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"Green Financing as a Tool to Mitigate Climate Change for Sustainable Development"

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Green Financing as a Tool to Mitigate Climate Change for Sustainable Development

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Abstract:

To achieve the 2030 Agenda for Sustainable Development and the Paris Climate Accord[1], investment will have to be directed away from carbon- and resource-intensive investments, and toward sustainable investment. Responsibility for financial and macroeconomic stability implicitly or explicitly rests with the central bank, which therefore ought to address climate-related and other environmental risks on a systemic level. Furthermore, central banks, through their regulatory oversight over money, credit, and the financial system, are in a powerful position to support the development of sustainable finance approaches and enforce an adequate pricing of environmental and carbon risk by financial institutions. Against this backdrop, the paper discusses the extent to which central banks should incorporate environmental considerations into their operations and reviews the public financial governance policies through which central banks, as well as other relevant financial regulatory agencies, can promote green finance. The paper is organized as follows; after the introduction Section 2 reviews the literature on aligning finance with sustainable development. In doing so, it differentiates between the impact of environmental factors on the conventional goals of central banking, and a potential promotional role of central banks with regard to green finance and sustainability. Subsequently, Section 3 is an empirical insight with special focus on Egypt to promote green finance and sustainable development. Section 4 discusses data and econometric model followed by results and discussion in Section 5. Last section 4 concludes.

Keywords: Green Finance, Sustainable Investment, Climate Change
JEL Classification: G1, G2, G3, Q01, Q5

[1] The 2015 COP21 United Nations Climate Change Conference, held in Paris from 30 November to 12 December 2015, following the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the Conference of the Parties following the 1997 Kyoto Protocol.

1. Introduction

Throughout the years, with the increasing pollution, "Green Finance"[2] is becoming a strategic and viable solution for the finance sector to encourage a world with lower carbon, a healthy climate and to reduce environment damage (Bank, 2020). As mentioned by Ehlers and Packer (2016) green finance enhance and sustain the natural environment along with managing current plus future environmental risks. it includes products (including services) that will draw capital towards green industry sectors[3]. Green finance mainly promotes the flow of financial instruments towards the development of sustainable business projects, social investment, social trade, and environmental policies (Lindenberg, 2021). Green Finance provides a vital way to introduce and develop policies to reduce global warming (BIS, 2017).

There are several concepts related to green finance, sustainable finance, climate finance and low carbon finance. All these concepts 'refer to the use given to financial resources'. The concept of green finance came into the discussion when the world started to face climate changes which are not in their favor. The importance of Green finance had been highlighted by introducing investment products that protect the environment and make sure to provide economic prosperity[4] (Isaac Akomea-Frimpong, 2021). Green finance is a rapidly growing sector, reshaping the financial system (Alemzero et al., 2020a ; Alemzero et al., 2020b; Sun et al., 2020).

The Intergovernmental Panel on Climate Change report notes the importance of mobilizing green finance in order to limit global warming to 1.5°C and prevent catastrophic climate change. Fully implementing the Paris Agreement to meet this climate target will require US$ 1.5 trillion in green financing annually through 2030, according to the United Nations Framework Convention on Climate Change. At the same time, raising green finance is key to surging energy demand, which is fueled by economic growth, population growth, and enhanced

[2] Whether it's sustainable finance or environmental finance or say green investment or climate finance; all the terms are relatively used in green finance.

[3] The most common green industry sectors include industry that focuses on renewable energy production, storage, distribution, transport (green), recycle, prevent pollution, and conserve water as well as forest. It encourages approach, strategy, culture, business process focusing environment throughout the industry.

[4] Banks created and allocated green financial products but now, green finance policies are binding on financial institutions and corporates.

energy access. Therefore, scaling up green finance is needed. A major shift in investment patterns will be needed to ignite green finance and creating this shift is a growing focus of regional government policies. The number of countries promoting green finance is growing and new measures supporting green finance are being implemented. Learning from these recent experiences should help to design effective policies to further promote green finance. (UNEP and the World Bank Group (2017, 83).

Notwithstanding its popularity in recent years, green finance remains a complex topic. Green finance refers to financial investments made specially to promote environmental protection. Green finance includes green asset financing, green loans, and green investing[5]. Green finance laws govern loan availability in less developed financial ecosystems and state-owned enterprises. Green finance should utilize existing bank and corporate relationships as well as current technology (Bodnar et al., 2018; Yu and Solvang 2020). Carbon emission-based green finance schemes often benefit both companies and suppliers. Green finance helps the industrial sector as well. In conclusion, the positive relationship between green finance instruments and business innovation makes green finance a promising tool for transition to intelligent and sustainable manufacturing (Liu and Wu 2019). Global capital market monitoring of green bonds is helping develop a more dynamic green finance ecosystem (Gerlagh et al., 2018).

In line with recent studies by Tiep et al. (2021), Yang et al. (2021), He et al. (2020) and Mohsin et al. (2020b), environment has been changing rapidly since the mid-1990s, but this is particularly true now throughout the world. Various procedures and tactics are proposed and put into practice at various scales in order to lessen the impact of climate change. According to Ikram et al. (2019a), Shah et al. (2019) and Liu et al. (2021), the carbon strategy and execution is one of the biggest new businesses to deal with climate change. On the other hand, central banks may be mandated to actively use the tools at their disposal to promote green investment or discourage brown investment and play a "developmental role" (Dafe and Volz 2015).

In conclusion, the green financing aimed at mitigating the climate change by decreasing the carbon drifts do not reach their envisioned effects. There is a need

[5] The private sector may help finance environmental projects that the government doesn't fund sufficiently. Environmental degradation is more probable in poorer countries, necessitating significant green financing initiatives. Developing country governments may create and implement policies that promote green finance.

to identify the nexus between green financing, carbon drifts and climate change mitigation, and present the policy guidelines for key stakeholders if suggested policy measures applied effectively, are expected to enhance climate control specifically during crises periods.

At this end, this study fills that knowledge gap by investigating the impact of green financing on climate change in Egypt along with other control variables that are influencing it.

2. Literature Review on Green Finance and Climate Change:

The literature review begins with an inquiry of logical reasoning which underlines the widening of the green debt market, which is followed by the examination of the efficiency of the green financial system. However, stakeholders always prefer to make a profit over the environment. Stakeholders cover shareholders, communities, employees, customers, suppliers and also, government officials.

Across the globe, climate change and sustainability have received a lot of attention. It is stated in the 2015 Paris Agreement, which was adopted as part of the United Nations Framework Convention on Climate Change (UNFCCC), that world leaders have come to a general consensus on this subject. As a result of the agreement of the member countries to work together to reduce greenhouse gas emissions, one of the most difficult challenges is financing climate change mitigation and adaptation actions and their long-term viability. We will have to invest highly into to get things back to normal. Global warming must be kept below 2°C by 2035, which will require $53 trillion for investments in energy-related projects (Moz-Christofoletti and Pereda, 2021).

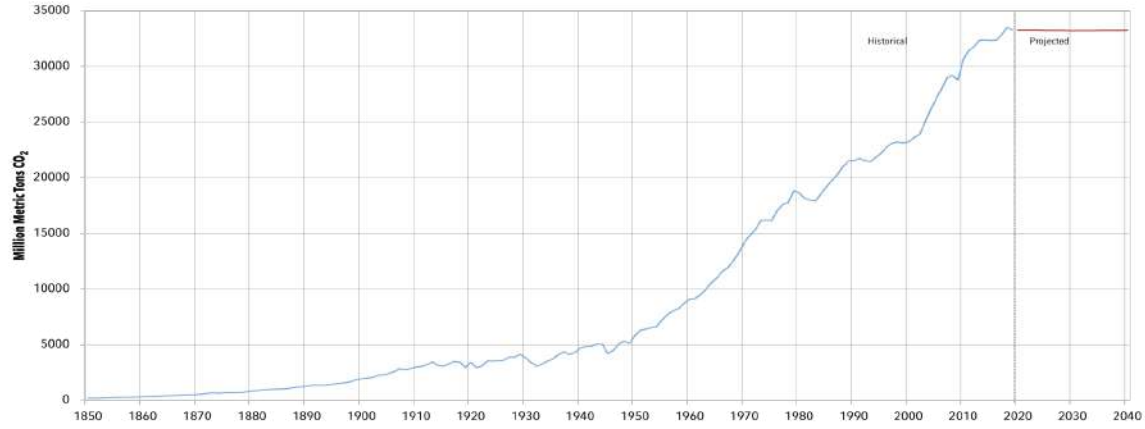
"Greenhouse gas[6] (hereafter abbreviated as GHGs) emissions are externalities and represent the biggest market failure the world has seen"(Stern, 2008, P.1)[7].

[6] The UN identifies seven main greenhouse gases (GHGs) that are major drivers of climate change: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2 O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3). As CO2 is by far the most common GHG caused by human activity, it is sometimes used as a shorthand expression for all greenhouse gases.

[7] A comprehensive and illuminating departure point for understanding the economics of climate change is the 2007 Stern Review.

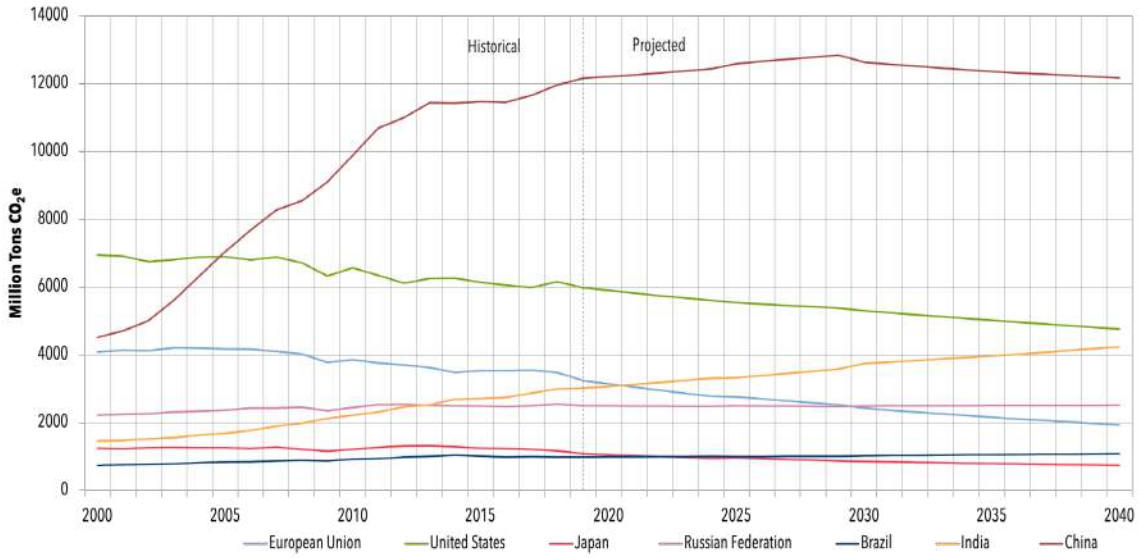
The past and present production and consumption patterns have emitted excessive GHGs as presented in figure (1) and figure (2) below, especially carbon dioxide, whose accumulated concentration above critical thresholds[8] in the atmosphere affects global average temperatures, causing what is known as global warming or climate change.

Figure (1): Global Carbon Dioxide Emissions, 1850–2040



Notes: Carbon dioxide emissions have risen rapidly for the past 70 years. However, they are projected to remain steady, albeit at a very high level, in the coming decades.
Source: Carbon Dioxide Information Analysis Center (Oak Ridge National Laboratory, 2021) and World Energy Outlook (International Energy Agency, 2021).

Figure (2): Greenhouse Gas Emissions for Major Economies, 2000–2040



Source: World Energy Outlook (International Energy Agency, 2020) and CO2 Highlights (International Energy Agency, 2021)

[8] Beyond our ecosystem's absorptive and recycling capabilities.

That, in turn, affects the entire socioeconomic system through complex channels. All this can have severe consequences for global sociopolitical-economic equilibria: standards of living, productivity, refugees and massive migration, etc., and all this involves the ingredients that make collective rational decisions difficult[9]. There is the classical way of dealing with externalities through general Pigovian[10] taxes and subsidies. There could also be implicit pricing through reputation and exposure, by creating processes for disclosing climate-related financial assets and financed projects[11].

Carney (2015) highlighted that climate change is global, its origins are local, and its effects will be felt only after our generation's lives. The effects are most likely irreversible, but the science must address significant layers of uncertainty[12]. The best science today recommends stabilizing the stock of GHGs below a certain target and thus acting to control and reduce new flows or emissions now in order to avoid causing irreversible damage beyond 2050. The mitigating measures naturally have a cost of abatement. Changes have to occur in production and consumption habits, and not just the obvious candidates like transportation and energy (UNEP, 2017).

There are many options for abatement, ranging from improving current energy efficiency, to changing our energy matrix to renewable sources, to tackling non-energy emissions/damages in agriculture and deforestation. Ironically, in some options, benefits exceed costs and might create a new, virtuous, low carbon growth cycle. New technology is fundamental to reduce risk and lower abatement costs. However, as of now and facing uncertainty, any good policy to combat climate change requires a price to act as an incentive to reduce a negative externality such as GHGs, in line with basic welfare economics. The price needs

[9] In the light of considerable uncertainty, large time lags before becoming apparent (especially to climate change sceptics), free riding and collective action problems.

[10] From Arthur C Pigou, who proposed the concept and the solution to externality problems by taxation, an idea that is key to modern welfare economics and to economic analysis of environmental impacts.

[11] In response to the G20, the Financial Stability Board (FSB) established a private sector, industry-led Task Force on Climate related Financial Disclosures to develop voluntary, consistent, climate-related financial disclosures for use by companies in providing information to investors, lenders and insurance underwriters. The FSB delivered the Task Force final report "Recommendations of the Task Force Climate-related Financial Disclosures" in July 2017 at the G20 Hamburg Summit. http://www.fsb.org/what-we-do/policy-development/additional-policy-areas/developing-climate-related-financial-disclosures/

[12] Therefore, we are dealing with a subject that mixes uncertainty, risk, prioritizing ethical choices and international coordination for the common good.

to reflect what we already know about the medium- to long-term additional costs of climate change. In theory, such a "shadow price" incorporating the social cost of carbon would be enough to reduce emissions and should be used in economic and financial calculations, in particular in the cost-benefit analysis of investment projects, to take into account these negative externalities (e.g. congestion, pollution, toxic emissions). But the "right price of carbon" is a tricky issue[13]; it is needed to be pragmatic and use various metrics to reach emission targets, calculating abatement costs while incorporating all the available information on new technologies that reduce them.

Much of the economic literature on the optimal financial response to climate change has focused on the trade-off between direct costs and the potentially uncertain long-term benefits of investments to reduce carbon emissions (Giglio et al., 2015). In this regard, finance was considered from the standpoint of solving two problems: (I) climate change in the right direction, (II) adaptation of the production and household system to climate change. The impact of financial innovation on climate change is being actively studied. Policymakers and academics are just beginning to examine the scope and impact of COVID-19's impact on the financial industry and its involvement in post-pandemic economic recovery. However, the link between climate change and the current pandemic in light of the development of green finance is a new topic.

In the baseline scenario of post-pandemic development, considered by the experts of the World Economic Forum, the key condition for normalization of activity includes investments in long-term human health, the environment, and a green economy (Wyns, 2020). Green finance plays a leading role in creating measures to preserve the environment and the sustainability of the economy, and in the new conditions in providing epidemiological measures to protect humans, which is extremely important for the effective reproduction of human capital[14]. The green

[13] The Stern Review (2007) and technical modelling using work by the Nobel-Prize winning Intergovernmental Panel on Climate Change (IPCC) suggest that we need to limit the concentration of GHGs in our atmosphere to 550 parts per million (ppm) CO2 equivalent (CO2e). That means emission cuts of 20 gigatonnes of CO2e by 2030 and thus a CO2 price of about 30 euros per tonne. Moreover, social cost of carbons also implies sensitive assumptions about models, the social utility of consumption, fairness in burden-sharing, social discount rates, etc. The key is that we end up with an abatement cost of about 1% of world GDP, which seems to be a reasonable insurance cost.

[14] Even small changes in the behavior of people, companies, governments, and investors can have a significant impact on the state of green finance.

focus of post-pandemic economic recovery will increase the resilience of society to pandemics and other emergencies, including climate change (Cox and Piccolo, 2020).

The transition to a green economy is necessary for the world to avoid catastrophic climate change. The International Energy Agency (IEA) estimates that additional investment in renewable energy and energy efficiency alone between 2015 and 2040 was the US $ 26 trillion. Overall, reaching the global targets in 2030 may require mobilizing green finance of $ 90 trillion (Wang, 2020). Under the influence of the pandemic, many problems in the economy and finance have worsened significantly. It is widely believed that it is precisely the green focus of financial investment after the pandemic that will open up new prospects for sustainable growth, reduce the threat to society from climate change and create millions of additional jobs in the coming decades (Cho, 2019). Big data finance analysts have observed that epidemiological methods of studying disease incidence and prevalence are well-suited for assessing financial risk and for building models that can analyze green inclusions in finance and economics.

The inclusion of current events that indicate changes, expand the possibilities for the preparation and operational revision of investment processes (Dans, 2020). It can also enhance the impact of predictive models on decision-makers, and with broad information about the results of forecasts and on-demand. Thus, the green focus of finance in the post-pandemic business cycle will to a certain extent become a predictive function. Potential new pandemics, climate change, and their impacts around the world will threaten businesses in a variety of ways (Watkiss, 2020). Thus, during the pandemic, global CO2 emissions decreased and living conditions in large cities and industrial centers improved. This is an improvement in air quality due to a reduction in traffic. Satellite images show dramatic declines in air pollution in many countries, linked to the economic slowdown caused by the virus outbreak (Harvey, 2020).

In the same context, World Bank statistics indicate that losses resulting from damage caused by natural disasters and climate change have quadrupled since the eighties rising from 50 billion to about 200 billion in the last decade (World Bank, 2020)

Several studies on climate change indicate that temperatures rise, and negative repercussions are expected to slow global economic growth and adversely affect the performance of financial markets. Also, the $ 143 trillion non-bank financial

assets, according to the Financial Stability Board, may be affected negatively by global warming. A study by the London School of Economics indicates that if temperatures rise by two and a half degrees by the end of the century, it is expected that roughly $ 5.2 trillion of financial assets would be at risk. The same study expected 0.5 per cent of total financial assets would be at risk, according to an optimistic assumption, and to 17 per cent according to severe assumptions.

The Arab Monetary Fund (AMF) (2021) is developing a framework for green and sustainable finance ("AGSFF") with the aim of highlighting how the fund can support central banks and ministries of finance in Arab countries in moving towards green and sustainable finance and managing climate change risks in accordance with the fund's vision and strategy. This framework is considered a basic pillar for integrating the risks of climate change and environmental sustainability into the financial decision-making process and risk management in the Arab countries, with the aim of enhancing the supply and demand for green and sustainable finance, supporting green investments, and green finance tools, through establishing effective Arab and international partnership and cooperation in the form of a network integrated.

3. Green Finance and Climate Change: An Empirical Insight from Egypt

Egypt pulled in orders for nearly five times the $750 million size of the Middle East and North Africa's first sovereign green bond, as it pushes ahead with anti-pollution and renewable energy projects[15]. After a record Eurobond sale in May, Egypt is targeting as much as $7 billion in debt sales in the fiscal year that began in July[16]. According to Bloomberg and Environmental Finance Data fixed income debt market total issuance 2007-2021 is $276 billion. While real economy bond issuance is valued by $720 million and sustainable bond issuance is $850 million for the same time period[17].

[15] The government plans to issue more green bonds in 2022 as part of stepping up its efforts to add more green energy capacities in the build-up to the next UN Climate Change Conference of Parties (COP) 27 in November 2022 hosted in Sharm el-Sheikh.

[16] There are additional plans to offer the country's first sukuk, or Islamic bonds, in both local and international markets.

[17] See: Bloomberg and Environmental Finance Data – date range 2007-2021

Recent reports state that there are potential opportunities in many sectors, at the top of the list are energy and transport seeking reduction of climate change such as 800MW of solar photovoltaic and wind power plants, the construction of oil terminals with a storage capacity of 1 million m3, the international air cargo hubs, improvements to freight capacity and more. However, it is expected that Egypt will face a significant financing gap between 2018 and 2038, estimated to be at least $230 billion. During this period, the estimated financing capacity for the Government could reach $445 billion, while the total needed for infrastructure investments would be approximately $675 billion (Global Partnership for Effective Development Cooperation (2018). According to World Bank study on infrastructure investment in Egypt (2021), the country has benefited historically from a high share of public investment in infrastructure among countries in the MENA Region; however, public infrastructure investment has been declining without a corresponding rise in private investments.

Egypt is working on increasing the supply of electricity generated from renewable sources to 20% by 2022 and 42% by 2035. Its strategy is supported by an ambitious action plan for green hydrogen production that the government is devising in 2022, the financing of those projects is one of the main challenges to the transition to clean energy in the country. This financing shortfall represents a potential opportunity for real economy companies to issue sustainable bonds to fund clean energy projects[1819].

Egypt is one of the least emitter countries, the current level of CO2 emissions in Egypt is 0.67% which is far lower than the world average[20]. It also noted that climate change adaptation and mitigation actions would require a total estimated cost of about $73 billion over the 2020–2030 period. It also emphasized the importance of mobilizing international financial support and technical assistance for technology transfer and capacity-building for the implementation of its intended nationally determined contributions (CBE, 2020).

The basic tools for green finance in Egypt are:

[18] See: Country Private Sector Diagnosis Creating Markets in Egypt, IFC, December 2020.

[19] The magnitude of the gap in Africa to meet with the SDGs. This gap is estimated to be a yearly USD 1.3 trillion investment gap, with only 15% of the needs currently met (UNEP, 2018).

[20] See: World Bank Data C02 Emissions, World, Egypt.

- *Public Private Partnership PPP*[21]*:* Fifty-five projects for a total of USD 10.3 billion in total have reached final closure since 1990. The largest project was the Suez Canal Container Terminal, with its financial closure in 2000 totaling USD 893.9 million. The most recent project finalized was West Bakr Wind Farm, with its financial closure in 2019 USD 35 million. 53 projects are under construction or operation for an estimated outstanding of USD 3.5 billion.

- *Green Bond:* As mentioned above, Egypt is the first government in the MENA region to have issued a green bond. The amount of the issue was USD 750 million, directed mainly at funding clean transport projects. In addition, the Ministry of Planning and Economic Development and Ministry of Environment have designed and implemented the Environmental Sustainability Guidelines[22], a set of criteria to ensure the greening of the national budget. Under these criteria, 15% of the projects funded from the public budget under the national investment plan of the physical year 2020–2021 are green projects. The government wants to double that target (reaching the 30% of the national investment plan) for the year 2021/2022 is aiming to reach 50% of green projects by the year 2024/2025. The overall license of the Finance Ministry for issuing bonds is USD 7.8 billion. The estimated Green bond current outstanding is USD 750 million.

- *Blended Finance:* Based on Multilateral Development Banks (MDB's) and Development Finance (DFI's) reports[23], the estimated amount of MDB/DFI outstanding loans is approximately USD 27.9 billion[24]. To obtain the full amount of blended finance in Egypt, (i.e. including the privately financed part), it could be considered that only 70% of MDB/DFI finance is "blended finance" and that the ratio between MDB/DFI and private finance is 50/50. This would lead to a global outstanding of USD 39.1 billion integrating the private finance part.

In terms of Egypt's position in climate change negotiations in line with African

[21] PPP Knowledge Lab, Egypt, 1 September 2021.

[22] Decarbonisation et économie verte : Guide des programmes de financement et d'appui pour les entreprises marocaines—AMEE

[23] IFC, EIB, EBRD, IDB, ADB, AFD, KFW, GIZ, FMO, IBRD/IDA are the sources for these numbers.

[24] This estimation may involve some double accounting bearing in mind that individual OUTMDBs/DFIs may in practice only be covering a share of the PPPs.

and Arab group positions; adaptation to climate change negative impacts is an essential priority for developing countries and must have enough global attention in terms of providing financial, technical, and capacity building support from developed countries according to the UNFCCC principles and provisions. Moreover, the international system for combating climate change is based on historical responsibility of developed countries on the accumulation of emissions in the atmosphere and common but differentiated responsibilities and respective capabilities and equity, and the right for developing countries to achieve sustainable development and poverty eradication according to their national priorities and strategies[25].

The plans are clear and extensive and outline the government's desire to weave sustainability and green projects into every facet of the environment. In addition, and most recently the Government of Egypt approved the National Climate Change Strategy 2050 (NCCS), which marks an important step for Egypt's climate policy, laying down priorities for action in mitigation and adaptation, supported by enabling goals on regulatory, financing, technology, and capacity constraints. It reflects Egypt's efforts of the past years to become a regional frontrunner for climate action in the region. The strategy builds on various other national articulations, which have helped make significant progress in climate change adaptation and mitigation action[26].

Increased fiscal consolidation provides the Government with sufficient fiscal space to address potential crisis situations that may have an abrupt negative impact on the SDGs. The COVID-19 crisis is one such example. The expected costs of climate change for Egypt are another important consideration. Furthermore, enhanced fiscal space reduces the cost of government borrowing (via a premium effect) by improving the path to public debt sustainability (Ministry of Planning and Economic Development, 2021).

[25] Debt-for-climate swaps are also among the measures considered to close SDG financing gaps and overcome fiscal distress resulting from the COVID-19 pandemic. The Government participated in the launch of the ESCWA climate/ SDG debt swap initiative, which aimed to support debt relief efforts and improve climate finance in middle-income countries in the Arab region that are facing increasing debt burdens, growing SDG related needs and heightened risks in the wake of COVID-19 and its impact on debt trajectories. Efforts in this regard are still progressing and must be intensified to close SDG financing gaps.

[26] Please see: Egypt Vision 2030, The Green Growth Knowledge.

Another priority flow is that of private investment from both the domestic private sector and Foreign Investment. Increased fiscal consolidation creates more room for private sector growth. Reprioritized spending may also crowd in the private sector if a comprehensive public-private partnership approach is adopted. This provides more space for the private sector to participate and increases the availability of funds, since the lower budget deficit reduces the need for borrowing. In parallel, immediate and significant reforms in the business environment are needed to ensure that the private sector adequately participates in economic activity (Egyptian Agency of Partnership for Development, 2021).

4. Data and Methodology

This study is an attempt to examine the linkage between finance and ecology. Environmental sustainability can be attained by arranging funds for solar energy, according to Zhou et al. (2020). Environmental finance or sustainable financing was found to be the most effective method of reducing environmental degradation in a study by Chishti and Sinha (2022). Investing in renewable energy is one way that sustainable finance or green finance promotes new technology and innovation (Ansari et al., 2022). In order to assess the nexus between green finance on climate change in Egypt the analysis proceeds in two steps: measure the green finance, and then evaluate its impact on climate change for the time span from 2000 to 2022. In what follows, the definitions and sources of data used in the empirical evaluation are described.

4.1 Measuring Green Finance

In order to achieve a green economy, it is encouraged to build a green finance system. When the government with their political support failed to build a green finance system that supports reduction in carbon emission, a green policy introduced green debt market instruments via Green bonds and Green loans. According to the social responsibility reports released by major banks, under the guidance and promotion of government's policies, financial institutions such as banking industry has consciously implemented the requirements of resource and environmental protection and supported green industries, actively shared green development investment opportunities, compressed the development space of polluting enterprises. However, there was no unified statistical caliber for green credit data in many countries.

Green bonds are increasingly being used to provide long-term financing of environmental projects. Green bonds are long-term investments that benefit the environment while providing a regular income. These bonds typically come with tax advantages to encourage adoption and bridge the green funding gap. Emerging markets are worried about green finance (MacAskill et al., 2020). To promote long-term sustainable growth, t is recommended to establish a green financing system. Shareholders prefer green bonds because they can increase the company's long-term value (Pereira da Silva, 2016). However, numerous practical micro and meso level difficulties persist (Agyekum et al., 2021; Zhang et al., 2021).

In this context, some countries have developed stress tests to measure the extent of financial soundness against the effects of climate change risks. Stress tests are intended to assess the occurrences of a comprehensive financial shock caused by the climate change, such as a sudden drop in economic growth or a significant fall in real estate prices.

4.2 Constructing Green Finance Index (GFI)

Because green bond is recently issued in Egypt, data will not be to run the econometric time-series model. Therefore, this study builds a green finance index system that covers five elements in order to quantify green finance in Egypt over the time span from 2000 to 2021 more objectively and thoroughly. GFI[27] is explained as follows:

$$GFI_j = W_{j1}X_1 + W_{j2}X_2 + \cdots + W_{jp}X_p \qquad (1)$$

Where GFI_j is the Green Finance Index; W_j is the weight on factor score coefficient; p indicators related to green finance X_j (j = 1, 2,…, p). Suppose that there is a total of T years, and X_1, X_2, …, X_T are lined in order to construct index for green finance. With reference to availability of data, selected indicators are shown in table (1) below.

[27] Generalized form of PCA is used because Classical PCA can be used only for cross-sectional data and is not suitable for dynamic analysis. In contrast, the GPCA method, which combines PCA and time series analysis, can analyze time series data and explore the trajectory of the overall level of a system over all time.

Table (1): Indicators of the Green Finance Index

Indicator Name	Source
Energy Saving	IEA Statistics © OECD/IEA (http://www.iea.org/stats/index.asp) (https://www.iea.org/t&c/termsandconditions)
Environmental Protection Projects Public Private Participation	Investment in Energy Project Database (http://ppi.worldbank.org)
Service Loans	Loans World Bank, Enterprise Surveys (http://www.enterprisesurveys.org/)
Renewable energy	World Bank, Sustainable Energy for All (SE4ALL) database (jointly by the World Bank, IEA, and the Energy Sector Management Assistance Program)
Micro Credit	International Financial Statistics https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b&sId=1390030341854

Two diagnostic tests are conducted for Exploratory Factor Analysis (EFA), Kaiser-Meyer-Olkin (KMO) test and Bartlett's test to determine whether the data can be analyzed using the GPCA method, results are shown in Table (2). The result of the KMO test is 0.781 (> 0.5), which indicates that there is a strong correlation among test indicators. The approximate chi square of Bartlett's test is 1047.482 and the significance level is 0.00 (< 0.01), indicating that the result rejects the null hypothesis. Therefore, the data can be analyzed using the GPCA method.

Table (2): Results of the KMO test and Bartlett's test

Test Method	Statistics	Results
Kaiser-Mayer-Olkin test	Measure of sampling adequacy	0.781
Bartlett's test of sphericity	Approx. chi square	1047.482
	Df.	15
	Sig.	0.000

Source: Author computation using SPSS

4.3 Regression and Variables Selection

This study employs regression analysis to determine the impact of green finance on a climate change and environmental sustainability. As explained in function (2) and table (3), the dependent variable is GHG emissions which specifies the overall quality and herby used as a proxy for climate change. While a high degree of GHGs emissions denotes ecological degradation, the absence or low level of GHGs emissions denotes improved environmental quality. In addition, the

primary independent variable in this analysis is green finance, which is denoted as (GF). It is significant because it fosters and cares for the drift of financial tools and associated facilities toward formulating and implementing sustainable business models, investment, economic, trade, social and environmental initiatives, and regulations. To facilitate the creation and implementation of financial tools and allied services, the green finance variable is crucial. As a result, green finance has an impact on economic activities and contributes to the country's ecological performance. Furthermore, the flow of financial instruments is a factor that is highly dependent on the country's economic conditions. Because of this, GDP could be an effective factor for presenting a country's economic situation because it measures health and size over a particular period of time. It considers aggregate investment, consumption, production, and other macroeconomic variables to determine the health of an economy. As a result (Mastini et al., 2021), a high degree of GDP could stimulate financial activity, which would, in turn, consume more natural resources and energy, potentially having a negative influence on the environment.

On the other hand, this study integrates other control variables in the model which are foreign direct investment (FDI), research and development investment (RDI) and population. Following Azhgaliyeva, D. & Liddle, B (2020), FDI has the potential to influence environmental conditions by implementing flexible or stringent policies and making investments that can potentially impact a country's economic conditions significantly.

Throughout the world, R&D investment and technology has advanced at a rapid pace since 1990, both in developing and developed countries. This advancement accelerates the rate of production and other economic activities, allowing for achieving higher economic goals. However, as a result of its rapid industrial development, countries such as USA and China have risen to become the world's leading carbon emitter and energy importer, making significant contributions to

global warming and climate change. As claimed by Zhang D. et al. (2021) and Tang et al. (2022) China has concentrated on the growth of green finance to combat the potentially catastrophic issue of climate change and global warming. To fully recognize this connection, it is necessary to look back over the last three decades. To advance green innovation and green development, R&D investment is essential. This has been proven to have threshold effect. Consequently, the threshold variable in this article is the ratio of R&D internal spending to GDP, which represents R&D investment (RDI).

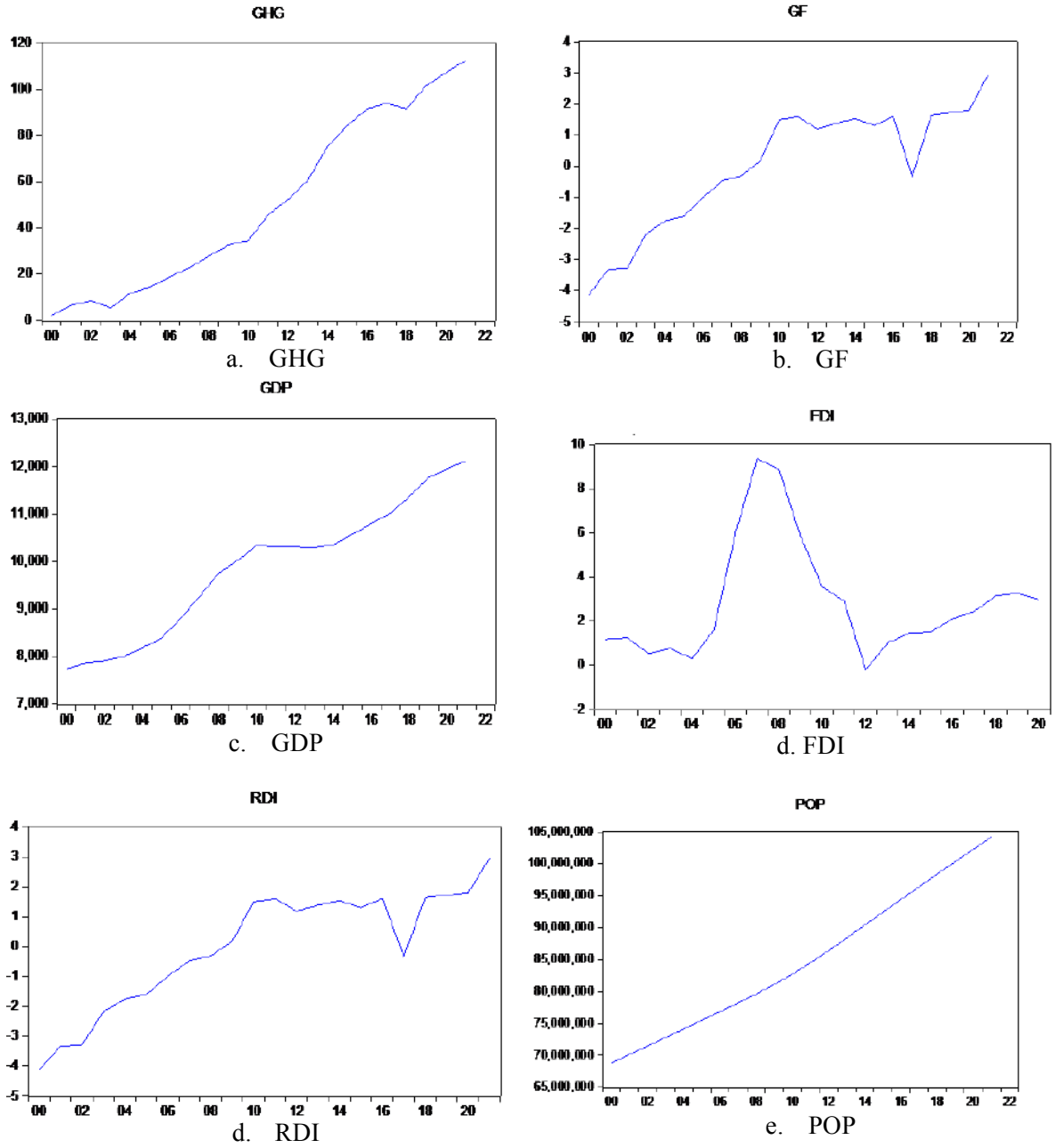
Studies such as Ahmad B. et al. (2021), Gao et al. (2021) and others show that an increase in population (Pop) lead to an increase in CO2 emissions, which is consistent with the findings of previous studies.

$$GHG = f(GF, GDP, FDI, RDI, POP) \quad (2)$$

Table (3): Specifications for the variables, units of measurement and data sources

Symbols	Descriptions	Data Sources
GHGs (Dependent Variable)	**Greenhouse Gas:** Total greenhouse gas emissions (kt of CO2 equivalent)	Climate Watch. 2020. GHG Emissions. Washington, DC: World Resources Institute. (https://www.climatewatchdata.org/ghg-emissions)
GF	**Green Finance Index:** Energy saving, service loans, public private partnership in environment project and renewable energy	Author Computation as explained in table (1)
GDP	**Gross Domestic Product:** GDP per capita, PPP (current international $)	World Bank Database https://databank.worldbank.org/source/world-development-indicators
FDI	**Foreign Direct Investment:** FDI net inflows (%GDP)	World Bank Database https://databank.worldbank.org/source/world-development-indicators
RDI	**Research and Development:** R&D internal expenditure/GDP	World Bank Database https://databank.worldbank.org/source/world-development-indicators
POP	**Population:** Population, total	United Nations Population Division. World Population Prospects.
T	Time Index	
α and β	Parameters to be estimated	
ν_{it}	Error Term	

Figure (3): Trend Analysis for Selected Variables



a. GHG b. GF

c. GDP d. FDI

d. RDI e. POP

Source: Author's preparation using data sources from table (3).

4.4 Model Specification

The Vector Error Correction Model (VECM) methodologies are used to determine the impact of green finance on climate change and environmental sustainability. It is often used to predict the interconnected time series system and analyze the dynamic influence of random disturbance on variable system. The VECM technique, which stands for long-term interaction of components, is used to examine how components interact over time. It is possible that the VECM

demonstrates short-term causation. Control variables set in this model include progress in the GF, GDP, FDI, RDI and POP. Because of this, the VECM equation looks like the following:

$$GHG_{it} = \alpha + \beta_1 GF_{it} + \beta_3 GDP_{it} + \beta_4 FDI_{it} + \beta_5 RDI_{it} + \beta_6 POP_{it} + \mu_I + \nu_{it} \quad (3)$$

In order to estimate Equation (3), we employ an econometric methodology that is divided into three parts. The first step entails determining the degree of integration of each variable that has been employed. Several statistical tests are employed in the econometric literature to determine the degree of integration of a variable. The following are some examples: These are the tests that will be used in this study: Dickey-Fuller Augmenté (ADF); and Phillips-Perron (PP). The next stage will be to investigate the possibility of cointegration relationships between the variables, which may occur over a lengthy period of time once the integration order of the series has been determined for each of the variables. This analysis will be carried out in accordance with the Pedroni test technique. The third stage is concerned with the testing of causality between the variables in the model. The so-called sequential test technique as well as the non-sequential vector error correction model (VECM) procedure will be used in this investigation.

5. Results and Discussion

This section analyzes the findings of this study and discuss them in more detail. GHG, GF, GDP. FDI, RDI and POP are the variables selected for this study and are shown in Table (3) for the period from 2000 to 2022.

5.1 Unit Root Test

The Unit Root Test (Im et al., 2003) is conducted, using Augmented Dickey–Fuller (ADF) test and Phillips-Perron (PP) test to identify the root of the problem. Variables are tested in both level and 1st difference forms, with intercept and with intercept and time trend. The findings of the ADF and PP unit root tests are presented in Table (4) and (5). According to the results of the ADF and PP tests, data were nonstationary at the level form. ADF and PP tests results strongly reject the null hypothesis of a unit root (variables are stationary) for 1st difference, as the absolute value of t-statistics is higher than critical values at 5% level and p-values are less than 5%. While results at level form, both with intercept and with intercept and time trend were insignificant at 5% level so that data is integrated to order (1).

Table (4): ADF Test Statistics

Variables	At Level				At 1st Difference			
	Intercept		Intercept + Time Trend		Intercept		Intercept + Time Trend	
	t-Statistics	Prob.*	t-Statistics	Prob.*	t-Statistics	Prob.*	t-Statistics	Prob.*
GHG	0.965	0.994	-1.995	0.571	-3.475	0.002*	-3.689	0.004*
GF	-1.605	0.462	-2.422	0.358	-6.215	0.000*	-6.196	0.000*
GDP	-1.376	0.568	-4.096	0.229	-3.162	0.031*	-3.844	0.039*
FDI	-2.784	0.0775	-2.697	0.247	-6.769	0.000*	-6.628	0.000*
RDI	-1.844	0.350	-2.929	0.173	-5.821	0.000*	-5.657	0.001*
POP	0.967	0.993	-4.551	0.010*	-3.052	0.000*	-3.710	0.000*

Source: Author's estimation (statistical work is performed using E-views software version12)
*denotes result is significant at 5% level

Table (5): PP Test Statistics

Variables	At Level				At 1st Difference			
	Intercept		Intercept + Time Trend		Intercept		Intercept + Time Trend	
	t-Statistics	Prob.*	t-Statistics	Prob.*	t-Statistics	Prob.*	t-Statistics	Prob.*
GHG	0.875	0.992	-1.995	0.570	-3.475	0.002*	-3.689	0.004*
GF	-1.693	0.419	-2.422	0.358	-6.248	0.000*	-6.196	0.000*
GDP	-0.165	0.929	-4.096	0.644	-3.142	0.021*	-3.844	0.023*
FDI	-2.715	0.088	-2.697	0.273	-6.822	0.000*	-6.628	0.000*
RDI	-1.752	0.392	-2.929	0.180	-6.018	0.000*	-5.657	0.001*
POP	5.117	0.995	-4.551	0.891	-3.092	0.005*	-3.710	0.008*

Source: Author's estimation (statistical work is performed using E-views software version12)
*denotes result is significant at 5% level.

5.2 Cointegration Test

As resented in table (6), results of trace and maximum eigenvalue indicate that there are four cointegration relations. Which concludes that there is a long-run relationship between variables and their major fundamentals.

Table (6): Cointergration Test Results

Sample (adjusted): 2001 2021
Included observations: 21 after adjustments
Trend assumption: Linear deterministic trend
Series: GHG GF GDP FDI RDI POP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05Critical Value	Prob.**
None *	0.998285	288.7277	95.75366	0.0000
At most 1 *	0.985605	161.3578	69.81889	0.0000
At most 2 *	0.893567	76.54042	47.85613	0.0000
At most 3 *	0.593676	31.73566	29.79707	0.0295
At most 4	0.495534	13.72359	15.49471	0.0908
At most 5	0.001923	0.038497	3.841466	0.8444

Source: Author's estimation (statistical work is performed using E-views software version12)
Notes: Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

5.3 Vector Error Correction Model (VECM)

Because of the co-integration of previous estimates, it is possible to create a casualty among variables in this study. This, as well as long-term inference, was accomplished through the application of VECM techniques based on Engle and Granger (1987) two step procedures. The lag period of the model is determined according to the Akaike Information Criterion (AIC) and Schwarz Criteria (SC). After many tests, it was found that the AIC and SC are the smallest when the lag period is 2. Table (7) shows the outcomes of the VECM estimates. In order to understand the results of the VECM, Impulse Response Functions (IRF) is estimated.

Table (7): Vector Error Correction Estimates

Vector Error Correction Estimates
Sample (adjusted): 2001 2021
Included observations: 21 after adjustments
Standard errors in ( ) & t-statistics in [ ]

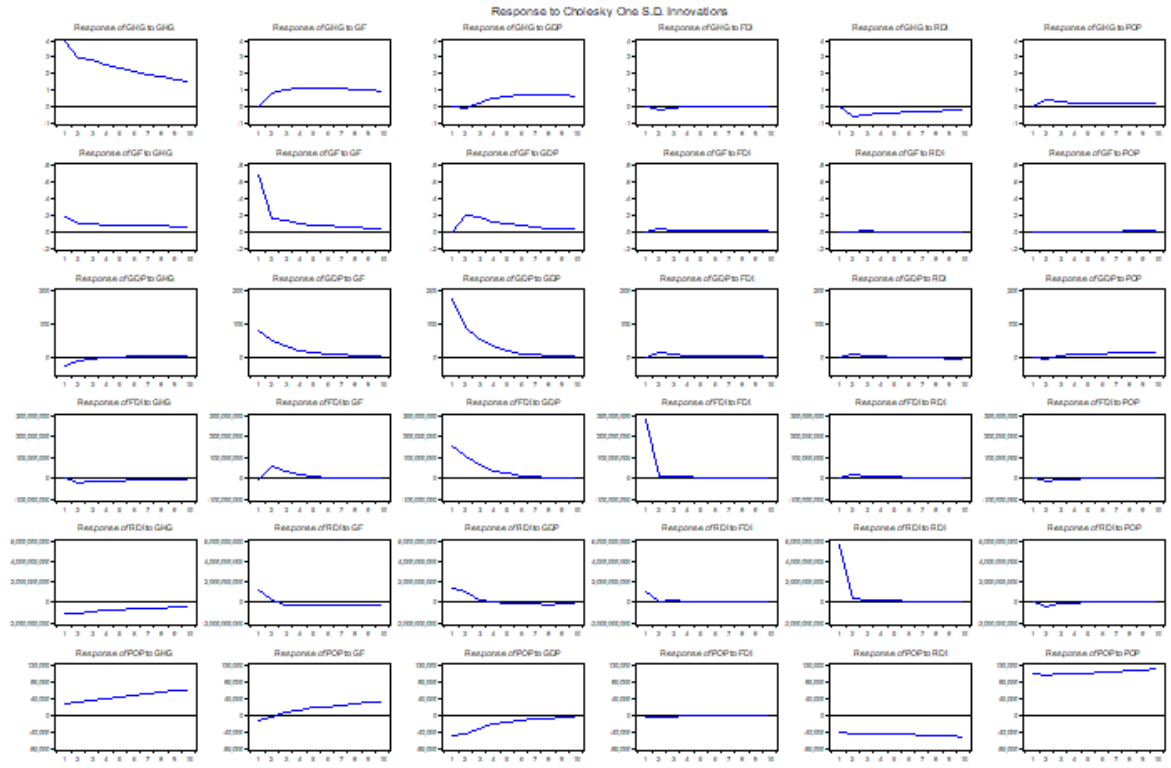
	GHG	GF	GDP	FDI	RDI	POP
GHG(-1)	0.106096	-0.012502	-3.798804	-3104110	-1.07E+08	2464.736
	-0.09175	-0.01488	-2.58574	-8875432	-1.70E+08	-1141.06
	[1.15631]	[-0.84047]	[-1.46913]	[-0.34974]	[-0.62911]	[2.16003]
GHG(-2)	0.007665	-0.003324	-0.727157	-691640.7	1951592	192.0042
	-0.04898	-0.00793	-1.3786	-4732291	-9.10E+07	-608.362
	[0.15649]	[-0.41908]	[-0.52746]	[-0.14615]	[0.02148]	[0.31561]
GF(-1)	0.41736	0.070377	16.36704	16539405	-83550750	16124.29
	-0.55089	-0.09082	-15.6591	-5.40E+07	-1.00E+09	-6908.92
	[0.75761]	[0.77488]	[1.04521]	[0.30776]	[-0.08098]	[2.33384]
GF(-2)	0.067756	0.024016	3.185925	3119736	-1.71E+08	5471.319
	-0.29366	-0.04847	-8.34597	-2.90E+07	-5.50E+08	-3682.99
	[0.23073]	[0.49547]	[0.38173]	[0.10890]	[-0.31068]	[1.48556]
GDP(-1)	-0.002194	0.000786	0.432509	517941.9	4771592	34.18206
	-0.00255	-0.00042	-0.07283	-248579	-4771489	-31.9459
	[-0.86111]	[1.88557]	[5.93894]	[2.08361]	[1.00002]	[1.07000]
GDP(-2)	0.000163	0.000219	0.041943	48263.08	-474523.7	48.37573
	-0.00162	-0.00026	-0.04642	-157927	-3031895	-20.3013
	[0.10050]	[0.82747]	[0.90352]	[0.30560]	[-0.15651]	[2.38289]
FDI(-1)	-3.89E-10	9.77E-11	3.59E-08	0.006419	-0.106746	4.72E-06
	-9.60E-10	-1.60E-10	-2.70E-08	-0.0941	-1.7907	-1.20E-05
	[-0.40719]	[0.62513]	[1.32247]	[0.06821]	[-0.05961]	[0.39377]
FDI(-2)	3.47E-11	2.54E-11	1.29E-09	0.000632	0.218076	5.39E-06
	-5.00E-10	-8.20E-11	-1.40E-08	-0.04917	-0.9349	-6.30E-06
	[0.06959]	[0.31112]	[0.09117]	[0.01285]	[0.23326]	[0.86064]
RDI(-1)	-3.12E-11	9.33E-13	1.26E-09	0.001583	0.016621	-6.72E-07
	-5.00E-11	-8.20E-12	-1.40E-09	-0.0049	-0.09494	-6.30E-07
	[-0.62159]	[0.11356]	[0.88350]	[0.32303]	[0.17507]	[-1.06655]
RDI(-2)	-8.56E-12	7.75E-13	2.36E-10	2.60E-05	-0.00298	-1.32E-08

	-2.60E-11	-4.30E-12	-7.40E-10	-0.00254	-0.04932	-3.30E-07
	[-0.32825]	[0.18175]	[0.31835]	[0.01021]	[-0.06042]	[-0.04048]
POP(-1)	6.87E-06	1.04E-07	-6.16E-05	-180.1342	-5692.882	0.976281
	-3.30E-06	-5.30E-07	-9.30E-05	-318.889	-6122.66	-0.04135
	[2.09979]	[0.19473]	[-0.66359]	[-0.56488]	[-0.92981]	[23.6120]
POP(-2)	-3.61E-06	-5.02E-08	0.000144	126.4231	4940.614	0.027007
	-3.30E-06	-5.40E-07	-9.40E-05	-321.824	-6178.9	-0.04173
	[-1.09326]	[-0.09306]	[1.54046]	[0.39283]	[0.79959]	[0.64713]
C	-212.8317	-13.44767	-1187.807	-2.52E+08	4.55E+10	541659.9
	-28.0249	-4.55455	-791.151	-2.70E+09	-5.20E+10	-349105
	[-7.59438]	[-2.95258]	[-1.50136]	[-0.09291]	[0.87240]	[1.55157]
R-squared	0.989445	0.877415	0.981272	0.529114	0.680359	0.999883

Akaike information criterion*	**8.96246**
Schwarz criterion	**14.83610**

*The lag length is determined by Akaike's Information Criterion (AIC)
Source: Author's computation, using E-views software version 12

Figure (4): Impulse Response Function (IRF)



Source: Author's computation, using E-views software version 12

According to the study results, green finance has a negative and significant impact on GHGs emissions. The strong correlation between green finance growth and GHG emissions predicts that a 1% increase in green finance will result in a 0.013% decrease in GHG emissions. This result is consistent with Sun et al. (2021), they discovered an opposite relationship between green finance and CO2 emissions, signifying that increasing concept of green finance reduces CO2 emissions. On the other hand, opposing these results, Fu et al. (2021) revealed that green finance does not influence CO2 emissions.

GDP positively impacts GHG emissions but statistically insignificant. This could be justified by an increase in GDP is not accompanied by an increase in the country's primary production components and also because agribusiness is a major component of the Egyptian economy, contributing 11.3% to GDP[28]. GDP is not a significant long-term driver of CO2 emissions, as previously proposed by Khan and Chaudhry (2021).

FDI still does not represent an effective component for climate change mitigation as shown by the lack of significance. An earlier study by Fu et al. (2021), Khan and Chaudhry (2021), Tang et al. (2022) found FDI is an important predictor of GHG emissions. However, this study found that an increase in FDI has insignificant effect on the country's emissions.

Results emphasized that RDI leads to an inverse and strong impact on climate change. This finding is in line with the immediate roadmap that proposed "towards an operative taxonomy for climate finance" which focused on implementation, the long-term roadmap by investing more on R&D to upscale green finance for environment sustainability (UNEP, 2022).

The findings of this study proves that population growth is positive and significant, higher population can result in GHG emissions. The result is aligned with the expectation about population growth, as it is well above natural birth replacement levels and is expected to double by 2078[29].

[28] See: Agriculture and Food Security Egypt, U.S. Agency for International Development (USAID), July 2020.
[29] See: Egypt Population 2022, World Population Review.

Conclusion:

Environmental degradation is one of the most pressing issues facing the world today, and it affects both developing and developed countries. Several nations are vigorously engaged in developing environmental protection policies and programs. In the background of economic development and growth, ecological degradation turns out to be even more serious as economic growth has the potential to have negative consequences for the environment. In this paper GHG emissions is used as a proxy for investigating climate change. To consolidate the determinants of GHG emissions, there are some variables to consider. For this reason, and due to the importance of the variables described above to the environment, VECM model has been used to analyze the impact of green finance, foreign direct investment, economic growth, investment on R&D and population growth on GHG emissions from 2000 to 2021 in Egypt. According to the study results green finance improves the Egyptian ecosystem. In contrast, GDP is positive but statistically insignificant at all. RDI has both significant and negative impact on GHG emissions (meaning that improvements in RDI is straight forwardly related to enhancements in ecological situations). In the short term, dynamics reveal that population variations are significantly and positively affect emissions. Nonetheless, the argument for a carbon-free future is based on using a negative emission source until a significant proportion of renewable energy is included in the energy mix. As a result, fiscal policies and financial instruments must be implemented to gradually reduce taxes, while incentivizing policies to attract investment from financial crowdfunding and non-financial crowdfunding within the public and private sectors. Aside from that, due to the pressing need to upgrade existing infrastructure and construct new infrastructure in the energy sector, it is essential to develop an infrastructure strategy that makes use of funds from pollution trading schemes, such as carbon taxes or cap-and-trade programs, on conventional energy sources. In the same way, a commitment should be noted to a gradual trade-off between traditional energy sources and the achievement of net zero-emissions energy sources. Based on the above findings, the following policies are recommended to promote the development of green finance; The government should use fiscal policies to promote the development of green finance, and use fiscal funding to guide credit funds and social capital into green investment. The government should improve the green financial system and give priority to green activities in the approvals processes, and simplify the green, ecological, and low carbon industries application process. It also should provide policy support for green financial development and give priority clean renewable energy sources.

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