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CLIMATE RESILIENT AGRICULTURE: TRANSLATING DATA TO POLICY ACTIONS

Case Study of AquaCrop Simulation in Egypt

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Case Study of AquaCrop Simulation in Egypt

UNITED NATIONS
Beirut

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Overview

Within the framework of an initiative supported by the Swedish International Development Cooperation Agency (Sida) on “Promoting food and water security through cooperation and capacity development in the Arab region”, ESCWA prepared reports on the impact of changing water availability due to climate change on agricultural production in selected Arab countries.

A technical country team[1] was established and trained by ESCWA, the Food and Agriculture Organization (FAO) and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) to assess the impact of projected climate change, expressed in terms of water availability, temperature and carbon dioxide (CO_2) changes, on selected crops and locations in Egypt. The assessment findings, derived from a national case study report[2], are used as a baseline to recommend adaptation measures to key actors in promoting water and food security under changing climate.

The assessments used the AquaCrop simulation programme developed by FAO. The assessments were carried out on selected irrigated crops to identify the impact of climate change on crop productivity. The programme used the climate-variable projections of the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR)[3], while soil, yield and crop data were acquired from national sources. The climate change projections correspond to representative concentration pathways (RCP), i.e., greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change, of two levels: RCP 4.5: generally describing a moderate-emissions scenario; and RCP 8.5: generally describing a high-emissions or ‘business-as-usual’ scenario. In a way, RCP 4.5 and RCP 8.5 correspond to a more ‘optimistic’ and more ‘pessimistic’ scenario, respectively. The time horizons for the two RCPs consider the periods 2020-2030 (represented by 2025) and 2040-2050 (represented by 2045). Furthermore, to analyse the effect of elevated CO_2 on crop yield loss, two sets of projected CO_2 concentration changes, for each of the RCP scenarios, were simulated: one which considered the effects of increasing CO_2 concentrations; and another which kept CO_2 concentrations at the baseline level.

The present case study provides a general background of the assessment, and the main findings of the AquaCrop simulation undertaken to identify a variety of country-specific recommendations on adaptation measures in the agricultural sector.

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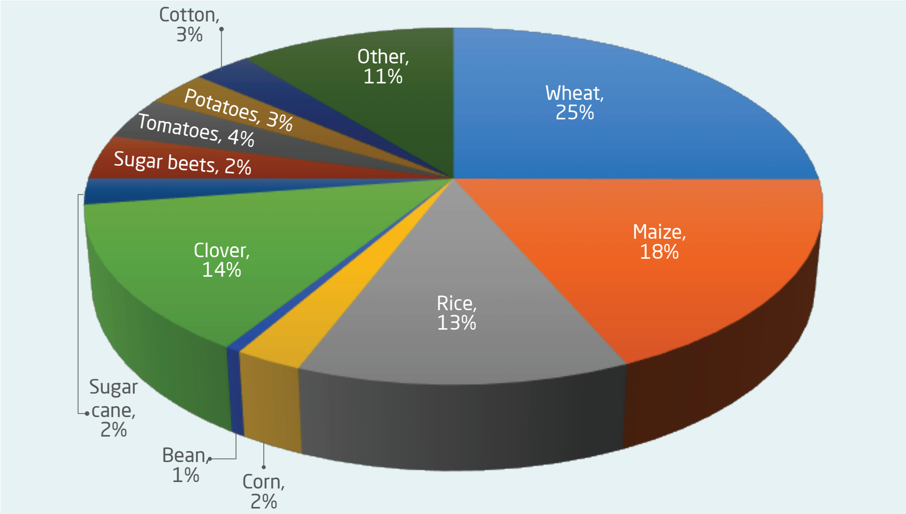
1. Country Background

Egypt is well known for its agricultural activity despite its challenging geographical nature, with the desert occupying 95% of its total land area, in addition to being one of the most arid and most water-limited regions around the world. Egypt has always been deeply engaged in agricultural activities whereby 95% of the total cultivated areas relies primarily on permanent irrigation.

Agriculture contributes to 12% of the country's GDP and employs a quarter of the labor force, and this ratio increases to more than 50% of the labor force when considering seasonal employment. This makes it a vital source of income for a large segment of the population, especially those living in rural areas (about 60% of total population).

The agriculture sector in Egypt faces many existing and future challenges, notably ensuring food for its growing population at a rate of 2.56% annually in light of limited agricultural areas and water resources and increased competition among different sectors to increase their share of water consumption at the expense of the agricultural sector. With the climate change unknowns compounding these challenges, there is high risk of reduction in agricultural production and consequent impact on the Egyptian economy. Box 1 highlights the challenges faced by rural women and initiatives to reduce their vulnerability in relation to climate change impacts on the agricultural sector.

Figure 1. Crop distribution in Egypt (% of the total cultivated area) 2006 -2016



2. Selected Crops and Areas for AquaCrop Simulation

The selected crops for this study, wheat, maize and tomato constitute 25%, 18% and 4% of the total cultivated area in Egypt, respectively, as shown in Figure 1. Wheat represent 19% of the country's food composition whereas maize and tomato represent 9%.

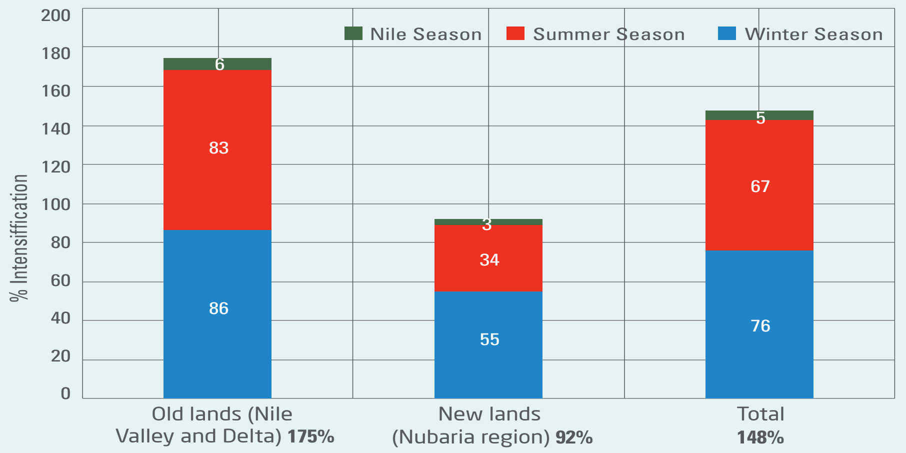
Three cropping systems of which all are irrigated were selected for the study:

(1) Wheat in the **old lands, Sakha area;** application of surface irrigation;
(2) Maize in the **old lands, Sakha area;** application of surface irrigation; and
(3) Tomato in the **new lands, Nubaria region;** application of drip irrigation.

Wheat and maize are the most critical food crops produced in the old lands of the Nile Valley and Delta, where wheat is cultivated in 25% of the total cultivated area of the old lands during the **winter season** (Nov-May), while the maize yield accounts for 21% of the total cultivated area of the old lands during the **summer season** (May-Sept).

Tomatoes were also selected as one of the most important crops grown by new farming systems in the new lands, Nubaria region, where tomato cultivation is expected to be about 23% of the total area planted with tomatoes in Egypt, annually estimated at 200,000 hectares during the three seasons of cultivation, Winter, summer and Nile (July-Dec). These three crops together constitute important food crops produced by Egyptian farming systems and hold a great place in the country's food composition.

Figure 2. Average Area cultivated per Season in the old and new lands (2006-2016)

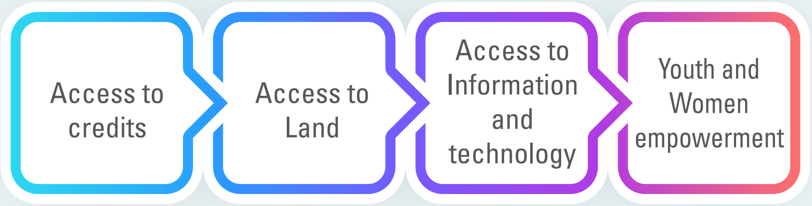


Box 1. Enhancing resilience of rural women to adapt to climate change impacts on agriculture

Although Egyptian women are actively involved in all agricultural and farming activities, they are identified as the unacknowledged labour. The challenge is exacerbated for young women in Upper Egypt, rural area where pockets of severe poverty, illiteracy, and early marriage exists.

In recognition of the severity of the situation in rural Upper Egypt, the Population Council, three non-governmental organizations, and 30 village-level community development associations implemented the “Neqdar Nesharek’ or “We can Participate” program. The main objective of this project was to empower the young women in the rural areas of Upper Egypt socially and economically through training and supporting them in starting a business or searching for jobs. The training consisted of three main components: (i) business skills training, (ii) vocational training, and (iii) life skills, legal rights and civic education and included aspects such as loans applications, opening bank accounts, and formalizing businesses.

Following the program participation, surveys revealed that while the economic situation of these young women improved, their social status did not as gender decision-making powers of the participants, and their attitudes towards gender roles, remained almost constant. Nonetheless, such initiatives are critical as they prove that improving women’s human capital is a main pillar in their economic empowerment. Further, local communities need to be engaged in such initiatives to ensure the success of similar programs. There also remains much work needed regarding training on gender dynamics to enhance social empowerment of women.



Source: Ilo, 2017; Empowering young women through Business and Vocational Training: Evidence from a field intervention in rural Egypt

3. Assessment methodology

The assessment aimed to evaluate the impacts of climate change on agriculture productivity using the AquaCrop simulation program (version 6)[4] and the climate-variables projections of the RICCAR Initiative on Climate Change in the Arab Region, led by ESCWA, to assist in shaping evidence based agricultural strategies.

The steps involved in the use of AquaCrop were as follows:

- **Data collection** was required for climate, soil, crop types, and crop management. Climatic data including min. and max. temperature, and wind speed were obtained for both Sakha and Nubaria regions. However, daily rainfall data were available only for Sakha area. The related information were collected from two research stations, Sakha in Kafr El-Sheikh and El-Bustan in El-Nubaria. Crop data was reviewed and compared to literature before being used as input to AquaCrop. Only soil texture data at the two sites were available from previous studies, without any data on the physical properties of soil moisture which were thus obtained from AquaCrop database.
- **Calibration** of AquaCrop to simulate the productivity of the three selected crops under local conditions, using field data including soil characteristics, groundwater depth, irrigation scheduling, main farm-management practices, climate data and crop yield. Observed wheat yield data used for calibration included 12 winter seasons from 2003-2004 to 2014-2015.For maize and tomato, 16 summer seasons were included from 1999-2000 to 2014- 2015. The objective of such calibration was to provide the model with parameters that can simulate the actual productivity of the three crops within an acceptable accuracy range. The calibrated model was then used to simulate the crop yield under future climate change .
- **Simulation** of the impacts of climate change on the productivity of the three crops using the prediction of the RICCAR project model (EC-Earth, CNRM-CM5, and GFDL-ESM2M) for two periods: the 2020- 2030 period (represented by 2025) and the 2040-2050 period (represented by 2045) and for two scenarios RCP 4.5 and RCP 8.5. The reference period is the 1986-2005. Moreover, two sets of projected changes were implemented: one which considered the effects of both CO_2 concentrations and associated climatic changes (temperature and water); and one which considered tem perature and water changes only and no change in CO_2 concen trations (i.e., keeping CO_2 concen tra tions at the baseline level). This allowed to disaggregate the mitigating effect of increased CO_2 on yield losses derived by adverse impacts of temperature rise and water scarcity, and account for related uncertainties.
- **Testing adaptation measures** to overcome the impacts of reduced water availability due to climate change on irrigated crops by using two deficit irrigation measures: reducing irrigation by 40% and 20 % of the allocated irrigation amount for both RCP scenarios and both periods. Further the fourth irrigation for wheat and the second irrigation for maize were eliminated to determine its impact on productivity.

4. Description of Assessment Findings

Description of Assessment Findings

Overall, the results of the model simulations showed that the actual and the simulated productivities, during the period of observations of each crop (12 seasons for wheat and 16 seasons for maize and tomato), differ by 0.572 ton/ ha for wheat, 0.266 ton/ ha for maize, and 0.213 ton/ha for tomato with normalized root mean square error of 8.8% , 3%, and 9.2%, respectively.

Comparing both regions' yearly climatic projections to the "growing season" projections shows a higher degree of variability. For example, the average temperature for the wheat cultivation season (winter), maize cultivation season (summer), and tomato cultivation season (summer) increases for both scenarios and periods. However, max. temperatures are projected to decrease under certain scenarios and climate models.

Table 1. Main Findings of assessment for the 2045 period

	Wheat	Maize	Tomato
Average total cultivated area (million ha)	1.1*	0.84*	0.11**
Average production for the total area (million tons / year)	6.8	6.7	3.9
Change in productivity as a result of climate change [%] for 2045***			
Fixed CO_2 Concentration	- 4.8	- 2.9	- 1
Changing CO_2 Concentration	+12.8	+0.4	+28
Average production for the total area (million tons / year) for 2045			
Fixed CO_2 Concentration	6.5	6.5	3.9
Changing CO_2 Concentration	7.7	6.7	5
Self-sufficiency ratio of the crop (%)			
Present value	47.7	56.3	103
Fixed CO_2 Concentration	45.4	54.7	102
Changing CO_2 Concentration	53.8	56.5	132.4

* Average of production area in old lands only
**Average production area for new lands only
*** Average values from the three crop simulations using the AquaCrop model.

- **SAKHA SITE FINDINGS**

Climate variable projections

Climate projections predict in general an increase in rainfall by around 4% in Sakha for both scenarios (RCP 4.5 and RCP 8.5) for the 2045 period. As for temperatures, the max. temperature rises by 0.48-0.66 ^{0}C and by 0.72-0.94 ^{0}C for the 2025 and 2045 periods, respectively, for RCP 4.5 scenario. However, for RCP 8.5, the rise in max. temperature is around 0.61-0.69 ^{0}C and 1.05-1.22 ^{0}C for the 2025 and 2045 periods, respectively.

Crop productivity

In Sakha, varying results were observed for the case of fixed or changing CO_2 concentration. In the case of fixed CO_2, rising temperatures has limited impact on productivity of irrigated wheat and maize whereas the increase in CO_2 concentration increases productivity for both crop yields.

The effect of changing CO_2 concentration has less significant positive effects on maize yield compared to those of wheat. This can be explained by the fact that maize belongs to the C4 group, which reacts less with an increase in

Box 2. Main Findings of AquaCrop Simulation in Sakha

- Under the RCP 4.5 scenario:

  The productivity of wheat decreases by 1.7 and 3.9% for 2025 and 2045 periods, respectively. In case of changing CO_2, productivity increases by 10.3 and 13.2 % for both periods, respectively.

  The crop water productivity of wheat increases by 11 and 10 % for the 2025 and 2045 periods, respectively in case of fixed CO_2. In case of changing CO_2, the crop water productivity increases by 26 and 33% for both periods, respectively.

  The productivity of maize decreases by less than 3% for both periods in case of fixed CO_2. In case of changing CO_2, productivity increases by about 1% for both periods.

  The crop water productivity of maize increases by 8.2 and 7.1% for 2025 and 2045 periods, respectively, in case of fixed CO_2. In case of changing CO_2, the crop water productivity increases by 12.4 and 13.3% for both periods, respectively.

- Under the RCP 8.5 scenario:

  The productivity of wheat decreases by around 2.9 and 5.7 % for the 2025 and 2045, respectively in cases of fixed CO_2. In case of changing CO_2, productivity increases by 10.1% and 12.5% for 2025 and 2045 periods, respectively.

  The crop water productivity of wheat increases by 18% for both periods in case of fixed CO_2. In case of changing CO_2, the crop water productivity increases by 36 and 46% for both periods.

  The productivity of maize decreases by less than 3% for both periods in case of fixed CO_2. In case of changing CO_2, productivity increases by less than 1% for both periods.

  The crop water productivity of maize increases by about 13.2 and 12.9% for 2025 and 2045 periods, respectively, in case of fixed CO_2. In case of changing CO_2, the crop water productivity increases by 18 and 20.1 % for both periods, respectively.

CO_2 concentration while wheat belongs to the C3 group. Further impacts of the model in comparison to the reference period (1986-2005) are addressed in box 2.

Decrease in productivity is accompanied by a shortage in the crop cycle for wheat of up to 9 days, and a decrease in evapotranspiration up to 20% by 2045 for RCP 8.5. Although the change in temperature for wheat and maize crop cycles was close, rising temperatures had a smaller impact on the crop growth cycle of maize (2-day and 3-day lower crop growth cycle in 2025 and 2045 periods, respectively). The reduction in the crop cycle could be interpreted as a result of rising temperatures.

The value of crop water productivity increases for both wheat (by 18%) and maize (by 12.9%) for the 2025 and 2045 periods, for RCP8.5 as the plant, achieving its thermal needs over a shorter period, reduces the total amount of evapotranspiration during the season and diminishes the time of the formation of dry matter which is directly reflected on crop productivity.

• NUBARIA SITE FINDINGS

Climate variable projections

Climate projections predict in general an increase in rainfall by around 14%, in Nubaria, for both scenarios (RCP 4.5 and RCP 8.5) for the 2045 period. These results carry over a high uncertainty especially since rainfall data was not readily available for Nubaria region. Therefore, the implication of rainfall for the calibration of AquaCrop for tomato in Nubaria was disregarded.

As for temperatures, there is an increase in max and min temperatures to varying degrees in both regions such that higher increase is shown in RCP 8.5 scenario compared to RCP 4.5.

Crop productivity

In Nubaria, varying results were observed for the case of fixed or changing CO_2 concentration. In the case of fixed CO_2, rising temperatures had a limited impact on productivity of

Box 3. Main Findings of AquaCrop Simulation in Nubaria

- Under the RCP 4.5 scenario:

  The productivity of irrigated tomato decreases by less than 1% for the 2025 and 2045 periods in case of fixed CO_2. In case of changing CO_2, the simulation predicts an increase in yields by 17.4 and 25.7%, for both periods, respectively.

  Crop water productivity for tomato decreases by 1.8 and 2.5% for 2025 and 2045 periods in case of fixed CO_2. In case of changing CO_2, the crop water productivity increases by 16 and 23.8% for both periods, respectively.

- Under the RCP 8.5 scenario:

  The productivity of irrigated tomato decreases insignificantly (-0.1%) in the 2025 period and increases by 2.7% in the 2045 period in case of fixed CO_2. In case of changing CO_2, productivity increases by 19.5 and 32.6 %, for both periods, respectively.

  Crop water productivity for tomato decreases by less than 2% for both periods. in case of changing CO_2.The crop water productivity increases by 17.4 and 29.1 % for both periods.

irrigated tomato. The change in CO_2 concentration increased productivity as it enhances the photosynthetic rate of plants while reducing transpiration. The reduction in length of crop cycle is attributed to rise in average temperatures. Further impacts of the model in comparison to the reference period (1986-2005) are addressed in box 3.

- Applying deficit irrigation

  Deficit irrigation simulations of the three crops using 40% and 20% deficit irrigation were carried out as an adaptation measure for water shortages in Sakha area. The results illustrated in Box 4 showed very minor changes in yield for both wheat and maize whereas significant changes were registered for tomato. For instance, a 40% reduction in irrigation water resulted in a 45% decrease in the productivity of tomato for the two periods and both scenarios. However, an 20% reduction in irrigation water, resulted in a 22% decrease only . Similarly, insignificant changes in crop yield were observed when eliminating fourth and second irrigation for both wheat and maize.

Box 4. Main Findings of AquaCrop Simulation when applying deficit irrigation

- Applying 20% deficit irrigation

  Productivity of wheat increases by less than 1% and productivity of maize does not change for both periods and scenarios in case of fixed and changing CO_2.

  In case of fixed CO_2 and for RCP4.5, productivity of tomato decreases by around 22.2 % for both periods. For RCP 8.5, productivity decreases by 22.5 and 22.1% for 2025 and 2045 periods, respectively. In case of changing CO_2, for RCP 4.5 productivity decreases by around 21.7% for both periods. For RCP 8.5, productivity decreases by 22.0 and 21.3 % for both periods, respectively.

- Applying 40% deficit irrigation:

  Productivity of wheat increases by less than 1% and productivity of maize does not change for both periods and scenarios in case of fixed and changing CO_2.

  In case of fixed CO_2 and for RCP4.5, productivity of tomato decreases by around 44.5 % for both periods. For RCP 8.5, productivity decreases by 44.8 and 45.3% for 2025 and 2045 periods, respectively. In case of changing CO_2, for RCP 4.5 productivity decreases by around 43.9% for both periods. For RCP 8.5, productivity decreases by 44.4 and 44.0 % for both periods.

- Eliminating the fourth irrigation for wheat and second irrigation for maize:

  Productivity of wheat decreases by 0.15% for 2025 period and increases by 0.35% for 2045 period for RCP 4.5. However, it decreases by less than 1 % for both periods for RCP 8.5 in case of fixed CO_2.

  Productivity of maize increases insignificantly by less than 1% for both periods and scenarios in case of fixed and changing CO_2.

5. Analysis of Assessment Findings

The productivity losses for the three investigated cropping systems due to the climate change scenarios were found to be limited at fixed CO_2 concentration, and productivity increased at changing CO_2 concentration. Nevertheless, this should not be overly optimistic when given that there are current studies that refer to the low nutritional value of crops produced under conditions of increased carbon dioxide, especially when combined with rising temperature. A loss in nutritional value may result from the change in CO_2 concentration and this can partially counteract to possible advantage in increasing quantity, worsening the food insecurity of Egypt's population which is already at 17%.

More research is thus required to cover agricultural areas in central and southern Egypt, to include essential crops in each region, to provide more geographical representation and to assess the impact of climate change on important food crops. Also, since implications of rainfall on the two selected sites were disregarded as rainfall data was not readily available for Nubaria region, recording precipitation and weather data is highly recommended to improve the simulation results by establishing a network of climatic stations.

Moreover, 82% of irrigated land depend on a low-efficiency surface irrigation system (averaging 50% and below), often coupled with a low level of intra-farm water management, as well as the trend to cultivate crops with high water needs for their profitability. Applying deficit irrigation on maize and wheat crops showed limited adverse effects, hence a potential for water saving. Therefore, establishment of proper water accounting systems and encouraging investments for modernisation of irrigation systems could control water allocations to the irrigation sector within sustainable limits In this context, and is inline with the 2030 strategy for agricultural development that aims to improve irrigation efficiency from about 50% to about 75% and 80%.

Box 5. Economic Impact of Climate Change on Agriculture sector

The agricultural sector contributes to 12% of the gross domestic product (GDP), following the industrial (17%) and trade sectors (14%). Further, it is the most important economic activity supporting social stability as nearly a quarter of the labor force is engaged in the agricultural sector reaching more than 50% of the labor force when considering seasonal employment.

Egypt imports more than half of its total food consumption. Its cereal requirement in the 2016-2017 year were estimated at about 17.8 million tons and its import requirement about 12 million tons, implying that two-thirds of cereals consumed are imported. Costs of these imports are high, leaving the country with large budget deficits with an import bill amounting to 1.7 billion $ in 2016. Food security should be a concern for policymakers as Egypt's population is increasing at a fast rate, with part of it being already food insecure.

Overall losses due to climate change effects will be very limited on yields of irrigated wheat, corn and tomato crops given the relatively low productivity losses incurred in the case of scenarios involving fixed CO_2 concentrations. Decrease in income will also be relatively small for farmers as long as irrigation supply is not affected. But given an increasingly growing population, with Egypt already being a net importer of wheat, such declines in productivity suggest the country's food security might be at risk.

As the agricultural sector uses 80% of the country's water resources, applying deficit irrigation on a large scale for these two crops could help ease Egypt's water pressures With scenarios involving deficit irrigation suggesting no adverse effects on maize and wheat crops, could point out to a potential for improving water efficiency use. This should be a priority for policymakers given the increased demand for water by other sectors of the economy.

6. Recommendations for enhancing the resilience of the Agriculture Sector

Climate change is an increasing environmental challenge that is expected to affect agricultural production significantly in Egypt. In old lands, the use of deficit irrigation would allow water saving while preserving farmers income, earmarked subsidies could be used to incentivize conversion to deficit irrigation practice.

Figure 3. Action framework to adapt to climate change

In terms of general economic policy, economic development should be of an utmost priority, as such, it is required to perform economic assessment of impact of climate change especially in the most vulnerable regions. It is critical to empower rural workers with the skills needed for sound economic growth to mitigate the negative effects that climate change can have on the local population. Hence it is recommended to adopt comprehensive policy that includes innovations in measures to reduce and transfer risks through climate insurance.

Table 2 below lists the suggested actions for each key recommendation generated for this study in Egypt. Recommendations are identified based on the multiple dimensions they are connected to, including institutional, policy and financial arrangements, knowledge generation, and capacity development.

Table 2. Key recommendations and actions for adaptation of agriculture to climate change

1. Improve on use and effciency of irrigated agriculture

Institutional and Financial Arrangements:

- Establish proper water accounting systems to monitor water resources availability and control water allocations to the irrigation sector within sustainable limits of water consumption
- Promote implementation of the agricultural development strategy (Strategy 2030) of the Ministry of Agriculture and Land Reclamation in Egypt that focuses on increasing the productivity of the water unit and land used in agriculture and adopting mechanisms and procedures that lead to increased productivity of food crops.
- Provide financial incentives promoting adoption of modern irrigation systems in the old lands that rely on surface irrigation systems
- Provide incentives to farmers applying conservation irrigation technologies
- Improve on use of safely treated wastewater effluents for irrigation (food and fodder crops)

Knowledge generation:

- Evaluate irrigation water productivity and analyse the marginal benefit of water use for different crops and season
- Assess application of deficit irrigation and impact on productivity of various crop types.
- Undertake research to compare yields, soil properties development and plant growth phases, under various irrigation conditions and publish results

Technical Arrangements

- Increase efficiency and development of irrigation systems or applying more water-efficient field irrigation practices compared to traditional methods to reduce irrigation water losses
- Conduct field experiments to assess the impact of deficit irrigation on crop productivity, to determine the competency of its simulations by the AquaCrop model.

Capacity development:

- Enhance the skills of farmers in the use of deficit irrigation
- Enable farmers to apply water efficient field irrigation practices through participatory processes that identify best irrigation practices within sustainable consumption limits

2. Undertake economic assessments for adaptation measures

Knowledge generation:

- Collaborate with specialized researchers on economic assessments of impact of climate change and financial returns of adaptation measures
- Perform an expanded economic evaluation of the impacts of climate change on the crops of the study considering the evaluation of the interaction between the water, energy and food security components.

Technical Arrangements

- Empowering small farmers through linking them with markets, and enabling them to cultivate high-value crops. In addition to improving extension services through capacity building and farmer field schools.

3. Develop the use of new crop varieties and modify seeding dates

Financial arrangements:

- Dedicate funds to programs for adaptation in the agricultural sector in research institutes to prepare related studies.
- Invest in promoting innovative approaches and technologies to develop use of new crop varieties resilient to climate change impacts and/or modify seeding dates to maintain or increase crop yields under climate change conditions

Knowledge Generation:

- Analyse use of new crop varieties and modify seeding dates by testing crops with characteristics that could adapt more easily to expected climate changes such as crops with shorter growing season, drought-resistant crops, and crops that can tolerate high salinity levels.
- Research most vulnerable crops to climate change and assess the changes in agricultural production due to climate change
- Test the modification of seeding dates and crop sequence to account for shifting periods of rainfall
- Research further the impact of heatwaves on crop growth cycle, productivity, and water consumption.

Technical Arrangements

- Change planting dates and crop varieties
- Adjust planting dates and modify agricultural measures such as fertilization and soil preparation to address the effects of climate change on agricultural production

4. Improve data collection, monitoring and accessibility

Institutional arrangements:

- Establish institutional coordination mechanisms for data collection, harmonization and Data sharing between agencies
- Improve collection of agricultural, and climatic data and dissemination of this information to allow more productive use of this information
- Improve data collection, monitoring and accessibility to allow dissemination of agricultural and climatic data required for calibration and simulation of AquaCrop model and updating climate change data projection thus improving the productive use of this information.
- Increase the number of climatic stations and improving soil and crop data testing to decrease result uncertainty.

Knowledge generation:

- Prepare interactive map using geographic information systems that represent the impacts of climate change on agriculture areas to display and download data as a tool to support and formulate future agricultural and food policies
- Update the climate change data projection through cooperation between national, regional, and international institutions

5. Promote further research and assessments on different varieties of crops and other regions of the country and expand the use of the AquaCrop program

Institutional arrangements:

- Encourage partnership between research institutes and universities to perform studies on other crops and regions and agricultural environments using the AquaCrop and RICCAR climate datasets
- Establish and join a Regional Network of AquaCrop practitioners and collaborate with the (NENA) Regional and Global Network of AquaCrop practitioners, established and managed by FAO
- Identify focal point/coordinator to follow up on the implementation of assessment program for different crop types and different regions

Knowledge generation and sharing:

- Expand the scope of the study by applying AquaCrop to undertake further assessments on different crops and different geographical and agricultural areas in central and southern Egypt
- Assess optimization of water use in irrigation for the main crops in irrigated areas using AquaCrop model and analyze various irrigation methods and systems using the model
- Encourage publication of research using AquaCrop model to provide more evidence-based adaptation measures for the agricultural sector under climate change conditions

Capacity development:

- Build Capacity of trainers on the application of AquaCrop and RICCAR Data sets through GIS for crop and water productivity assessments
- Organize training sessions and workshops at different institutions and universities that facilitate the use of AquaCrop and mainstream the AquaCrop simulation tool and methodology
- Develop training programs on the use of simulation tools (water deficit irrigation) linked to AquaCrop

Endnotes

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1. The country team comprised of three experts from the Egyptian Agriculture Research Center
2. ESCWA. Assessing the impacts of changing water availability on agricultural production in Egypt. 2019 Available at https://www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-Egypt-arabic.pdf
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4. Developed by FAO.

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