Center for Sustainable Development at BROOKINGS

FEBRUARY 2023

WORKING PAPER #180.3

KEYS TO CLIMATE ACTION

CHAPTER 3: CLIMATE ACTION IN EGYPT—CHALLENGES AND OPPORTUNITIES

HALA ABOU-ALI
AMIRA ELAYOUTY
MAHMOUD MOHIELDIN

Keys to climate action

Chapter 3 | Climate action in Egypt: Challenges and opportunities

FEBRUARY 2023

Working Paper #180.3

About Center for Sustainable Development
Launched in 2020 by the Global Economy and Development program, the Center for Sustainable Development generates leading research and insights to advance global sustainable development and implement the Sustainable Development Goals within and across all countries.

AUTHORS

Hala Abou-Ali, Professor, Department of Economics, Faculty of Economics and Political Science (FEPS), Cairo University, Egypt, Vice President of Research and Postgradute Studies at the Institute of National Planning, Egypt and Research Fellow at the Economic Research Forum.

Amira Elayouty, Assistant professor, Department of Statistics, FEPS, Cairo University, Egypt.

Mahmoud Mohieldin, Professor, Department of Economics, FEPS, Cairo University, Egypt and an IMF Executive Director. He serves as the UN Special Envoy on Financing the 2030 Agenda for Sustainable Development and UN 7th High-Level Champion for Climate Action.

ACKNOWLEDGEMENTS

The Brookings Institution is a nonprofit organization devoted to independent research and policy solutions. Its mission is to conduct high-quality, independent research and, based on that research, to provide innovative, practical recommendations for policymakers and the public. The conclusions and recommendations of any Brookings publication are solely those of its author(s), and do not reflect the views of the Institution, its management, its other scholars, or its funders.

Brookings gratefully acknowledges project support provided by The Rockefeller Foundation.

Brookings recognizes that the value it provides is in its commitment to quality, independence, and impact. Activities supported by its donors reflect this commitment.

This publication is part of an edited volume, "Keys to Climate Action: How developing countries could drive global success and local prosperity," edited by Amar Bhattacharya, Homi Kharas, and John W. McArthur. As described in the acknowledgments of the overview chapter, available in a companion publication, the editors thank the remarkable network of collaborators who contributed to the research, production, and support of the full volume and this chapter. The views expressed herein are entirely the authors' and should not be attributed to the United Nations or the International Monetary Fund, its Executive Board or Management. The authors have benefitted from extensive discussions with Amar Bhattacharya, Homi Kharas, John McArthur, and the participants in the Brookings Institution workshop at The Rockefeller Foundation Bellagio Center in June 2022.

Introduction

Climate change is posing a serious threat to humanity. It not only encompasses rising average temperatures, but also climate-related loss and damage, including rising sea levels, coastal erosion, extreme weather events, shifting wildlife populations and habitats, desertification, and the loss of soil fertility leading to food and water insecurity. No part of the world is insusceptible to its disastrous effects. Four decades after the first world climate conference in Geneva in 1979, more than 11,000 scientists from 153 countries urged policymakers to cooperate and confront climate change before it was too late (Ripple et al., 2019).

Climate scientists blame the economic activities that emit greenhouse gas (GHG) emissions as the essence of the climate problem. Meanwhile, economists emphasize economic growth and distributive policies as critical in the fight against extreme poverty, stressing that the world would not have pulled millions of people out of poverty in recent decades without persistent economic growth in the global south, even if climate change is a side effect. However, there is mounting evidence of climate change's negative economic effects on growth, productivity, and other potential outcomes (Abdelfattah et al., 2021; Khan et al., 2021). Economic expansion is vital, but it can also cause environmental harm with huge economic consequences, slowing economic growth in the long run.

Although Egypt accounts for only 0.6 percent of annual global carbon dioxide (CO_2) emissions, it is becoming one of the most heavily affected by extreme weather patterns (Global Carbon Project, 2021). Divided into two unequal sections by the Nile River, the country consists mostly of a hot desert climate with very hot, dry summers and mild winters. The extreme sensitivity of the Nile River flow to heat waves and sea level rise makes Egypt's population of more than 100 million people particularly susceptible to climate change. By one measure, Egypt ranks as the 83rd most vulnerable country facing the threat of climate change and 63rd when it comes to lack of preparedness to face climate change (University of Notre Dame, 2020). Among the elements of climate change, heatwaves can have adverse impacts on many spheres, including water stress, sea levels, biodiversity, livestock, food security, land use, urban development, tourism, and public health. Abou-Ali et al. (2022) have already shown that Egyptian labor productivity is at risk due to heat stress and worsening air quality. Also, Elayouty, Abou-Ali, and Hawash (2022) have demonstrated that the changes in Egypt's climate have negative impacts on children nutrition and growth while controlling for all other socio-economic variables.

Higher average temperatures will have a negative influence on Egypt's GDP growth, but the simultaneously increasing economic activities are contributing to increasing CO_2 emissions (Elayouty and Abou-Ali, 2022) and hence higher temperature levels. Therefore, policymakers

need to take quick steps to mitigate and adapt to the effects of climate change. Egypt has shown commitment to the climate agenda by hosting the United Nations Climate Change Conference of the Parties (COP27), by recently finalizing the National Climate Change Strategy (NCCS) to support its 2030 Sustainable Development Agenda, and by updating its Nationally Determinant Contributions (NDCs). However, Egypt's focus should turn from managing climate change risks to capturing opportunities associated with climate change and catalyzing the private sector to contribute broadly to delivering green transition.

Egypt possesses an abundance of land, sunny weather, and high wind speeds, making it a prime location for renewable energy projects. This presents a great opportunity for the Egyptian government to pursue a sustainable energy mix to accommodate the increasing demand on energy and to simultaneously move to a more sustainable environment. According to the 2035 Integrated Sustainable Energy Strategy adopted in 2016, Egypt is working on increasing the supply of electricity generated from renewables from less than 10 percent at the time of launch to 20 percent by 2022 and 42 percent by 2035, the latter includes 14 percent wind, 2 percent hydropower, and 26 percent solar (Arab Republic of Egypt, 2022b; Ministry of Electricity and Renewable Energy, 2022a).

Egypt is also increasing its offshore natural gas production capacity. In the run-up to COP27, Egypt will play a key leadership role in promoting development and reinforcing cooperation regarding liquified natural gas and renewable energy-produced green hydrogen supplies between Africa and Europe. Natural gas and renewable energy projects have created a marketable electricity surplus. Given its strategic location in the eastern Mediterranean, this presents a great opportunity for Egypt to service electricity markets on Europe, Africa, and the Middle East, which in turn reduces the CO_2 emissions and limits the effects of pollution on people's health compared to current trends.

This chapter considers how well Egypt sets out a pathway to the green transition. With the urgent need to translate climate ambitions into action and results, Egypt needs to harness the long-standing experience in climate-related policy of other countries, including those in the OECD, to seize the opportunities available in the global wave of achieving climate goals. The most salient obstacles to Egypt's green transition can be categorized into three main pillars. The first relates to data systems availability to track and measure progress toward climate goals. The second concerns the implementation capacity for efforts relating to emissions mitigation, adaptation and resilience, and multilateral and multi-disciplinary collaboration. The third impediment is the mobilization of financing, investments, and business action. Finally, the chapter presents opportunities for progress in critical sectors such as agriculture, power, and transport.

Development challenges and climate change policies

Rising temperatures will put enormous strain on Egypt's crops, livestock, and already scarce water supplies, which in turn affect public health, food security, and potentially migration patterns. Increasing temperatures, water scarcity, and soil salinity represent aggressive threats to food security. Water strains can have direct influence on crop yields. The sea level rise and saline water intrusion have a negative impact on 12 to 15 percent of the Nile Delta's most fertile agricultural land (Arab Republic of Egypt, 2017).

These collective dangers pose unprecedented problems to macroeconomic policy, necessitating major initiatives to mitigate their harmful consequences. Although expanding the implementation of climate-mitigation and adaptation measures may lower the risk of exposure to climate-related loss and damage, these may be of a severity and magnitude far beyond the scope and capacities of typical climate-mitigation and adaptation efforts.

Egypt's development challenges

In 2016, Egypt adopted a bold economic reform and stabilization program to address a problematic social and economic situation which manifested itself in rising structural unemployment, mounting external debt, above average inflation, and increasingly negative fiscal and external deficits. Stabilization and liberalization have been achieved and macroeconomic indicators have slightly improved, in addition to showing some resilience during the COVID-19 pandemic. However, a few negative aspects have persisted, including social injustice, slow growth of GDP, escalating unemployment, rising poverty, and, in 2022, recurring balance of payments challenges due to the war in Ukraine. Several important issues need to be addressed to achieve sustainable development while aligning climate change actions, namely, undertaking institutional reform, addressing slow-moving GDP growth, and tackling mounting unemployment and expanding poverty amid high population growth.

Recent reforms to Egypt's energy sector helped increase gas and electricity exports and allowed a greater role for private enterprise, particularly in the field of renewable energy. The negative effects of the pandemic, however, eroded advancements and highlighted enduring difficulties. These include the weak private sector involvement outside the oil sector, low exports and foreign direct investment, a high government debt-to-GDP ratio, under-mobilization of revenues, and the unfavorable budget structure, with inadequate education and health expenditures.

Socio-economic circumstances remain challenging, with almost 30 percent of the population living under the national poverty line in 2019 (Ramadan, 2022; World Bank, 2021d). The pandemic's detrimental effects on economic activity and incomes hence call for stepping up measures to reduce poverty. At the beginning of the COVID-19 crisis, Egypt started to improve social protection, expand existing programs, and implement temporary mitigating measures. However, poverty has already been on the rise since 2005. This, along with average fertility rates being persistently above 3 births per woman, is leading to around 0.7 million young Egyptians entering the labor force each year (CAPMAS, 2021). With little productivity growth and hardly any job creation, it is difficult to integrate these new workers into the job market; and therefore, unemployment remains high and contributes to the exclusion of women and youth (Assaad, 2022). The prospect for quicker growth is enormous, however, if Egypt can foster the development of a robust and dynamic private sector that can effectively employ this new generation of workers. To create the enabling environment that would allow the private sector to flourish and unlock its competitiveness, it is essential to improve governance and strengthen the role of the government in its policy-making and regulatory functions.

Climate change policies

In 2015, 196 parties embraced the Paris Agreement during COP21. Through Nationally Determined Contributions (NDC), each country specified its responsibilities to that agreement by pursuing steps to help limit global warming to 1.5 degrees Celsius. Egypt filed its initial NDC in 2017, with the intention of activating it in 2020 and then updating it every five years. Egypt's first NDCs offered a list of adaptation actions to address the adverse impacts of climate change. Yet, it lacked definitive means of implementation, quantification, strategic direction, and prioritization. The updated NDC was officially released in July 2022, tackling the earlier lack of ambition and quantification in order to show Egypt's full potential and commitment to reducing CO_2 emissions.

The updated 2022 NDC strengthens adaptation plans with added policies and actions. It specifies key adaptation projects along with their expected cost. It describes the financial resources required to the adaptation interventions at U.S. $50 billion out to 2030, which annualizes to roughly 1–1.6 percent of national output per year, depending on timing issues and the economy's growth trajectory from its current size of more than U.S. $400 billion. It also revises the mitigation measures reported in the first NDC and expands them by sector to realign Egypt's developmental and climate change policies. Finally, it introduces quantified GHG emission reduction commitments. The new NDC moves toward clearly stated and defined sectoral targets, transparent monitoring, and emissions reduction metrics, suggesting appropriate systems for tracking progress toward those targets. This enables Egypt to make a

stronger argument for more international investment. The 2022 NDC does not set a general scenario nor distinguish between conditional and unconditional scenarios as compared to the business-as-usual (BAU) GHG emission projections. Mitigation targets are set on the sectoral level, with emphasis on three main sectors—electricity, oil and gas, and transport—to reduce GHG by 33 percent, 65 percent, and 7 percent, respectively, compared to BAU. The mitigation interventions in the updated NDC stipulate financial resources mounting to U.S. $196 billion, equivalent to roughly 4–6 percent of gross domestic product per year, again depending on the economic growth trajectory. The total is comprised of U.S. $97.7 billion for the electricity sector, U.S. $3.3 billion for oil and gas, U.S. $40.3 billion for transport, U.S. $11.9 billion for industry, U.S. $0.25 for building and urban cities, U.S. $0.3 billion for tourism, and U.S. $5.6 billion for waste sectors. However, the updated NDC is contingent on mobilizing international funds, without specifying local, private, or public amounts required (Abdallah, 2020; Arab Republic of Egypt, 2017, 2022b).

Egypt is also demonstrating its adherence to the Paris Climate Agreement through its National Climate Change Strategy (NCCS) released in May 2022. This strategy aims at enabling the country to plan and manage climate change at various levels in a way that supports Egypt's desired sustainable economic development goals. The NCCS is based on four main elements: the constitution; the Sustainable Development Strategy (SDS); an analysis of strengths, weaknesses, opportunities, and threats of climate change management in Egypt; and the integration of all sectoral strategies and plans. The NCCS offers a wider range of mitigation and adaptation interventions spanning on a longer timeframe, reaching 2050 in some areas. It further specifies a cumulative financial gap for adaptation and mitigation to be U.S. $94.7 and U.S. $153.6 billion, respectively. The NDC and NCCS numbers do not match due to differences in time horizon for the relevant interventions; the NDC timeframe is out to 2030 while the NCCS reaches 2050. Furthermore, the NCCS covers interventions in the civil aviation and biodiversity sectors that are not mentioned in the updated NDC.

The NCCS defines five main targets and 22 sub-targets to promote climate change resilience and decrease emissions. The first recognized goal is to achieve low-emission economic growth in all sectors. This will rely on scaling up renewable energy and mainstreaming green economic development in all energy intensive sectors, while promoting efficient power use and eliminating electricity subsidies. The second goal builds on resilience and adaptation to climate change while mitigating its negative impacts. This involves establishing an effective health system with early detection and preparedness for any unexpected climate crises that may negatively impact human health, and mitigating short- and long-term health disasters to avoid replication of COVID-19-type pandemic situations (Gonzalez-Perez et al., 2021; El-Shal et al., 2022). The other three goals act as enabling factors toward the first two—through emphasis on governance;

financing infrastructure; and scientific research, technology transfer, knowledge management, and awareness.

An important sub-target is the preservation of state assets, such as infrastructure and historical heritage monuments, from the negative impact of climate change. The preservation of ecosystems is another sub-target of paramount importance to maintain the ecological balance and prevent negative social, health, and economic impacts that may result from any potential imbalances. These targets will take gender issues into consideration, given the important role of women in Egyptian society and their higher vulnerability to climate change especially, in rural areas and less educated societies. Due to insufficient financial and material resources, affected groups are often unable to deal with the effects of climate change on their own. Dealing with this has become one of the most important aspects of climate justice.

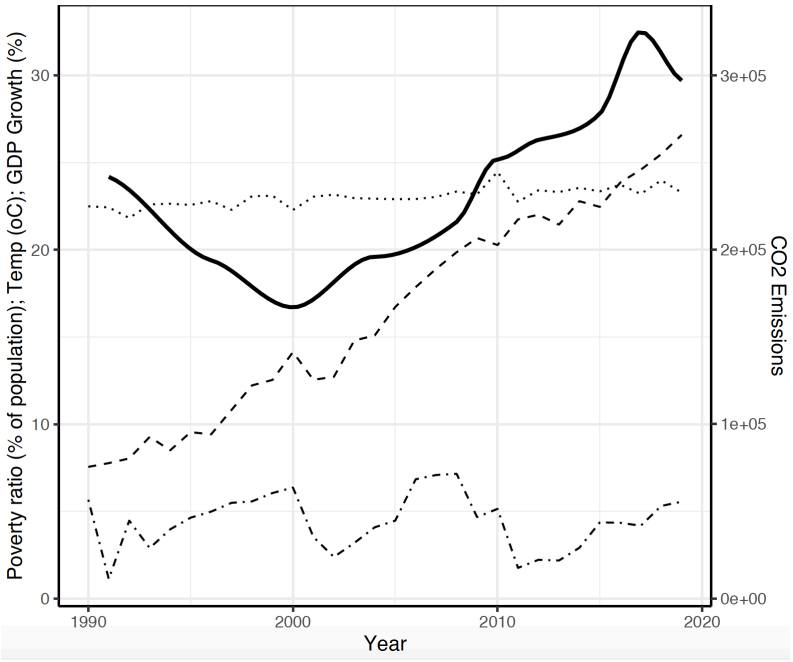
As an institutional structure, the National Climate Change Council (NCCC) was established in 2015 through a prime ministerial decree. At that time, the head of its board was the Minister of Environment and the membership comprised of relevant ministries' representatives. The decree was amended in 2019 to include a supreme committee across some line ministries and headed by the prime minister. This amendment was enacted in recognition of the importance of climate change, but the supreme committee is still inactive and missing the most relevant ministries regulating the sectors driving pollution in Egypt—namely, the Ministry of Electricity and Renewable Energy, the Ministry of Petroleum and Mineral Resources, and the Ministry of Transportation. The institutional structure of the NCCS also lacks public and scientific participation which is key to climate action. One suggestion would be to form a climate change committee in parliament to fill the gap of public participation, another is to engage the universities and the supreme council of universities to create a climate change observatory to ensure scientific inclusion.

Interlinkage between climate action and sustainable development

Egypt's vulnerability to the adverse impacts of climate change is pronounced and multidimensional. It affects coastlines, agriculture, food security, water resources, poverty, inequality, health, and infrastructure. In the context of the Sustainable Development Goals, addressing climate change, SDG13, is interdependent with the achievement of other SDGs. Aligning the NDC with the SDGs presents an excellent chance to accelerate the realization of both agendas. In Egypt, two distinct sets of focal points and working groups are in place to carry out the two agendas. Action alignment can begin by recognizing how these individuals, bodies, and structures can cooperate and improve collaboration between relevant institutions and platforms.

Following the work of Brandi et al. (2017), Dzebo et al. (2019), and Shawoo et al. (2020) we identify gaps and possible synergies between the SDGs and the NDC. We find that Egypt's current climate action plans overlap with all 17 goals, to varying degrees. The climate action plans intersect most explicitly with affordable and clean energy (SDG7), followed by life on land (SDG15), food security (SDG2), clean water and sanitation (SDG6), and sustainable cities and communities (SDG11). However, the existing plans articulate the fewest interlinkages in reducing inequalities (SDG10), promoting peace, justice, and strong institutions (SDG16), achieving gender equality and empowering women (SDG5), and eradicating poverty (SDG1). These gaps exist even though a growing body of research demonstrates that well-structured climate change action offers significant prospects for eradicating poverty without representing a burden in terms of development, growth, or jobs, but rather an appealing route to more equitable, adaptable, and sustainable progress (Lankes et al., 2022; World Bank, 2021c). One study suggests that the effects of climate change will cause the poverty rate to rise by as much as 6 percentage points (Hallegatte et al., 2016; see figure 3.1). Therefore, Egypt needs to reconsider strengthening the practical interlinkages between climate actions and SDG1 since the two goals cannot be thought of separately. Rather, they must be jointly addressed through an integrated strategy. This can establish a "win–win" scenario such that climate change initiatives aid in curbing poverty. Moreover, eradicating gender inequality in Egypt (SDG5) will improve family health and wellbeing, enhance household food security, and reduce poverty since women are key stakeholders in climate action and key actors in climate change adaptation and mitigation (United Nations Climate Change, 2022; UN Women Watch, 2022). When it comes to institutions and SDG16, institutional fragmentation is an important factor influencing policy coherence. Egypt has currently recognized that limited coordination between the institutional bodies for climate and SDG and the lack of broad stakeholder involvement in the implementation of the two agendas is a prime reason for slowing down the accomplishments.

Figure 3.1: Evolution of poverty (percent of the population) (solid line), CO_2 emissions (kt) (dashed line), average annual temperature (^oC) (dotted line), and GDP growth (percent) (dotted-dashed line) in Egypt, 1990-2019



Source: World Bank (2021d)

Obstacles to the implementation of climate change policies and actions

According to existing studies, climate change will manifest in the country as heat stress, desertification, floods, sea level rise, increased water scarcity, loss of agriculture land, and poor air quality in metropolitan areas. The 2022 Climate Change Performance Index (CCPI) ranked Egypt 21st out of 60 countries for its climate protection efforts and progress (Burck et al., 2022). The CCPI score is based on assessment of four underlying areas, namely GHG emissions (on which Egypt ranks 8th), energy use (12th), renewable energy (56th), and climate policy (29th). However, the existing climate challenges have been exacerbated by the outbreak of COVID-19 and the Ukrainian–Russian war (Gaind et al., 2022). Adding such shocks to already vulnerable communities can potentially cause economic, environmental, and social upheavals. COVID-19 resulted in a demand driven food crisis, while the Ukrainian-Russian war resulted in a supply driven crisis. Soaring international food prices have only put more pressure on food security for food importing countries like Egypt.

This combination of pressures calls for urgent and accelerated action to adapt to the impacts of climate change. Egypt has a unique opportunity to transition to a more sustainable, inclusive, and resilient economy by undertaking urgent action and laying the basics for financial, economic, and social recovery. The recovery efforts should prioritize investments that boost jobs and economic activity, have positive impacts on human, social and natural capital, protect biodiversity and ecosystems services, boost resilience, and advance the decarbonization of economies (World Bank, 2021). To undertake appropriate actions, it is of interest to understand the obstacles Egypt is facing to achieve its green transition.

Data and data systems

In both public and private sectors, data are critical for conducting operations, tracking progress, and making decisions. In a similar vein, data availability, accessibility, and completeness are key to government, people, and firms coping with uncertainty, strengthening resilience and adaptation, and implementing a green transition. Data collected for climate change and CO_2 emissions from different sources are inconsistent, making it difficult to determine the true scale of the challenge. It is essential to ensure that the national climate change and atmospheric monitoring systems, including monitoring networks with high-resolution spatial distribution and periodicity, are sustained and enhanced (Arab Republic of Egypt, 2017). The implementation and support of national strategies and plans rest on reliable and available data in order to

design policies, improve efficacy and efficiency of actions, and establish efforts oriented toward vulnerability reduction and progress tracking. Further approaches should also be considered, such as using systems for sectoral monitoring tools, integrating adaptation and climate information, developing a platform for integrating tools for low-emission development, and monitoring climate risk (UNDP, 2018).

In Egypt, the agriculture sector is highly dependent on data quality and quantity to adapt and build resilience to climate change. It is therefore of high priority to develop early warning systems to better predict seasonal and daily changes in rainfall and flows in the Nile Basin, both for improved water management practices and to improve preparedness for floods or extended dry seasons. Mapping Egypt's agricultural products is also important for more effective land use and future resource management (World Bank, 2021). For an efficient use of improved forecasting and information generation technologies, the government must pair the obtained data and information with improved information dissemination, awareness-raising efforts, and clear preparedness plans for all stakeholders, including small-scale farmers.

To track the progress in achieving a green transition, the environmentally relevant SDG indicators offer a helpful starting point, with 92 indicators in focus (UNEP, 2021). Currently, three national sources report different SDG indicators and statistics in Egypt: The Central Agency for Public Mobilization and Statistics (CAPMAS), the Ministry of Planning and Economic Development, and the Ministry of International Cooperation. Since the year 2000, the Ministry of Environment has published a yearly State of the Environment Report, comprising data related to environmental and climate change indicators. This leaves Egypt without a consolidated and updated statewide environmental monitoring system or database, resulting in an insufficient number of indicators for quantifying the state of the environment. To overcome this, enhanced data acquisition and coordination between government entities is essential to efficiently screen the implementation of SDG targets. The CAPMAS (2019) report encompasses only 28 environmental SDG indicators measuring the status of the environment, including air quality, greenhouse gas emissions, fish stock, forests, forest cover, plant and animal genetic resources, and water quality. The temporal resolution of the data varies across indicators and lacks harmonization; calculation methods are also unclear for some indicators (Hassan and Amin, 2022). To address these limitations, Hassan and Amin (2022) recommended benchmarking to common levels of disaggregation, updating frequency, and using big data to monitor and analyze the impact of development projects. Expanding the infrastructure needed for collecting and storing reliable and timely data and information requires big investments and integrated efforts from both the private and the public sectors. Legislative reforms are also needed to strengthen governance, especially regulations governing information freedom and data protection.

Implementation capacity

In recent years, technological innovation has generated massive opportunities for mitigating the effects of climate change. Although innovation can facilitate service delivery, negative externalities can arise, such as increasing social inequities in addition to higher reliance on foreign knowledge and suppliers. Such imbalances can be averted by good policies and governance. The government can harness climate technology innovation through supply-focused (push) or demand-focused (pull) policy instruments. Examples of the former include conducting research and expanding the supply of experienced engineers and scientists. Examples of the latter are adoption subsidies, carbon prices, intellectual property legislation, direct financing, and regulatory tools (IPCC, 2022).

To regulate GHG emissions today, Egypt uses a command-and-control system, whereby a fine is levied by law if emissions from a source exceed a predefined threshold. The abatement cost facing most businesses is usually greater than the fine, so they choose to pay the fine instead of abating (Elshennawy and Willenbockel, 2021). This has resulted in an ineffective technique for reducing GHG, as reflected in the 183 percent increase in CO_2 emission between 1990 and 2020 (Global Carbon Project, 2021). Therefore, adopting a regulatory framework that increases compliance with and participation in green management practices by different stakeholders, including the private sector, could facilitate the implementation of climate action.

Capacity building is a prerequisite for implementing Egypt's green transition. It is a cornerstone to formulate policies, access finance, integrate adaptation and mitigation into sectoral planning processes, and deliver the necessary knowledge for understanding and transparency of the green transition. Identifying capacity-building needs can facilitate education, training, awareness raising, and peer-to-peer learning. It can also support institutional strengthening and promote sustainability and retention of skills at the national level. For example, the NCCC is the major authority in charge of climate change in Egypt. Its composition of stakeholders from many disciplines, as well as the prime minister's leadership, are among its advantages. But climate change actions and policies are developed and executed by a variety of ministries, resulting in fragmentation and coordination issues (UNDP, 2021; Abdel Monem and Lewis, 2020; Hefny, Elmakkawe, and Ramadan, 2019). The overlapping institutional roles and responsibilities among different ministries, governorates, and agencies lead to duplication of efforts and weak accountability. Better coordination is required.

Egypt features a dual executive system in which national ministries have sectoral directorates and governorate-level sectoral budgets, implying that any fragmentation difficulties in national-level climate action and planning will be replicated at the local level. Therefore, it is highly

important for Egypt to take strong steps toward defining and distributing roles among all stakeholders. The NCCS proposed an integrated institutional framework for articulating climate action until 2050 through streamlined mitigation and adaptation priorities, as well as enabling goals aimed at overcoming legal, regulatory, financial, technological, and capacity limitations. The NCCS also establishes objectives for the creation of specialized climate change units in all ministries, which are expected to strengthen sector and overall institutional cooperation. However, local-level institutions must be empowered, and their institutional ability and mechanisms must be developed to advance climate change action to build resilience to climate hazards and chronic stressors and to decarbonize the economy.

Financing, investments, and business action

Green investments have a two-fold beneficial macroeconomic effect on aggregate supply and demand. According to UNEP (2011), a strategy of reallocating investments toward the green transition may result in slower short-term economic growth as renewable natural resources are replenished—an effect that can be strong in some sectors, such as fisheries. But in the long run, such investment will result in faster economic growth by mitigating the negative consequences of climate change, energy shocks, water scarcity, and ecosystem service loss, as well as creating more job opportunities. For Egypt to achieve this accelerated long-term economic growth, given its vulnerability to climate change, a sizable flow of investments is needed. As described earlier, the NDC outlines U.S. $246 billion of required investments and financial support for adaptation and mitigation by 2030 (Arab Republic of Egypt, 2022). For context, the Green Climate Fund is funding 4 projects in Egypt with a total of U.S. $296 million, or less than 0.5 percent of the total estimated financial needs (GCF, 2022).

A challenge facing green finance in Egypt is the fragmentation of the investment planning process, which causes the sub-national socio-economic development plan to lack a focus on climate resilience and low-carbon development. But the government of Egypt has recently disseminated a new planning law for governorates that mandates all spatial, economic and investment plans at the local level to be climate-risk informed and to incorporate development solutions. One example is the ongoing government program “Haya Karima,” which supports the government’s direction toward climate-resilient and green development approaches for long-term sustainability. Yet, Egypt needs to create the enabling environment that would attract much more climate financing.

Looking at government accounts, addressing the threat of climate change necessitates balancing deficit-increasing policies with those that promote fiscal sustainability. This balance can help government entities to be more accountable for climate action while strengthening

public financial management systems for mobilizing and reporting climate funds. Despite continued fiscal consolidation, the government debt-to-GDP ratio grew from 87 percent at the end of June 2020, to 91.6 percent at the end of June 2021 (World Bank, 2021a). An overall budget deficit that is bigger than that of Egypt's peer countries consumes a considerable portion of domestic savings that are already low, notably due to the extent of debt service (World Bank, 2021b). As a result, only a limited amount of domestic financing is available for new investment. In 2021/2022, the funding gap for development projects was estimated to reach 6.4 percent of GDP (UNDP, 2021). Egypt has had also low and declining foreign direct investment (FDI) inflows in recent years, out of which nearly three-quarters are primarily directed toward the petroleum sector (IFC, 2020). Due to limited fiscal space, low savings rates, and a lack of foreign investment, Egypt confronts a finance vacuum to support green projects.

Under the Green Financing Framework, Egypt has set a goal for 50 percent of public investment projects to be green by 2025, implying that public assets and investments comply with climate change disaster and risk assessments criteria (Arab Republic of Egypt, 2022b). The Environmental Sustainability Criteria Guideline has already supported the corresponding ratio to increase from 15 percent in FY2019/20 to 30 percent in FY 2020/21 (Arab Republic of Egypt, 2022b). Public investments that ignore climate change hazards risk being turned down for international finance. Furthermore, mobilizing private financing on climate change priorities will be critical in the coming years. A significant step in this direction that could be leveraged and expanded was already taken by Egypt in 2020, issuing the MENA region's first-ever sovereign green bond, valued at U.S. $750 million (IFC, 2021). Egypt’s Ministry of Finance launched the green bond through a partnership between the International Finance Corporation (IFC) and the Commercial International Bank (CIB), with the financing directed toward for green energy enterprises and green buildings (IFC, 2021).

In addition to external funds and private finance of green projects, the government of Egypt has other options to raise climate funds from domestic sources. One option is through phasing out subsidies for environmentally hazardous goods and activities, such as fossil fuel subsidies. Egypt has already reduced its fuel subsidies by 75 percent, from 115 billion pounds in FY2016/2017 to 28.2 billion Egyptian pounds in FY2021/2022, and should continue to lift the rest as part of its economic reform (UNDP, 2021). However, removing fuel subsidies can disadvantage poor people if not associated with appropriate social protection schemes and measures. For this reason, Egypt has introduced the successful “Takaful and Karama” cash-subsidies programs. Nonetheless, fuel subsidies are expected to increase again to 28 billion pounds in the 2022/2023 Egypt Government Budget in order to protect the poor and limited income classes from the negative economic impact of the war in Ukraine, the variability in fuel prices and the devaluation of the Egyptian pound. Another option for the government is to tax

emissions based on the carbon content of the fossil fuels that produce them. This environmental tax could be directly levied on specific goods and services based on the environmental externalities produced through consumption or production. According to simulations using an intertemporal general equilibrium model calibrated to Egypt's social accounting matrix for 2014/2015, a gradually phased-in carbon tax with a final rate of U.S. $20 per ton CO_2 could reduce Egypt's fossil-fuel-related GHG emissions by 6 to 10 percent compared to the baseline path (Elshennawy and Willenbockel, 2021). The carbon tax in this case would generate roughly 2.1 percent of GDP once fully implemented (Elshennawy and Willenbockel, 2021). But the effect of the carbon tax on economic growth and household welfare depends on how the additional tax revenue is used. Simulation results indicate that the carbon tax could have a positive impact on economic growth without adverse effects on the distribution of household income if the revenue is used to reduce other tax rates in a way that stimulates additional investment (Elshennawy and Willenbockel, 2021). Hence, a carbon tax should be viewed as a promising potential outcome of incorporating climate change into the fiscal framework. However, it should be coupled with a clear plan to eliminate current carbon subsidies and pricing distortions, while also freeing up fiscal space and incentivizing decarbonization through market-based instruments.

The private sector has a critical role to play in Egypt’s green transition as an investor, developer, and producer of environmentally friendly goods and services, as well as a key contributor to climate change that is also affected by climate change. Involving private sector expertise in the development of private and public–private finance solutions can support climate change actions and encourage private participation in the green transition. Public–private investments can help meet changing demand patterns, alleviate pressure on natural resources, and build resiliency to climate risks. Promoting actions to facilitate private sector adoption of green technologies will be critical, as will offering tools and services to help companies mitigate the risk of asset damages or supply chain disturbances. To unleash the latent potential of Egypt’s private sector to contribute to the green transition, reduced non-tariff barriers are necessary. Moreover, the government needs to revisit its price control policies and technical barriers to trade on most environmental goods. The large extent of state-owned enterprises in Egypt impedes fair competition and creates market distortions that hinder private and foreign investment (IFC, 2020). The government therefore need to improve accountability, disclosure, governance, and transparency of state-owned enterprises to reduce uncertainties in the private sector.

Pathways to Egypt's green transition

In Egypt, the responsibilities and opportunities for green transition must be shared across the entire country and its stakeholders and sectors. Every individual, institution, and economic sector contributes to emissions, either directly or indirectly, through their role in global production and consumption systems. Tracking the distribution of CO_2 emissions in Egypt from 1970 to 2018 using the Emissions Database for Global Atmospheric Research shows a great shift between sectors' contributions to CO_2 emissions (Crippa et al., 2021). In 1970, the top sector contributing to CO_2 emissions was the building sector with 43 percent of the total, followed by the transport and power sectors with 14 percent and 13 percent, respectively. The industrial sector's contribution to CO_2 emissions at that time was barely 9 percent. As of 2018, Egypt's CO_2 emissions stem mainly from power production at nearly 44 percent, followed by the transport sector with 20 percent, while industry emits 15 percent and the construction sector dropped to less than 13 percent. Sectors that contributed the most will not likely carry the greatest cost of climate change. Instead, some sectors will need increase their resilience and others will need to mitigate for a low-carbon development path.

The rest of this section covers the potential pathways to green transition in Egypt's three sectors with the biggest opportunities: agriculture, the lowest contributor to climate change; and power and transport, which are together responsible for about 65 percent of the country's GHG emissions (Crippa et al., 2021). The agriculture sector has several opportunities in the area of resilience and adaptation, whereas the power and transport sectors can offer opportunities in the area of mitigation.

Resilience and adaptation of agriculture sector

Egypt's agriculture sector is highly vulnerable to heatwaves, sea level rise, increased soil salination, rainfall retention, and desertification. Agricultural degradation affects overall food production, farmer incomes, and food insecurity, leading to potentially devastating impacts on the country's economy as well as people's health and wellbeing. Hence, it has become critical to identify and evaluate strategies for adaptation. However, outdated legislation and a lack of funding over the last two decades have weakened the capacity to pursue adaptation.

Following from this, a climate change adaptation policy framework is crucial to outline principles, actions, roles, and financing recommendations that guide national to local stakeholders' engagement in implementing agriculture-related climate change adaptation programs in Egypt. The core of this framework would be "scaling up of best practices" including

technologies, research and development (R&D), policies, capacity building, and financing to reduce vulnerability and enhancing resilience to climate change as well as benefiting from opportunities associated with climate change. In 2013, the World Food Programme and the Ministry of Agriculture and Land Reclamation (MALR), with funding from Climate Change Adaptation Fund, launched an initiative to support adaptation of farmers in Upper Egypt. The program focused on tackling climate change by consolidating land, building early warning systems, testing heat-tolerant varieties of common crops, promoting intercropping, and boosting livestock production. Financing still needs to be increased to move the recommended framework into action. In the meantime, the agriculture sector in Egypt should concentrate on easy and low-cost adaptation measures that can be influenced by traditional knowledge, meeting local conditions, and relevant to sustainable development requirements.

As a key step toward improving the planning of adaptation measures, Egypt needs to improve its scientific capacity. This can be done by seeking technical support from academics and international institutions, catalyzing investments, and engaging the private sector in the development and deployment of earth observation sensors and “internet of things” technologies. Such efforts can foster more transparent, standardized, and complete data in terms of spatial and temporal coverage. Recent studies have also shown that data science, machine learning, and artificial intelligence tools can play an important role in discovering novel insights, understanding multi-variate relationships, and developing adaptation strategies to climate change. However, improving scientific capacity will not achieve intended outcomes without efforts to bridge the gap between science, local knowledge, and stakeholder awareness, including among farmers. This in turn can help communities better plan for adaptation through planting of crops such as drought-resistant wheat, which require significantly less irrigation water compared to dry season rice. Other priorities include developing new crops adapted to a greater temperature, changing planting dates and crop varieties, mixed cropping, improving the irrigation efficiency, and raising farmer awareness about the importance of proper use of water resources (Arab Republic of Egypt, 2010).

The MALR recently signed an agreement for the “Scaling up Climate Change Ambition on Land Use and Agriculture” project with the UN Food and Agriculture Organization in an attempt to help Egyptian smallholder farmers promote smart practices for climate resilience. The project explores techniques like trying soil-less hydroponics, using alternative crop varieties, converting traditional irrigation systems to drip or sprinkler irrigation, and using solar-powered harvesting equipment. Expanding smart agriculture and early warning systems in Egypt represents another opportunity for innovation and farming tech-based businesses. Climate-smart agriculture and new technologies that involve cloud computing and big data can provide breakthrough solutions to help farmers access dramatically augmented data to inform their decision-making. Big data

technologies that encompass the creation of cloud-based ecosystems from multiple data sources integrated with the right tools and software have been introduced already in many agricultural applications (Astill et al., 2020; Cockburn, 2020; Pylianidis, Osinga, and Athanasiadis, 2021; Saiz-Rubio and Rovira-Mas, 2020; Wolfert et al., 2017). To narrow the R&D gap in Egypt, overall investment increases in agriculture must be at the top of the new climate change policy agenda. The share of agriculture in the national investments should increase to 10 percent, up from approximately 5.3 percent in 2020 (Khorshed and Shaker, 2022). The execution of this climate change adaptation policy is expected to simulate considerable net gains for Egypt's economic growth, food insecurity and rural poverty.

Decarbonization of transport sector

The transport sector has a been a major driver of Egypt's increasing CO_2 emissions, with road transport as the largest component contributor. Hence, sustainable road transport is a pillar of the Egyptian carbon emissions mitigation strategy that aims to reduce the sector's emissions by 7 percent by 2030, relative to the BAU scenario (Arab Republic of Egypt, 2022b). The transport sector presents several broad opportunities. The first lies in accelerating electrification, while continuing to advance fuel economy. The Greater Cairo Air Pollution Management and Climate Change project, financed by the World Bank with U.S. $200 million, includes the purchase of 100 electric buses by the Ministry of Environment, which will work with its Environmental Affairs Agency, Cairo Governorate, and the Cairo Transport Authority to implement the project (Wes, 2022). The same project supports the monitoring of climate pollutants, which will help Egypt integrate its climate and air quality management plans (Wes, 2022).

Decarbonization in the transport sector is not only about replacing vehicles with internal combustion engines with electric ones, but more about shifting away from cars through improving public transport, which can in turn improve incomes, work opportunities, school attendance, and health facility access, thus reducing poverty and mortality rates. The National Authority for Tunnels, part of the Egyptian Ministry of Transport, is currently working on expanding and improving the underground metro network across Greater Cairo, developing the metro and rehabilitating the tram service in Alexandria, and developing and operating two monorail lines with a total length of 96 km to link Cairo with new urban communities. Other projects include railway improvements across the country. In May 2022, Egypt ratified a contract with the German company Siemens Mobility to build a safe and sustainable fully electric railway system, consisting of high-speed trains and a new 2,000 km railway network with a large investment of 8.1 billion Euro. In addition, the Ministry of Housing and Ministry of

Environment is working with UNDP-GEF on introducing a high-quality bus system operating on less carbon intensive fuels (i.e., natural gas).

Road quality forms another key ingredient for an Egyptian climate strategy. A recent study by Moussa (2022) suggests that the street quality in Egypt affects the amount of CO_2 emissions produced, because a car moving at a constant speed produces less CO_2 emissions than a car forced to stop for external factors like cracks in the roads. Since 2014, Egypt has aimed to upgrade its quality of road network and infrastructure by constructing 1,000 bridges and tunnels, constructing paved roads and utilizing modern asphalt recycling technologies to reduce environmental impacts (Arab Republic of Egypt, 2022b). This should improve the interconnections between cities and decrease the commuting time and fuel consumption for road vehicles. According to the World Economic Forum's (WEF) Global Competitive Report, Egypt's quality of road infrastructure now ranks second in Africa and 28th worldwide, jumping from 118th in 2014 (IDSC, 2021).

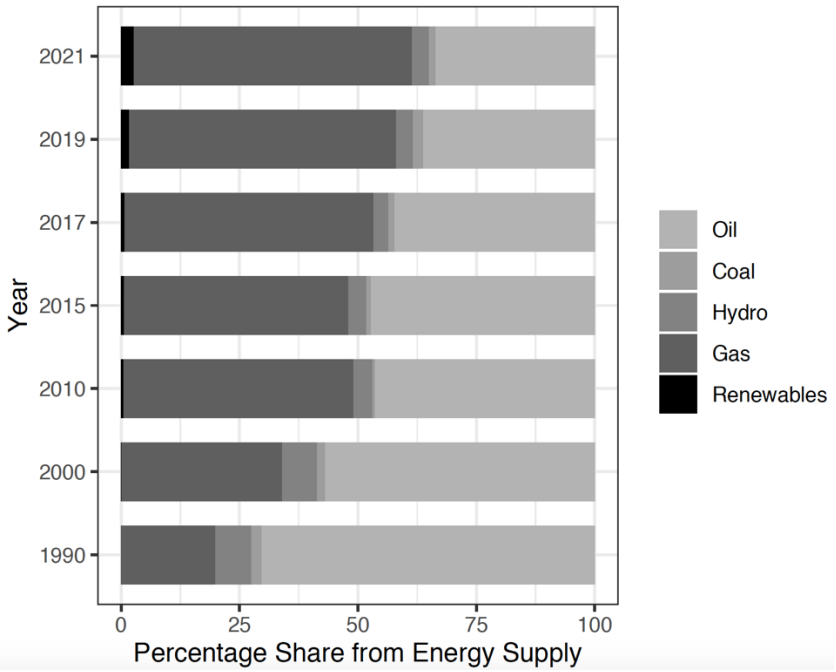
Most of the above projects aim at convincing car owners to use public transportation in the daily commute and hence reduce the share of transport from fossil-fuel emissions. Shifting from private passenger and freight vehicles into mass public transit involves large investments in public infrastructure; presenting opportunities for private investment or commercial finance (Arab Republic of Egypt, 2022; Wes, 2022). However, government should pair the funds on these projects with fiscal measures to align incentives, such as reducing and eliminating fuel subsidies and imposing taxes on emissions, as highlighted earlier in Section 3.3.

Restructure of power sector

The power sector in Egypt needs a significant expansion of renewable energy to lead the country to a low carbon path, strengthen its competitiveness, promote electrification of transportation, and expand export opportunities. In 1986, Egypt established the New and Renewable Energy Authority (NREA) with a goal to develop renewable energy from wind and solar. In 2016, the country launched the Integrated Sustainable Energy Strategy (ISES) to safeguard a secure and stable power supply. It has set an ambitious goal for renewables to account for 20 percent of power generation by 2022 and 42 percent by 2035 (IRENA, 2018; Ersoy and Terrapon-Pfaff, 2021). Ever since, several sizeable renewable energy projects have been implemented and bidding has received a great deal of international attention. Projects in partnership with the United Nations have urged factories to use solar energy as one of the primary sources of energy in industry, which is one of the main factors and sectors affecting Egypt's pathway toward green transition. However, Egypt's current power mix displays a fluctuating trend of only around 8 to 9 percent of renewable energy in the share of total power

generation, while natural gas represents the fastest growing share (CAPMAS, 2021; see figure 3.2).

Figure 3.2: Evolution of energy supply mix shares in Egypt, 1990-2021



Source: Our World in Data based on BP Statistical Review of World Energy (2022). OurWorldInData.org/energy

Investments in renewable energy were encouraged by the Government of Egypt through multiple policy measures regulated under Renewable Energy Law (Decree No 203/2014) and other supporting legislations. As a partial result of this, the total installed wind and solar power generation capacity has increased by 340 percent from 887 MW from FY2015/16 to 3,016 MW in FY2019/20 (Arab Republic of Egypt, 2022b). Among the most prominent renewable energy accomplishments in the power sector is the construction of Benban solar park in Upper Egypt, financed by the European Bank for Reconstruction and Development (EBRD), the International Finance Corporation (IFC), and other international financial institutions (Salah et al., 2022). External investors and developers from Western and Eastern Europe, the United Arab of Emirates, and Japan have also signed multiple partnerships with the Egyptian government for the construction of other renewable energy power plants, including the Assuit hydropower plant, Kom Ombo solar PV Plant, Gabal El-Zeit wind power plant, and Al-Dabaa nuclear power plant (Salah et al., 2022).

The government plan of increasing the share of renewable energy involves accelerating the scale-up of on-grid renewable energy by reducing coal capacity in the generation mix and replacing inefficient thermal power plants. This scale-up requires the transformation of the electricity grid to a smart grid through modern digital technology, smart metering, and flexible solutions appropriate to the local context and expanding on regional interconnections (IRENA, 2018). New technologies like green hydrogen provide a better alternative to produce electricity without emitting CO_2 and present large opportunities for green investment. Egypt is now preparing its national hydrogen strategy, expected to be completed before COP27, and signing several memorandums of understanding between its government bodies, the private sector, and international companies aiming at establishing projects to produce green ammonia and green fuel and develop hydrogen-based industry in Egypt with the capability of export (Ministry of Electricity and Renewable Energy, 2022b). However, the government is yet to focus on transforming these agreements and memorandums of understanding into binding contractual arrangements for implementation.

Even though investment and its uptake in renewable energy is rising, the high growth in total power demand due to the fast-growing population, is to some extent met by the increased use of fossil fuels (Mondal et al., 2019). Instead of flaring, the associated gases generated from the crude oil fields are directed to gas processing facilities to produce Liquified Natural Gas (LNG). The latter has been reclassified in February 2022, by the EU as being in line with its climate and environmental objectives and will help accelerating the shift from solid or liquid fossil fuels toward a climate-neutral future. This represents a big opportunity for Egypt, especially after the Ukrainian–Russian war, as Europe seeks new sources of gas supplies like LNG.

Owing to the new offshore natural gas discoveries of Zohr field in 2019, Egypt achieved natural gas self-sufficiency and is becoming a net energy exporter of LNG (Esily et al., 2022). Natural gas and Egypt's renewable energy projects can create a marketable electricity surplus that is set to grow significantly. In April 2022, seeking to create a balance between promoting renewable energy and procuring reliable and affordable supplies of LNG, the EU and Egypt signed a major agreement on LNG and green hydrogen. This type of agreement shows how electricity interconnections to Europe, the Middle East, and sub-Saharan Africa could transform Egypt into an inter-regional energy power and a global leader in the production of green hydrogen and its derivatives. However, it is also critical to assess from a macro-fiscal perspective the extent to which investments in natural gas minimize or suspend the opportunities of investment in green power projects. Acceleration of renewable energy in power generation might be hindered by cross-subsidized prices of gas provisions.

Concluding remarks

Humankind bears a significant amount of the responsibility for the climate damage it has inflicted through harmful emissions that have raised our planet's temperatures to increasingly dangerous levels. Sadly, the trend has not begun to reverse due to failure to commit to pledges to stop the harm—as though the cumulative damage already caused since the first Industrial Revolution has not already been enough. Egypt is among those countries where temperature is projected to increase, and rainfall is projected to decrease over the next fifty years. These changes can have devastating impacts on the country's public health, human capital, and economic growth, on top of the recent string of challenges, including the pandemic, inflation, stagnation, increasing debt, and the war in Ukraine. As long as there is money, knowledge, and technology to reduce greenhouse gas emissions and keep global temperatures from rising by more than 1.5 degrees Celsius compared to pre-Industrial Revolution levels, the fight against climate change is as urgent and necessary as ever.

It is also important that the responsibilities and opportunities of green transition are shared across the entire country and its sectors, because every individual, institution and economic sector contributes to emissions, either directly or indirectly through their role in global production and consumption systems. To achieve green transition, some sectors like agriculture have opportunities to adapt and increase their resilience, while others like energy and transport have more opportunities to mitigate emissions on a low-carbon development path.

Egypt is demonstrating its adherence to the Paris Climate Agreement and its pathway to green transition through its national climate change strategy (NCCC) and nationally determined contribution (NDC). The recently updated NDC is strengthening actions, adaptation, and policies, while also offering sectoral targets. However, it is still difficult for Egypt to plan effectively for climate hazards and assess implementation progress, due to limited and inadequate data availability, low data accuracy, and limited resources. Egypt also lacks a comprehensive framework for assessing the climate change implications of various projects within a national system, with few standards for analyzing project social implications, including climate change-related social impacts. Among the multiple challenges facing climate change efforts in Egypt, the most important is the lack of public awareness in the use of scarce resources. Another is the weak implementation of laws and policies because of limited institutional capacities and poor coordination between stakeholders. Overlapping laws and obsolete environmental standards coexist with the inadequate mechanisms to ensure the integration of environmental dimensions and principles of sustainable development into sectoral plans. Limited government

funding and private sector participation in financing climate action remain major obstacles too. In short, Egypt needs to adopt a holistic approach that urgently tackles adaptation needs, fast-tracks mitigation investments, and supports more Egyptians pivot from struggling to succeeding. Many ingredients for greater progress are now in place. The opportunity just needs to be seized with urgency.

References

Abdallah, L. (2020). Egypt's nationally determined contributions to Paris agreement: Review and recommendations. *International Journal of Industry and Sustainable Development*, *1*(1), 49–59.

Abdelfattah, Y., Abou-Ali, H., Abdel-Latif, H. and Abdelfattah, A. (2021). Long-term macroeconomic effects of climate change: Evidence from the MENA region. Economic Research Forum Working Paper, ERF27_115.

Abdel Monem, M. A., and Lewis, P. (2020). Governance and institutional structure of climate change in Egypt. *Climate Change Impacts on Agriculture and Food Security in Egypt* (pp. 45–57). Springer, Cham (New York). DOI: 10.1007/978-3-030-41629-4

Abou-Ali, H., Hawash, R. Ali, R. Abdelfattah, Y. and Hassan, M. (2022). Is it getting too hot to work? Investigating the impact of climate change on labour supply in the MENA region. *Applied Economics*. DOI: 10.1080/00036846.2022.2107165.

Arab Republic of Egypt. (2010). Egypt National Environmental, Economic, and Development Study (NEEDS) for climate change. UNFCCC, p.5. Retrieved from http://unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/egypt_final_report_needs.pdf

Arab Republic of Egypt. (2017). Egyptian intended nationally determined contribution.

Arab Republic of Egypt. (2022a). Summary for policymaker. Egypt National Climate Change Strategy 2050. [In Arabic].

Arab Republic of Egypt. (2022b). Egypt's first updated nationally determined contribution. Retrieved from https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated% 20NDC.pdf.pdf

Assaad, R. (2022). Beware of the echo: The evolution of Egypt's population and labor force from 2000 to 2050. *Middle East Development Journal*, *14*(1), 131. DOI:10.1080/17938120.2021.2007649

Astill, J., Dara, R.A., Fraser, E.D.G., Roberts, B., and Sharif, S. (2020). Smart poultry management: Smart sensors, big data, and the internet of things. *Comput. Electron. Agric.*, *170*, 105291.

Brandi, C., Dzebo, A., Janetschek, H., Lambert, C. and Savvidou, G. (2017). NDC-SDG Connections. Deutsches Institut für Entwicklungspolitik (DIE), German Development Institute, and Stockholm Environment Institute. DOI: 10.23661/ndc-sdg_2017_1.0

Burck, J., Uhlich, T., Bals, C., Hohne, N., Nascimento, L., Tamblyn, A., and Reuther, J. (2022). Climate Change Performance Index 2022: Results, monitoring climate mitigation efforts of 60 countries plus the EU–covering 92% of the Global Greenhouse Gas Emissions, Berlin, Germany, Germanwatch, New Climate Institute and Climate Action Network.

CAPMAS. (2019). National Statistical Report for Monitoring SDGs in Egypt [in Arabic].

CAPMAS. (2021). Statistical Yearbook. Retrieved from https://www.capmas.gov.eg/Pages/StaticPages.aspx?page_id=5034

Cockburn, M. (2020). Review: Application and prospective discussion of machine learning for the management of dairy farms. *Animals*, *10*(9), 1690. DOI: 10.3390/ani10091690

Crippa, M., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, Eleonora, et al. (2021). EDGAR v6.0 greenhouse gas emissions [Dataset]. European Commission, Joint Research Centre (JRC) PID. Retrieved from http://data.europa.eu/89h/97a67d67-c62e-4826-b873-9d972c4f670b

Dzebo, A., Janetschek, H., Brandi, C., and Iacobuta, G. (2019). Connections between the Paris Agreement and the 2030 Agenda: The case for policy coherence. SEI Working Paper. Stockholm Environment Institute, Stockholm

Elayouty, A. and H. Abou-Ali. (2022). Functional data analysis of the relationship between electricity consumption and climate change drivers. *Journal of Applied Statistics*. DOI: https://doi.org/10.1080/02664763.2022.2108773.

Elayouty, A., Abou-Ali, H., and Hawash, R. (2022). Does climate change affect child malnutrition in the Nile Basin? Economic Research Forum Working paper.

El-Shal, A., Mohieldin, M., and Moustafa, E. (2022). Indirect impact of health disasters on maternal and child mortality. *Economic Analysis and Policy*, *74*, 477–493

Elshennawy, A, and D. Willenbockel. (2021). The effect of a carbon tax on the Egyptian economy: A general equilibrium analysis. Economic Research Forum Working Paper, No. 1525.

Ersoy, S. and Terrapon-Pfaff, J. (2021). *Sustainable Transformation of Egypt's Energy System*. Friedrich-Ebbert-Stiftung. Retrieved from https://library.fes.de/pdf-files/bueros/aegypten/19259.pdf

Esily, R., Chi, Y., Ibrahiem, D., and Amer, M. (2022). The potential role of Egypt as a natural gas supplier: A review, *Energy Reports*, *8*, 6826–6836.
DOI: https://doi.org/10.1016/j.egyr.2022.05.034.

Gaind, N., Abbott, A., Gibney, E., Witze, A., Tollefson, J., Irwin, A., and Van Noorden, R. (2022). Seven ways the war in Ukraine is changing global science. *Nature, 607*, 440–443. DOI: https://doi.org/10.1038/d41586-022-01960-0

GCF (Green Climate Fund). (2022). Egypt. Retrieved from https://www.greenclimate.fund/countries/egypt

Global Carbon Project. (2021). Supplemental data of Global Carbon Project 2021 (1.0) [Data set]. Global Carbon Project. https://doi.org/10.18160/gcp-2021.

Gonzalez-Perez, M.A., Mohieldin, M., Hult, G.T.M., and Velez-Ocampo, J. (2021). COVID-19, sustainable development challenges of Latin America and the Caribbean, and the potential engines for an SDGs-based recovery. *Management Research*, *19*(1), 22–37. https://doi.org/10.1108/MRJIAM-12-2020-1119

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., and Vogt-Schilb, A. (2016). Shock waves: Managing the impacts of climate change on poverty. *Climate Change and Development.* Washington, DC: World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/22787

Hassan, H. and Amin, E. (2022). Data and data systems. In M. Mohieldin (Ed), *Financing Sustainable Development in Egypt Report*. 22-42. Cairo: League of Arab States.

Hefny, H., Elmakkawe, M. and Ramadan, M. (2019). Climate governance in Egypt. The public policy HUB The School of Global Affairs and Public Policy The American University in Cairo. Retrieved from https://documents.aucegypt.edu/Docs/GAPP/Public%20Policy%20Hub%20Webpage/17-%20Climate%20Governance%20in%20Egypt%20-%20En.pdf

IDSC (The Egyptian Cabinet Information and Decision Support Center). (2021). "Implementation of a nationwide smart system for roads in Egypt", IDSC Policy Perspective.

IFC. (2020). Country private sector diagnostic: Creating markets in Egypt. Retrieved from https://www.ifc.org/wps/wcm/connect/af513599-08b4-45a4-b346-1a44de58cda6/CPSD-Egypt.pdf?MOD=AJPERES&CVID=npT1-BJ

IFC. (2021). Going green: How a landmark bond is supporting climate-friendly projects in Egypt. Retrieved from https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/going+green+how+a+landmark+bond+is+supporting+climate+friendly+projects+in+egypt

IPCC. (2022). Sixth Assessment Report Working Group III – Mitigation of climate change. Retrieved from https://www.ipcc.ch/report/ar6/wg3/

IRENA. (2018). Renewable Energy Outlook, Egypt. Retrieved from https://www.irena.org/publications/2018/oct/renewable-energy-outlook-egypt

Khan, M., Mohaddes, K., Ng, R., Pesaran, M. Raissi, M., and Yang, J.C. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics, 104*. Retrieved from https://doi.org/10.1016/j.eneco.2021.105624.

Lankes H.P., Soubeyran E., and Stern, N. (2022) *Acting on Climate and Poverty: If We Fail on One, We Fail on the Tther.* London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science.

Mondal, M.A.H., Ringler, C., Al-Riffai, P., Eldidi, H., Breisinger, C., and Wiebelt, M. (2019). Long-term optimization of Egypt's power sector: Policy implications. *Energy, 166*, 1063–1073. https://doi.org/10.1016/j.energy.2018.10.158

Ministry of Electricity and Renewable Energy. (2022a). Renewable Energy Targets. http://nrea.gov.eg/test/en/About/Strategy

Ministry of Electricity and Renewable Energy. (2022b). Unpublished presentation on energy investment in Egypt: Opportunities of Egypt energy transition, May 2022.

Moussa, R.R. (2022). Reducing carbon emissions in Egyptian roads through improving the streets quality. *Environ Dev Sustain*. DOI: 10.1007/s10668-022-02150-8

Parry, I., Black, S., and Vernon, N. (2021). Still not getting energy prices right: A global and country update of fossil fuel subsidies, international monetary fund. Working Paper No. 2021/236.

Pylianidis, C. Osinga, S., and Athanasiadis I.N. (2021). Introducing digital twins to agriculture. *Comput. Electron. Agric., 184*, 105942.

Ramadan, R. (2022). The state of the sustainable development goals in Egypt: Focus on poverty and inequality. In M. Mohieldin (Ed.), *Financing Sustainable Development in Egypt Report*. 2-21. Cairo: League of Arab States.

Ripple, W., Wolf, C., Newsome, T., Barnard, P., Moomaw, W., and Grandcolas, P. (2019). World scientists' warning of a climate emergency. *BioScience*. 70(*1*), 8-12. DOI 10.1093/biosci/biz088

Saiz-Rubio, V. and Rovira-Mas, F. (2020) From Smart farming towards agriculture 5.0: A review on crop data management. *Agronomy-Basel*, *10*(2), 207. DOI 10.3390/agronomy10020207

Salah, S., Eltaweel, M., and Abeykoon, C. (2022). Towards a sustainable energy future for Egypt: A systematic review of renewable energy sources, technologies, challenges, and recommendations, *Cleaner Engineering and Technology*, 8, 100497. DOI 10.1016/j.clet.2022.100497

Siam, G., Kotb, M., and Abdrabbo, M. (2013). Policy brief to climate change adaptation of agriculture sector. MDG Achievement Fund.

Shawoo, Z., Dzebo, A. Hägele, R., Iacobuta, G., Chan, S., Muhoza, C., Osano, P., Francisco, M., Persson, Å., Linner, B-O., and Vijge, M.J. (2020). Increasing policy coherence between NDCs and SDGs: A national perspective. SEI policy brief. Stockholm Environment Institute. Stockholm.

UN Women Watch. (2022). Women gender equality and climate change. Retrieved from https://www.un.org/womenwatch/feature/climate_change/downloads/Women_and_Climate_Change_Factsheet.pdf

UNDP. (2018). National adaptation plans in focus: Lessons from Egypt. Retrieved from https://www.adaptation-undp.org/sites/default/files/resources/naps_in_focus_lessons_from_egypt.pdf

UNDP (United Nations Development Programme). (2021). National Human Development Report 2021: Egypt: Development, a right for all: Egypt's pathways and prospects. New York.

UNEP (United Nations Environmental Programme). (2021). Measuring progress: Environment and the SDGs. Nairobi.

UNEP (2011). Towards a green economy: Pathways to sustainable development and poverty eradication. A Synthesis for policy makers, February. Retrieved from http://www.unep.org/greeneconomy/GreenEconomyReport/tabid/29846/Default.aspx

United Nations Climate Change. (2022). Gender and climate change: An important connection. Retrieved from: https://unfccc.int/gender

University of Notre Dame (2020). Notre Dame global adaptation initiative. Retrieved from https://gain.nd.edu/our-work/country-index/

Wes, M. (2022), Egypt: Acting against climate change for a healthier, more prosperous future. World Bank News. Retrieved from https://www.worldbank.org/en/news/opinion/2022/04/19/-egypt-acting-against-climate-change-for-a-healthier-more-prosperous-future

Wolfert, S., Ge, L., Verdouw, C., and Bogaardt, M.J. (2017). Big data in smart farming–A review. *Agric. Syst., 153*, 69–80

World Bank. (2021). Climate risk profile: Egypt (2021). The World Bank Group.

World Bank. (2021a). Egypt economic monitor, December 2021: The far-reaching impact of government digitalization.

World Bank. (2021b). Unlocking Egypt's potential for poverty reduction and inclusive growth. Egypt Systematic Country Diagnostic Update.

World Bank. (2021c). Green resilient, and inclusive development.

World Bank. (2021d). World development indicators database. Retrieved from https://databank.worldbank.org/source/world-developme
nt-indicators. Accessed July 2022.

BROOKINGS

1775 Massachusetts Ave NW,
Washington, DC 20036
(202) 797-6000
www.brookings.edu