J. Agric. & Env. Sci. (Damanhour University) 2024, 23 (2): 438-471
Print: ISSN 1687-1464 Online: 2735-5098

THE IMPACT OF INFRASTRUCTURE INVESTMENT ON CLIMATE CHANGE IN EGYPT: ECONOMETRIC STUDY ON TRANSPORTATION SECTOR

Ruhoma, khaled Omar **sallam, Marwa Zaki**

Department of Economics, Faculty of Commerce, Damanhour University

Corresponding Author: khaled_rohuma@com.dmu.edu.eg

Abstract:

Infrastructure plays a crucial role in economic development, providing essential services such as energy, transportation, water supply, and waste management. However, traditional infrastructure systems heavily rely on fossil fuels, contributing to greenhouse gas emissions and exacerbating climate change. As Egypt strives to achieve its sustainable development goals, it is essential to understand the impact of infrastructure investment on climate change and explore strategies to mitigate these effects. (Al-Shakhaibi and Suleiman, 2020, 35).

this paper examines the relationship between infrastructure investment and climate change in Egypt, by providing a comprehensive analysis of the current infrastructure landscape, climate change vulnerabilities, and the potential for infrastructure development to contribute to climate change mitigation and adaptation. The paper will also explore the policy and regulatory framework, financing mechanisms, and social and environmental impacts associated with infrastructure projects.

To investigate the impact of infrastructure investment on climate change in Egypt, a time series methodology was held, using OLS two stages model, The time series extends from 1990 to 2020, and annual data sourced from the World Bank and the Central Agency for Public Mobilization and Statistics, the sample includes 30 observations.

The results of the model showed that the relationship between infrastructure investment and climate change in Egypt is significant in the long term.

Keywords: Infrastructure, investment, climate change, Egypt, OLS model

https://doi.org/ 10.21608/jaesj.2024.303503.1180

Introduction:

Infrastructures are the physical and institutional systems on which society is based. The word "infrastructure" contains the Latin word "infra," which means "below." It is therefore clear that without these foundational systems, modern industrial life would not be possible.

Infrastructure plays an important role in the economy, as the huge impact and role played by transportation, communications, electricity, potable water and sanitation, health infrastructure and other basic facilities in improving the quality of life and well-being. Infrastructure facilities and services are effective tools for production. Efficient transportation and trade, all of which stimulate economic growth, which in turn helps reduce poverty. Infrastructure can be divided into two classifications:

- Social infrastructure: It is concerned with providing services that meet the basic needs of society. These basic services are education and training and also include health, sanitation, drinking water, housing, etc. This type is also called "general social expenditures." These expenses Indirectly support economic systems, because they have a significant impact on raising productivity indirectly, but their impact on the economy appears after some time, and social infrastructure contributes to long-term growth, Fosu P (2019).
- Physical infrastructure: It is directly concerned with the needs of production sectors such as agriculture, industry, and trade. This type supports economic production directly and supports the production and distribution process in the economy indirectly. Examples of this include energy, irrigation, transportation, communications, banking, and insurance. , technology, and finance, and thus they contribute to increasing productivity directly, and their impact on the economy appears immediately

and then leads to immediate growth in the short term (Xu, Y., & Li, A. 2020, p. 33)

Research Hypotheses:

Infrastructure projects (transport sector) have significant relationship with climate change in Egypt

The importance of research:

The importance of the study stems from estimating the impact of infrastructure projects represented by road and bridge projects on climate change in Egypt during the period (1990-2020) AD, which is the period that witnessed a major boom in the development of roads and bridges, as roads and bridges are among the basics of the infrastructure necessary to push the wheel of investment and economic development.

The study is also concerned with monitoring the difficulties and problems that faced road and bridge projects in Egypt during that period, which contributes to providing solutions and proposals for these problems.

Research Objectives:

The primary objective of this research is to examine the impact of infrastructure investment on climate change in Egypt. Specifically, the research aims to achieve the following objectives:

1. Assess the current state of infrastructure in Egypt.
2. Evaluate the Egyptian situation with climate change.
3. Examine the relationship between infrastructure development and climate change.
4. Investigate the role of infrastructure resilience and adaptation in climate change.
5. Assess the social and environmental impacts of infrastructure development.

Research Methodology:

the methodology used in this research to investigate the impact of infrastructure investment on climate change in Egypt can be explained in light of the following:

1- The inductive approach uses the descriptive analytical approach to identify the road and bridge projects that were constructed in Egypt during the study period.
2- The quantitative descriptive approach using an econometric model based on estimating the impact of road and bridge projects established in Egypt on climate change.

Research Limitations:

While this research aims to provide valuable insights into the impact of infrastructure investment on climate change in Egypt, it is important to acknowledge its limitations. These limitations are as follows:

1- **Data Availability:** The availability of reliable and up-to-date data on infrastructure investment, climate change impacts, and project outcomes may pose a limitation. The study relies on the data that is accessible and may not capture the complete picture of infrastructure development and its impact on climate change in Egypt.
2- **Time Constraints:** The study covers road and bridge projects in the period from (2000-2020) AD.
3- **Geographical Focus:** This research primarily focuses on Egypt and its specific context. While the findings and recommendations may have broader applicability, they may not be directly transferable to other countries or regions with different socio-economic and environmental conditions.

Literature reviews

Wind power projects may pay for themselves in 7 to 15 years, depending on turbine size and location. Wind power projects cost $2-6 million per megawatt, while green roofs, while healthier for the environment, cost $15-$45 per square foot to build. This increases the repayment period beyond 20 years. PV systems provide strong ROIs (returns on investment) of 15-20% (Saini et al., 2022). This is especially true given the net metering incentives. Wind power projects can have an IRR of 8% to 15%, depending on wind availability and market circumstances; however, geothermal heat pumps have IRRs of 15-25% (Abdo, El-Shazly, & Medici, 2023). They have reduced running expenses and may be eligible for tax benefits. Case studies demonstrate their ideas by exhibiting these figures. The Seattle Bullitt Centre, a LEED Platinum office construction, utilizes nearly no energy. Integrating a large amount of solar PV and conserving energy should result in long-term cost savings. Walmart's California attempts to put rooftop solar photovoltaic systems on 340 shops has resulted in cost savings, with the project aiming to reduce energy use by 20%. The Bank of America Tower in New York may lower its carbon footprint by 40% while saving money by utilizing biogas to power its combined heat and power system (Villarroel-Schneider et al., 2022). Real-world case studies and statistical insights demonstrate how renewable energy in construction projects influences economics and profits (Akram et al. 2023).

In 2020, NREL discovered that businesses with solar PV systems save money (Souza et al., 2023). According to Barwińska-Małajowicz et al. (2023), solar PV systems have lower levelized costs than grid-based systems over 25 years. The International Energy Agency 36 (IEA) assessed a Swedish net-zero apartment complex in 2023, and it had a 40% lower LCC than conventional constructions (IEA, 2021). Solar photovoltaic and geothermal heat pumps were accused. Financial analyses employing net present value, internal rate of return, and payback period indicate that renewable energy sources are feasible. 2022 Berkeley research discovered that a rooftop photovoltaic (PV) system in a California single-family home had a positive net present value of $24,000 over 20 years (Wang et al., 2023). The Rocky Mountain Institute (RMI) predicted a 12% IRR for geothermal heat pumps and 15% for solar PV systems in US commercial constructions in 2021 (RMI, 2023). According to LBNL (EMP, 2023), US household solar photovoltaic (PV) systems can pay for themselves in four to eight years, depending on geography and incentives. Comprehensive financial analyses employing NPV, IRR, and Payback Period prove that renewable energy sources are lucrative. El-Sayeh et al. (2021) and Al-Khatib et al. (2022) discovered that grid-connected photovoltaic (PV) systems in Egyptian residences, as well as geothermal and solar systems in Jordanian hotels, had positive NPV, IRR, and payback periods

J. Agric. & Env. Sci. (Damanhour University) 2024, 23 (2): 438-471
Print: ISSN 1687-1464 Online: 2735-5098

Research problem:

The infrastructure sector significantly affects climate change through its impact on carbon emissions, resource consumption, and environmental degradation. Below are keyways in which the infrastructure sector impacts climate change:

1. Greenhouse Gas (GHG) Emissions from Construction and Operation

Construction Materials: The production of materials such as cement, steel, and asphalt is energy-intensive and heavily reliant on fossil fuels. Cement production alone accounts for about 8% of global CO_2 emissions.

Construction Activities: The process of constructing roads, bridges, buildings, and other infrastructure involves the use of heavy machinery, which consumes large quantities of fuel, typically releasing CO_2 and other GHGs.

Operation of Infrastructure: Buildings, transportation systems, and industrial facilities require current energy for heating, cooling, lighting, and other functions. If powered by fossil fuels, these systems contribute to emissions across their entire life cycle.

2. Energy consumption

Buildings: The construction and operation of buildings account for approximately 40% of global energy consumption. Inefficient buildings lead to higher energy demands, particularly in heating and cooling, which can be a major source of GHG emissions.

Transportation Infrastructure: Roads, railways, airports, and seaports facilitate the movement of goods and people, often through fossil-fuel-driven vehicles. This contributes greatly to CO_2 emissions, especially in urban centers.

Electricity Grid: Expanding infrastructure for electricity generation (such as coal-fired power plants) can contribute to high emissions if renewable energy is not priority.

3. Urbanization and Land Use Change:

Deforestation: Expanding infrastructure often leads to the clearing of forests for roads, buildings, and other developments. Deforestation releases the carbon stored in trees and reduces the Earth’s capacity to absorb CO_2.

Urban Sprawl: Rapid urbanization, if unplanned, leads to urban sprawl, requiring more energy for transport, water supply, and waste management. It also increases the impermeable surface area, affecting local climates (urban heat islands) and reducing natural carbon sinks.

4. Transportation Emissions Road Transport: The construction of highways and roads promotes increased use of vehicles, contributing to emissions from gasoline and diesel consumption. Transport is responsible for nearly a quarter of global CO_2 emissions.

Aviation and Shipping: Building and expanding airports and ports supports industries that depend on fossil fuels for long-distance transportation, with aviation alone contributing around 2% of global emissions.

5. Waste and Pollution Waste Generation: Construction activities generate significant amounts of waste, much of which is non-recyclable and ends up in landfills. Decomposing waste in landfills releases methane, a potent greenhouse gas.

Water Use and Wastewater Management: Infrastructure for water and sewage systems requires energy for treatment and transportation. If not efficiently managed, this can also lead to higher emissions and environmental contamination.

6. Resilience to Climate Change

Vulnerability to Climate Impacts: Existing infrastructure is vulnerable to the effects of climate change, such as extreme weather events (floods, hurricanes) and rising sea levels. Damaged infrastructure often requires energy-intensive reconstruction, exacerbating the problem.

Adaptation: On the positive side, climate-resilient infrastructure can help communities adapt to the impacts of climate change by reducing risk. However, the process of creating resilient infrastructure also requires careful planning to reduce its carbon footprint.

7. Climate-Friendly Infrastructure Solutions

Sustainable Construction Practices: Using low-carbon materials (e.g., recycled steel, green cement), energy-efficient designs, and renewable energy sources can significantly reduce the sector's carbon footprint.

Green Buildings: Incorporating energy saving features such as solar panels, green roofs, and efficient insulation can reduce operational energy consumption in buildings.

Public Transport Systems: Investments in mass transit systems (e.g., electric buses, rail) reduce dependence on personal vehicles, leading to lower emissions.

Renewable Energy Infrastructure: Expanding infrastructure for renewable energy sources, such as wind and solar farms, can replace fossil fuel-based power generation, decreasing overall GHG emissions.

The specific problem of infrastructure with climate change lies in the fact that the sector both contributes significantly to climate change and is highly vulnerable to its impacts, according to that the research try to investigate the relationship.

The economic importance of infrastructure:

Infrastructure facilities are necessary for the continuous and effective operation of the economy, because they are wheels of development without which the economy would not be able to function, and therefore their impact appears as follows:

1- Agriculture development: which depends largely on adequate expansion and development of irrigation, transportation, energy, marketing, training and education, as well as on improving research and development and other similar facilities.

- Industrial development: Industrial production requires not only machinery and equipment, but also energy, skilled manpower, management, banking, insurance, and transportation services are important, which directly leads to the development of the industrial sector.

- Encouraging investment: Infrastructure development is a prerequisite for obtaining increased economic investments. Regions with sound infrastructure may succeed in attracting more capital for investment. Lin, B.; Zhou, Y.(2022).

- Improving productivity: Developing infrastructure such as transportation and education facilities increases productivity. The development of science and technology is also important in improving economic productivity, in addition to the important role played by research and development in economic improvement.

- Providing job opportunities: Infrastructure plays a crucial role in providing job opportunities and improves mobility, efficiency and labor productivity. Moreover, greater investment and development of industry and agriculture create more job opportunities. Fan, D.; Liu, K.2021
- Development of slum areas: Developing slum areas and eliminating regional imbalances represents a major and important contribution to infrastructure facilities, while the lack of infrastructure facilities in backward areas will be a restriction on the development of those areas. Khan, H., et, al., (2020).
-Social development: Infrastructure facilities will also serve as an instrument of social changes and the development of industries and transportation facilities will lead to a changed economic outlook.
- GDP growth: There is a strong relationship between infrastructure spending and GDP growth, and studies have indicated that a 1% growth in infrastructure stock is often associated with a 1% growth in per capita GDP.
- Comprehensive development: Infrastructure development is important not only for economic growth but also for comprehensive development, as the latter represents the state and the economy is crucial, and infrastructure facilities are essential for technological innovation and also important for eradicating poverty and promoting sustainable development. (Fosu P and Twumasi MA , 2022, p. 35)

Infrastructure is essential to modern life, whether it is transportation or housing. Soft infrastructure promotes a better quality of life. From entertainment to quality and choice in education, all of which are essential to economic well-being, and even physical health are all essential components of a thriving economy. If workers' places of residence are far from the facilities in which they work and appropriate means of transportation are not available to transport them, then unemployment becomes a problem. Lee, M.T.; Suh, I. 2022.

Infrastructure and Climate Change

Infrastructure plays a crucial role in both contributing to and mitigating climate change. In Egypt, where the effects of climate change are becoming increasingly evident, it is essential to understand the relationship between infrastructure development and climate change.

I. Transportation Infrastructure and Climate Change

Transportation is significantly contributing to greenhouse gas emissions and air pollution. In Egypt, the transportation sector heavily relies on fossil fuel-powered vehicles, leading to high carbon emissions and poor air quality, particularly in urban areas. The expansion of road networks and the increasing number of vehicles exacerbate these issues. Nedić, V., et., al.,(2020).

To address the impact of transportation infrastructure on climate change, Egypt is investing in sustainable transportation solutions. This includes the development of public transportation systems such as metro lines, tramways, and bus networks. By providing efficient and affordable public transportation options, the government aims to reduce private vehicle usage and promote sustainable mobility.

Additionally, the promotion of electric vehicles (EVs) is gaining momentum in Egypt. The government has introduced incentives and subsidies to encourage the adoption of EVs, which have lower emissions compared to conventional vehicles. The establishment of charging infrastructure across the country is also essential to support the widespread use of EVs. Égert, B.; Koźluk, T., 2022.

II. Waste Management Infrastructure and Climate Change

Improper waste management practices contribute to greenhouse gas emissions, particularly through the release of methane gas from landfills. In Egypt, waste management has been a significant challenge, with inadequate infrastructure and limited recycling facilities. As a result, a significant amount of waste ends up in landfills, contributing to climate change. Wensi, S., et., al,.(2022).

To address this issue, Egypt is investing in a waste management infrastructure that focuses on reducing waste generation, promoting recycling, and implementing proper waste disposal techniques. The establishment of waste-to-energy facilities is also being considered, which can convert waste into renewable energy while reducing greenhouse gas emissions.

Furthermore, public awareness campaigns and education programs are being implemented to encourage waste reduction, segregation, and recycling at the individual and community levels. By investing in comprehensive waste management infrastructure, Egypt can significantly reduce its carbon footprint and contribute to climate change mitigation. Wu, J., et., al.,(2021).

III. Integrated Approach to Infrastructure and Climate Change

To effectively address climate change, it is crucial to adopt an integrated approach to infrastructure development. This involves considering climate change impacts and mitigation strategies at every stage of infrastructure planning, design, construction, and operation. Wensi, S., 2020.

Key considerations include incorporating climate resilience measures into infrastructure design, such as building structures that can withstand extreme weather events and rising sea levels. Additionally, integrating renewable energy systems into infrastructure projects can help reduce carbon emissions and enhance energy efficiency.

Furthermore, policymakers and stakeholders need to collaborate to develop and implement climate-friendly policies and regulations that promote sustainable infrastructure development. This includes setting targets for reducing greenhouse gas emissions, promoting energy efficiency, and incentivizing the use of renewable energy sources.

In conclusion, infrastructure investment in Egypt has a significant impact on climate change. By investing in sustainable energy, transportation, and waste management infrastructure, Egypt can reduce its carbon emissions, enhance climate resilience, and contribute to global efforts in mitigating climate change. An integrated approach that considers climate change impacts and mitigation strategies is essential for sustainable infrastructure development in Egypt. Agrawal, A.; et., al.,(2019).

The reality of infrastructure in Egypt:

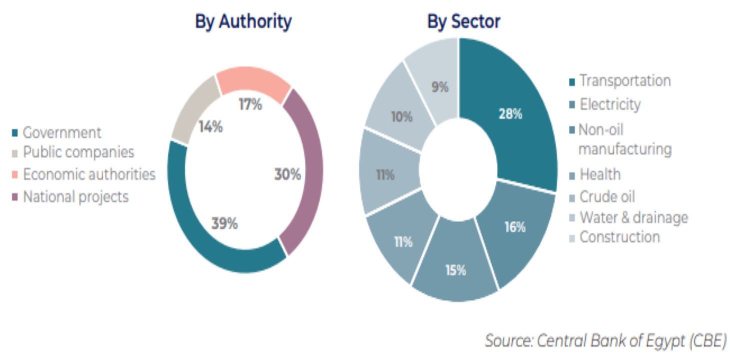
Egypt has many advantages and elements in the field of infrastructure and has achieved historic and unprecedented achievements in the field of infrastructure projects. These projects will contribute to making Egypt one of the most important countries in the Middle East and Africa, which enhances its regional and international role. As a result of these efforts, Egypt's ranking in the index has improved. Infrastructure in the Global Competitiveness Report for 2019 ranked 52nd compared to 56th in 2018 due to the state's keenness to implement many infrastructure projects, especially in the sectors of transportation, roads, electricity, energy, oil and natural gas. Egypt has also been working to expand the scope of its investments in infrastructure since 2014 Prus, P.; Sikora, M., 2021.

It concluded similar contracts in various sectors, including transportation, renewable energy, information and communications technology, water, electricity, and sanitation. The Global Competitiveness Report (GCR) issued by the Economic Forum recorded significant progress across many related infrastructures in Egypt between the years 2015 and 2019. The country's transportation infrastructure is ranked at 44 and facilities are at 64 out of 141 countries. The investments are due in large part to the rapid increase in population, which has been clustered over decades around 7% of its land area, resulting in overloaded facilities and strained roads. Railways and others. Xu, Y., & Li, A. (2020).

The 2019 Population Prospects Report issued by the United Nations expected that Egypt's population would reach 121 million by 2030, 160 million by 2050 and 225 million by the end of the century. In anticipation of the consequences of this population increase, the Egyptian government worked aggressively to add urban communities. Across the country raise the inhabited land area to 14% of the total area by 2030. Twelve new cities have been developed over the past decade, rising from 218 cities in 2007, reaching 230 in 2018, and work is underway on 15 smart cities. Other new cities around Greater Cairo, the Sinai Peninsula, the Nile Delta, Upper Egypt, the North Coast, and the Suez Canal (Central Bank of Egypt, 2020), and together these new cities cover 380,000 acres (about 1,600 square kilometers), which represents 50% of the area allocated to urban communities in the past four decades. Guo, C.; et., al., (2020).

Egypt's 120,000-km road network has witnessed significant development since the country launched the EGP 175 billion National Roads Project in 2014, adding at least 7,000 km of roads in the past seven years. The NRP has also modernized Existing roads as well, resulting in GCR's 'Quality of Road Infrastructure' measure rising to 28 in 2019 compared to 118 in 2015. Global Data. (2021).

Figure (2) Distribution of public investments in Egypt during 2020



It includes the Tahya Misr Bridge, which is 67.4 meters wide and spans the Nile River, which set a Guinness World Record as the largest suspension bridge in the world. Zhou A (2022).

In August 2020, the Ministry of Transport announced the allocation of 130 billion pounds to build 1,000 bridges and tunnels by 2024 (60% of which have been completed), and in total the state will invest 1.1 trillion Egyptian pounds in the road network between 2023 and 2024.

Most road construction work is concentrated in East Cairo, where the New Administrative Capital (NAC) is being built. The state is also leading pioneering developments such as the Ahmed Hamdy Tunnel Link 2, which runs under the Suez Canal, and $142 million was spent in 2020 on road construction. In the new city of El Alamein, work is underway to establish a highway worth 26 billion pounds, with a length of 1,150 kilometers, linking Cairo to Aswan. The first phase, which is 230 kilometers long, is nearing completion and extends from the capital through Fayoum and beyond. Work is also underway on other phases, including the extension Between Edfu and Aswan. Olaoye, O., et., al., (2020).

The Egyptian state has planned many transcontinental highway projects that are currently under implementation, the most important of which is the Cairo to Cape Road (Pan-African Highway), which has a length of 10,300 kilometers and connects Egypt to South Africa through eight other African countries. Egypt's share of the highway passes through... Eight governorates are on their way to the Sudanese border. The roads in Egyptian territory were completed in February 2019, and the final leg of Wadi Halfa in Sudan is scheduled to be completed by 2024 for 26 billion pounds. Other cross-border projects include a 1,100-kilometre road through Libya to Chad. And a coastal road from Salloum in northwestern Egypt to Benghazi in eastern Libya. Mbulawa, S. (2017).

Climate Change in Egypt:

Egypt's unique geographical features, coupled with its heavy reliance on natural resources, make it particularly susceptible to the adverse effects of a changing climate. This effect is represented in: (F. Creutzig, J. Roy, et al. , 2022) , (IPCC, Climate change, 2022)

I. Rising Temperatures:

One of the most significant climate change vulnerabilities for Egypt is the rising temperatures. The country already experiences hot and arid conditions, and climate change is exacerbating this issue. Rising temperatures have numerous implications for Egypt, including increased heatwaves, reduced agricultural productivity, and heightened energy demand for cooling purposes. These temperature increases also contribute to the accelerated melting of glaciers and ice caps, which poses a threat to Egypt's freshwater resources. R. Cioffi, et., al., (2020).

II. Water Scarcity:

Water Scarcity is a pressing issue in Egypt, and climate change further compounds this challenge. The country heavily relies on the Nile River for its water supply, but changing precipitation patterns and increased evaporation rates threaten the availability of freshwater resources. As temperatures rise, the demand for water increases, putting additional strain on already limited resources. This vulnerability has significant implications for agriculture, as the sector is heavily dependent on irrigation. Water scarcity also affects public health, sanitation, and overall socio-economic development. O. Z. Jasim, et., al., (2020).

III. Sea Level Rise:

Egypt's extensive coastline and low-lying delta regions make it highly susceptible to the impacts of sea level rise. The Nile Delta, home to a significant portion of Egypt's population and agricultural land, is particularly at risk. As sea levels rise, coastal erosion and saltwater intrusion into freshwater sources become major concerns. This not only threatens the livelihoods of coastal communities but also poses a risk to critical infrastructure such as ports, roads, and buildings. Additionally, the loss of coastal ecosystems, such as mangroves and coral reefs, further exacerbates the vulnerability to sea level rise. G. Lohmann, et., al., (2020).

IV. Extreme Weather Events:

Egypt is prone to various extreme weather events, including heatwaves, droughts, and flash floods. Climate change intensifies the frequency and severity of these events, posing significant risks to the country's infrastructure and population. Heatwaves can lead to heat-related illnesses and increased energy demand for cooling, while droughts can result in water scarcity and agricultural losses. Flash floods, on the other hand, can cause infrastructure damage, displacement of communities, and loss of lives. These extreme weather events not only disrupt daily life but also hinder economic development and exacerbate social inequalities. S. L. Zubaidi et., al., (2020).

V. Biodiversity Loss:

Climate change also poses a threat to Egypt's rich biodiversity. The country is home to diverse ecosystems, including coral reefs, mangroves, and desert habitats. Rising temperatures, changing precipitation patterns, and sea level rise all contribute to the loss and degradation of these ecosystems. This not only affects the unique flora and fauna of Egypt but also disrupts the delicate balance of ecosystems and the services they provide, such as coastal protection and carbon sequestration. Z. Ebrahimi-Khusfi, et., al., (2021)

VI. Agriculture and Food Security:

Agriculture is a vital sector in Egypt, providing employment and ensuring food security for the population. However, climate change poses significant challenges to agricultural productivity. Rising temperatures, water scarcity, and changing precipitation patterns all impact crop yields and livestock production. Extreme weather events, such as droughts and floods, further disrupt agricultural activities. These vulnerabilities not only affect the livelihoods of farmers but also have broader implications for food security and the economy. (UN [United Nations], 2023)

Transportation Infrastructure:

Transportation Infrastructure plays a crucial role in the economic development of a country. However, it also contributes significantly to greenhouse gas emissions and air pollution, which are major drivers of climate change. In Egypt, transportation infrastructure is a key sector that requires attention and investment to mitigate its impact on climate change. (LF. Cabeza, Q. Bai, P. Bertoldi, et al., 2022)

I. Impact of Transportation Infrastructure on Climate Change

The transportation sector is a significant contributor to greenhouse gas emissions, primarily through the combustion of fossil fuels in vehicles. In Egypt, the majority of vehicles run on gasoline or diesel, which release carbon dioxide (CO_2), a major greenhouse gas, into the atmosphere. Additionally, transportation emissions contribute to air pollution, which has adverse effects on public health and the environment.

The expansion of transportation infrastructure without considering climate change mitigation measures can exacerbate these issues. Increased road construction and vehicle ownership lead to higher emissions, air pollution, and energy consumption. Moreover, the reliance on fossil fuels for transportation contributes to Egypt's overall carbon footprint and hinders efforts to achieve national and international climate change targets. A. K. Singh et al., (2022).

II. Strategies for Mitigating the Impact of Transportation Infrastructure:

To address the impact of transportation infrastructure on climate change, Egypt needs to adopt a comprehensive approach that focuses on both reducing emissions and promoting sustainable transportation alternatives. Several strategies can be implemented to achieve these goals:

III. Promoting Public Transportation:

Investing in public transportation systems, such as buses, trams, and metro networks, can help reduce the number of private vehicles on the road. By providing affordable, efficient, and reliable public transportation options, people are encouraged to shift from private cars to public modes of transport, thereby reducing emissions and congestion. M. Boroughani et al., (2020)

IV. Encouraging Electric and Hybrid Vehicles:

Promoting the use of electric and hybrid vehicles can significantly reduce greenhouse gas emissions from the transportation sector. The government can incentivize the purchase of electric vehicles through tax breaks, subsidies, and the development of charging infrastructure. Additionally, the adoption of electric buses for public transportation can have a substantial impact on emission's reduction.

V. Improving Fuel Efficiency:

Implementing fuel efficiency standards for vehicles and promoting the use of cleaner fuels can help reduce emissions from the transportation sector. The government can introduce regulations that require vehicle manufacturers to produce more fuel-efficient vehicles and encourage the use of cleaner fuels, such as biofuels or natural gas. A. Jahani and M. Saffariha, (2021)

VI. Investing in Cycling and Pedestrian Infrastructure:

Developing cycling and pedestrian infrastructure can encourage people to choose active modes of transportation, such as walking or cycling, for short-distance trips. This not only reduces emissions but also promotes a healthier lifestyle. Building dedicated cycling lanes, improving sidewalks, and creating pedestrian-friendly urban spaces can contribute to a more sustainable transportation system.

VII. Integrated Land Use and Transportation Planning:

Integrating land use and transportation planning is essential for creating sustainable and efficient transportation systems. By promoting compact and mixed-use development, where residential, commercial, and recreational areas are located close to each other, the need for long-distance travel can be reduced. This approach encourages walking, cycling, and the use of public transportation, leading to lower emissions and improved air quality. (IEA [International Energy Agency]., 2022)

Econometric Model

This study uses annual time series to analyze the relationship between variables. The time series extends from the year 1990 to 2020. It is annual data sourced from the World Bank and the Central Agency for Public Mobilization and Statistics, and the sample includes 30 observations.

One problem with estimation is that data quality is poor, as national accounts data on investment or capital stock sizes are only available in specific sectors, usually for a very short period and are not comparable. For example, estimates of the capital stock of infrastructure rely on assumptions about depreciation rates, which are often inaccurate.

Most available data do not contain any information about cost and quality, as the costs of constructing infrastructure can vary significantly (an additional kilometer of road or railway track will be more expensive than a bridge or tunnel), while the quality of infrastructure may also vary (it may provide investments that are well maintained yield more benefits than those that are poorly maintained) and the problem can be overcome by including economy-specific fixed effects in the regression model. Égert, Balázs, et. al. (2009)

To study the impact of public investments in infrastructure (transportation sector) on climate change in Egypt, the study adopts a standard model:

Dependent variable: Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP

Independent variables:

- Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring., ratio of renewable energy to total energy,

- Energy consumption in transportation, % of total energy consumption
- Public investments in the transportation sector
- Development of technologies related to the environment, % of all technologies,

Thus, Table.1 summarizes the measurement, definition, and source of each variable:

Table1. Variables definition and source

Variable	Description	Sources
SWC	Social welfare costs of premature deaths(dependent)	OECD.*stata*
CO E	Carbon dioxide emissions	World Development Indicators (WDI)
ECT	Energy consumption in transportation, % of total energy consumption	World Development Indicators (WDI)
PIT	Public investments in the transportation sector	International monetary fund (IMF)
DTE	Development of technologies related to the environment.	OECD.*state*

Note: *, **, *** denote the rejection of null hypothesis at 1, 5 and 10% levels of significance respectively

$$\boldsymbol{SWC_{it} = \alpha_0 + \beta_1 COE_{it} + \beta_2 ECT_{it} + \beta_3 PIT_{it} + \beta_4 DTE_{it} + \beta_5 GR\&Db_{it} + \beta_6 GR\&De_{it} + \mu_{it}} \quad (1)$$

The preliminary analysis of the quantitative data is the most essential analysis. It is used to measure the features of data among the variables. Table 2 presents the preliminary results of the variables, showing that the average range of measurement for these variables is from 1.93 For COE to 30121.25 for PIT. Furthermore, SWE maximum value is 11.7900, while the minimum value of SWE is 10.12000.

Table2. Summary of descriptive statistics

	SWC	***COE***	***ECT***	***PIT***	***DTE***
Mean	10.77409	1.933507	28.16194	30121.25	8.412312
Median	10.88000	1.961123	28.13000	12902.00	8.160000
Maximum	11.79000	2.402416	33.32000	184233.8	18.40000
Minimum	10.12000	1.400233	23.02000	282.8149	1.260000
Std. Dev.	0.429985	0.349808	2.836792	43785.84	4.027093
Skewness	0.149772	-0.069072	0.048689	2.088476	0.338631
Kurtosis	2.378323	1.351737	2.119552	6.716653	2.578445
Jarque-Bera	0.615104	3.533813	1.013534	40.37808	0.822006
Probability	0.735245	0.170861	0.602440	0.000000	0.662985
Observation	***31***	***31***	***31***	***31***	***31***

SOURCE: Prepared by researchers

The standard deviations lay in the range of 0.349808 and 43785.84 of the data. This highlights that all variables are slightly skewed to the left, meaning that they have longer right tails than for a normal distribution. However, these 31 observations have sufficient distribution because their kurtosis is inferior to a normal distribution. Accordingly, the J-B test strongly accepts the null hypothesis of normality for the variables. Furthermore, the empirical results of this preliminary analysis indicate a high interrelationship between these variables, meaning that a strong positive association is detected between (see Table 3).

Table 3. Correlation matrix

Correlation					
Probability	SWC	COE	ECT	PIT	DTE
SWC	1.000000				
COE	-0.049232	1.000000			
	0.7925	-----			
ECT	-0.052568	0.445715	1.000000		
	0.7788	0.0120	-----		
PIT	-0.407019	0.471397	0.542932	1.000000	
	0.0231	0.0074	0.0016	-----	
DTE	0.112907	0.567242	0.489613	0.199268	1.000000
	0.5453	0.0009	0.0052	0.2825	-----

SOURCE: Prepared by researchers

J. Agric. & Env. Sci. (Damanhour University) 2024, 23 (2): 438-471
Print: ISSN 1687-1464 Online: 2735-5098

The unit root test

Begin with the examining the stationary properties of the variables at hand, Augmented dickey-fuller (ADF), should apply to test integration order of the variables (table 4 details the results of unit root tests). The result showed that the variables are non-stationary at level, thus contain problems of unit root. After the first difference, stationery is found for all variables. Thus, showing that all series are integrated at I (1). The core idea of stationery is that the probability distribution does not change over time or, in simple words; stationery depends on the assumption that future and past are the same at least in the probability sense.

Table 4. Results of unit root test

Variables	ADF- test	
	level	***Difference***
SWC	-2.8603T 7	-5.49745T***7
CoE	-1.3797C 7	-3.18078C***7
DTE	-0.4580N 7	-9.3337N*** 7
ECT	-2.0558C7	-5.4778C***7
PIT	2.56312C7	-4.51514C***3

Note: (*), (**) and (***) mean that the variable is stationary at 10% , 5% and 1%, respectively.
The numbers beside the critical values represent the number of lags, while *t, c,* and -after the critical values represent the variant of the series trend and constant, constant, and no constant or trend, respectively.
SOURCE: Prepared by researchers

Figure (1) the variables in the level (1990:2020)

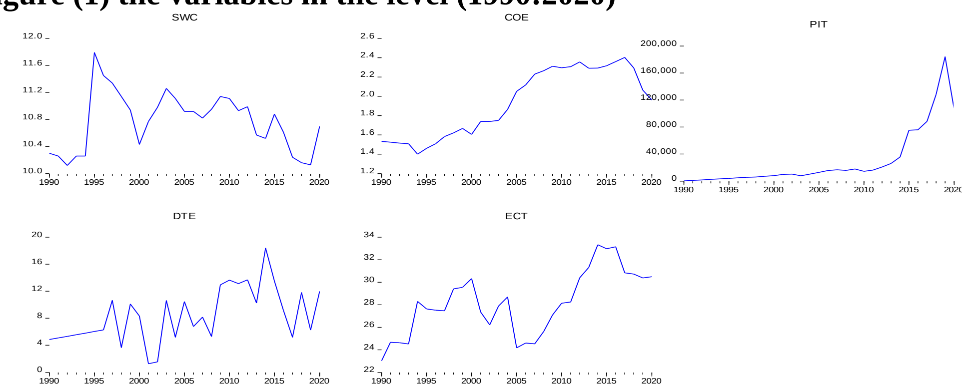
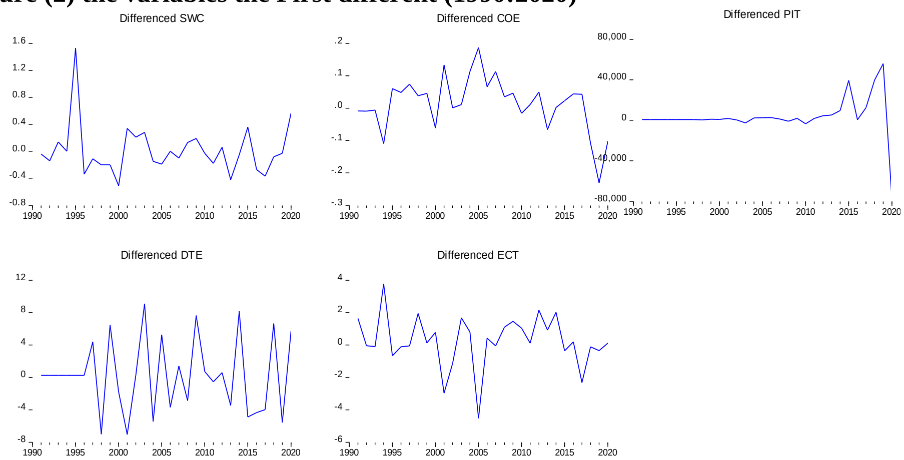


Figure (2) the variables the First different (1990:2020)



After ensuring that all variables are stationary at the first difference. The relationship is estimated using the VAR model. The VAR model is estimated using the logarithm of the model variables, including the constant. Estimation of the individual equations results in R_2, R_{adj} ranging from 88% to 99% for all variables.

Granger causality was tested for the variables and the results appear in the following table. For the ISWC equation, all variables combined do not affect SWC. As for COE variable, all variables combined affect it at 5% significance, while PIT the variables together affect it at a significance of 1%.

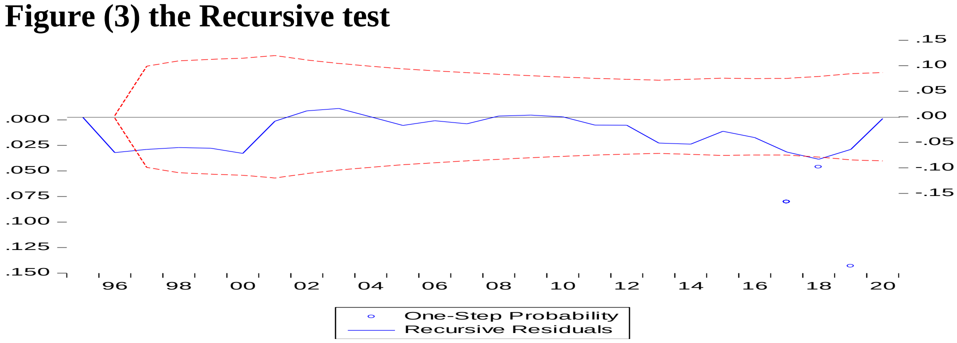
J. Agric. & Env. Sci. (Damanhour University) 2024, 23 (2): 438-471
Print: ISSN 1687-1464 Online: 2735-5098

Table 5. Granger causality test

Excluded Variables	LSWC			Excluded Variables	LCOE		
	X^2	*df*	*p- value*		X^2	*df*	*p- value*
LCOE	2.360176	1	0.1245	LSWC	8.629286	1	0.0033
LDTE	0.042403	1	0.8369	LDTE	0.060803	1	0.8052
LECT	0.423568	1	0.5152	LECT	0.608147	1	0.4355
LPIT	1.527651	1	0.2165	LPIT	0.917327	1	0.3382
jointly	3.624435	4	0.4592	jointly	10.02707	4	0.0400
Excluded Variables	LDTE			Excluded Variables	LECT		
	X^2	*df*	*p- value*		X^2	df	p- value
LSWC	0.773706	1	0.3791	LSWC	0.006364	1	0.9364
LCOE	2.983594	1	0.0841	LCOE	0.157921	1	0.6911
LECT	0.035673	1	0.8502	LDTE	0.941352	1	0.3319
LPIT	0.201025	1	0.6539	LPIT	0.005770	1	0.9394
jointly	6.039277	4	0.1962	jointly	2.135549	4	0.7108
				Excluded Variables		LIR	
					X^2	*df*	*p- value*
				LSWC	8.860602	1	0.0029
				LCOE	9.476878	1	0.0021
				LDTE	0.427896	1	0.5130
				LECT	8.119615	1	0.0044
				jointly	27.44727	4	0.0000

The Recursive test was used to estimate whether the relationship remains stable throughout the sample period.

Figure (3) the Recursive test



SOURCE: Prepared by researcher

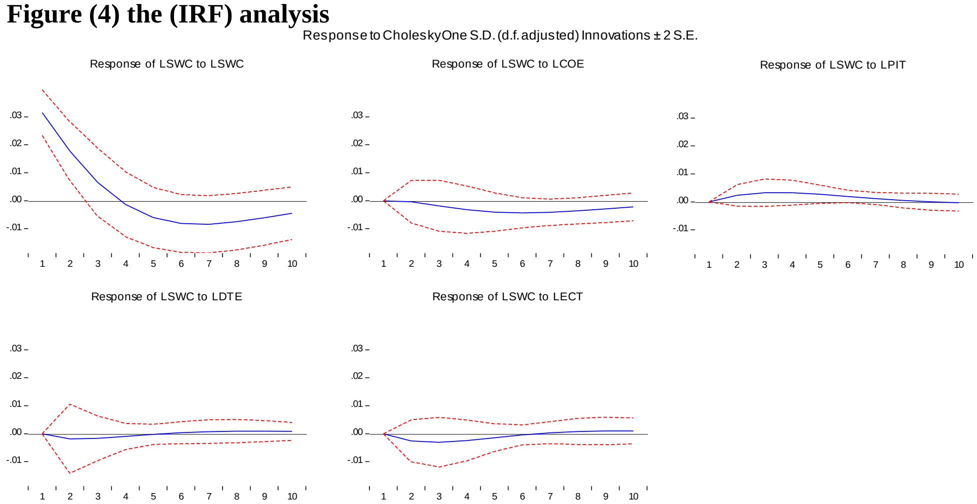
J. Agric. & Env. Sci. (Damanhour University) 2024, 23 (2): 438-471
Print: ISSN 1687-1464 Online: 2735-5098

The previous graph indicates that some values do not maintain stability at certain points. It exceeds the standard error limits, but this does not affect the stability of the time series in the long run.

To measure the short- and medium-term impact, the impulse and response function (IRF) is used, followed by variance partitioning. Variance Decomposition Response functions (IRE) according to Cholesky decomposition, are used here to interpret the internal relationship between variables.

The following figure reflects the response of the SWC variable to shocks from the rest of the independent variables.

Figure (4) the (IRF) analysis



SOURCE: Prepared by researcher

The next table shows the Variance Decomposition for the VAR model; It measures the relative importance of variables in influencing each other, and it represents the probability of a long-term relationship, or in other words, the existence of integration between variables. This analysis follows the Johansen integration test to estimate that long-term relationship between variables.

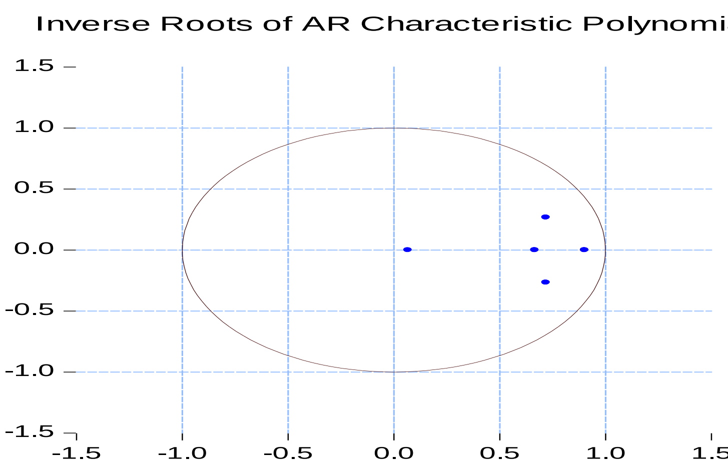
Table 6. variance decomposition analysis

Period	S.E.	LSWC	LCOE	LDTE	LECT	LPIT
1	0.031550	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.036399	98.83861	0.009550	0.248318	0.497238	0.406287
3	0.037338	97.03262	0.246567	0.435121	1.136494	1.149193
4	0.037728	95.15180	0.953662	0.496673	1.527284	1.870577
5	0.038538	93.61425	2.018541	0.480645	1.599070	2.287494
6	0.039676	92.51995	3.101768	0.460983	1.520219	2.397078
7	0.040794	91.77051	3.967574	0.468725	1.444772	2.348419
8	0.041661	91.25341	4.560439	0.497807	1.422370	2.265979
9	0.042225	90.89902	4.922042	0.532442	1.440625	2.205867
10	0.042539	90.66690	5.120228	0.561307	1.473216	2.178350

SOURCE: Prepared by researcher

To test the dynamic stability of the VAR model, we apply the inverse root test. It is clear from the following figure that all the roots are located inside the unit circle except for a root located on the circumference of the circle and not outside it, and therefore the model can be considered dynamically stable. This confirms that the model does not suffer from correlation in errors or non-stationarity of variance.

Figure (5) Results of the dynamic stability test for the VAR model



SOURCE: Prepared by researcher

Table 7. Johansen cointegration test

Hypothesized H0 H1	**Eigenvalue**	**Trace - test**		**Max- test**	
		Statistic	p- value	Statistic	**p- value**
r = 0 r > 0	0.726799	79.87620*	0.0063	37.62883*	**0.0170**
r ≤ 0 r > 1	0.466046	42.24737	0.1519	18.19590	**0.4789**
r ≤ 0 r > 2	0.322831	24.05147	0.1983	11.30518	**0.6169**
r ≤ 0 r > 3	0.277018	12.74629	0.1245	9.406772	**0.2539**
r ≤ 0 r > 4	0.108773	3.339517	0.0676	3.339517	**0.0676**

SOURCE: Prepared by researcher

The results of the Johansen cointegration test appear in the following table, which confirms the existence of integration between the variables of the VAR model. The trace and max tests also indicate the possibility of integration at a 5% significance level. Here we have one integral equation. We can perform a VECM model to estimate the long-term relationship between the variables.

To apply the VECM model using one integral equation, if we want to convert the VAR model to the VECM model, we need to reduce the optimal lag period by 1, because the variables in the VECM model are taken to have a first difference, so we decrease one period.

After we have confirmed the existence of integration between the study variables, we will now reveal the relationship in the short term and the long term from the results of applying the VECM model as follows:

The results of the short-term model show that the relationship between COE, DTE, ECT and PIT are significant with SWC where:

- (COE) Carbon dioxide emissions is negatively significant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.
- (DTE) Development of technologies related to the environment, % of all technologies is positively significant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.

- (ECT) Energy consumption in transportation, % of total energy consumption is positively significant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.
- (PIT) Public investments in the transportation sector is negatively significant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.
- COE) Carbon dioxide emissions is insignificant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.
- (DTE) Development of technologies related to the environment, % of all technologies is positively significant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.
- (ECT) Energy consumption in transportation, % of total energy consumption is insignificant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.
- (PIT) Public investments in the transportation sector is positively significant with (SWC) Social welfare costs of premature deaths resulting from exposure to ambient PM2.5, equivalent to GDP.

Recommendations

As Egypt continues to face the challenges of climate change, it is crucial to prioritize sustainable infrastructure development that can mitigate and adapt to its impacts. The following recommendations are proposed for future infrastructure projects in Egypt:

I. Integration of Climate Change Considerations

Future infrastructure projects should integrate climate change considerations from the planning stage to ensure long-term sustainability. This includes conducting comprehensive climate risk assessments and incorporating climate change projections into infrastructure design and development. By considering the potential impacts of climate change, such as increased temperatures, sea-level rise, and extreme weather events, infrastructure can be designed to withstand and adapt to these challenges.

Table 8. Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 12/23/23 Time: 04:11
Sample (adjusted): 1992 2020
Included observations: 29 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LSWC(-1)	1.000000
LCOE(-1)	0.058339
	(0.04409)
	[1.32324]
LDTE(-1)	-0.036447
	(0.00929)
	[-3.92439]
LECT(-1)	-0.131879
	(0.05794)
	[-2.27596]
LPIT(-1)	0.006723
	(0.00829)
	[0.81093]
C	-1.967361

Error Correction:	D(LSWC)	D(LCOE)	D(LDTE)	D(LECT)	D(LPIT)
CointEq1	-0.100279	0.308319	15.74169	0.416372	-5.176187
	(0.25309)	(0.31768)	(4.71203)	(0.46513)	(1.44512)
	[-0.39621]	[0.97053]	[3.34075]	[0.89517]	[-3.58184]
D(LSWC(-1))	0.068532	-0.199397	-4.952081	0.034475	0.897547
	(0.22399)	(0.28115)	(4.17026)	(0.41165)	(1.27897)
	[0.30595]	[-0.70921]	[-1.18747]	[0.08375]	[0.70177]
D(LCOE(-1))	-0.429961	0.341822	-10.54610	-0.434514	5.109449
	(0.22452)	(0.28182)	(4.18008)	(0.41262)	(1.28198)
	[-1.91502]	[1.21293]	[-2.52294]	[-1.05305]	[3.98560]
D(LDTE(-1))	-0.009506	-0.005152	-0.231884	0.031660	0.002046
	(0.00930)	(0.01167)	(0.17310)	(0.01709)	(0.05309)
	[-1.02245]	[-0.44143]	[-1.33957]	[1.85287]	[0.03854]
D(LECT(-1))	-0.013271	0.313327	-0.667430	-0.171095	1.503063
	(0.12017)	(0.15084)	(2.23732)	(0.22085)	(0.68616)
	[-0.11043]	[2.07725]	[-0.29832]	[-0.77471]	[2.19055]
D(LPIT(-1))	-0.018447	-0.010765	0.729636	0.016698	-0.032292
	(0.02688)	(0.03375)	(0.50053)	(0.04941)	(0.15351)
	[-0.68616]	[-0.31901]	[1.45771]	[0.33796]	[-0.21036]
C	0.010207	0.004524	-0.019999	0.009396	0.100367
	(0.00859)	(0.01078)	(0.15994)	(0.01579)	(0.04905)
	[1.18813]	[0.41956]	[-0.12504]	[0.59515]	[2.04614]
R-squared	0.334519	0.322404	0.454949	0.174991	0.539190
Adj. R-squared	0.153024	0.137605	0.306299	-0.050011	0.413515
Sum sq. resids	0.022927	0.036122	7.947164	0.077438	0.747489
S.E. equation	0.032282	0.040521	0.601028	0.059329	0.184328
F-statistic	1.843130	1.744618	3.060533	0.777731	4.290340
Log likelihood	62.42015	55.82884	-22.37925	44.77169	11.89659
Akaike AIC	-3.822079	-3.367506	2.026155	-2.604944	-0.337696
Schwarz SC	-3.492042	-3.037469	2.356192	-2.274907	-0.007659
Mean dependent	0.001438	0.008678	0.029578	0.007306	0.159275
S.D. dependent	0.035078	0.043634	0.721620	0.057899	0.240692

Determinant resid covariance (dof adj.)	2.90E-11
Determinant resid covariance	7.29E-12
Log likelihood	166.1092
Akaike information criterion	-8.697188
Schwarz criterion	-6.811263
Number of coefficients	40

II. Emphasis on Renewable Energy Infrastructure

Given the significant contribution of the energy sector to greenhouse gas emissions, future infrastructure projects should prioritize the development of renewable energy infrastructure. This includes investing in solar, wind, and hydroelectric power projects to reduce reliance on fossil fuels and promote clean energy generation. By transitioning to renewable energy sources, Egypt can significantly reduce its carbon footprint and contribute to global efforts in mitigating climate change.

III. Implementation of Energy Efficiency Measures

In addition to investing in renewable energy infrastructure, future projects should also focus on implementing energy efficiency measures. This includes incorporating energy-efficient technologies and practices in buildings, transportation systems, and industrial processes. By reducing energy consumption and improving energy efficiency, Egypt can not only lower greenhouse gas emissions but also achieve cost savings and enhance energy security.

IV. Sustainable Transportation Infrastructure

Transportation is a significant contributor to carbon emissions and air pollution. Future infrastructure projects should prioritize the development of sustainable transportation systems, including the expansion of public transportation networks, the promotion of electric vehicles, and the improvement of cycling and pedestrian infrastructure. By providing viable alternatives to private car usage, Egypt can reduce emissions, alleviate traffic congestion, and improve air quality.

V. Integrated Water Management

Water scarcity is a pressing issue in Egypt, exacerbated by climate change impacts such as reduced rainfall and increased evaporation rates. Future infrastructure projects should focus on integrated water management approaches that promote water conservation, efficient irrigation systems, and the development of water storage and desalination facilities. By adopting sustainable water management practices, Egypt can ensure water security and resilience in the face of climate change.

VI. Green Building Practices

Future infrastructure projects should prioritize the adoption of green building practices to minimize environmental impacts and enhance energy efficiency. This includes incorporating sustainable design principles, using eco-friendly materials, and implementing energy-efficient technologies in construction. By promoting green building practices, Egypt can reduce energy consumption, lower carbon emissions, and create healthier and more sustainable built environments.

VII. Enhancing Infrastructure Resilience

Given the increasing frequency and intensity of extreme weather events, future infrastructure projects should prioritize resilience measures. This includes designing infrastructure to withstand climate-related hazards such as floods, storms, and heat waves. Additionally, incorporating nature-based solutions, such as green infrastructure and ecosystem restoration, can enhance resilience and provide multiple benefits, including flood mitigation, improved water quality, and biodiversity conservation.

VIII. Strengthening Policy and Regulatory Frameworks

To support sustainable infrastructure development, it is essential to strengthen policy and regulatory frameworks. This includes developing and implementing comprehensive climate change policies, setting targets for greenhouse gas emissions reduction, and establishing clear guidelines and standards for sustainable infrastructure. Additionally, promoting public-private partnerships and providing incentives for sustainable investments can help mobilize funding and accelerate the implementation of climate-friendly infrastructure projects.

IX. Capacity Building and Knowledge Sharing

To ensure the successful implementation of sustainable infrastructure projects, capacity building and knowledge sharing are crucial. This includes providing training and technical assistance to relevant stakeholders, including government agencies, private sector entities, and local communities. Additionally, fostering collaboration and knowledge exchange with international partners and organizations can facilitate the transfer of best practices, innovative technologies, and financial resources for sustainable infrastructure development.

X. Monitoring and Evaluation

To assess the effectiveness of future infrastructure projects in addressing climate change, robust monitoring and evaluation mechanisms should be established. This includes tracking key performance indicators related to greenhouse gas emissions, energy consumption, water usage, and resilience to climate impacts. Regular monitoring and evaluation can provide valuable insights into the success of implemented measures and inform future decision-making processes.

By implementing these recommendations, Egypt can enhance its infrastructure resilience, reduce greenhouse gas emissions, and contribute to global efforts in mitigating climate change. Sustainable infrastructure development not only benefits the environment but also promotes economic growth, improves public health, and enhances the overall quality of life for the Egyptian population.

References

1. - Fan, D.; Liu, K.2021. The Relationship between Artificial Intelligence and China's Sustainable Economic Growth: Focused on the Mediating Effects of Industrial Structural Change. Sustainability 2021, 13, 11542.
2. - Fosu P and Twumasi MA (2022). "The impact of transportation and water infrastructure spending source on economic growth: Evidence from U.S. state and local and federal government". International Journal of Contemporary Economics and Administrative Sciences, 12(1): 075–092. https://doi.org/10.5281/zenodo.6850541
3. - Global Data. (2021). Global Construction Outlook to 2023 – Q4 2019 Update https://store.globaldata.com/report/global-construction-outlookto-2023- q4-2019-update. /
4. - Guo, C.; Wang, J.; Liu, H. Studies on How New Infrastructure EmpowersHigh- quality Development of China's Economy. Beijing Univ.Technol. 2020, 20, 13–21.
5. - Nedić, V., Despotović, D., Cvetanović, S., Djukić, T., & Petrović, D. (2020). Institutional reforms for economic growth in the Western Balkan countries. Journal of Policy Modeling, 42(5), 933–952.https://doi.org/10.1016/j.jpolmod.2020.04.002

6. A. Jahani and M. Saffariha, "Human activities impact prediction in vegetation diversity of Lar National Park in Iran using artificial neural network model," Integr. Environ. Assess. Manag., vol. 17, no. 1, pp. 42–52, 2021.
7. A. K. Singh et al., "An integrated statisticalmachine learning approach for runoff prediction," Sustainability, vol. 14, no. 13, p. 8209, 2022.
8. Agrawal, A.; Gans, J.S.; Goldfarb, A. Artificial Intelligence: The Ambiguou Labor Market Impact of Automating Prediction. J. Econ. Perspect. 2019, 33, 31–49.
9. Banerjee A, Duflo E and Qian N (2020). "On the road: Access to transportation infrastructure and economic growth in China". Journal Of Development Economics, 145: Art. 102442.
10. Edquist, H.; Goodridge, P.; Haskel, J. 2021.The Internet of Things and economic growth in a panel of countries. Econ. Innov. New Technol. 2021, 30, 262–283.
11. F. Creutzig, J. Roy, P. Devine Wright, J. Díaz-José, F.W. Geels, A. Grubler, et al., Demand, services and social aspects of mitigation, in: P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, et al. (Eds.), IPCC, 2022: Climate Change 2022: Mitigation of Climate Mitigation of Climate Change. Contribution of Working
12. Fosu P (2019). The Determinants of Economic Growth: The Role of Infrastructure (MPRA Paper No. 93101). Munich Personal RePEc Archive
13. Fosu P (2021). "Do railway line investments matter for economic growth?" ECONOMICS-Innovative and Economic Research, 9(1): 11 24. https://doi.org/10.2478/eoik-2021-0004
14. G. Lohmann, M. Butzin, N. Eissner, X. Shi, and C. Stepanek, "Abrupt climate and weather changes across time scales," Paleoceanogr. Paleoclimatology, vol. 35, no. 9, p. e2019PA003782, 2020.
15. IEA [International Energy Agency]. Tracking Buildings 2021. Paris, France, 2021,https://www.lea.org. eports/tracking-buildings-2021 (accessed July 26, 2022).
16. IPCC [Intergovernmental Panel on Climate Change), Climate change 2022: Mitigation of climate change, in: Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, 2022, https://doi.org/10.1017/ 846 1157926.

17. Khan, H., Khan, U., Jiang, L. J., & Khan, M. A. (2020). Impact of infrastructure on economic growth in South Asia: Evidence from pooled mean group estimation. The Electricity Journal, 33(5), 106735. https://doi.org/10.1016/j.tej.2020.106735.
18. Lee, M.T.; Suh, I. 2022. Understanding the effects of environmental, Social, and Governance conduct on financial performance: Arguments for a process and integrated modeling approach. Sustain. Technol. Entrep. 2022, 1, 100004.
19. LF. Cabeza, Q. Bai, P. Bertoldi, J.M. Kihila, A.F.P. Lucena, É. Mata, et al., [Buildings, in: P.R. Shukla, J. Skea, R. Slade, A., al Khourdajie, R. van Diemen, D. McCollum, et al. (Eds.), IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press, Cambridge, 2022, pp. 381-458, https://doi.org/10.1017/9781009157926.
20. Lin, B.; Zhou, Y. 2022. Does energy efficiency make sense in China? Based on the perspective of economic growth quality. Sci. Total Environ. 2022,804, 149895.
21. M. Boroughani et al., "Application of remote sensing techniques and machine learning algorithms in dust source detection and dust source susceptibility mapping," Ecol. Inform., vol. 56, p. 101059, 2020.
22. Mbulawa, S. (2017). The impact of economic infrastructure on long-term economic growth in Botswana
23. O. Z. Jasim, N. H. Hamed, and M. A. Abid, "Urban air quality assessment using integrated artificial intelligence algorithms and geographic information system modeling in a highly congested area, Iraq," J. Southwest Jiaotong Univ., vol. 55, no. 1, 2020
24. Olaoye, O. O., Eluwole, O. O., Ayesha, A., & Afolabi, O. O. (2020). Government spending and economic growth in ECOWAS: An asymmetric analysis. The Journal of Economic Asymmetries, 22, E00180. https://doi.org/10.1016/j.jeca.2020.e0018
25. Pan, X.; Guo, S.; Li, M. 2021; Song, J. The effect of technology infrastructure investment on technological innovation—A study based on spatial Durbin model. Technovation 2021, 107, 102315.

26. R. Cioffi, M. Travaglioni, G. Piscitelli, A. Petrillo, and F. De Felice, "Artificial intelligence and machine learning applications in smart production: Progress, trends, and directions," Sustainability, vol. 12, no. 2, p. 492, 2020.
27. S. L. Zubaidi et al., "A method for predicting long-term municipal water demands under climate change," Water Resour. Manag., vol. 34, pp. 1265–1279, 2020
28. UN [United Nations], Conference of the Parties, Adoption of the Paris Agreement, Dec. 12, 2015 U.N. Doc. FCCC/CP/2015/L.9/Rev/1, 2015, https://unfccc.int/sites/default/files/english paris agreement.pdf (accessed December 1, 2023).
29. Wensi, S. Effects of New Infrastructure Investment on Labor Productivity: Based on Producer Services Perspective. Nankai Econ. Stud. 2020, 6, 181–200.
30. -Wensi, S.; Wang, W.; Ran, Q.; Irfan, M.; Ren, S.; Yang, X.; Wu, H.; Ahmad, M.; Research, P. Analysis of the mechanism of the impact of internet Development on green economic growth: Evidence from 269 prefecture cities in China. Environ. Sci. Pollut. Re. 2022, 29, 9990– 10004.
31. Wu, J.; Zhang, Y.; Shi, Z. Crafting a Sustainable Next Generation Infrastructure: Evaluation of China's New Infrastructure Construction Policies. Sustainability 2021, 13, 6245. [Google Scholar] [CrossRef]
32. Xu, Y., & Li, A. (2020). The relationship between innovative human capital and interprovincial economic growth based on panel data model and Spatial econometrics. Journal of Computational and Applied Mathematics, 365, 112381. https://doi.org/10.1016/j.cam.2019.11238
33. Z. Ebrahimi-Khusfi, R. Taghizadeh-Mehrjardi, and M. Mirakbari, "Evaluation of machine learning models for predicting the temporal variations of dust storm index in arid regions of Iran," Atmos. Pollut. Res., vol. 12, no. 1, pp. 134–147, 2021.
34. Zhou A (2022). "Digital infrastructure and economic growth—Evidence for China". Journal of Infrastructure, Policy and Development, 6 (1) Art. 1397. https://doi.org/10.24294/jipd.v6i1.1397