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Climate Change Adaptation Strategies for Egypt's Agricultural Sector

A 'Suite of Technologies' Approach

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Climate change negatively affects Egypt's agriculture sector. This brief summarizes the results of a modeling exercise to examine a range of climate change adaptation approaches to counteract agricultural productivity declines. Rather than simulating a single technology, a 'suite of technologies' approach was used.

For several food crops, none of the technology suites, individually or in combination, are shown to counteract the adverse impacts of climate change. For these crops, which include maize, oilseeds, pulses, and sugar, even stacking of technologies will not return productivity to pre-climate change levels. However, for fruits and vegetables, potatoes, rice, and wheat, crops less adversely affected by climate change, increased investments in climate change-responsive crop traits, soil fertility improvement, water management, crop protection, or a combination of these technologies can counteract the adverse impacts of climate change on agricultural productivity.

From a policy perspective, strong cooperation with the rest of the world on climate change adaptation will ultimately benefit Egyptian consumers. Doing so will reduce disruption of global food markets, which is of particular importance for countries, like Egypt, that are well integrated into those markets. In particular, Egypt's economy and all Egyptian consumers benefit from the importation of lower-value, high water-consuming cereals under the hotter and drier conditions that can be expected in Egypt in the future due to climate change.

Over the last 30 years, Egypt's agricultural sector had taken historic strides in performance, achieving some of the highest agricultural productivity levels worldwide. These advances have been due chiefly to large, long-term investments in irrigation and drainage, agricultural research, and mechanization. However, as a result of growing natural resource constraints and slowing investment in the sector, productivity growth of many key food crops has slowed or even contracted. Climate change is among the key stressors constraining agricultural productivity, with heat waves and droughts compounding already high temperatures and scarce water resources. This is even more concerning as the negative impacts of the COVID-19 pandemic on economic growth, jobs, and household income were critically cushioned by Egypt's agri-food system.[1] Both climate change and the pandemic present powerful reminders of the importance of a resilient agricultural sector for food security and livelihoods in the country.

To counteract the slowing growth in food crop production and the accelerating need for greater resilience to recurring shocks to the agricultural sector, the Government of Egypt (GoE) has undertaken measures to improve irrigation efficiency; to develop technologically advanced production systems, including greenhouses; and to increase the area planted with high-value and specialty crops. Nonetheless, additional strategies and investments that increase agricultural productivity and value together with those that improve resource use efficiency and reduce greenhouse gas emissions are particularly needed. These actions should be part of post-pandemic recovery and development efforts to enable the sector to respond to the intensifying adverse impacts of climate change on agriculture in Egypt.

Government Adaptation Plans

The GoE plays an important role in guiding agricultural activities, whether by promoting sustainable use of agricultural land, improving irrigation and cultivation techniques, growing high-value but low water-consuming crops (often export-oriented), or targeting investment and land reclamation efforts.

- In Egypt's Nationally Determined Contribution to the United Nations Framework Convention for Climate Change, various adaptation strategies were proposed.[2] These include the development and promotion of heat, salt, and pest tolerant cultivars, changing planting dates, improving crop water use efficiency, and enhancing livestock feeding practices and species.
- Egypt's Strategy for Development and Management of Water Resources 2050, similarly, includes rehabilitating water pumping stations, rationalizing reuse, improving and extending sewage networks, developing additional groundwater resources, raising awareness to preserve natural resources, and employing advanced water technologies.[3]
- The GoE has also included climate resilience in its Sustainable Agricultural Development Strategy 2030, which was recently revised.[4]

Developing Resilience Strategies Against Climate Change

Egypt's agricultural future ultimately depends on the extent of the impacts of climate change and adaptation choices made by various actors, including the GoE, agricultural producers, and consumers. Key interventions in the adaptation toolbox include technological responses, such as the development, adoption, and scaling of technologies that are resilient to climate change, while also increasing farm profitability, promoting food security, and improving society's welfare.

This policy note summarizes a series of climate change adaptation scenarios focused on counteracting projected agricultural productivity declines in Egypt that will result from climate change (see MENA Regional Program Policy Note 17).[5] Rather than simulating a single technology, or 'silver bullet', strategy, a 'suite of technologies' approach to climate change adaptation was used, since

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[1] Breisinger, C., M. Raouf, M. Wiebelt, A. Kamaly, and M. Karara. 2020. *Impact of COVID-19 on the Egyptian economy: Economic sectors, jobs, and households*. MENA Policy Note 6. Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/p15738coll2.133764

[2] MALR (Ministry of Agriculture and Land Reclamation). 2020. *Sustainable Agricultural Strategy 2030: Action Plan*. Accessed: March 2021. http://extwprlegs1.fao.org/docs/pdf/egy141040.pdf

[3] MWRI (Ministry of Water Resources and Irrigation). 2016. *Strategy for Development and Management of Water Resources 2050*. Accessed: February 2020. https://www.mwri.gov.eg/water-staretgy-2050/

[4] UNFCCC (United Nations Framework Convention on Climate Change). 2014. The Arab Republic of Egypt: Intended Nationally Determined Contributions as per United Nation Framework Convention on Climate Change. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Egypt%20First/Egyptian%20INDC.pdf

[5] Perez, N.D., Y. Kassim, C. Ringler, T.S. Thomas, and H. ElDidi. 2021. *Climate change and Egypt's agriculture*. MENA Policy Note 17. Washington, DC: International Food Policy Research Institute (IFPRI). https://ebrary.ifpri.org/digital/collection/p15738coll2/id/134318

farmers tend to combine various resilience strategies to counteract the adverse impacts of climate change. Moreover, to truly fight climate change in Egypt, as elsewhere, it is important that the research system focus on all agricultural commodities and not just strategic or food security crops. The suites of technologies considered are grouped according to their key characteristics and, where feasible, according to how directly or indirectly they counter the negative impacts of climate change.

'Suite of Technologies' Adaptation Scenarios

We use IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT)[6] to explore the robustness of different investments in climate change adaptation for Egypt by comparing the outcomes of these investments against a reference climate change scenario in which no specific adaptation effort is undertaken. In addition, to better understand the differential impact on crop productivity from climate change, a no-climate-change scenario that assumes continuation of historical climate patterns from 1970 to 2000 was added to the analysis. The different technology suites used in the adaptation scenarios are described in Table 1.

Table 1. Climate-Resilient Technology Suites Evaluated

Climate Change Adaptation Suites	Individual Technologies
1) Seed Varietal Technology Suite	Heat tolerance
	Flood tolerance
	Drought tolerance
	Salinity tolerance
2) Soil Fertility Management Technology Suite	No-till and direct seeding
	Integrated soil fertility management
	Organic farming, brown and green manuring
	Full and partial intensification
	Precision agriculture
3) Irrigation Water Management Technology Suite	Water harvesting
	Laser land leveling
	Alternate wet and dry system
	Precision water application
4) Crop Protection Technology Suite	Weed protection
	Insect protection
	Disease protection
5) Stacked Technology Suite	Mix of complementary technologies

Source: Authors.

Output from three General Circulation Models (GCM) of global climate patterns were used to simulate future climate conditions.[7] These three models serve as the basis for estimating the impacts of a with-climate-change scenario for use with the IMPACT model. The five adaptation technology suites (Table 1) were simulated under the with-climate-change scenarios to examine their ability to reverse some of the adverse impacts of climate change on agricultural productivity in Egypt. Two different levels of farm-level adoption of these technology suites were evaluated: Moderate – 60 percent adoption for Suites 1 to 4; 40 percent for Suite 5, and High – 80 percent for Suites 1 to 4;

[6] The IMPACT model combines biophysical models of climate, hydrology, and crop growth with economic data around a core agricultural sector economic model. IMPACT simulates global and national production, area, yield, trade, demand, and prices for agricultural commodities as well as water supply and demand. The model facilitates the simulation of the impacts and costs of climate change and has been used extensively in policy analysis of climate change adaptation and mitigation, studies of impacts of agricultural technology developments, irrigation investments, and for projections of food supply and demand, trade and food security to 2050. See https://www.ifpri.org/project/ifpri-impact-model

[7] The three General Circulation Models used are the GFDL from the Geophysical Fluid Dynamics Laboratory of Princeton University, USA; the HGEM, the Global Environmental Model of the Met Office Hadley Centre in the U.K.; and the IPSL model of the Institute Pierre-Simon Laplace in France. All simulations were done under the representative concentration pathways (RCP)/shared socio-economic pathways (SSP) framework, applying RCP 8.5 emissions and SSP2 population and Gross Domestic Product (GDP) assumptions. RCP 8.5 represents high levels of emissions across all of the RCPs, but is also reflective of recent emissions levels.

60 percent for Suite 5. As adoption of more complex, stacked technologies is more challenging, lower adoption levels were assumed for this scenario. All simulations run from 2020 to 2050.

Agricultural Productivity and Single and Stacked Climate-Resilience Strategies

For several food crops, we find that none of the adaptation technology suites can counteract the adverse impacts of climate change. For these crops, even stacking of technologies will not return productivity to pre-climate change productivity levels. These crops include maize, oilseeds, pulses, and sugar (Table 2).

Table 2. Yield effects on major food groups in Egypt by 2050 of adoption of suite of climate-resilient technologies (moderate adoption rate)

Commodities	Yield effect of climate change, % change relative to no climate change scenario	Minimum yield change needed to counter climate change	Yield impact of suite of climate-resilient technologies, percent change in yield relative to climate change scenario				
			Seed Technology	Soil Fertility Manage-ment	Irrigation Water Manage-ment	Crop Protection	Stacked Technology
All food crops	-6.2	6.6	9.9	4.7	1.7	3.7	13.2
All cereals	-10.4	11.6	7.2	7.3	1.5	3.1	12.7
Maize	-19.5	24.3	13.6	10.1	1.4	3.0	19.0
Rice	-8.5	9.3	7.3	3.5	1.7	3.5	10.4
Wheat	-0.6	0.6	1.4	5.9	1.6	3.4	7.8
Fruits and vegetables	-8.3	9.0	12.4	6.0	2.0	4.6	16.5
Oilseeds	-12.1	13.7	8.8	4.7	1.6	3.3	12.2
Pulses	-10.0	11.1	5.8	3.0	1.6	3.6	9.0
Roots and tubers	3.6	-3.4	4.3	2.3	1.6	2.3	6.6
Sugar	-13.3	15.3	8.5	4.3	1.6	3.3	11.6

Source: IMPACT model simulation results.
Notes: Highlighted cells indicate that changes in yields from climate-resilient technologies fully counteract the effects of climate change for the particular crop.
Values are averages of three GCMs: GFDL = General Fluid Dynamics Laboratory model; HGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace model; All these GCM simulations are based on RCP 8.5 and SSP2 assumptions.

However, for those crops that are less adversely affected by climate change, including fruits and vegetables, potatoes, rice, and wheat, increased investments in climate change-responsive crop traits or a combination of measures, such as additional investments in soil fertility improvement, water management, and crop protection, can counteract the adverse impacts of climate change.

Across all food crops, investments in climate-resilient seed technologies provide the largest returns in terms of reducing the adverse impact of climate change on productivity, followed by investments in soil fertility, crop protection, and irrigation. However, joint advances on all fronts are needed, as almost all crops require multiple improvements.

Impacts on Food Production, Food Security and Trade

Strong cooperation of Egypt with the rest of the world on climate change adaptation will ultimately benefit Egyptian consumers. Adaptation to climate change undertaken by the global community, rather than individual countries, like Egypt, is projected to boost global agricultural production and lower food prices to a much larger extent than if only Egypt accelerated such adaptation actions. Even at moderate adoption rates by farmers both in Egypt and in the rest of the world of the suites of technologies examined here, prices of all food commodities decline – by as much as 16 percent across all technology suites for maize and rice.

In a scenario in which only Egypt (and not the rest of the world) accelerates its climate change investments in the agriculture sector, Egypt would still benefit through reducing its levels of imports. Such imports otherwise would have to be purchased at higher, climate change-induced world prices, which would need to be financed through Egypt increasing its exports and national production (Table 3). Higher national production can substitute for some of the increased import demand, such as for cereals. At the same time, net exports of fruits and vegetables would rise.

Table 3. Changes by 2050 in net trade of major food crops between Egypt and the rest of the world due to climate change and average across all adaptation technologies (moderate adoption rate), thousands of mt

Commodities	No climate change scenario	Climate change scenario	Egypt adapts, rest of the world does not	Both Egypt and rest of the world adapt
All food crops	-29,139	-27,810	-20,164	-32,694
All cereals	-35,957	-32,770	-31,116	-35,695
Maize	-17,609	-14,231	-13,092	-17,257
Rice	-2,868	-2,770	-2,603	-3,076
Wheat	-12,373	-12,558	-12,193	-12,209
Fruits and vegetables	12,387	7,777	13,055	6,668
Oilseeds	-1,105	-1,025	-983	-1,143
Pulses	-1,653	-1,843	-1,819	-1,791
Roots and tubers	4,263	7,244	6,483	5,511
Sugar	-2,077	-2,076	-1,820	-2,137

Source: IMPACT model simulation results.
Values are averages of three GCMs: GFDL = General Fluid Dynamics Laboratory model; HGEM = Hadley Centre Global Environmental Model; IPSL = Institut Pierre-Simon Laplace model; All these GCM simulations are based on RCP 8.5 and SSP2 assumptions.

Every simulated adaptation technology suite, on average, effectively contributes to reduced imports or increased exports. Using average yield gains across all climate change adaptation technologies described in Tables 1 and 2, at moderate adoption level, net food crop imports would decline by 27 percent, on average, compared to a climate change scenario without adaptation, and by 31 percent compared to a scenario without climate change. However, without accelerated global adaptation efforts, global food prices would remain largely unaffected, and thus domestic consumption levels would remain depressed.

The implications for food security are more profound with global cooperation, reducing disruption of global food markets, which is of particular importance for countries such as Egypt, who are well integrated into those markets. In particular, Egypt's economy and all Egyptian consumers would benefit from the importation of lower-value, high water-consuming cereals under the hotter and drier conditions that can be expected in Egypt in the future due to climate change.

Policy Conclusions

Egypt's agriculture sector, economy and food security would dramatically benefit from accelerated climate change adaptation strategies. Moreover, results suggest that many technologies do better when applied in tandem and impact is magnified if all adaptation strategies are considered for all agricultural commodities and not just strategic or food security crops. Many of these technologies are already listed in the GoE's Nationally Determined Contribution to the United Nations Framework Convention for Climate Change of 2014. However, more research is needed to examine the full set of benefits from adaptation strategies that are currently in Egypt's fields and to identify appropriate complementary institutions to support the climate change adaptation needs of Egypt's farmers.

Importantly, no single technology suite could fully counter the negative impacts of climate change on productivity at the national scale. Even technology stacking is insufficient for the crops that will be hit hardest by climate change, including maize, oilseeds, pulses, and sugar.

Moreover, given Egypt's strong linkages with world food markets, the country will benefit from climate change adaptation efforts elsewhere in the world, through the lower world prices of agricultural commodities and the increased opportunities for food trade that will result. With such efforts, global pressure on food prices will be lower, reducing the adverse impacts of higher prices on Egypt's consumers, while food imports will remain more accessible, which is particularly important for those crops most hit by climate change in Egypt. Under a global adaptation scenario, net imports of cereals, including wheat, rice, and maize, return to within almost one percent of no-climate-change levels in 2050, with only fruits and vegetables showing continued export declines under this scenario.

As such, Egypt will benefit greatly from accelerating adaptation efforts both in-country and globally. Efforts to reduce emissions of greenhouse gases should be prioritized. Moreover, by supporting adaptation (and mitigation) efforts elsewhere in the world, Egypt, as a country experiencing rapid population growth with limited land and water resources, will be able to more readily sustain national agricultural production, food security, and trade.

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