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Climate Change in Egypt: Opportunities and Obstacles

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Introduction

Because of climate change, Egypt's already arid climate will suffer from additional environmental stresses, including extreme temperatures, irregular precipitation, elevated sea levels and land subsidence, coastal flooding, shoreline erosion, deteriorating soil salinity, and persistent drought. These mutually reinforcing impacts will build on one another, worsening water scarcity, hindering food security, displacing exposed populations, and destabilizing the Egyptian economy. Climate change will therefore exert added pressures on already precarious populations and push still other groups to unprecedented levels of vulnerability. Efforts to adapt to a changing climate will also exact a steep price, exposing existing governance shortfalls and deepening deficits. As climate change escalates burdens on state capacity, it will become even more urgent for the country to take proactive measures. Egypt needs, therefore, to accelerate its climate governance efforts if it hopes to stabilize its economy and protect its vulnerable populations.

Before evaluating the socioeconomic and political consequences of climate change, it is necessary to outline Egypt's preexisting environmental challenges. This overview will establish a baseline for understanding the compounding impact of climate change, with a view to how climate change deepens existing vulnerabilities, aggravates governance challenges, and requires new public policy designs to address it.

Pre–Climate Change Profile: Environment, Economy, and Demographics

Hot, dry, and consisting almost entirely of uninhabited desert, Egypt has long had environmental challenges. The North African country overlooks the Mediterranean and Red Seas, and almost all of its fresh water comes from the Nile River. Owing to the arid climate, 95 percent of Egyptians live on less than 6 percent of the land, mostly around the Nile.[1] This population distribution has come about in part because Egypt's scarce annual precipitation is limited to a mean of 33.3 mm, with most centered along the Mediterranean coastline in Lower Egypt.[2] Rainfall in the country amounts to less than 1.8 cubic kilometers annually, of which only 1 cubic kilometer is successfully exploited for agriculture. It comes as no surprise that Egypt has historically turned to, and settled around, the Nile for thousands of years.[3]

The current water situation is not sustainable. Once the breadbasket of the Roman Empire, Egypt today can no longer depend on the Nile to meet all of its freshwater needs, particularly irrigation. This shortfall is attributable in part to demographics and their consequences on water demand. Between 1989 and 2018, Egypt's population grew at a rapid rate of 2.1 percent per year, almost doubling in three decades to reach 109 million people in 2021.[4] As its population increased, so too did the demand on fresh water, with four-fifths of consumption going to agriculture. The process of reclaiming desert land (or "new land") over the past several decades has only made water demands worse. With its population expected to grow to 160 million by 2050, Egypt will have to confront still greater demands for food and fresh water amid restrained state capacity as climate effects restrict natural resources.[5]

These demographic realities are important to keep in mind. The composition and distribution of Egypt's population will influence how climate change is experienced and by whom, and it may make governance more challenging. Overcrowding in Egypt's megacities offers an example of this disproportionate impact. Already, the population density in Cairo is more than 510 times greater than the national average, with about 60 percent of Greater Cairo's residents still living in informal, impoverished settlements in spite of ongoing government efforts to change this.[6] Residents in these settlements suffer from obstructed access to key municipal services and other resources, such as water or electricity, and consequently are disproportionately vulnerable to climate impacts like extreme heat.[7] The projected pace of urbanization will make this problem worse. In 2021, 57 percent of Egyptians lived in rural areas, constituting a slim but rapidly declining majority.[8] By 2041, however, a greater part of Egyptians are projected to reside in urban zones, with potentially up to 75 percent of the entire population dwelling in cities by 2050.[9] As Egypt urbanizes and as its cities become more crowded, urbanites may have to cope with increasingly burdened resource systems.

These concerns are not limited to cities; demographics will also play a role in aggravating coastal vulnerability on Egypt's northern shore. Even without considering future sea level rise, Egypt's low-lying Mediterranean shoreline is already at severe risk of flooding, coastal erosion, and land subsidence. In 2000, an estimated 2.4 percent of Egypt's territory (23,676 square kilometers) was defined by international experts as a low elevation coastal zone (LECZ), a designation denoting vulnerable coastal regions positioned at altitudes less than 10 meters above sea level. The same year, Egypt ranked seventh in the world for its LECZ population—a substantial 25.5 million Egyptians—meaning that 37.6 percent of the Egyptian population at the time lived in areas directly threatened by sea levels.[10]

With population density in Egypt's LECZ being orders of magnitude greater than the national average (1,075 people per square kilometer in the LECZ compared to seventy people per square kilometer nationally) and with four-fifths of Egypt's population residing within 100 kilometers of the sea, crowding in coastal cities may make accessing services or emergency relief more difficult.[11] As Egypt's national and coastal populations rise, the problem will only become more urgent. This is especially alarming considering that between 11.75percent and 15.56 percent of the entire belt of the Nile Delta may be inundated by the year 2100 because of land subsidence alone—that is, even without accounting for sea level rise or other effects of climate change.[12]

Egypt's economic conditions make the problem even more difficult. Even as Egypt faces the demand to finance climate mitigation and adaptation, it also must contend with an economy suffering from surging debt, skyrocketing inflation, and persistent inequality.[13] With unemployment hovering around 7 percent and annual core inflation soaring to over 40 percent in May 2023, millions of Egyptians are struggling to make ends meet, with about three in ten (29.7 percent) living below the country's national poverty line.[14] Difficult macroeconomic conditions may increase the challenges involved in adapting to climate change. Egypt's economic dependence on its agriculture and livestock sector is a case in point.

For Egypt, agriculture is economically vital. Approximately 55 percent of the country's labor force is involved in various agricultural activities, and in 2019 the sector formally employed 21 percent of Egyptian workers.[15] The Ministry of Agriculture alone employs around 100,000 workers, making it the country's second-largest employer.[16] The agricultural sector generated about 11.3 percent of Egypt's overall gross domestic product (GDP) in 2021. Moreover, its products satisfy around 30 percent of the county's food requirements, making it a crucial source of both sustenance and income for countless Egyptians.[17]

Wheat cultivation is especially crucial, since millions of Egyptians depend on state-subsidized *baladi* bread on a daily basis. This is not without its drawbacks, as Egypt has increasingly relied on wheat imports to meet growing demands. Though Egypt accounted for roughly 40 percent of food production in the Arab world between 2013 and 2014, its "cereal import dependency ratio has increased from 34% to 42% from 1999–2001 to 2011–2013."[18] This reliance on wheat imports has left Egypt vulnerable to food supply shocks, aggravating crises of food insecurity. The coronavirus pandemic and the war in Ukraine have both been recent sources of such shocks. Indeed, since the start of the pandemic, over a quarter of the population have experienced varying degrees of food insecurity, ranging from moderate to severe.[19] The imperative to strengthen food sovereignty and strengthen resilience for the agricultural sector is already clear, even without considering climate-related disruptions.

Equally pressing is the need to build resilience for other climate-exposed sectors, such as tourism, which before the pandemic generated more than 10 percent of GDP and accounted for over 7 percent of jobs.[20] As climate change jeopardizes these critical income streams, it may become increasingly difficult to mobilize the resources necessary to transform vulnerable sectors and accelerate adaptation. In other words, already vulnerable Egyptians may grow even more precarious at the same time that governance becomes increasingly costly and difficult.

Climate Changes and Consequences

Extreme Temperatures, Irregular Precipitation, and Drought

Climate change will lead to heightened temperatures and unpredictable rainfall patterns in Egypt. This weather shift is already underway as the North African country warms at an accelerating speed. Though average annual temperatures have increased at an overall rate of 0.1°C per decade between 1901 and 2013, the rate of temperature rise in the past thirty years alone has shot up to an alarming 0.53°C per decade.[21] Surface temperatures in Egypt and elsewhere in the Nile River Basin have also kept pace with this rise, increasing by an average of 0.16°C to 0.4°C, with El-Minya Governorate in Upper Egypt reaching temperatures of between 40°C and 44°C in recent years.[22]

These rising temperatures show no signs of abating. Rather, climate models predict that Egypt's average annual temperature may rise by a steep 2.1°C by the middle of the century and by a significant 4.4°C by the close of the century, if global emissions persist.[23] Areas such as South Sinai and Aswan will be especially vulnerable to extreme temperatures, warming by an even greater 5.12°C and 5.49°C by 2100, respectively.[24] This projected trend of "more hot weather and less cold weather" is deeply troubling for Egypt's human security, food production, and water scarcity.[25]

The clearest and most immediate impact of atmospheric warming would, of course, be heat stress on humans, animals, and plants. As the global climate warms, heat-related mortality is expected to increase by as much as forty-seven times by 2080.[26] Research suggests that "increased particulate matter concentrations and heat stress could result in approximately 2,000 to 5,000 more deaths per year, with an equivalent loss of 20 to 48 billion [Egyptian pounds] per year."[27] Although these figures are worrying for all Egyptians, not everyone will bear the burden evenly.

Egypt's densely populated cities will suffer disproportionately from the heat-island effect. As urbanites turn to air conditioning to survive the summer heat, increased energy consumption for cooling will backfire, expelling hot air to make cities like Cairo even warmer. This trend is likely to be especially onerous for lower-income residents in informal settlements, who may lack reliable or consistent air conditioning because they are comparatively less able to afford expensive energy costs—especially as government subsidies are reduced.[28] Other populations that are sensitive to heat, such as pregnant women, young children, the elderly, and those suffering from chronic health conditions, also will be more vulnerable. Thus, even though all Egyptians will feel the effects of climate change, overlapping societal and economic vulnerabilities will leave those experiencing a combination of gender-based, class-based, and other inequalities at even greater risk.

Of course, rising temperatures do not only affect humans. Livestock and crops will also suffer from heat stress, resulting in reduced crop yields and decreased milk and meat production, affecting multiple important sources of food and income for rural Egyptians.[29] Rising temperatures also mean escalating water demands as increased heat results in greater plant evapotranspiration. This rise has already been observed as the amount of water lost to evapotranspiration across the Nile Basin in recent years has consistently surpassed the amount gained through precipitation for 90 percent of the time between 2009 and 2019.[30] By 2100, summer and winter crops, including wheat, may require as much as, respectively, 10.9 percent and 13.2 percent more water to grow.[31] These increased demands will cost the water-scarce country precious resources it cannot spare.

For the economy, heat stress may also mean declining productivity. In 1995, Egypt's workers across all sectors lost an estimated 0.16 percent of their annual work hours to heat on average. Whereas heat deprived the economy of around 25,000 productive work hours in 1995, it is expected to waste up to 134,000 work hours per year by 2030. These calculations are based on a best-case scenario of containing global warming to under 1.5°C, with the agriculture and construction sectors experiencing the steepest declines.[32] Of course, this estimate does not account for the other dimensions of heat-induced economic loss, which include health expenditure, costly energy consumption for cooling, and damage to agriculture and livestock.

The consequences of extreme temperatures do not stop there. Atmospheric warming is further expected to disrupt Egypt's domestic food supply chains as elevated temperatures influence the duration of crop-growing periods and even alter the zones suitable for cultivating specific crops.[33] For instance, the increasingly warmer climate in Egypt could drive the cultivation of wheat and deciduous fruits toward northern regions, where relatively cooler temperatures may be more conducive to agriculture.[34] In this context, the contraction of growing seasons because of heat, diminished crop outputs, and the relocation of cultivation zones will reshape Egypt's agricultural terrain. Not only will this curb biodiversity and unsettle the country's food production, but in doing so it may lead to surges in food prices or supply shortages.[35] Decreased rainfall or irregular precipitation are other potential detrimental outcomes.

Climate change will also make Egypt's precipitation less predictable. Indeed, in the past thirty years alone, Egypt's total annual rainfall decreased by about 22 percent.[36] If current trends persist, Egypt's could see its rainfall decline further by 2.9 millimeters annually before the end of the century.[37] As climate change disturbs regional weather patterns, Egypt's rain-dependent dry-land farmers will especially struggle to find alternative sources of irrigation.[38] The agriculture sector as a whole will have to grapple with decreased rainfall, but vulnerable smallholders will be hit the hardest, thereby amplifying the existing economic inequalities between large agrobusinesses and small-scale subsistence farmers.

To make matters even more challenging, the joint impact of decreased precipitation and rising temperatures may also subject Egypt to more drought. By increasing surface water evaporation and reducing groundwater recharge rates, higher temperatures and decreased rainfall could predispose Egypt to more frequent and prolonged hot and dry episodes. Heat waves may be prolonged by nine days to seventy-seven days, while "dry spells [could possibly] increase by 75 days by the 2080s."[39] Needless to say, Egypt's water scarcity and food production will likely suffer as a result.[40]

Sea Level Rise, Land Subsidence, and Flooding

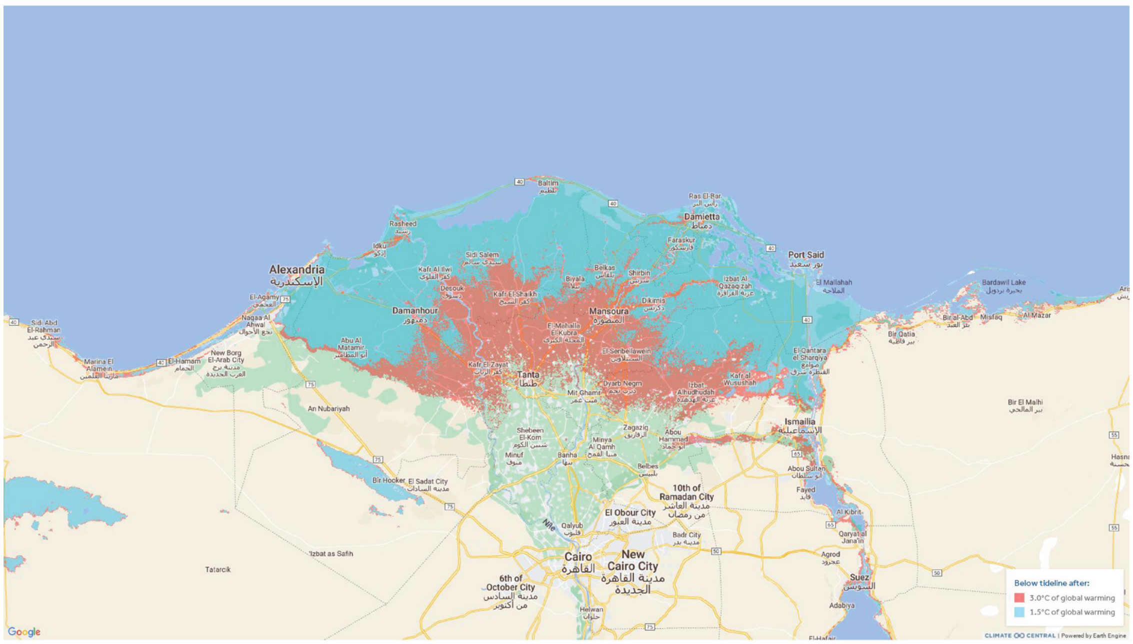
Egypt will also need to reckon with rising sea levels, erosion along its coasts, and land subsidence, as well as their associated problems of flooding, saltwater intrusion, and rising soil salinity. Before demonstrating the effects these issues will have on Egypt's water scarcity, food production, and human security, it is useful to first highlight Egypt's existing coastal vulnerabilities.

As previously mentioned, Egypt's low-lying coasts are already prone to flooding: 2.4 percent of all of Egypt's territory is classified as falling into a LECZ, lower than 10 meters above sea levels.[41] Especially vulnerable is the country's Mediterranean coast. Even without considering the rise in sea levels, land along Egypt's northern coastline is actively subsiding. The Nile Delta is expected to undergo a concerning sinking rate of "1–5 [millimeters]/year to 3.7 [millimeters]–8.4 [millimeters]/year."[42] Alexandria and Port Saied are also sinking at rates of 1.6 millimeters per year and 2.3 millimeters per year respectively.[43] Climate change and the rise in sea levels will exacerbate this already dire situation.

These impacts are already being felt. Between 1993 and 2010, sea levels in the Mediterranean rose by a "significant positive trend of 2.6 cm [per] decade."[44] By the close of the century, they may rise by 22 centimeters, though these are conservative figures.[45] Consequently, projections for 2030 and 2060 anticipate substantial increases in Egypt's vulnerable LECZ population, owing in part to predicted sea level rise, ongoing land subsidence, and continued population growth. By 2030, it is expected that 45 million Egyptians will be seriously threatened by rising sea levels, and by 2060, Egypt's population residing in the LECZ is anticipated to reach 63.5 million—a 249 percent increase in sixty years.[46] The same models forecast equally sharp rises in the number of Egyptians at risk of unusually extreme, once-in-a-century floods—an increase of 281 percent, from 7.4 million people in 2000 to 20.7 million in 2060.[47] With only 26 percent or so of its Mediterranean shoreline considered to be "low vulnerability" or "very low vulnerability," within the span of a few decades Egypt may well become the world's sixth most at-risk country to rising sea levels.[48]

As a result, coastal communities on Egypt's Mediterranean coast are dangerously exposed to climate change. Take Alexandria for example: with 45 percent of its population already living in areas below sea level, Alexandria is at acute risk of flooding.[49] As little as 0.5 meters of sea level rise "would place 67% of the [city's] population, 65.9% of the industrial sector, and 75.9% of the service sector, below sea level . . . 1.5 million people would have to be evacuated, and over 195,000 jobs would be lost."[50] At 1 meter rise, 76 percent of Alexandria's population, 64 percent of its beaches, 52 percent of its residential areas, 72 percent of its industrial sector, and 82 percent of the city's services would be at risk of inundation.[51]

Figure 1. Projected Sea Level Rise at 1.5°C and 3°C



Source: "Comparison: Long-Term Sea Level Outcomes," Climate Central, accessed October 18, 2023, https://coastal.climatecentral.org/map/9/31.1766/31.0103/?theme=warming&map_type=multicentury_slr_comparison&basemap=roadmap&elevation_model=best_available&lockin_model=levermann_2013&refresh=true&temperature_unit=C&warming_comparison=%5B%221.5%22%2C%223.0%22%5D.

Land loss and property damage would be equally devastating in other Nile Delta cities. In a 0.5-meter rise scenario, sea levels may claim $3 billion of property in Rosetta.[52] Port Said is unlikely to fare any better, incurring about $2 billion of lost beach land at 0.5 meters.[53] A 1-meter sea level rise would cause even greater wreckage in these coastal cities.

The impacts of rising sea levels also do not stop at the shore, as the damage done to Egypt's critical coastal cities would ripple across the national economy. Coastal cities contain half of Egypt's industrial sector and 40 percent of its agriculture, with Alexandria's shoreline alone sourcing around 13.3 percent of Egypt's fish production.[54] The government has acknowledged as much, estimating that "about three-fifths of Egypt's food production is secured from agricultural land in the Nile Delta region" which "is expected to lose up to a minimum of 30% of its food production by 2030."[55] This means the impact of rising sea levels on coastal cities would stretch to Egypt's interior, likely disrupting national food supply chains. Coastal erosion would aggravate the problems affecting Egypt's receding shorelines, with saltwater intrusion and increased soil salinity also having corrosive effects on water scarcity and agricultural production. Undoubtedly, protecting Egypt's shores is paramount.

The Aswan High Dam is partly responsible for these issues, because it has disrupted sediment flow running from the Nile to the Mediterranean coast, thereby depriving the latter of important minerals needed to replenish the northern shoreline.[56] This environmental alteration has been compounded by both natural and human-induced factors, including excessive urbanization and cement building along the coast, as well as the removal of crucial shoreline sand dunes to make way for manmade structures. All of these changes have left the Nile Delta coast vulnerable to erosion.[57] Besides resulting in a receding shoreline, coastal erosion has caused sharp increases in salinity by Rosetta's coast, rising significantly from under 27 percent in 1964 to over 29 percent in 2015.[58] By driving saltwater intrusion and increasing soil salinity, coastal instability contributes to the "deterioration of the cultivated land" in Egypt and the "degradation of . . . fresh groundwater."[59] Again, coastal issues become national problems, exacerbating water scarcity and threatening agricultural production.[60]

Considering all these risks on human security and displacement, as well as water scarcity, food security, and economic output, it is clear that robust climate governance is urgently needed to confront Egypt's emerging climate risks and manage evolving communal vulnerabilities.

Climate Governance

How is Egypt responding to climate change? How should it do so?

Answering this question requires a clear definition of climate governance. Put simply, climate governance is how countries like Egypt address climate challenges, either preventatively or reactively. For example, countries can reduce climate change risks by proactively curbing greenhouse gas (GHG) emissions, or they can respond to disasters by evacuating displaced people or providing relief. They can also plan for the future by taking serious steps to adapt to the evolving climate. In the simplest sense, climate governance rests on the pillars of mitigation and adaptation.

Mitigation is straightforward: countries limit their emissions through reduction or removal. Countries like Egypt may reduce their emissions by transitioning away from fossil fuels to renewables, cutting back on energy consumption, or adopting other policies intended to restrict the emissions released. Removal is also self-explanatory; states can preserve or expand "carbon sinks" such as rainforests, which trap or actively remove GHGs from the atmosphere. The shared objective of these strategies is to stop, limit, or at least slow climate change.

Adapting to unavoidable climate change is equally important. The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "the process of adjustment to actual or expected climate and its effects in order to moderate or avoid harm or take advantage of beneficial opportunities." This can be anticipatory or reactive, and typically involves both risk reduction and resilience-building.[61] As the name implies, risk reduction refers to strategies that focus on protecting communities and systems from harmful climate impacts. For example, building sea walls, stabilizing shorelines, and implementing air conditioning all are risk reduction efforts to address present climate challenges or anticipated hazards such as rising sea levels, coastal erosion, and extreme heat. In this sense, risk reduction policies are preventative and protective, with the objective being harm avoidance.

Adaptation also requires enhancing the resilience of societies and institutions to withstand climate pressures. The IPCC defines resilience as the "capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance . . . in ways that maintain their essential function, identity and structure."[62] In other words, adaptation also involves efforts to reorganize and strengthen systems by diversifying economies from precarious revenue streams, for example, or by steering industries and communities away from critical resource dependence. Building capacity—especially learning, monitoring, and creating responsive systems—is another way to strengthen resilience, allowing governments to better plan for and respond to climate emergencies. For this reason, both risk reduction and resilience-building are critical for coping with climate change.

All these dimensions of climate governance, mitigative and adaptive, should not be understood in isolation. Rather, they are complementary and should inform one another. In this sense, even though individual projects may range from effective to misguided, policies that are mismatched can also be cumulatively unsuccessful.

The following sections evaluate Egypt's climate governance in this light. The first section assesses how Egypt is performing on mitigation and emissions reduction, while the second and third sections describe Egypt's adaptive efforts as they relate to hazards, disasters, and water and food security. To that end, the second and third sections devote particular attention to both risk reduction and resilience-building efforts, ranging from sea walls and emergency preparedness to rationalizing water use and fortifying food sovereignty.

Mitigation and Emissions Reduction

Producing 3.5 tons of carbon dioxide (CO_2) per person, Egypt emits below the global average and pollutes at less than half of European Union (EU) levels. However, although the country accounts for 0.73 percent of global GHGs, its emissions have nevertheless skyrocketed by 74 percent in less than three decades (1990–2019).[63] Egypt will have to reverse this trend if it wishes to achieve energy security and build a greener economy.

In the years between 2005 and 2019, Egypt's GHGs rose rapidly by about 44 percent, driven primarily by the power sector (particularly electricity and heat) and by the transport sector (especially roads).[64] These two most polluting sectors have been responsible for 36 percent of emissions and remain on the rise in both absolute and relative terms.[65] They also consume significant volumes of fossil fuels. Indeed, only 10 percent of energy for the power sector comes from renewable energy.[66] The industrial sector is not much better, with fossil fuels dominating around three-fourths of the sector's energy supply.[67]

These trends are not all negative, though. Seen from a glass-half-full perspective, they present Egypt with key opportunities for high-impact reforms if the country succeeds in propelling renewable adoption and improving public transport. Furthermore, while Egypt's prospects may be bleak, successful mitigation is not impossible. Indeed, there may even be some glimmers of hope. Since 1990, Egypt's emissions intensity has declined by 42 percent and the carbon intensity of its economy has fallen by almost a quarter between 2005 and 2019, signaling a trend toward less intensive energy consumption.[68] Additionally, even though Egypt's emissions remain steadily on the rise, the rate of increase does not appear to be exponential. In other words, Egypt's may have not reached the peak of its emission rates, but a future decline is still possible and may even be visible from a long-term perspective.

The goal of net-zero emissions, by contrast, is an entirely different matter. As of August 2023, Egypt still has not announced an unconditional pledge for its Nationally Determined Contribution (NDC) under the Paris Agreement, let alone a net-zero target.[69] Indeed, the word "net-zero" is notably absent from the country's Second Updated Nationally Determined Contributions report.[70] Defining and vigorously pursuing a reasonable but ambitious net-zero target should be a priority for Egypt ahead of the 2023 United Nations Climate Change Conference (COP28).

In the meantime, Egypt must work to meet its existing pledges. To fulfill its NDC under the Paris Agreement, Egypt will need to actively scale up renewable investment and accelerate decarbonization. Specifically, Egypt would need to slash emissions by 23 percent by 2030 in order to be Paris Agreement–compliant.[71] That pledge, however, is a conditional one, contingent on Egypt's receiving $196 billion in international finance to fund mitigation and an additional $50 billion for adaptation.[72]

In the next seven years, Egypt must manage to cut emissions by an amount that is 22 percent below 2015 levels. To do so would entail rapid decarbonization, slashing fossil fuel consumption by up to two-thirds within the decade, and a 15 percent to 38 percent increase in renewables adoption.[73] That figure is a tall order; while renewable energy consumption has increased by 28 percent in the past six years, progress in overall decarbonization has lagged behind, with nonrenewable energy consumption also rising by 0.4 percent between 2016 and 2021.[74] To remain on the Paris Agreement path, Egypt would also have to supplement its efforts with another 5 percent to 21 percent reduction of fossil fuels and a 50 percent to 84 percent increase in renewable adoption by 2050.[75] Barring these increases, it is unlikely Egypt will meet its emissions pledges. The 2030, 2040, and 2050 benchmarks of 23 percent, 50 percent, and 66 percent emissions reductions may be more than what Egypt can feasibly achieve if it sticks to its current path.

Nevertheless, if its announced plans are taken at face value (or as sincere demonstrations of political will), Egypt's mitigation efforts may stand a chance. In its second updated NDC document, published in June 2023, Egypt sped up its targets for renewable adoption by 2030. Within the decade, Egypt plans to source 42 percent of its electricity from renewable power. In its most recent NDC update, Egypt has taken up gas-flaring reduction as a primary part of its agenda to modernize the oil and gas sector.[76] Egypt has also signed a memorandum of understanding for methane management with Chevron and many other companies.[77] Currently, Egypt is working on seven major gas-flare recovery projects and has completed twenty-two projects since 2016.[78] Combined, key flare capture projects under Naftogaz, Pharos Energy, United Oil and Gas, and Apache have successfully captured around 240 million cubic meters per year (around 24 million standard cubic feet per day) and reduced emissions by 1.3 million CO_2-equivalent tonnes per year.[79] Utilizing flared gas for power generation instead of more carbon-intensive sources like diesel or coal will continue to facilitate Egypt's goal in achieving an energy efficient, low-carbon economy. Between 2005 and 2019, the carbon intensity of Egypt's economy—GHG emissions per unit of GDP—dropped by 23 percent.[80]

Egypt is also taking aim at other sources of pollution. Although the energy sector is Egypt's largest gas emitter, the transport sector saw one of the largest emission increases (76 percent) between 2005 and 2019, with road transport being the largest GHG contributor.[81] To tackle this, Egypt has turned to a cleaner energy source, compressed natural gas, which has successfully fueled 500,000 vehicles.[82] Investments in public infrastructure are also spearheading Egypt's green energy transition, particularly in the Greater Cairo area, where diesel bus emissions have helped to make the urban area Egypt's most polluted city.[83]

GHG emissions caused by public transport are being addressed in the most affected areas via large-scale projects—including the Bus Rapid Transit project, which will substitute diesel-operated buses with up to 100 electric buses between 2022 and 2025.[84] Other efforts include the continued expansion of the Greater Cairo underground network to link east and west Cairo by 2024, and the development of Cairo's electric light rail, which will build nineteen stations over a total distance of 103 kilometers.[85] The transformation of Egypt's transport sector is highly significant, since over 90 percent of transport sector carbon emissions reduction hinges on transitioning away from the utilization of cars and taxis.[86] Additionally, as per Egypt's second updated NDC document, the government plans to generate 42 percent of its energy through renewables by 2030 instead of 2035, which was its initial target.[87]

Achieving Egypt's NDC emissions target of a 65 percent reduction in the oil and gas sector and a 33 percent reduction in the electricity sector, however, will require actions beyond scaling back energy-intensive consumption. The country's population will need to make the switch to renewable energy sources while simultaneously limiting reliance on fossil fuels.[88] As of 2019, fossil fuel consumption makes up 95 percent of Egypt's primary energy mix, while renewable energy makes up only 5 percent.[89] Egypt's industry sector represented the largest share of renewable energy consumption in 2019, but 77 percent of its energy supply still comes from fossil fuels.[90]

Egypt's mitigation efforts that focus on lowering the use of carbon-intensive fuels via gas recovery projects and integrating natural gas into public transport are logical first steps. Nonetheless, they bypass the underlying issue of nonrenewable consumption and emissions. For instance, Egypt plans to reduce only 5 percent of the petroleum sector's energy consumption, even though petroleum makes up the second-largest share of energy consumption in Egypt after natural gas.[91] Emissions reduction target plans should encompass more sectoral- and energy source–specific frameworks that also promote cooperation between different government sectors, which is currently lacking.[92]

Even though farming accounts for 9 percent of Egypt's GHG emissions and a third of methane emissions comes from Egypt's agricultural sector alone, efforts to engage the agricultural community in emission reduction planning are lacking.[93] By overlooking the agricultural sector, Egypt continues to underutilize biomass potential—which, according to studies, could contribute up to 3 percent of electricity production in Egypt by 2035 if incorporated in Egypt's renewable energy strategy.[94] Egypt's NDC sets emission targets only for the electricity, transport, and oil and gas subsectors, while other high-emitting sectors—including industry, buildings and urban development, tourism, and waste management—are merely assigned policy measures.[95] Assessing the efficacy of Egypt's mitigation methods is further complicated by the absence of an absolute emissions reduction target in its NDC document. Instead, emission reduction targets are based on a below-BAU (business as usual) rate, which makes it difficult to quantify NDC-reported emissions levels in the context of climate change progress.[96]

Still, it is worth acknowledging instances of effective and holistic climate governance. In advancing emissions reductions, Egypt has also worked to address social needs and improve community resilience. One leading example of Egypt's efforts to mitigate climate-induced hazards is the Housing for All program, launched in 2015 and ongoing until 2030, which creates heat-adaptive housing that is inclusive of lower-income women and youth.[97] The program aims to certify 25,000 housing units with a Green Building Standards certification under the Green Pyramid Rating System (GPRS), which ensures that buildings meet energy efficiency, water efficiency, and environmental quality credentials. Temperature-increase adaptation measures have been extended to rural communities as well. The Building Resilient Food Security Systems to Benefit the Southern Egypt Region project is in its second implementation phase, having established forty-nine functioning early warning systems that have thus far benefited 200,000 farmers and reduced agricultural losses by 60 percent.[98] The Sustainable Agriculture Investments and Livelihoods project, established in 2014 and ongoing till 2024, has also provided early warning systems for thirty villages in Upper, Middle, and Lower Egypt.[99]

Beyond strengthening infrastructural capacities for extreme heat and temperature increase, Egypt has also issued adaptation plans addressing the consequences of rising sea levels and flooding in coastal zones. By 2025, Egypt will have completed its Enhancing Climate Change Adaptation in the North Coast of Egypt project.[100] The project is currently 70 percent complete and will expand existing sand barriers to prevent flooding in the vulnerable low-lying governorates of Kafr El-Sheikh, Beheira, Port Said, Damietta and Dakahlia.[101] Flooding hazards have also proven to be effectively mitigated by Egypt's flash flood warning system, established as a part of the Flash Flood Manager project, known as FlaFloM, in 2007–2009. Significant project outputs include successfully forecasting flash floods up to forty-eight hours prior and implementing an atlas for flash floods covering the Sinai Peninsula.[102]

Egypt's climate hazard mitigation measures have helped safeguard the most vulnerable segments of its population from environmental disasters while also accounting for socioeconomic protections. However, a long road still lies ahead for Egypt's emergency response and disaster reduction strategies. Specifically, there is room for improvement in research, data and information sharing, and institutional capacities. Egypt's 2011 National Strategy for Adaptation to Climate Change and Disaster Risk Reduction stresses sectoral and national and subnational governmental coordination, yet public-private partnerships and communication between Egypt's scientific community and policy makers remains limited.[103]

Although Egypt's GPRS has brought it closer to meeting energy efficiency goals and combating extreme temperature risks, many construction workers in Egypt have admitted that they do not know about the existence of the GPRS, which indicates a gap in technical capacities.[104] Egypt's national strategy for disaster reduction calls for an integrated information system and database across sectors and an improvement in modeling systems for climate hazards, yet on-the-ground follow-through has not been extensive. And even though flooding is one of the biggest climate hazards to urban areas, Egypt has only one flash flood warning system.[105] Additionally, Egypt's Third National Communication Under the United Nations Framework Convention on Climate Change, published in 2016, identified major modeling deficiencies in the case of preparing against droughts.[106] This is one area where international investment could be especially impactful. Building learning and monitoring capacities is an integral part of any governance strategy and would allow Egypt to better observe and respond to climate impacts.

Water Scarcity

Even without factoring in the effects of climate change, Egypt faces a dire water scarcity crisis. Since the late 1970s, Egypt's "total demand on water outstripped supply [from] the Nile," even though the country is already "fully utilizing the available resources of the Nile River."[107] This deficit is especially alarming given that the Nile accounts for 98 percent of Egypt's renewable water supply.[108]

Economic development and a growing population have exacerbated the country's water stress. Egypt's explosive population rise of 2.1 percent annually between 1989 and 2018 and its concomitant GDP increase by 4.4 percent yearly during the same period escalated water demand and consumption, a substantial amount of which was used for agriculture and municipal services.[109] Between 1990 and 2021 alone, the Egyptian population almost doubled, increasing from 56 million to 109 million and compounding pressures on water reserves.[110] Though fertility rates slowed during the same period (from 4.4 to 3.2), by 2050, Egypt's population is projected to reach 160 million.[111]

Thus, even without considering surging consumption demands, Egypt's population growth has strained and will continue to strain its renewable water resources. Between 1977 and 2022, Egypt's per capita annual renewable water supply dwindled from 1,426 cubic meters to around 558 cubic meters; since the early 1990s, Egypt has been well below the Falkenmark threshold of water scarcity (1,000 cubic meters).[112] Now, the country is fast approaching the critical threshold of absolute water scarcity, set at 500 cubic meters per capita. It may well reach this level in the next five years if the current population growth rates do not change. Rising water demands and unsustainable consumption patterns also threaten continued access to the water supply.

Because of its economic development and fast-growing population, Egypt has already felt the pressures of water scarcity over the past few decades. Improved water reuse practices have allowed Egypt to satisfy its freshwater demand gap since the late 1970s.[113] Still, water stress remains a persistent issue. In 2000, water stress, calculated as freshwater withdrawals over freshwater supply, amounted to 103.88 percent. Less than two decades later, in 2019, water stress climbed to a staggering 141.17 percent, not including the vast amounts of freshwater imported to meet the enduring demand gap.[114] Even with enhanced water reuse, Egypt's average consumption of the Nile between 1988 and 2017 amounted to an estimated 61.5 cubic kilometers annually, supplemented by 40 cubic kilometers of annual freshwater imports since the 2010s.[115] The water crisis is already here, and it is steadily getting worse.

By 2030, Egypt is projected to increase the volume of its freshwater imports so substantially that it may eclipse the volume of locally supplied water from the Nile—a situation unprecedented in Egypt's history. From there, the rate at which virtual water dependency increases is further expected to accelerate over time, owing to the "compounding nature" of economic development and population growth.[116] Unless urgent action is taken, Egypt's water scarcity crisis will worsen quickly.

Climate change will intensify Egypt's ongoing and preexisting water scarcity challenges. Sea level rise and seawater intrusion into the Nile have already begun to deplete the river's freshwater supply, while extreme temperatures and irregular precipitation are likely to increase surface water evaporation across the country, thereby worsening droughts and crop failure.[117] Moreover, because the Nile is only about a meter above sea level, rising sea levels can cause the river to shrink. In fact, the Nile is already shrinking at an alarming rate: 3 to 5 millimeters per year.[118] A 0.5- to 1-meter rise in sea levels would cause the Nile to shrink by a predicted 19 to 32 percent, which means that climate change may well deplete up to one-third of the river's freshwater resources by the end of the century.[119]

Given the indispensability of freshwater to agriculture, water scarcity problems in turn contribute to food security challenges.

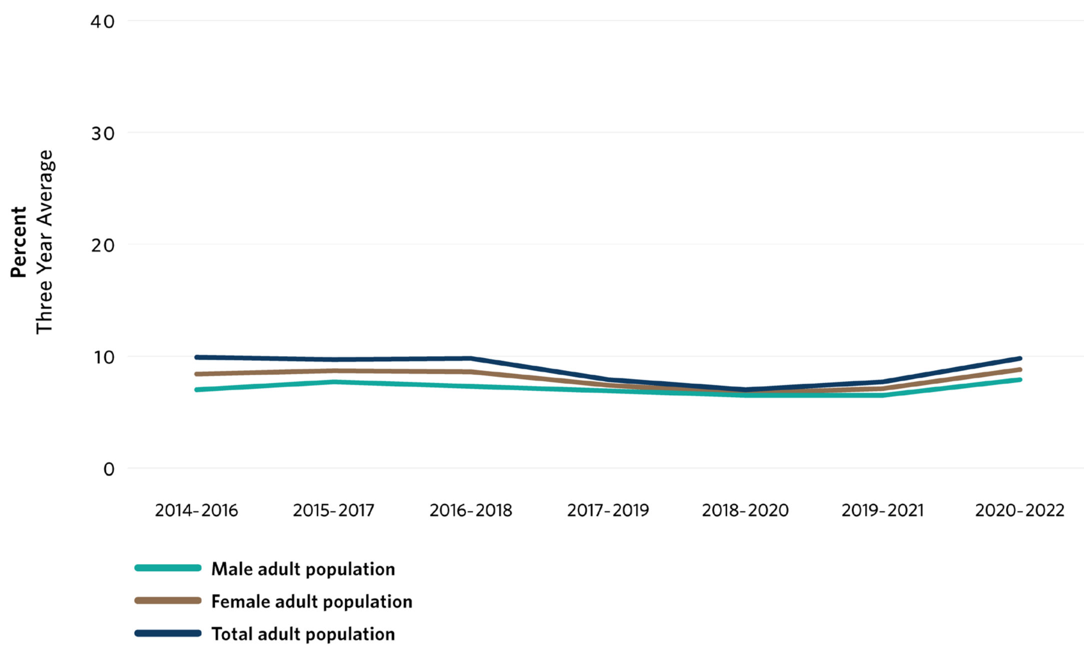
Food Security, Agriculture, and Livestock

Egypt's agriculture is vital, not just in terms of feeding the country's domestic population or advancing regional food security, but also as a pillar of the national economy. As an industry, agriculture and livestock sustain Egyptian livelihoods. Approximately 55 percent of Egypt's labor force is engaged in agricultural activities, and the sector formally employed 21 percent of workers in 2019.[120] The Ministry of Agriculture is the country's second-largest employer, with 100,000 workers.[121] Consequently, the agricultural sector accounted for 11.3 percent of Egypt's overall GDP in 2021, making it an equally important source of income for citizens and revenue for the state.[122]

More directly, Egypt's agriculture and livestock sectors are critical for regional food production and national food security. Domestically, Egyptian agriculture satisfies around 30 percent of the country's dietary requirements while also exporting food regionally and internationally.[123] Between 2013 and 2014, Egypt accounted for about 40 percent of food production in the Arab world and was responsible for roughly 27 percent of regional agricultural exports (as expressed in kilocalories).[124] This does not mean that Egypt can satisfy its food security on its own, however, especially when it comes to critical cereals. Rather, the dramatic increase in Egypt's agricultural import rates since 2000 includes a cereal import dependency ration that has increased from 34 percent to 42 percent in just over a decade.[125] The trend is toward less self-sufficiency.

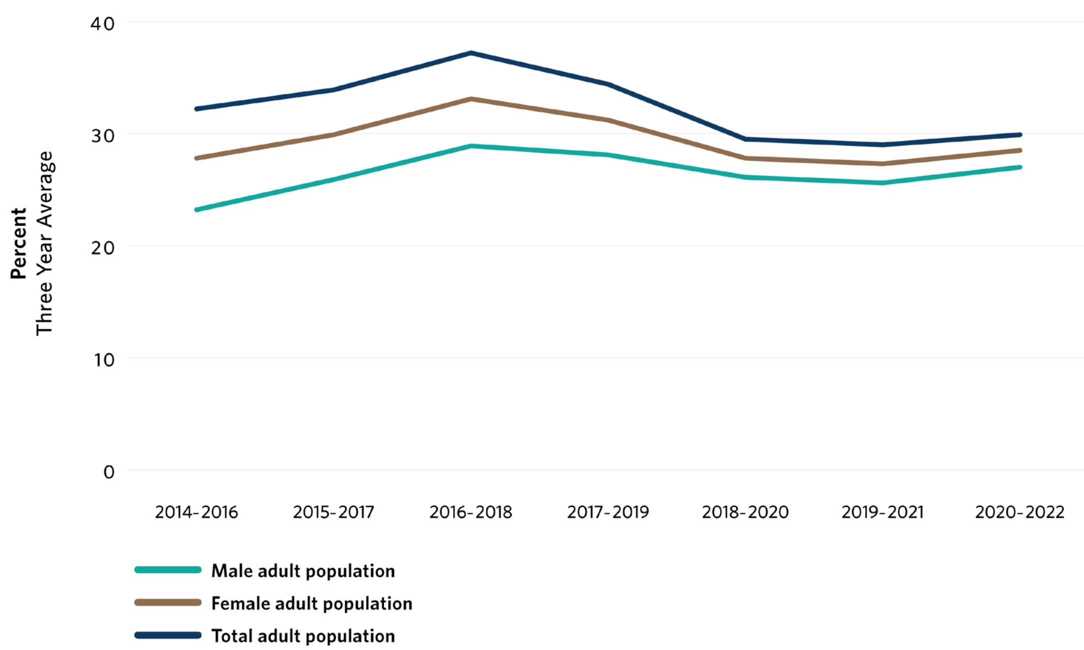
The strains of recent events, such as the coronavirus pandemic, have aggravated the situation. More than a quarter of the population has continued to face mild to acute food insecurity, with 8.8 percent of Egyptians suffering from severe food insecurity (see figure 2).[126] Adult women are disproportionately vulnerable, with 9.8 percent of adult women being severely food insecure and 29.9 percent moderately to severely food insecure. This is noticeably higher than the rates of 7.9 percent and 27 percent for adult men.[127] (See Appendix A.) Unsurprisingly, domestic agriculture and livestock production—as well as food imports—are critical for sustaining Egypt's relatively food insecure population.

Figure 2. Prevalence of Severe Food Insecurity in the Population



Source: Suite of Food Security Indicators," United Nations Food and Agriculture Organization, accessed October 18, 2023, https://www.fao.org/faostat/en/#data/FS/visualize

Figure 3. Prevalence of Moderate and Severe Food Insecurity in the Population



Source: Suite of Food Security Indicators," United Nations Food and Agriculture Organization, accessed October 18, 2023, https://www.fao.org/faostat/en/#data/FS/visualize

Domestic wheat production is also essential. Though Egypt currently ranks among the top countries globally in its daily per capita caloric supply (3,522.000 calories per capita daily), about a third of this caloric intake and over 38 percent of daily protein intake comes from wheat products alone.[128] (See Appendix B.) This demand requires significant imports to bolster domestic wheat production. Although Egypt produces about 9 million metric tons of wheat annually, it nevertheless imports an additional 12 to 13 million metric tons to meet ever-increasing domestic demand. Egypt has become the leading global wheat importer, spending $5.2 billion on wheat imports alone.[129]

Egypt's massive wheat imports are the result of a demand gap driven by a growing population and a constrained supply stemming from limited arable land and water resources. Nevertheless, Egypt's per capita wheat consumption is unparalleled, equal to over twice the global average.[130] In fact, daily wheat consumption is so vast in Egypt (an estimated 1,153.830 calories per capita daily) that it accounts for more than double the country's combined daily consumption of meat, seafood, eggs, milk, butter, and rice (an estimated 612.000 calories per capita daily).[131] For this reason, wheat (and its chief product, bread) are literally vital for feeding Egypt's population, which numbers over 100 million people. This high demand makes climate change's adverse impacts on wheat yields all the more critical—even existential.

Plummeting wheat crop yields may plunge Egypt into deeper cereal import dependence and could severely jeopardize nutrition and domestic food security in the country. As seen in early 2023, Egypt's cereal import dependence leaves it prone to international shocks in food prices, as was the case following Russia's invasion of Ukraine. As climate change reduces wheat yields, Egypt may become even more vulnerable to international food shocks and may further suffer domestic ones as climate changes affecting growing seasons, cultivation areas, and soil salinity threaten to disrupt domestic food supply chains. In this sense, climate change may undermine both food security and food sovereignty in the country.

In the coming years, climate change will deal Egyptian agricultural production and food security a serious blow. Projections based on the GHG concentration trajectory in a representation concentration pathway of 6.0 predict declining crop yields for wheat and maize by 10 to 12 percent and 13 to 15 percent respectively as early as 2030. These two crops are especially important, since wheat is crucial for production of bread (which is the chief cereal consumed in Egypt) and maize is similarly essential as both food and livestock feed.[132] Reduced crop yields for wheat and maize therefore directly worsen severe food insecurity in the country and will likely cause significant disruptions to rural economies and livelihoods.

Because it must meet escalating demands and persistent population pressures, agriculture accounts for about 80 percent of Egypt's freshwater consumption.[133] As previously mentioned, less than 3 percent of Egypt is arable, and that land is mostly in irrigated areas along the Nile and around oases in the Sinai Peninsula. Approximately 80 percent of cultivated land in Egypt is known as "old land," with the remaining 20 percent dubbed "new land." As the name suggests, "old land" refers to the areas in the Nile Valley and Delta that have been cultivated and irrigated over centuries, whereas "new land" describes desert land recently reclaimed for agriculture.[134] The government has spearheaded agricultural land reclamation efforts, but state policies undertaken in the name of boosting food security may backfire, deepening water scarcity.

Increasingly conscious of the water-food climate nexus and realizing the need to manage those resource systems holistically, Egypt has pursued more promising climate governance efforts in recent years. For example, Egypt is embarking on a partnership with the Republic of Congo that aims at boosting mutual food security without sacrificing Egypt's own scarce water resources. Under this agreement, Egypt is investing in the cultivation of 20,000 hectares of arable land in the relatively water-abundant Congolese city of Mossendjo, in exchange for 60 percent of its wheat and rice yields.[135] In this way, Egypt has turned to collaborative climate governance as a way to better manage its own resource systems, allowing it to bypass the steep tradeoffs involved in expanding domestic wheat production at the cost of aggravating its water scarcity, while still benefiting regional partners. Such bilateral partnerships are promising not only because they increasingly exemplify robust nexus governance, but also because they showcase the potential for broader regional cooperation around cross-border resource systems, such as the Nile. Fortunately, Egypt is increasingly adopting comprehensive, cross-sectoral solutions. Encouraging organic agriculture is one example, simultaneously improving crop resiliency, water efficiency, and drought and flood resistance.[136] Egypt's National Competitiveness Council, in collaboration with the United Nations Environment Programme, is another case in point. Following an integrated approach, the National Competitiveness Council's green transition agenda encompasses both mitigation and adaptation strategies, tackling decarbonization and green economic growth through a set of energy, agriculture and waste reforms.[137] To that end, Egypt has already implemented twenty-eight projects across thirteen different government facilities throughout at-risk regions, with an eye toward job creation.[138] Egypt's policymakers are thus increasingly prioritizing progress towards linked objectives: economic transformation and emissions reduction, improved resource use, and a greater fulfilment of social needs. This may be a promising recipe for designing complementary and cumulatively successful policies.

Proactive efforts to reduce climate risks and build resilience have also gained momentum. As climate change is expected to undermine Egyptian agriculture and exacerbate food scarcity, the United Nations Food and Agriculture Organization (FAO) has supported the government in implementing disaster risk reduction regional strategies. The FAO also has made significant strides in building early warning and information systems to facilitate anticipatory action across agriculture sectors.[139] Of course, considerable progress needs to be made if Egypt is to rise to the challenge of climate challenge. Nevertheless, it is important to acknowledge the scale of investments made and the promising governance innovations taking shape.

Conclusion

Egypt's environmental challenges are significant and multifaceted, but not all of Egypt's resource troubles can be attributed to climate change. Rather, ongoing resource constraints, evolving demographics, and preexisting inequalities all play a role in informing climate vulnerability and shaping governance limitations. In this sense, climate disruptions—including extreme temperatures, irregular precipitation, elevation of sea levels, land subsidence, saltwater intrusion, and soil deterioration—will amplify existing risks and introduce new ones, potentially compounding governance challenges and making the situation of marginalized populations even more precarious. These considerations warrant a rethinking of existing public policy designs that seeks to open them to integrated nexus approaches.

Preexisting pressures like Egypt's historic exploitation of the Nile, urban and coastal population increases, and subjection to global economic shocks makes effective mitigation and adaptation even more challenging. As climate change depletes the country's already scarce resources, Egypt's agriculture-centric economy could amplify major losses in sustenance and livelihood on a national scale, if announced adaptation plans and targets are not swiftly realized. Furthermore, the classed and gendered consequences of climate change cannot be ignored, as the intensification of climate-related disasters continues to disproportionately harm lower-income populations (in health, economic, and social terms) who traditionally lack access to key services and cannot afford immediate remedies. It is therefore crucial for the climate crisis to be addressed through the prism of socioeconomic exclusion, where vulnerable populations are equally prioritized.

Egypt has made promising and significant strides toward sourcing clean energy and achieving energy efficiency through its decarbonization strategy, green housing projects, and organic agriculture methods. However, failure to implement transparent mitigation targets and, more importantly, incapacity to supplement targets with coordinated intergovernmental and cross-sectoral action will only hinder Egypt's progress. Additionally, as Egypt contends with a new water scarcity threshold and diminished national food security, it will have to walk the tightrope of meeting the pressing energy, water, and food demands of today while cultivating a sustainable, climate-resilient infrastructure for tomorrow.

In this vein, innovative policy solutions including the nexus approach; collaborative, cross-border resource management; and vulnerability-informed policy design present Egypt with critical opportunities for decisive action. The international community also has a role to play in supporting Egypt's green transformation; sharing technology, resources, and best practices can help develop Egypt's learning, monitoring, and response systems and equip the North African country with the tools needed to protect its vulnerable populations and make better informed policy decisions. Ultimately, meeting the climate challenge will demand bold actions and resolute political will as well as creative policy thinking and material support from international partners.

Appendix

Appendix A

See the dataset at "Suite of Food Security Indicators," United Nations Food and Agriculture Organization, accessed October 18, 2023, https://www.fao.org/faostat/en/#data/FS. From the dataset, select the country and the relevant indicators/dates: "**Egypt, Value, -- Prevalence of moderate or severe food insecurity in the total population (percent)," and "2020 / 2019-2021 2021 / 2020-2022 2022 / 2021-2023**."

Appendix B

The calculation for 38 percent of daily protein in 2020 was produced by the following calculation:

Egypt – Value – Food supply (kcal/capita/day) AND Protein supply quantity (g/capita/day) – Wheat and Products – 2020": (34.98 + 6.46 + 0.02 + 15.05 + 0.98 + 0.05 + 0.04 + 0.29 + 0.09 + 0.16 + 2.29 + 0.09 + 0.63 + 0.01 + 0.22 + 0.26 + 0.01 +1.61 + 0.96 + 2.18 + 0.36 + 0.02 + 0.34 + 0.06 +0.61 +0.21 +0.32 + 0.09 + 0.1 + 0.2 + 0.03 +0.25 + 0.14 + 0.01 + 2.97 + 0.24 + 5.03 + 0.42 + 1.92 + 0.03 + 0.01 + 0.92 + 4.19 + 3.4 +1.23 +1.66 +0.09 + 0.09 + 0.14 + 0.03) should add up to 91.49 g/per capita/day. 34.98 / 91.49 = 0.38233686741 (or 38.23 percent).

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