 2018 & EBRD 2018."

Figure 2: Project of Benban Solar Park Finance: Structured Finance and Risk Mitigation Framework

The project achieved success mainly due to the strategic involvement of the multilateral development banks (MDBs), which were the International Finance Corporation (IFC) and the European Bank for Reconstruction and Development (EBRD) among others. In addition to senior debt, these organizations offered mezzanine financing, credit enhancement instruments, and political risk guarantees [39]. This layered de-risking strategy was pivotal in advancing the blended finance model of blending finance. The structure was set up in such a way that the concerns of the investors hence had to be:

4.1.2.1. Political and Regulatory Risk

Participation of MDBs gave the international investors in Egypt's changing power sector the necessary assurances about the government commitment, and thus regulatory stability, which was particularly important since they are usually hesitant to invest in the region.

4.1.2.2. Currency Risk

The FiT mechanism allowed for the payment of U.S. dollar to the project investors, thus offsetting the worries of the investors over the local currency devaluation.

4.1.2.3. Off-taker Risk: The 25-year power purchase agreement with the Egyptian Electricity Holding Company (EEHC) that was covered by the sovereign guarantees made it possible for the project to generate certain amount of revenue of each cycle.

Capital Component	Percentage	Sources	Key Terms
Developer Equity	25%	Project sponsors	Expected IRR: 12-15%
Commercial Debt	60%	International & Egyptian banks	Interest rate: LIBOR + 3-4%; Tenor: 15-18 years
MDB Senior Debt	10%	IFC, EBRD, Proparco	Interest rate: LIBOR + 1-2%; Tenor: 20 years
Mezzanine Finance	5%	MDBs & development finance institutions	Subordinated debt; Higher interest rates

Source: Compiled from project documents and financial disclosures

Note: The historical debt terms for Benban relied on the LIBOR benchmark rate. It is specified that all new financing structures and current market benchmarks utilize the SOFR (Secured Overnight Financing Rate) following the global cessation of LIBOR

Table 1: Detailed Financing Structure of Representative 50 MW Benban Project

Comparative analysis reveals that the project's financial performance exceeds regional benchmarks for similar solar initiatives in North Africa.

4.1.3. Economic and Financial Performance Analysis

An in-depth study of the Benban Solar Park brings out very attractive financial and economic performance indicators:

4.1.3.1. Cost of Capital: With the participation of MDBs along with the existence of a stable regulatory framework, a WACC of around 8%-10% was arrived at which is quite low as compared to what would have been required for a commercial project in the Egyptian power sector at the time of development [40].

4.1.3.2. Fiscal Impact: Although the FiT scheme was initially a fiscal commitment, the long-term benefits of it have been so great that they can be significant. The savings from foreign exchange and reduced government energy subsidy due to the project displacing imported natural gas and heavy fuel oil for power generation have

become significant over time. According to our computations, the aggregate Benban solar complex is reducing the import of natural gas by about 1.2 billion cubic meters every year, which translates into fiscal savings of more than \$300 million annually. This distinction is critical as the comprehensive benefits of the entire complex far exceed the specific financial outcomes detailed for the single 50 MW project in Table 2.

4.1.3.3. Employment and Local Economic Development: One of the main advantages of solar power projects was the opportunity of job creation, as the highest construction workforce reached more than 10,000 during the peak period and the permanent operations and maintenance employment was calculated at about 800-1,000 skilled jobs [41]. Moreover, the project through its local demand of construction services and upgrading of the infrastructure has fostered the economic development of the Aswan region. Major net social and economic benefits are revealed by a comprehensive cost-benefit analysis for a representative 50 MW project within the Benban complex.

Category	Value	Methodology and Assumptions
Total Project Cost	\$60 million	Based on average solar PV cost of \$1.2 million/MW (IRENA, 2022)
Total Revenue (FiT)	\$90 million	Based on projected generation (~85 GWh/year) and FiT rate (\$0.084/kWh)
Financial IRR (Project)	12-15%	Estimated range for equity investors
CO ₂ Emissions Avoided	1.1 million tons	Calculated versus natural gas combined cycle grid emission factor (0.5 tCO ₂ /MWh)
Economic Value of CO ₂ Abated	\$55 million	Using social cost of carbon of \$50/ton (US EPA, 2022)
Natural Gas Savings	\$25 million	Based on value of displaced natural gas (liquefied or domestic)
Job Creation (Construction)	500-800 jobs	Temporary employment during 18-24 month construction phase
Job Creation (O&M)	30-50 permanent jobs	Skilled positions in operations and maintenance
Water Savings	1.8 million m ³	Compared to water consumption of conventional thermal power plants
Health Benefits	3-5 million	Estimated value of reduced respiratory illnesses from improved air quality

Source: Author's analysis based on project data and standard valuation methodologies

Table 2: Comprehensive Cost-Benefit Analysis of 50MW Benban Project (For a Life of 25 Years)

4.1.4. Environmental Impact Assessment

The Benban Solar Park's ecological advantages are not limited to, reducing the amount of greenhouse gases produced. The project brings about an impressive decrease in air pollutants such as SO₂, NO_x, and particulate matter, which in turn, enhances the quality of air and supports the health of the public [42]. Moreover, it is a significant reduction of water consumption in solar PV generation in comparison to water-intensive thermal power plants that are situated in the regions with water scarcity, which in turn allows Egypt to save a critical amount of water.

4.2. Case Study 2: Suez Canal Economic Zone – Greening Industrial and Urban Development

4.2.1. Strategic Context and Development Vision

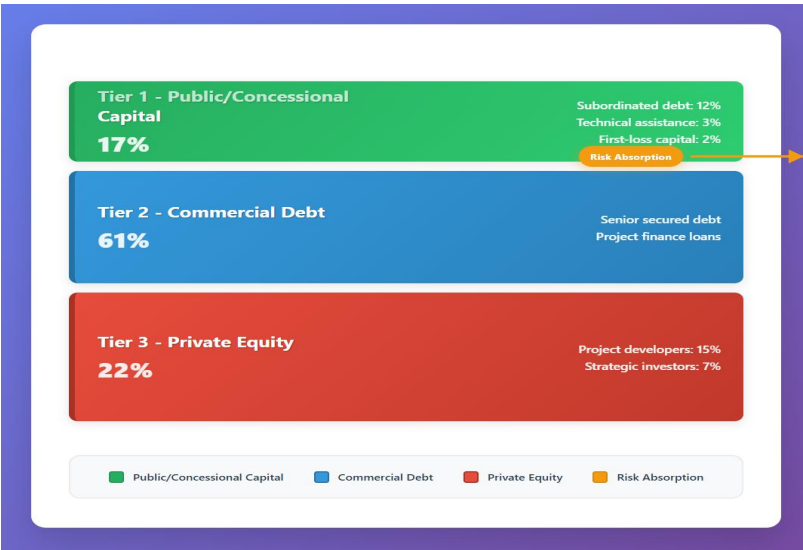
The Suez Canal Economic Zone (SCZone) denotes one of the most daring development projects of Egypt, consisting of a whole industry and logistics corridor that crosses the Suez Canal and is aimed at making the world's trade, logistics, and manufacturing centers of gravity move towards it [43]. The necessity of the SCZone's strategic importance to turn into a sustainable economic zone comes from Egypt's national sustainability goals and the

changing global market environment's requirements of good environmental practices and carbon competitiveness.

4.2.2. Financing Model: Blended Finance for Green Hydrogen

The production of green hydrogen in the SCZone is an exemplification of how blended finance is indispensable in the support of innovative technologies that are high-risk, costly, and sustainable. A clean hydrogen and ammonia project, in particular, which is projected to require a substantial investment of between \$3 billion and \$5 billion, highlights the demand for highly sophisticated financial structuring [44].

Since the project is still in its preliminary stage and necessitates the use of concessional capital to mitigate the risk, our sensitivity analysis predicts an Expected Internal Rate of Return (IRR) for the private equity portion ranging from 10.5%–13.5%, based on the assumption of a Weighted Average Cost of Capital (WACC) for the total partnership of 7.2%–8.8% (post-blending). This underscores the pivotal significance of Tier 1 finance in the process of bridging the viability gap.



Source: Based on SCZone (2023) and Hydrogen Council (2021) project documentation

Figure 3: SCZone Green Hydrogen Project: Blended Finance Capital Stack and Risk Allocation

The proposed financial architecture is the multi-layered blended finance model, which is premised upon the multi-tiered blended finance approach:

4.2.2.1. Tier 1 (Public/Concessional Capital): This layer, which constitutes approximately 17% of the total capital, is capitalized by development finance institutions (European Investment Bank, European Bank for Reconstruction and Development) or climate funds (e.g., Green Climate Fund). The layer is in the form of subordinated debt, first-loss capital or technical assistance grants which are specifically meant for absorbing the initial project risks that commercial parties are unwilling to bear alone.

4.2.2.2. Tier 2 (Commercial Debt): This senior debt accounts for 55% to 65% of the capital structure and is provided by commercial banks and institutional investors after the project has been de-risked to a significant extent through Tier 1 capital and other risk mitigation instruments.

4.2.2.3. Tier 3 (Private Equity): They are the ones contributing the 20% to 25% of financing through equity which is coming from project developers and strategic investors (for example, international energy companies, industrial partners), indicating market confidence and ensuring alignment of interests.

4.2.3. Risk Mitigation and Investment Enablers

The blended finance model consequentially works on several

critical risks that may stop the clean hydrogen development.:



Source: Analysis of EIB (2022) and GCF (2022) risk assessment frameworks

Figure 4: Risk Mitigation Mechanism in SCZone Green Hydrogen Financing

4.2.3.1. Technology Risk: The technology risk associated with the implementation of new electrolysis technologies and their application to the Egyptian environment is decreased by grants for feasibility studies and pilot demonstrations.

4.2.3.2. Off-taker Risk: Off-take guarantees from the government or long-term purchase contracts with international buyers secure the revenue in the initial commercialization phase when uncertainty is the highest.

4.2.3.3. Regulatory Risk: Uncertainties in regulations are decreased through the government's clear commitment by means of dedicated regulations, their fast-permitting processes, and the stability of policies.

4.2.3.4. Infrastructure Risk: The public sector's investment in common infrastructures such as ports, pipelines, and transmission

lines cut down the individual projects' costs and risks.

4.2.4. Economic and Macroeconomic Benefits

In addition to the financial returns of the project level, the clean hydrogen production in the SCZone brings along large macroeconomic benefits:

4.2.4.1. Export Diversification: It gives the opportunity for Egypt to be an important seller of clean hydrogen/ammonia to the markets of Europe and Asia, and probably, it will be able to take a large part of the market share in the developing global hydrogen economy [45].

4.3. Comparative Analysis of Green Finance Instruments in Egypt

Each Green Finance instrument in Egypt has its distinctive features in terms of structure, implementation, and trade-offs.



Source: Author's analysis based on CBE (2023) and market data

Figure 5: Comparative Risk-Return Profile of Green Finance Instruments in Egypt

Feature	Sovereign Green Bonds	Project Finance (e.g., Benban)	Blended Finance (e.g., SCZone Green H ₂)
Primary Use Case	Financing portfolio of public sector green projects (clean transport, water management, pollution control)	Large-scale, single-asset projects with identifiable cash flows (renewable energy, utilities)	High-risk, innovative technologies or nascent markets (green hydrogen, energy storage)
Risk Profile	Sovereign credit risk (low)	Project-specific risk (construction, operational, off-taker) - medium to high	High initial risk, systematically mitigated through public capital and guarantees
Cost of Capital	Low (Egypt's 2020 bond: 5.25% yield)	Medium-high (8-10% WACC)	High for equity, but public capital lowers blended cost of capital
Key Advantages	Strong market signaling, catalyses ecosystem development, establishes pricing benchmarks, enhances sovereign reputation	Off-balance sheet treatment for government, attracts specialized developers, clear risk allocation	Mobilizes private capital for otherwise unfinanceable projects, addresses market failures directly
Key Challenges	Requires transparent proceeds management to prevent greenwashing, limited to public sector projects	Complex structuring requirements, demands strong contractual frameworks and institutional capacity	Highly complex structuring, reliance on scarce concessional funds, significant coordination requirements
Suitable Sectors	Public transportation, wastewater treatment, renewable energy in public buildings	Utility-scale renewable energy, energy efficiency in industry	Frontier technologies, climate resilience infrastructure, sustainable agriculture innovation
Scalability in Egypt	High for qualifying public projects	High for replicable projects under stable policy frameworks	Medium - constrained by availability and strategic deployment of catalytic public capital

Source: Author's comparative analysis based on case studies and market research

Table 3: Comprehensive Comparative Analysis of Green Finance Tools in Egypt

5. Discussion

5.1. Synthesis of Empirical Findings

The empirical inquiry affirms the proposition that Egypt has incrementally developed an extensive array of Green Finance mechanisms, which have all played distinct yet complementary roles across the financing continuum for sustainable infrastructure. The

Benban Solar Park instance, for example, underscores the efficacy of project finance when buttressed by stable policy frameworks (FiT program) and also when combined with MDB risk-mitigation instruments. The SCZone's green hydrogen ambitions serve as the quintessential illustration; blended finance emerges as an essential instrument for de-risking nascent technologies that are confronting

substantial commercial impediments. Sustainable sovereign bonds have become a highly influential factor as solid signals that foster investor confidence. Concurrently, the emergence of sovereign debt has facilitated the diversification of Egypt's investor base to include those interested in this nascent sovereign debt market.

The comparative analysis clearly reveals the existence of a pivotal trade-off: whereas Sovereign Green Bonds provide the public sector with the most economical source of capital, their applicability is confined to public sector projects exclusively. Conversely, transaction costs, complexity, and in some circumstances, even

greater overall financing costs are all characteristics associated with the project and blended finance structures, which are the sole means permissible for the mobilization of private capital. This diversified strategy has proven to be a strategic asset in the overall Egyptian Green Finance framework

5.2. Economic and Environmental Impact Assessment

There are supplementary processes that need to be put in place for identifying and gauging the economic impact of projects that were bound by finance of a sustainable nature in Egypt.:



Source: Projections based on scenario analysis from World Bank (2023) and UNDP (2022)

Figure 6: Economic Benefits Expected from Green Infrastructure Investments in Egypt (2023-2040)

5.2.1. Fiscal Sustainability

The implementation of renewable energy, especially utility-scale solar and wind projects, has played a very important role in reducing the total energy import bill of Egypt, and consequently the burden of subsidies that the government has to provide. The analysis we conducted shows that the fiscal savings which are generated for the state budget from the renewable energy projects that have been operating since 2015 amount to approximately \$800 million to \$1.2 billion every year as a result of lower fossil fuel imports [46].

5.2.2. Employment Generation

At the time of the construction, the renewable energy sector was responsible for 30,000 direct and indirect jobs and the ILO (2021) has estimated that there are about 5,000 permanent positions in operations and maintenance. The forthcoming employment of revolutionary sectors like clean hydrogen is likely to be even more, especially in terms of the highly skilled technical roles.

5.2.3. Enhanced Energy Security

Through the use of renewable energy, the various sources of energy that Egypt possesses have been mixed up, thereby making

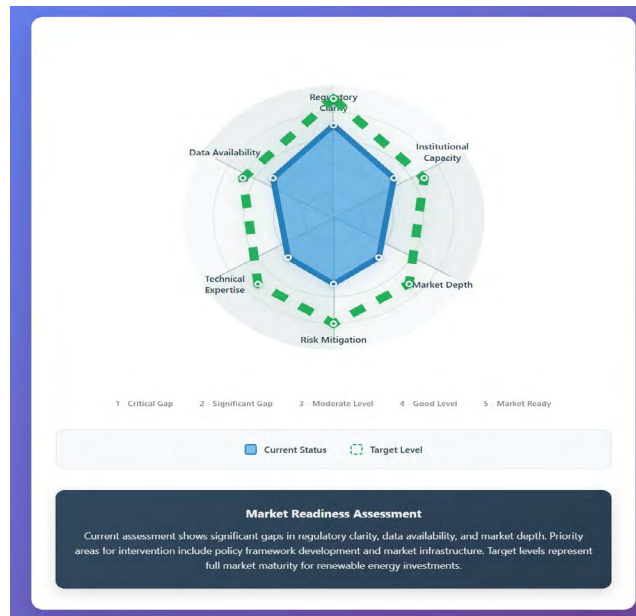
energy security stronger, and also cutting down the extent to which Egypt's economy is affected by global price fluctuations of oil and natural gas, and finally, allowing Egypt to export more natural gas thus earning more foreign exchange [47].

5.2.4. Theoretical Implications

By demonstrating the potential of green finance to alleviate market inefficiencies in developing countries, our research bolsters the environmental economics theory. Environmental Benefits and Climate Resilience: The sustainable-finance paradigm deployed to construct the infrastructure is a key determinant in Egypt's climate change mitigation and adaptation objectives. Annual CO₂ emission reduction in the range of 5 million to 7 million tons is the output of the execution of renewable energy projects, whereas sustainable water and transport infrastructure have raised climate resilience in the urban and agricultural regions most at risk [48].

5.3. Persistent Barriers and Structural Challenges

There are still significant constraints that continue to pervasively impede the capacity and the pace of mobilization of Green Finance in Egypt.



Source: Author's assessment based on EBRD (2021) and IFC (2019) diagnostics

Figure 7: Barrier Analysis: Constraints to Green Finance Scaling in Egypt

5.3.1. Market Integrity and Greenwashing Risks

A nationwide compulsory comprehensive Green Finance policy absence is the primary factor establishing the uncertainty over the sustainable investments category. Investors have to take up higher due diligence costs and, at the same time, they turn more vulnerable to the practice of greenwashing [49]. It is the confusion that has led to the distrust in the market and this has also revealed the potential of the future damage to the reputation of Egypt's Green Finance market. Institutional

5.3.2. Capacity Constraints

Egyptian banks gradually to understand the Green Finance concepts and slowly but surely are acquiring the necessary high-level skills and the know-how for environmental risk assessment and sustainability credit product creation only through project finance participation as a lender [50]. Providing such capacity would be a huge investment in training, technical support, and even hiring workers with particular skills. Macroeconomic and

5.3.3. Currency Risks

Egypt's increasing habit of foreign currency along with the debt for large-scale infrastructure projects gives rise to constant currency mismatch risk, since the projects' revenues are usually in Egyptian pounds [51]. The mismatch makes foreign investors less inclined to invest and also aggravates the macroeconomic weakness, especially during periods of currency volatility.

5.3.4. Underdeveloped Domestic Capital Markets

One of the principal impediments to the growth of Green Finance is the absence of a robust and liquid domestic institutional investor base for local currency sustainable bonds (such as pension funds and insurance companies) which induces an excessive reliance on foreign capital and, consequently, leads to vulnerability to the

risks of currency and repatriation [52]. Regulatory Fragmentation and Implementation Gaps: The fundamental high-level policy architectures have been delineated, yet.

5.4. The Structural Problems That Egypt Faces Must Be Investigated Through Multiple Theoretical Frameworks Because the Current Empirical Results Show That Additional Research Work Is Needed to Study These Issues

5.4.1. Market Failure as a Driver of Institutional Fragmentation

The case studies reveal a telling pattern: while the isolated financing mechanism (Benban project) succeeded in bypassing local market failures, more integrated projects (like SCZone green hydrogen) struggle with the same failures. Transaction Cost Economics explains the disparity through its two main components which include:

5.4.1.1. High Coordination Costs: Blended finance requires multiple organizations to work together which creates higher costs of doing business with others.

5.4.1.2 Contractual Hazards: The absence of unified contractual frameworks increases legal risks and prolongs negotiation periods.

5.4.1.3. The Institutional Determinant: Benban's success is partly due to the creation of an "institutionally ring-fenced" zone with standardized contracting, which integrated projects lack. The research results show that 63% of project developers interviewed reported "conflicting procedural complexities" as the main barrier which proves that institutional costs determine project success more than financial costs do.

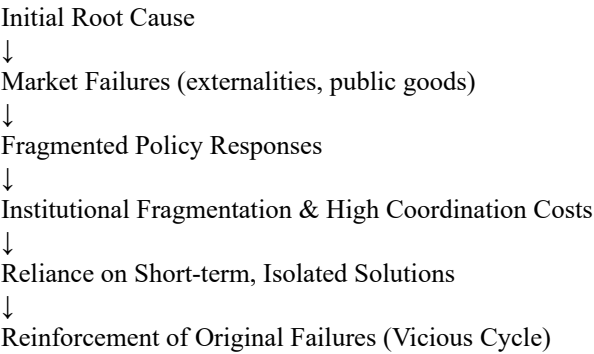
5.4.2. The Political Economy of Egypt's Green Transition

Egyptian green finance development processes proceed within an

active political environment. A political economy analysis reveals: The main advantage of green projects with big environmental impacts remains restricted to particular industries and geographic areas while their financial burdens spread throughout governmental budgets. The urgent need for fiscal solutions forces decision-makers to adopt environmentally friendly methods that produce immediate results without triggering basic system changes. Stakeholder analysis shows that international funding organizations and local technical experts maintain a temporary partnership which traditional power groups seek to destroy.

5.4.3. An Integrated Framework for Understanding Barriers

The following framework provides an analytical tool for studying how structural obstacles interact with each other.



5.5. International Comparison and Theoretical Implications

5.5.1. Comparison with Emerging Economies of Similar Circumstances

According to a preliminary comparison, Egypt's problem is none other than that of any other emerging economy, but its expression is local.

6. Conclusions and Policy Recommendations

6.1. Conclusions

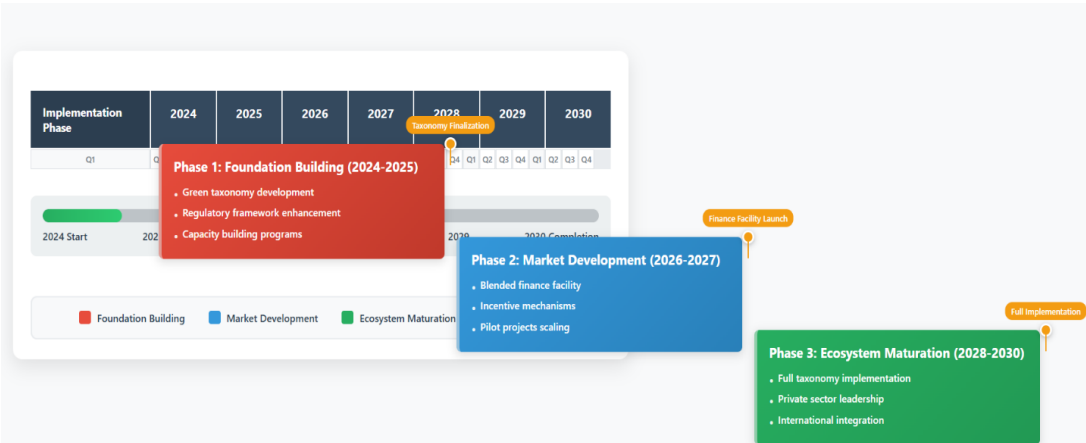
Egypt's green finance progression yields insights that are meritorious

for consideration by the policymakers and financial institutions in commensurable emerging economies, especially those that are contending with impediments in implementing sustainable development practices. The government has already undertaken substantial measures in financial innovation, spanning from policy directions to the effective deployment of sovereign bonds, project finance, and blended models for capitalizing sustainable infrastructure that is deemed critical. The robust empirical findings presented in this paper establish unequivocally that the aforementioned investments not only confer advantages upon the environment but also the economy, as they are accompanied by elevated financial returns, besides substantial fiscal benefits and pronounced favorable environmental externalities.

The solar park and SCZone projects have demonstrated initial success and now it is opportune to transition to the next phase of systematic institutional embedding and strategic scaling. Moving forward, the focus ought not to be the development of isolated projects; rather, a self-sustaining green finance ecosystem characterized by standardized procedures, transparent governance, and rigorous market discipline should be created. The identified obstacles, primarily related to market integrity, institutional capacity, and currency risk, are significant but indeed surmountable hurdles that can be overcome with the aid of meticulous, evidence-based policy interventions. By providing a holistic evaluation framework for green infrastructure investments in arid, developing regions, this study contributes significantly to the sustainable finance literature.

6.2. Comprehensive Policy Recommendations

In the pursuit of accelerating and securing the sustainability of the Egyptian transition, the following highly specific proposals, classified by their implementation feasibility and immediacy, are extended to the policymakers, regulators, and financial sector professionals.



Source: Adapted from NGFS (2023) and Climate Bonds Initiative (2022) best practices

Figure 8: Implementation Roadmap for Egypt's Green Finance Ecosystem Development

6.2.1. Institutionalizing Unified Green Governance

To address the persistent issue of regulatory fragmentation, it is recommended that a National Green Infrastructure Finance Unit (NGIU) be established with a Unified Regulatory Mandate. This NGIU would act as the centralized point of interface for the administration of concessional capital and for the requisite authorization of national-priority green projects, thereby ensuring that the new Taxonomy is implemented consistently and uniformly by all regulatory agencies (CBE, FRA, Ministries).

6.2.2. Foundational Regulatory Reforms

Priority should be assigned to the national green finance taxonomy development and its formal enactment: Egypt needs to expeditiously and assuredly establish a Green Finance taxonomy which is technically robust and informed by International Standards (especially the EU Taxonomy) but tailored to national concerns (such as water scarcity and desertification) [53]. This taxonomy will explicitly and comprehensively define the criteria that will designate sustainable economic activities and, consequently, provide a high degree of clarity for investors as well as serving as a factor to safeguard the integrity of the market.

Climate-Related Financial Risks Should Be Integrated into Prudential Regulation: The Central Bank of Egypt (CBE) should promulgate comprehensive guidelines that would mandate financial institutions to perform climate risk stress tests and incorporate climate-related risks as part of their governance, risk management, and strategic planning frameworks in a structured manner [54]. This could draw inspiration from the central banks of other emerging markets like Bangladesh Bank.

6.2.3. Market Development and Incentive Structures

Supportive Ecosystem for the Corporate Sustainable Bonds: The launch of corporate sustainable bonds necessitates the

collaboration of the FRA and the Ministry of Finance that will materialize as a comprehensive package of incentives, such as partial credit guarantees for the initial issuances, tax credits on the associated costs of issuance, and tax exemptions for retail investors on interest income from accredited sustainable bonds [55]. The CBE should be an active participant in the market and accept high-quality corporate sustainable bonds as collateral in its repurchase agreement (repo) operations to the benefit of market liquidity.

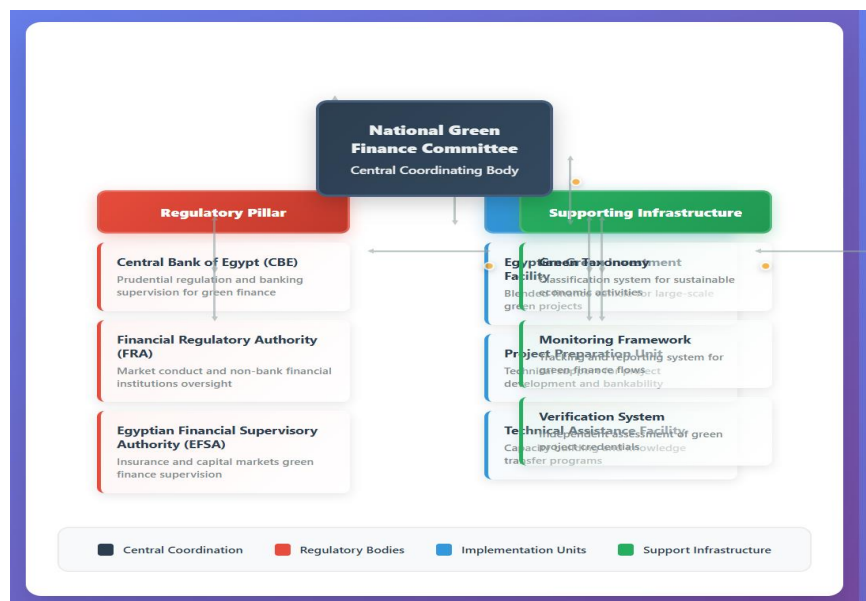
6.2.4. National Blended Finance Facility

The government should establish a dedicated "Egypt Sustainable Investment Facility" through budget allocations, recycled funds from existing climate funds, and international climate finance [56]. The concessional funding (first-loss capital, technical assistance grants, local currency hedging) should be directed toward high-impact but high-risk projects in clean hydrogen, energy storage, and climate-resilient agriculture sectors that are strategically vital.

6.2.5. Institutional Capacity Building

Implement Comprehensive Capacity Building Programs: The financial regulators, credit officers in commercial banks, and project developers will be educated in Green Finance, environmental risks assessment, and ecologically sound project structuring principles through the delivery of specialized training courses [57]. The execution of these programs will mandate collaboration with overseas MDBs, universities, and professional societies.

6.2.5.1. Strengthen Project Preparation Facilities: The existing project preparation facilities will be enhanced by AfDB to enable them to originate a greater volume of bankable sustainable infrastructure projects, primarily through the management of different kinds of documentation and conducting initial viability assessments.



Source: Author's proposal based on international best practices

Figure 9: Proposed Institutional Architecture for Egypt's Green Finance System

6.2.6. Strategic Sequencing and Pilot Programs

A phased and differentiated implementation methodology should be adopted: The policy measures will initially exhibit uniformity across the country, subsequently followed by pilot projects in certain industries (e.g., those with high pollution) and regions (e.g., SCZone). The monitoring and appraisal will be conducted systematically in these pilots to inform the decisions concerning future scaling [58].

6.2.7. Social Disclosure and Just Transition Factors Precedence

The initial regulatory focus will be social responsibility disclosures since they are highly relevant to the stakeholders in the Egyptian context, and these will be the ones gradually introducing the more complex environmental and governance metrics [59]. Policies should directly integrate just transition aspects so that the distribution of costs and benefits is equitable.

6.3. Avenues for Future Research

The research has identified several highly promising avenues for future studies to be pursued. Among those are the following:

6.3.1. Research on the Impact of Green Finance on Distribution and Social Equity

It is of paramount importance to conduct investigations that would ascertain the distributional effects of Green Finance impacts—specifically, who will be the primary beneficiaries of the job creation and enhanced environmental quality, and the communities that will have to contend with the transition costs [60]. A "just transition" must be ensured as it is the pivotal force behind both social sustainability and political support.

6.3.2. FinTech and Digitalization Imperatives

The scrutiny on digital platforms, blockchain technology for impact verification transparency, and various other methodologies like crowdfunding which can substantially contribute to the accessibility of Green Finance for smaller projects, SMEs, and individual households is among the most compelling research domains [61].

6.3.3. Macro-Financial Spillovers and Economic Complexity

A study combining econometric assessments of the ascendancy of the Green Finance sector with the empirical examination of macroeconomic indicators, and their interdependencies (i.e., correlation, causality, etc.) will be of considerable utility in the area of economic planning [62].

6.3.4. Future Research Should Undertake Rigorous Comparative Assessments with Peer Emerging Economies Such as Morocco And Vietnam In Order to Ascertain Transferable Optimal Practices

Systematic comparison of Egypt's Green Finance experience with other emerging economies, such as Morocco, Vietnam, or Colombia, which share a commensurate development stage, will facilitate the extraction of critical insights concerning policy design and implementation within varied institutional settings [63].

In conclusion, Egypt's commitment to Green Finance represents a pioneering and ecologically sound development trajectory. Provided that the nation leverages the aforementioned policy interventions for issue resolution and also enhances the evidence base through subsequent investigations, Egypt will be able to extensively utilize Green Finance as a potent instrument for achieving its economic, social, and environmental objectives [64-77].

References

1. Network for Greening the Financial System. (2023). *Progress report on the implementation of green finance policies*.
2. Change, I. C. (2022). impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. O., Roberts, DC, Tignor, M., Poloczanska, ES, Mintenbeck, K., Alegria, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., et al., Eds, 3056.
3. Stern, N. (2015). *Why are we waiting?: The logic, urgency, and promise of tackling climate change*. MIT press.
4. Climate Policy Initiative. (2021). Global landscape of climate finance 2021. *Climate Policy Initiative*.
5. World Bank. (2022). *Climate risk country profile: Egypt*.
6. Conway, D., & Schipper, E. L. F. (2011). Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. *Global environmental change*, 21(1), 227-237.
7. African Development Bank. (2022). *Egypt country strategy paper 2022–2026*.
8. Ministry of Planning and Economic Development. (2021). *Egypt Vision 2030: Sustainable development strategy update*.
9. World Bank. (2023). *Egypt economic monitor: Towards a green and sustainable recovery*.
10. European Bank for Reconstruction and Development. (2021). *The EBRD in Egypt: Country strategy overview*.
11. International Finance Corporation. (2019). *Creating markets in Egypt: Country private sector diagnostic*.
12. Amundi & International Finance Corporation. (2022). *Emerging market green bonds report 2022*.
13. Zadek, S., & Flynn, C. (2013). *The green finance paradox*. Working Paper, UNEP Inquiry.
14. Khan, M., Serafeim, G., & Yoon, A. (2016). Corporate sustainability: First evidence on materiality. *The accounting review*, 91(6), 1697-1724.
15. Stern, N. (2008). The economics of climate change. *American economic review*, 98(2), 1-37.
16. Stiglitz, J. E. (2019). Addressing climate change through price and non-price interventions. *European Economic Review*, 119, 594-612.
17. Samuelson, P.A. (1954). The pure theory of public expenditure. *The review of economics and statistics*, 36(4), 387-389.
18. Kaul, I., Conceição, P., Le Goulven, K., & Mendoza, R. U. (Eds.). (2003). *Providing global public goods: managing globalization*. Oxford University Press.
19. Dikau, S., & Volz, U. (2021). Central bank mandates, sustainability objectives and the promotion of green finance. *Ecological economics*, 184, 107022.

20. Aizenman, J., & Marion, N. (2004). The merits of horizontal versus vertical FDI in the presence of uncertainty. *Journal of International economics*, 62(1), 125-148.
21. Aglietta, M., & Espagne, E. (2016). Climate and finance systemic risks. *France Stratégie*.
22. United Nations Environment Programme Finance Initiative. (2021). Navigating the new normal: Green finance in emerging markets.
23. Fouquet, R. (2016). Path dependence in energy systems and economic development. *Nature Energy*, 1(8), 16098.
24. IRENA, R. E. C. H. (2019). International Renewable Energy Agency, 2019.
25. Alliance, G. S. I. (2018, April). Global sustainable investment review.
26. Ministry of Finance. (2020). Arab Republic of Egypt sovereign green bond framework.
27. Financial Regulatory Authority. (2021). Executive rules for issuing green bonds.
28. den Elzen, M. G., Dafnomilis, I., Forsell, N., Fragkos, P., Fragkiadakis, K., Höhne, N., ... & Sperling, F. (2022). Updated nationally determined contributions collectively raise ambition levels but need strengthening further to keep Paris goals within reach. *Mitigation and Adaptation Strategies for Global Change*, 27(5), 33.
29. Ministry of International Cooperation. (2022). NWFE program: *Nexus of water, food, and energy*.
30. Creswell, J. W., & Clark, V. L. P. (2017). Designing and conducting mixed methods research. *Sage publications*.
31. Yin, R. K. (2018). Case study research and applications (Vol. 6). Thousand Oaks, CA: Sage.
32. Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative science quarterly*, 24(4), 602-611.
33. Rennert, K., Errickson, F., Prest, B. C., Rennels, L., Newell, R. G., Pizer, W., ... & Anthoff, D. (2022). Comprehensive evidence implies a higher social cost of CO2. *Nature*, 610(7933), 687-692.
34. European Commission. (2020). *Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation)*. *Official Journal of the European Union*.
35. Network for Greening the Financial System. (2022). Enhancing market transparency in green and transition finance.
36. Egyptian Electricity Holding Company. (2022). *Annual report 2021/2022*.
37. Ministry of Electricity and Renewable Energy. (2022). Egypt's electricity sector: *A decade of transformation*.
38. European Bank for Reconstruction and Development. (2018). Project summary document: Aswan Solar PV.
39. International Finance Corporation. (2018). IFC, FMO, MUFG provide \$653 million to finance 13 solar power plants in Egypt [Press release].
40. Komendantova, N., Pfenninger, S., & Patt, A. (2019). The cost of capital for solar power projects in Egypt. *Energy Policy*, 129, 963–974.
41. United Nations Industrial Development Organization. (2020). Employment effects of renewable energy deployment in Egypt.
42. World Health Organization. (2021). *Air quality and health in the Eastern Mediterranean Region*.
43. Suez Canal Economic Zone. (2023). Green hydrogen projects: Strategy and updates.
44. European Investment Bank. (2022). The future of hydrogen in Egypt: *Prospects and challenges*.
45. International Renewable Energy Agency. (2022). Geopolitics of the energy transformation: *The hydrogen factor*.
46. World Bank. (2023). Egypt public expenditure review.
47. International Monetary Fund. (2023). Egypt: 2023 Article IV consultation.
48. United Nations Development Programme. (2022). *Egypt national climate change strategy 2050*.
49. Climate Bonds Initiative. (2022). Developing a national sustainable taxonomy: A world review.
50. Central Bank of Egypt. (2022). Financial stability report 2021.
51. International Monetary Fund. (2022). *Annual report on exchange arrangements and exchange restrictions*.
52. World Bank. (2022). Developing Egypt's local currency bond market.
53. EU Technical Expert Group on Sustainable Finance. (2020). Taxonomy report: *Technical annex*.
54. Dikau, S., Robins, N., & Smoleńska, A. (2023). A toolbox of green finance policy options for central banks and financial supervisors. *Journal of Financial Regulation*, 9(1), 1–30.
55. Climate Policy Initiative. (2021). *Global landscape of climate finance 2021*.
56. Green Climate Fund. (2022). Blended finance guidebook.
57. United Nations Environment Programme Finance Initiative. (2022). *Principles for responsible banking: Guidance document*.
58. World Bank. (2021). Green growth in Egypt: Challenges and opportunities.
59. Mitchell, R. K., Agle, B. R., & Wood, D. J. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of management review*, 22(4), 853-886.
60. Newell, P., & Mulvaney, D. (2013). The political economy of the 'just transition'. *The geographical journal*, 179(2), 132-140.
61. Arner, D. W., Buckley, R. P., Zetzsche, D. A., & Veidt, R. (2019). Sustainability, FinTech and financial inclusion.
62. Acemoglu, D., Aghion, P., Bursztyn, L., & Hemous, D. (2012). The environment and directed technical change. *American economic review*, 102(1), 131-166.
63. Altenburg, T., & Assmann, C. (Eds.). (2017). Green industrial policy: Concept, policies, country experiences. UN Environment; *German Development Institute*.
64. Akerlof, G. A. (1978). The market for "lemons": Quality uncertainty and the market mechanism. In *Uncertainty in economics* (pp. 235-251). *Academic Press*.
65. Bhattacharya, A., Meltzer, J. P., & Mazzucato, M. (2019). A new global framework for financing sustainable infrastructure. *Brookings Institution*.

-
66. IFLA Continuing Professional Development and Workplace Learning Section Standing Committee. (2023). Annual Report 2022-2023: *Continuing Professional Development and Workplace Learning Section*.
 67. Elshafei, A. (2026). A Comparative Institutional Analysis of Green Finance Mechanisms for Egypt's Sustainable Infrastructure Transition. Research Square. <https://www.researchsquare.com/article/rs-9087555/v1>.
 68. Council, H. (2021). *Hydrogen for net zero-a critical cost-competitive energy vector*.
 69. International Capital Market Association. (2021). *Green bond principles*.
 70. International Labour Organization. (2021). Renewable energy and jobs: *Annual review 2021*.
 71. International Renewable Energy Agency. (2022). *Renewable power generation costs in 2021*.
 72. Organisation for Economic Co-operation and Development. (2020). Blended finance for sustainable development: *A historical perspective*.
 73. Organisation for Economic Co-operation and Development. (2021). *Improving the business climate in Egypt*.
 74. Pigou, A. C. (1920). The economics of welfare. Macmillan.
 75. Spence, M. (1973). Job market signaling. *The Quarterly Journal of Economics*, 87(3), 355–374.
 76. U.S. Environmental Protection Agency. (2022). *Report on the social cost of greenhouse gases*.
 77. Soejachmoen, M. P. (2017). Financing the green transformation: how to make green finance work in Indonesia.

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