Food and Agriculture Organization of the United Nations

CLIMATE-SMART POLICIES TO ENHANCE EGYPT'S AGRIFOOD SYSTEM PERFORMANCE AND SUSTAINABILITY

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Country Investment Highlights
Number 22

CLIMATE-SMART POLICIES TO ENHANCE EGYPT'S AGRIFOOD SYSTEM PERFORMANCE AND SUSTAINABILITY

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Food and Agriculture Organization of the United Nations
Rome, 2023

Required citation:

Santos Rocha, J., Sanchez, Y. & Fathallah, H. 2023. *Climate-smart policies to enhance Egypt's agrifood system performance and sustainability.* Country Investment Highlights, No. 22. Rome, FAO. https://doi.org/10.4060/cc8718en

ISBN 978-92-5-138384-1

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Acknowledgements

This study – a joint effort between the Food and Agriculture Organization of the United Nations (FAO) and the World Bank – was developed as part of the World Bank's core advisory services and analytics in Egypt, under its initiative entitled *Agri-food Systems Performance and Options for Competitiveness Enhancing Policies*, which provides analytical context for supporting the government's agrifood agenda and formulating specific climate-smart policy measures towards a greener and more resilient agrifood sector. The study was conducted under the overall supervision of Wafaa El Khoury by a team comprising Jozimo Santos Rocha, Yerania Sanchez and Hadi Fathallah, all from the FAO Investment Centre; and under the oversight of Marianne Grosclaude and Svetlana Edmeades at the World Bank.

The authors would like to express their appreciation to a number of World Bank members, including: Artavazd Hakobyan, who led the conceptualization of the core analytics and supervised much of that work; and Fatma El Zahraa Yassin Aglan, Ena Shin, and Demetris Psaltopoulos for the advice and data provided during the study. The authors are also grateful to colleagues in FAO's Regional Office for the Near East and North Africa in Cairo; and to those in Rome, especially: Adel Zekaizak, Astrid Agostini, Fatma Abouzeid, Jacopo Monzini, James Tefft and the Food Systems Assessment Team, as well as to Mohamed Abdel-Monem and Tommaso Alacevich for their detailed feedback on drafts of the document. Special thanks go to the key stakeholders from academia, research, Egypt's Ministry of Agriculture and Land Reclamation (MALR), and the private sector, whose insights have been invaluable for building a clearer understanding of the policy and institutional setup of the agrifood sector in Egypt.

Abbreviations

ABE	Agricultural Bank of Egypt
AFOLU	agriculture, forestry, and other land use
AFS	agrifood system
ARC	Agricultural Research Centre
BaU	business-as-usual
BIS	bubbler irrigation system
BCM	billion cubic metres
CAPMAS	Central Agency for Public Mobilization and Statistics
CCDR	Country Climate and Development Report, World Bank
CO_2e	CO_2 equivalent
COMCEC	Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation
COP	Conference of Parties (UNFCCC)
CSA	climate-smart agriculture
EFA	economic and financial analysis
EGP	Egyptian pound
EIRR	economic internal rate of return
ENPV	economic net present value
EX-ACT	FAO Ex-Ante Carbon-balance Tool
FAO	Food and Agriculture Organization of the United Nations
FFI	fixed-furrow irrigation
FNS	food and nutrition security
FY	fiscal year
GASC	General Authority for Supply Commodities
GEF	Global Environmental Facility
GDP	gross domestic product
GFCF	gross fixed capital formation
GFSI	Global Food Security Index
Gg	gigagram
GHG	greenhouse gas
GoE	Government of Egypt
GNI	gross national income
GRID	green, resilient, and inclusive framework (World Bank)
HLPE-FNS	High-Level Panel of Experts on Food and Nutrition Security
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
kcal	kilocalories
kWh	kilowatts per hour
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
IRR	internal rate of return

MALR	Ministry of Agriculture and Land Reclamation
MAPs	medicinal and aromatic plants
MIC	middle-income countries
MoF	Ministry of Finance
MPED	Ministry of Planning and Economic Development
MRB	mechanized raised bed
MOSIT	Ministry of Supply and Internal Trade
MWRI	Ministry of Water Resources and Irrigation
NCCS	National Climate Change Strategy 2050
NDC	Nationally Determined Contribution
NENA	Near East and North Africa
NPV	net present value
NPK	nitrogen, phosphorus, and potassium fertilizer
NSRP	National Structural Reform Programme 2021–2024
NWFE	Nexus on Water, Food and Energy
OECD	Organisation for Economic Co-operation and Development
OFID	OPEC Fund for International Development
PBDAC	Principal Bank for Development and Agricultural Credit
PBP	pay back period
PRIDE	Promoting Resilience in Desert Environments
R&D	research and development
SADS 2030	Sustainable Agricultural Development Strategy for 2030
SDI	surface drip irrigation
SLM	sustainable land management
SSDI	subsurface drip irrigation
STAR	Sustainable Transformation for Agricultural Resilience
SVB	switching value for benefits
SVC	switching value for costs
tCO_2e	tonnes of CO_2 equivalent
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
WDI	World Development Indicators of the World Bank
WF	water footprint
WOCAT	World Overview of Conservation Approaches and Technologies

Executive summary

The agrifood system (AFS) is a key pillar in the Egyptian economy, and a major component of the country's social protection policies. While the relative importance of agriculture to the gross domestic product (GDP) has decreased in recent decades as part of the structural transformation of the Egyptian economy, the country's agricultural output has actually expanded fourfold; and in 2020, the agricultural sector still contributed 11.6 percent of the GDP and 20.5 percent of jobs. As a whole, the AFS accounts for more than 24 percent of Egypt's GDP, and 34 percent of full time equivalent jobs. AFS activities are important for monetary policy as a large source of foreign currency via agrifood exports, which amounted to USD 2.47 billion in season 2021/2022, up from USD 2.22 billion in the 2020/2021 season.

The transformation of the Egyptian economy has mirrored that of other similar middle-income countries (MIC), yet Egypt's case highlights five features that illustrate the importance of agriculture and the extended AFS in the Egyptian economy. First, the shares of agriculture in GDP and employment have decreased at a slower pace in Egypt than in other similar economies. Second, agriculture has been a key driver of economic transformation and expansion of the manufacturing and services sectors (increases in agricultural total factor productivity are associated with declining shares of employment in farming activities and job growth in the non-farm sector). Third, the marked increase in agricultural performance contrasts with the slow expansion of value addition downstream. Less than 10 percent of crops produced in Egypt are processed, 76 percent of the AFS's contribution to GDP is due to agriculture, and 68 percent of AFS jobs are farming related. Fourth, overall AFS growth has been pro-poor but AFS downstream activities have had a greater impact on the earnings of the poorest. Fifth, from the resource use point of view, water and arable land have been the main productive constraints for Egypt's AFS performance and sustainability.

Demographic changes have placed undue pressure on Egypt's food production and import capacity in the last few decades. On one hand, the Egyptian population has grown rapidly, expanding from 56 million people in 1990 to nearly 104 million in 2021 (average growth of 2.3 percent per annum). On the other hand, the fast pace of economic development and improvement in household incomes have promoted changes in consumer preferences in favour of more meat and dairy products, oilseeds, and sugar. The country has increased its average annual GDP per capita, from about USD 2030 per person per year in 1990 to about USD 4050 in 2021, an average income growth of 2.3 percent per annum. Besides the direct impact population growth has on food demand, it has also led to the expansion of urban centres, which – through land encroachment – has taken an important quantity of fertile land away from agriculture. In the last 20 years, more than 75 000 ha have been lost to urban expansion (Perez *et al.,* 2021a).

Egypt has made major strides in improving national and household food security in the last decades, but undernourishment has begun to increase again in the last ten years. Undernourishment climbed from 3.8 percent in 2010–2012, its recent lowest point, to 5.1 percent in 2019–2021. This coincides with a reduction in the average protein supply, which retracted from about 100 grams per capita per day in 2010–2012 to 96 grams in 2017–2019. In times of crisis and volatility in international markets, food availability is compromised, particularly impacting Egypt's most vulnerable population. Rising undernourishment has been accompanied by a sharp spike in obesity, which increased 10 percent in the adult population from 2000 to 2016 due to the high content of cereals, fat, and sugar in the average diet.

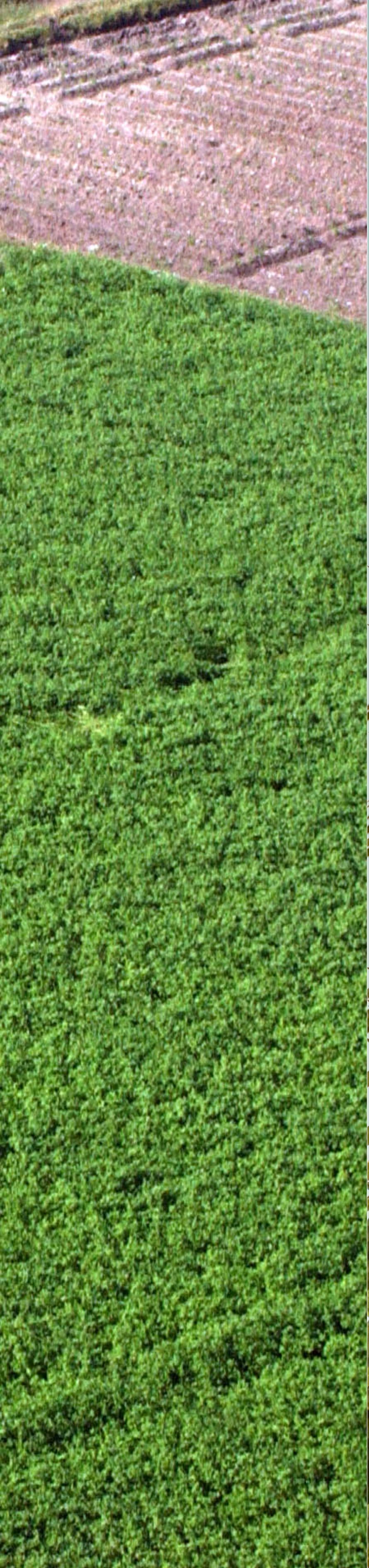
Demand for food has increased steadily in the last two decades; during that same time, the AFS has been experiencing major performance issues. In the last decade or so, the yields of major crops have stagnated, underperforming the global and regional yield averages. Major causes include the relatively low use efficiency of land and water resources, high land fragmentation, increasing soil salinity, and higher incidence of pests and diseases. The majority of Egypt's population occupies about 3.5 percent of the country's land, concentrated along the Nile valley and Delta. Egypt's water availability is not nearly enough to satisfy its demand, as water from the Nile River, rainfall, non-renewable groundwater and desalinisation yields only a total of 59.25 billion cubic metres (BCM) per year, which is less than the water required by different sectors, which need a combined total of 114 BCM per year. The water supply gap is overcome through water recycling (about 21 BCM) and water import. Agriculture is the main consumer, requiring 63.6 BCM per year to supply virtually all agricultural production areas, which depend on irrigation. Inappropriate agricultural practices, unregulated use of chemical fertilizers, and polluting waste disposal practices continue to reduce the amount of water available for irrigation. In 2004, water per capita was 950 cubic metres (m3); it decreased to 700 m3 per capita by 2011, and is projected to drop to 600 m3 by 2025 and 350 m3 per capita by 2050.

Climate change and unsustainable management of water resources exacerbate water scarcity and pose major threats to the AFS, potentially one of the most affected sectors in the economy. Climate change is also a present threat to national and household food security and the livelihoods of the Egyptian population, especially for the most vulnerable groups such as smallholder farmers. Egypt is expected to experience an increase in the average annual temperature, reduction in annual rainfall, and sea level rise, which will also result in salinization and desertification of soils. Climate change scenarios assessing the potential impacts of changes in temperature and rainfall on Egypt's agricultural sector, predict that – by 2050 – the yields for food crops will decline by 10 percent, with the highest decrease estimated for maize (-19 percent); sugar crops (-12 percent); and fruits and vegetables, which are the backbone of agrifood exports (-11.7 percent). Overall food production declines will reach 5.7 percent by 2050.

Government involvement in the AFS has historically been a policy priority across different administrations. Nevertheless, public sector policies and resources have focused on desert land reclamation for agriculture, irrigation infrastructure, and agricultural and food production, all geared towards securing food availability, while food and agricultural input subsidies have been set to ensure food accessibility. Since the public sector involvement in the AFS has evolved towards market-based strategies, the government has recently placed a greater focus on sustainable production of high-value but often export-oriented products, while also ensuring food security with imports of water-intensive food crops, particularly cereals and pulses. It has adopted a more holistic view of the economy as part of Egypt's Vision 2030, the country' umbrella sustainable development strategy, which now includes its Sustainable Agricultural Development Strategy (SADS), launched in 2009 and updated in 2019, as well as its National Structural Reform Programme 2021–2024 (NSRP). These promote the sustainable use of natural resources, increase land and water productivity, raise the degree of food security for strategic food commodities, increase the competitiveness of agricultural products, improve the environment for agricultural investment, and improve the livelihood of rural inhabitants while reducing rural poverty. The institutional setup and public expenditures, however, have been slow to serve these priorities. While the AFS expenditure has been increasing overall, certain agricultural public goods that are key for a vibrant and competitive AFS (research and development – R&D, extension, digitalization of agriculture, infrastructure, etc.) are still largely underfunded.

This study analyses the historical importance of Egypt's agrifood system in the economy, the AFS's performance related to food and nutrition security, employment and growth, as well as the sustainability of natural resources and climate change adaptation. It offers a summary of Egypt's main agrifood policies, focusing on developments in the context of recent reforms, the COVID-19 pandemic and the war in Ukraine, along with the reforms envisaged in the NSRP to promote climate-resilience, green recovery and green growth. The study provides an evidence-rich contextual foundation for identifying climate-smart policy and investment options that align with the government's agrifood goals, which may create transformational impacts along the AFS. The analytical work is conducted around four subsectors: dairy, dates, maize, and wheat. These were prioritized in collaboration with Egypt's Ministry of Agriculture and Land Reclamation (MALR) based on their importance in terms of food security, import dependence, output and employment, value addition potential, and because they offer the possibility to analyse a number of productivity and sustainability issues that may illustrate the challenges and opportunities the AFS as a whole and other value chains face in Egypt. The target climate-smart agriculture (CSA) technologies are prioritized based upon their potential to generate 'triple-wins' by increasing agricultural productivity and incomes, strengthening people and agrifood systems' resilience to climate change, and climate change mitigation.

The analysis of selected CSA options shows there is a business case for investing in such technologies, which make important contributions to AFS goals in the face of climate change. The selected CSA approaches have the potential to generate efficiency gains in terms of land, water, and energy. Investments at scale in these technologies would also lead to job creation, reduce the local production/consumption gap and improve food and nutrition security. While the productivity enhancements may lead to increased incomes for farmers and rural households, the water, land and energy savings associated with implementation of CSA technologies could be dedicated to diversifying production towards more nutritious and climate-resilient crops.



Chapter 1
Introduction

1.1 RATIONALE

The agrifood system continues to play a critical role in the Egyptian economy, not only in terms of food production, but also for employment, poverty reduction, and household food and nutrition security.[1] In the last 50 years, while agriculture has reduced its relative contribution to the national economy, the agricultural output has expanded fourfold, and the sector still accounts for 11.6 percent of GDP and 20.5 percent of all formal jobs in Egypt (World Bank Group, 2022a). A conservative analysis suggests that the agrifood system as a whole contributed more than 24 percent of GDP in 2015 (Breisinger *et al.*, 2019) and 34 percent of full-time equivalent jobs (Yeboah and Jayne, 2022), highlighting the important multiplier effects of the AFS in Egypt's domestic economy.

Egypt's AFS faces diverse structural challenges. The performance of agriculture has slowed in the last two decades as yields of major crops have stagnated and slightly decreased, underperforming compared to global and regional yield averages. This is driven by a relatively low use efficiency of land, labour, water and energy; high land fragmentation, environmental degradation and other factors (e.g. limited access new technology) that favour the incidence of pests and diseases. Furthermore, Egypt's agribusiness sector is held back by barriers to international trade, weak local supply chains and a frail extension and training system (International Finance Corporation, 2020). Domestic supply chains are characterized by inadequate transport facilities, insufficient bonded warehousing capacity, and weak cold-chain

1 Agrifood systems consider the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption, and disposal of food products.

infrastructure, as well as limited assurance of food safety and quality standards. This affects local access to inputs for agrifood processing and contributes to food waste and loss. The research on, extension of and access to finance connections require a concerted effort of improvement. Egypt's expenditure on innovation and research in the sector is below average for emerging economies at 0.44 percent of value added in agriculture (compared with 0.52 percent elsewhere). This calls for more public-private partnerships in agrifood innovation and R&D. The agribusiness policy environment can also be rethought to enable a transition to sustainable food systems with better targeting of support.

AFS challenges are compounded by population pressures. Achieving food security in Egypt is difficult because the population is growing quickly, as is per capita income. The country must produce more food to feed a larger population and needs to accommodate the growing demand for more varied types and qualities of food items. While progress has been made, the current structure of the agrifood sector favours self-sufficiency and focuses on cereals, which – given the country's agroclimatic conditions – has resulted in widening the food trade deficit. The share of dietary energy supply derived from cereals, roots and tubers (kcal/cap/day, three-year average 2017–2019) is 66 percent. The cereal import dependency ratio, a three-year average, has increased from 27.8 percent 2003–2005 (lowest level over the las two decades) to 47.8 percent 2017–2019 (highest level in the period) (FAO, 2022a). The region faces an important and complex nutrition challenge stemming from high levels of child malnutrition and growing obesity problems. Incorporating a nutritional lens into agrifood sector-related policies is therefore essential; this will require a cross-sectoral approach that includes education, health systems and social protection.

Climate change poses major threats to Egypt's development. Egypt is classified as 'highly vulnerable' to climate change effects (Notre Dame Global Adaption Index, ND-Gain, 2020). Temperatures in Egypt have already increased 0.53°C per decade over the last 30 years (World Bank Group, 2022b). By mid-century, temperatures are expected to increase between 1.5°C and 3°C, with greater increases in the country's interior and during the growing season. Heat waves will increase in their severity, frequency, and duration; an average of 40 more extremely hot days per year are projected by mid-century. High temperatures and more heat waves will raise the already high evaporation rate, accelerate crop transpiration, functionally increase soil aridity, and elevate water requirements for human consumption and agriculture. In the coming century, the variability of the region's rainfall is projected to increase with estimates showing a 50 percent spike in variability by the year 2100, thereby impacting the flow of the Nile River. This change will result both in more frequent drought years and more frequent high-flow years, as well as an increase in the frequency and intensity of flash floods in Egypt's coastal areas. The country is also highly vulnerable to sea level rise, which results in further salinization and desertification of soils, especially in the Nile Delta. The combined impact of climate change on water resources, tourism revenue, coastal resources, agriculture and human health through air pollution and water stress, will represent between 2 percent and 6 percent of Egypt's GDP by 2060 (World Bank Group, 2022b).

Climate change impacts on the AFS and the country's food and nutrition security (FNS) are high. Changes in temperature, rainfall and sea-level rise have important impacts in key assets of the AFS, such as land, water, energy, labour and ecosystem services, which will affect the system's outcomes – ultimately expressed in the four dimensions of FNS: availability, access, utilization and stability. Climate change scenarios predict that yields for food crops will decline about 10 percent by 2050. The highest declines are estimated for maize (-16.2 percent), sugar crops (-12.0 percent) and fruits and vegetables, which are the backbone of agrifood exports (-11.7 percent). Overall food production decline will reach 5.7 percent by 2050, compared to a 4.4 percent decline in the rest of the world (Perez *et al.*, 2021b). Livestock production is also likely to decrease due to heat stress and higher incidence of pests and diseases. Nearly 15 percent of the most fertile arable land in the Nile Delta, where about half of Egypt's crop production takes place, is already negatively affected by sea level rise and saltwater intrusion. The proportion of population affected by moderate to severe food insecurity is projected to increase by about 4 percent between 2021 and 2040. It would then increase further, albeit at a lower rate, until the year 2100, compared with historical estimates (1995–2014, 28 percent) (Climate Vulnerable Forum and Vulnerable Twenty Group, CVF and V20, 2022).

Concerted action for the sustainable transformation of AFS towards higher resource use efficiency, climate resilience, and competitiveness is urgent. These in turn may contribute towards Egypt's efforts to reduce its environmental footprint and achieve its climate change mitigation goals, also expressed in the country's First Updated National Determined Contribution (NDC), submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in June, 2022. A path to sustainable AFS growth requires Egypt to embark on a system-wide agenda to promote climate-resilient green growth that embodies structural changes in the production and distribution of food. A key pillar of such efforts is mainstreaming adaptable and tested CSA technologies and practices, involving all actors (small and large, public and private), and throughout the agrifood value chains.[2] CSA practices and technologies are diverse and specific to the conditions of different regions and production systems. Five technology clusters (water management, crop tolerance to stress, intercropping, organic inputs, and conservation agriculture) account for nearly half of CSA practices and technologies in a sample of 300 distinct production systems across 33 countries (Sova *et al.*, 2018). Increased resource use efficiency, reduced food losses, and integrated management of natural resources leads to important savings in terms of land, water and energy, which in turn could be directed to reduce the food security gap and enhance the diversity and nutritional value of Egypt's food basket. Given the importance of understanding the impact and scalability potential of CSA technologies in different contexts, five action points are typically proposed at the country level to implement CSA efforts: 1) expand the evidence base for CSA; 2) support enabling policies; 3) strengthen national and local institutions; 4) enhance funding and financing options; 5) implement CSA practices in the field (FAO, 2021).

2 CSA is an approach used to guide actions towards the sustainable transformation of agrifood systems through the promotion of green and climate resilient practices and technologies.

Scaling up the adoption of CSA practices and technologies can bring important economic returns. The adoption of CSA practices and technologies can generate 'triple-wins' in terms of increasing agricultural productivity and incomes, strengthening people and agrifood systems' adaptation and resilience to climate change, and climate change mitigation (FAO, 2021). Investments in climate-technologies and climate-smart agrifood practices have strong positive impacts on Egypt's regional and national GDP, with corresponding benefit-cost ratios ranging from 3.1 to 3.7. While investment in upstream agriculture brings positive returns, downstream agrifood processing and marketing result in a progressively stronger response to investment and higher impacts on GDP, with benefit-cost ratios that can reach up to 14.6. Investments in CSA practices and technologies are related to increases in employment, agricultural exports, and production capacity to meet the growing domestic demand for food (World Bank Group, 2021a).

1.2 ORGANIZING FRAMEWORK

The overall objective of this study is to analyse climate-smart policy options to improve performance of Egypt's agrifood system and enhance its competitiveness. The study was conducted in consultation with Egypt's MALR, the private sector, expert community, and academia. This study is part of an extended advisory and analytical work led by the World Bank to provide evidence-based guidance on the operationalization of NSRP's main objectives for the agrifood sector and the ambitions of the Nexus for Water, Food and Energy (NWFE) programme of the National Climate Change Strategy of Egypt.

The proposed CSA analytical framework helps identify the main climate-smart investment opportunities, to inform evidence-based results-oriented AFS planning in the face of climate-related uncertainty. The approach incorporates: literature review, stakeholder engagement, expert interviews and quantitative modelling and analyses as the main sources of information. It comprises four key steps: 1) defining the scope, mostly driven by the NSRP and sectoral strategies; 2) validating and prioritizing options suitable to the context of Egypt; 3) analysing and defining options of best-bet CSA technologies; and 4) aligning to context, assessment of the potential to scale up CSA strategies and the definition of policy options. Annex 1 provides details of each step.

Step 1. Defining the scope: formulation of AFS goals and subsectors, guided by the National Structural Reform Programme 2021–2024 and sectoral strategies. The criteria used for the selection of subsectors include: (a) economic relevance; (b) possibility to increase productivity with no or limited environmental footprint; (c) relevance to FNS; (d) potential to enhance climate change adaptation and mitigation. To support this process, the team applied inputs such as an AFS rapid assessment and an analysis of AFS policies and expenditures, focusing on Government of Egypt (GoE) priorities: NSRP, the National Climate Change Strategy 2050 (NCCS), the First Updated NDC and the NWFE (explained below). Consultations with decision-makers guided the preparation of inputs and the validation of AFS goals and the selection of subsectors for in-depth analysis.

The subsectors selected for in-depth analysis, following Step 1, are: dairy, dates, maize, and wheat. These value chains were prioritized in consultation with MALR, based on their importance in terms of food security, import dependence, output and employment, but also because they offer the possibility to analyse a number of productivity, climate resilience and sustainability issues, which may illustrate the challenges and opportunities faced by other value chains in Egypt and its AFS as a whole. As a starting point, the food systems assessment analytical framework developed by the European Commission's Directorate-General for International Partnerships, FAO, and the International Centre of Agricultural Research for Development (CIRAD), was used to analyse the historical importance of Egypt's AFS and its performance vis à vis outcomes such as: food and nutrition security, employment and growth, natural resources management and climate change (David-Benz *et al.*, 2022). The study adopts the guiding principles of the World Bank's Green, Resilient, and Inclusive Development (GRID) framework, which promotes sustainable pathways to recover from multiple shocks affecting the country, but which also require forward-looking transformative policy reforms (World Bank Group, 2021b). The analyses of CSA options, policy synergies and trade-offs are implemented at the level of the targeted value chains, yet with attention to how these subsector-specific policy options can help the whole AFS achieve its goals.

Step 2. Validating and prioritizing options: collaborative stakeholder-driven identification of key uncertainties, main trends, and priority climate-smart technologies. This step focused on the identification and refinement of best-bet CSA technologies for each subsector, taking into consideration inputs from Step 1, especially the contribution to climate change adaptation and mitigation. Besides the information from the AFS rapid assessment, directions from the First Updated NDC – NWFE and the policy framework provided by the AFS policies and expenditure analysis, particular attention was given to the climate change scenarios and projected impacts in AFS identified from the Country Climate and Development Report (CCDR) (World Bank Group, 2022b), studies from the International Food Policy Research Institute (IFPRI) (especially Perez *et al.* 2021a, 2021b and 2021c) and other secondary sources; consultation (workshop and interviews) with stakeholders (GoE, researchers and value chain actors) to select CSA packages based on expert knowledge about the climate smartness of technologies (efficiency, resilience, as well as climate change adaptation and mitigation). Step 2 led to the formulation of CSA packages for each subsector, including an initial description of technologies applied in the conventional system with respect to those adopted in the CSA scenario.

Step 3. Analysing and defining options: quantitative and qualitative analyses of the best-bet CSA options. This includes the technical, financial and economic analysis of CSA packages compared to conventional systems, and specification of minimum conditions relevant for adequate application and sustainability. Annex 1 presents a detailed description of the methodology applied here. The inputs of the analysis are data shared by the GoE and value chain stakeholders; research papers and other secondary sources of information (Annex 2). The outputs of Step 2 are the technical descriptions of

CSA investment models and estimates for key environmental indicators – water use efficiency, energy use efficiency, land-use efficiency and greenhouse gas (GHG) balance; financial performance indicators (incremental analysis) per investment model and per CSA package. This last included the internal rate of return (IRR), net present value (NPV), pay-back period for investments, switching value for costs (SVC), switching value for benefits (SVB), and socioeconomic data to: a) build the economic assessment and incremental analysis of CSA options at scale (economic IRR or EIRR, economic NPV or ENPV and sensitivity analysis of economic cost and benefit streams); b) delimitate minimum conditions for scaling up. Indicators are presented in comparable units among the various CSA packages. Annex 2 summarizes the quantitative and qualitative assessment of CSA options.

Step 4. Aligning to context: assessment of CSA potential scale-up and definition of policy options, including the analysis of co-benefits and barriers to adoption. This is based on quantitative (i.e. economic and financial analysis) and qualitative evaluation of barriers/opportunities for adoption of CSA packages. The inputs applied are the environmental and financial performance indicators per CSA package (Step 3); economic performance indicators at scale (based on the conventional system and CSA scenarios developed in Step 3), along with two other macroeconomic indicators – job creation potential (direct and indirect along the value chain) and contribution to FNS in terms of reducing the production/consumption gap; and, technical description of CSA investment models, including minimum requirements for adoption (Annex 2). The delimitation of CSA scale-up potential is based on conservative assumptions corroborated by secondary sources of information, mainly academic papers, reviewed during Step 2 and Step 3. The outputs of Step 4 are the identification of key factors hindering the adoption of CSA packages; the definition of general policy priorities to overcome the current barriers to CSA adoption; and the delimitation of investment priorities in the short, medium and long term.

The proposed CSA organizing framework aligns with the government's sustainable development strategy (known as Egypt's Vision 2030[3]) and the second-generation National Structural Reform Programme. These policies tackle long-standing problems associated with water scarcity, rapid population growth and climate change by improving crop productivity, enhancing resilience to water scarcity and climate change, and reducing agrifood supply chain losses. The NSRP encompasses the highest-level government policy responses to the COVID-19 pandemic and will likely guide reforms to address some of the mid- and long-term impacts on the Egyptian economy of both the pandemic and the Russian Federation-Ukraine war. Agriculture is one of three sectors prioritized in the NSRP, for it presents an unprecedented opportunity to scale up green investments and CSA

3 In 2016, the government launched its Egypt Vision 2030 to achieve a competitive, balanced, diversified and knowledge-based economy. Egypt's Vision 2030 addresses nine sectors: agriculture, water and irrigation, manufacturing, tourism, transportation, information and communication technology, supply and internal trade, housing and utilities, and foreign trade. Thus, the agrifood sector is highly relevant in attaining Egypt's development vision through the sector's linkages to food, water and energy. One of Egypt's Vision 2030 key objectives (3.1) is to address the challenges posed by climate change (Arab Republic of Egypt, 2016a).

technologies to achieve AFS green growth objectives while also creating quality jobs in rural areas, and increasing resilience, value-addition and agrifood exports. The second level of actions includes various initiatives to identify, test and deploy climate technologies in the agrifood sector.

Egypt also seeks to foster sustainable agricultural growth, modernize agriculture, and strengthen rural livelihoods through its Sustainable Agricultural Development Strategy 2030, part of Egypt's Vision 2030 initiative. Through SADS, the Ministry of Agriculture and Land Reclamation aims to promote sustainable management of land and water resources and strengthened resilience to climate change via the achievement of six objectives: 1) improving food and nutrition security; 2) promoting sustainable agriculture; 3) ending poverty and improving the living standards in rural areas; 4) reducing the impacts of climate change on the agrifood system; 5) increasing the competitiveness of agriculture; and 6) expanding job opportunities along the AFS, particularly for women and youth. While SADS 2030 considers several enabling policies and implementation mechanisms, these do not adequately address climate change impacts in agriculture, or the need to build the sector's resilience through adoption of CSA technologies.

The study also contributes knowledge towards the implementation of Egypt's National Climate Change Strategy 2050. The NCCS, launched in May 2022, articulates the country's national climate policy. It provides a comprehensive institutional framework for climate action to 2050, with two goals on mitigation and adaptation priorities and three enabling goals intended to address governance, financing and technology. The NCCS identified clear objectives and targets for Egypt to transition towards a low-carbon development pathway while enhancing resilience. It includes the establishment in all ministries of specialized units to deal with climate change issues, a measure intended to foster institutional coordination at the sector and overall level. The NCCS and the First Updated NDC both include high priority projects to be completed by 2030, several of which relate to the objectives of a more resilient and sustainable AFS.

The Nexus on Water, Food and Energy aims to operationalize the NCCS. Launched at the 27th UNFCCC Conference of Parties 2022 (COP27), the NWFE platform is a commitment to go "from pledges to implementation" (Moneim, 2022) to accelerate Egypt's implementation of its NDC. The platform will facilitate the design, structuring and preparation of concrete and implementable climate action projects. NWFE integrates nine high-priority projects for adaptation and mitigation – bundled around the nexus of water, food and energy – and selected through a prioritization process led by the GoE. These climate action projects are to be implemented under a programmatic approach that includes increasing crop yields and irrigation efficiency, building resilience of smallholder farmers and vulnerable regions, developing water desalination capacity and establishing early warning systems. The CSA options identified and assessed at scale in this study fully align with the NWFE and provide initial estimates of their contribution in terms of water, land and energy efficiency, as well as their ability to generate employment and support FNS.

There are other initiatives from the government and development partners to promote productivity-enhancing and climate-smart technologies at the level of farms and agrifood enterprises that possess significant potential for climate change adaptation and mitigation. These technologies have been tested in various technology centres of the Ministry of Supply and Internal Trade (MOSIT), and through the Agricultural Research Centre (ARC) of the Ministry of Agriculture and Land Reclamation. The MALR reports considerable resource use efficiency (around 35 percent reduction in water use) after introduction of the raised-bed wheat cultivation method in around 1 million hectares. This further demonstrates that scaling up CSA technologies in Egypt produces substantial benefits.

Chapter 2
The agrifood system in Egypt

2.1 KEY FIGURES AND TRENDS

The agrifood system remains critical to Egypt's economy and continues to play a prominent role for employment, poverty reduction, and food and nutrition security. The process of structural transformation that the Egyptian economy has experienced in the last five decades resulted in substantial reductions in the relative contribution of the agriculture sector to the national GDP, and to employment (Figure 2.1). Yet, agriculture has increased its output fourfold in the same period,[4] and still accounts for nearly 11.6 percent of Egypt's GDP and 20.6 percent of all jobs (World Bank Group, 2022a). The backward and forward linkages of agriculture with the rest of the economy in Egypt are strong. In 2015, the AFS accounted for nearly 24.2 percent of Egypt's GDP,[5] and 34.2 percent of full time equivalent jobs. These GDP estimations are based on a conservative definition of the AFS.[6] Modest estimates of the multiplier effect of agriculture in Latin American countries, for example, indicate that, on average, a 1 percent growth in agriculture (as a primary sector) could generate

4 The agricultural value added increased from USD 10.28 billion in 1970 to USD 43.97 billion in 2020, constant 2015 USD, based on WDI (World Bank Group, 2022a).
5 Breisinger *et al.*, 2019 using Egypt's 2015 Social Accounting Matrix (SAM).
6 The authors divided the agrifood system into direct production (agriculture and agroprocessing), input production, and trade and services related to agriculture and agroprocessing.

0.12 percent growth in the overall economy, when the share of the sector in the GDP is 12 percent (de Ferranti *et al.*, 2005). While the structural transformation of the Egyptian economy has mirrored the overall trend of other MIC economies in the region (Figure 2.1), the case of Egypt highlights five trends described below. They provide insights for the design of policies and investments aimed at accelerating agricultural productivity growth as a powerful way to continue an inclusive pro-poor and sustainable transformation of the Egyptian economy.

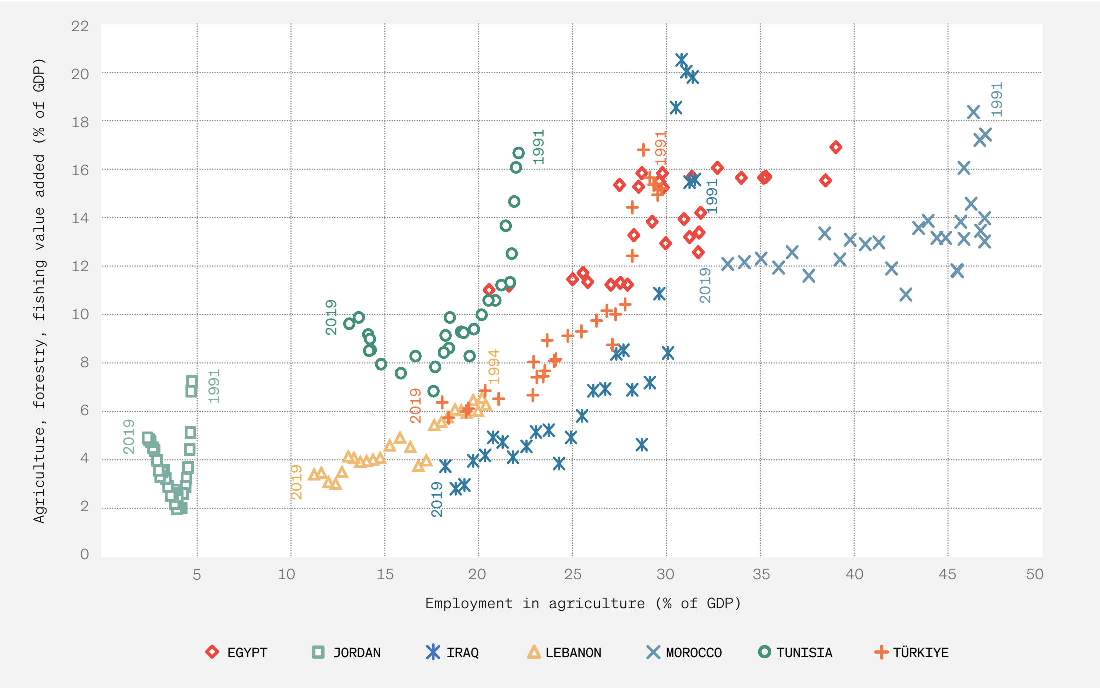


Figure 2.1
Agricultural transformation in Near East and North Africa countries (1991–2019)

SOURCE: Authors' own elaboration based on: World Bank Group. 2022a. World Development Indicators (WDI). In: *World Bank Data*. Washington, DC. [Cited 13 September 2022]. https://data.worldbank.org/indicator

First, the shares of agriculture in GDP and employment in Egypt have decreased at a slower pace than in other similar economies. In the early 1970s, agriculture's share of Egypt's GDP (27 percent) was less than the average share (31 percent) in MICs. As the relative importance of agriculture in the national economy continued to diminish, the size of the sector in Egypt contracted at a slower pace than in other MICs, and since the mid-1980s, Egypt's share of agriculture in GDP has been larger than the average of the MICs. In 2020, this share was 11.6 percent in Egypt and 9.2 percent in MICs, even though the GDP per capita in Egypt was already substantially higher than that of the MICs (Figure 2.2). This implies that while the structural transformation of the economy is incomplete, the comparatively high importance of the sector in the economy may be explained by the high productivity growth that key subsectors experienced in the same period, both in terms of labour productivity and yields (El-Enbaby *et al.*, 2016). The agriculture value added per worker has increased from USD 3122 in 1990 to roughly USD 7670 in 2020 (constant prices of 2015), and land productivity was substantially higher than the MICs average (WDI, 2022). The cereal yield, for example, was 7.15 tonnes per hectare in 2018, well above the region's 2.64 tonnes per hectare, and the 3.91 tonnes per hectare in MICs (World Bank Group, 2022a). Similarly, vegetables, citrus, and sugar crops – three important crop categories in the country – show higher yields in Egypt than the North Africa regional averages. In the case of employment, the share of agriculture in total employment in Egypt (21 percent) is higher than the average in the Near East and North Africa region (NENA) (15 percent), Latin America (14 percent), and other economies with similar GDP per capita. Additionally, in the last 20 years, the reduction of the contribution of agriculture to jobs in Egypt is faster than some Latin American countries, but substantially slower than in NENA countries and other comparable economies such as South Africa, Tunisia, and Ukraine.

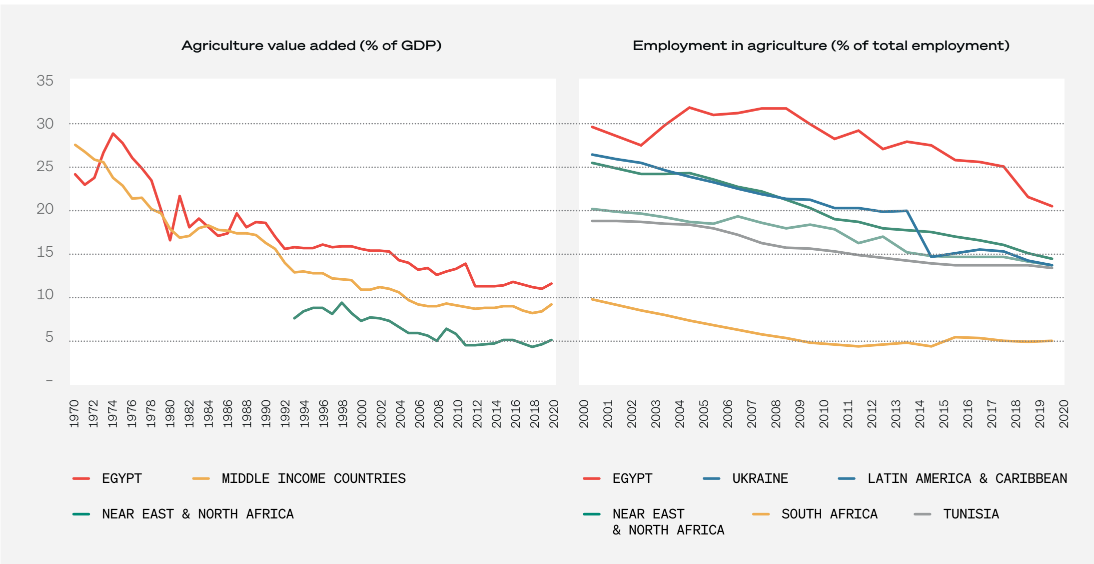
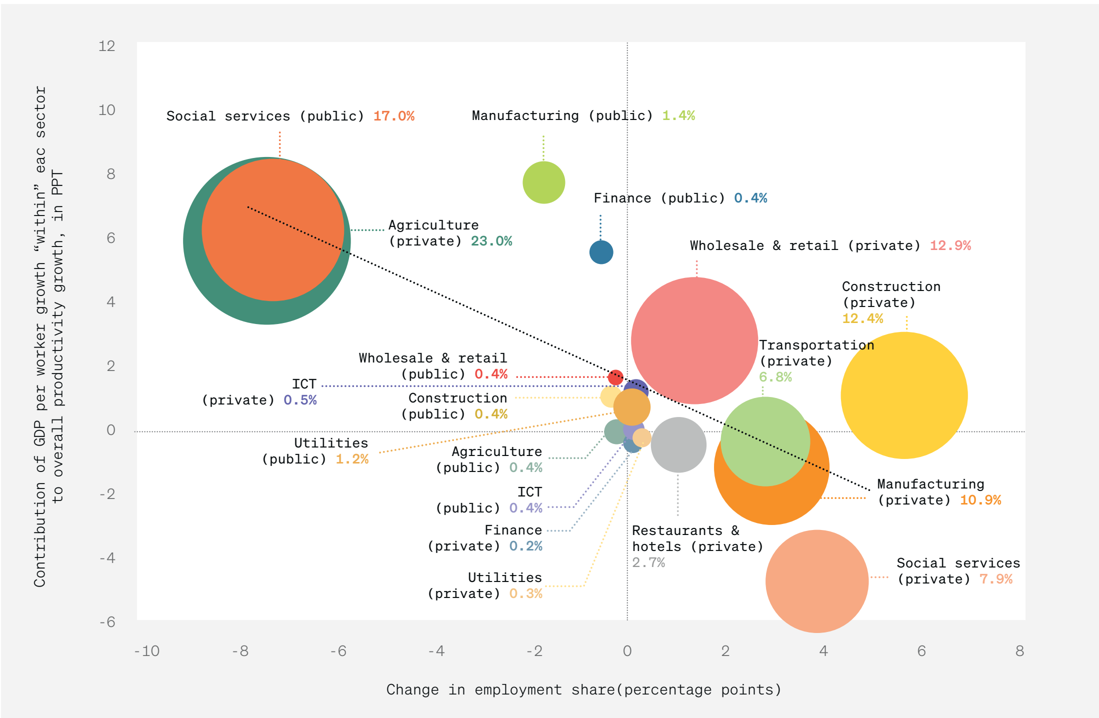


Figure 2.2
Relative importance of agriculture in GDP and employment in similar economies

SOURCE: Authors' own elaboration based on: World Bank Group. 2022a. World Development Indicators (WDI). In: *World Bank Data*. Washington, DC. [Cited 13 September 2022]. https://data.worldbank.org/indicator

Second, agriculture has been a major driver of economic transformation and expansion of the manufacturing and services sectors. The increase in agricultural total factor productivity in Egypt is strongly associated with declining shares of employment in farming activities (mostly private sector employment as indicated in Figure 2.3) and job growth in the non-farm sector, both within and outside the AFS. A recent analysis suggests improvements in Egypt's agricultural performance have enabled labour reallocation out of agriculture to other sectors, and employment growth in more productive and higher paid jobs in the non-farm sector (often in urban areas) over at least the last 15 years (Yeboah and Jayne, 2022). The exit from agriculture also correlates with rural-to-urban migration, which has generally been associated with a net welfare loss or limited welfare gains for most migrant groups (Hatab, 2022). Agricultural total factor productivity growth is also associated with higher earnings per hour in farming activities. This is similar to the trends in more industrialized countries, where sustained agricultural productivity growth created the demand for, and enabled labour reallocation into better paying non-farm jobs. It allowed incomes to equate food costs, resulting in major improvements in food security and living standards (Johnston and Mellor, 1961). Productivity growth in agriculture, have also contributed to accumulation of capital invested in non-farm activities up- and downstream the AFS, and in the services and manufacturing sectors. In the case of some key value chains (livestock, fruits and vegetables, bulbs and tubers, medicinal and aromatic plants or MAPs, etc.), the expanded agricultural surplus also enabled major increases in foreign exchange via exports.



NOTE The Figure shows the cumulative change in sectoral productivity and employment shares between 2004 and 2018. The size of the employment share in 2018 is represented by the size of the bubble for each subsector.

Figure 2.3
Sectoral productivity growth and changes in employment shares in Egypt (2004–2018)

SOURCE: Adapted from Alnashar, S. B. H., Elashmawy, F. I. M., and Youssef, J. 2020. *Egypt Economic Monitor: From Crisis to Economic Transformation – Unlocking Egypt’s Productivity and Job-Creation Potential* (English). Washington, DC, World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/256581604587810889/

Third, despite the major increase in agricultural performance, value addition has been low and well below potential. Egypt processes less than 10 percent of its fresh produce, which is a fraction of the global average of 25–35 percent, and exports less than 1 percent of its processed products (Oxford Business Group, 2022). Since the early 1990s, the agriculture sector has experienced moderate but steady growth in the order of 3 percent annually. While this growth in agriculture has contributed to the expansion of agroprocessing and agriservices, the value addition downstream the AFS has been starkly below potential. When compared with other similar economies, Egypt has a remarkably small agroprocessing depth ratio of food manufacturing to agricultural production (Figure 2.4). As of 2015, 76 percent of the AFS's GDP contribution originated in agriculture production (Randriamamonjy, 2019); today, 68 percent of AFS jobs are related to farming (cf. Yeboah and Jayne, 2022). Whereas agriculture represented 11.6 percent of GDP and 20.6 percent of jobs in 2021, agroprocessing only represented 3.7 percent of GDP and 4.6 percent of jobs (Breisinger *et al.*, 2019; Yeboah and Jayne, 2022). Following the experience of other developed economies, as the contribution of the primary sector to the economy diminishes, structural transformation of the primary sector (conversion from staple to higher value subsectors) and downstream AFS activities will play an increasingly important role in the economy, with trade, production of high value products, agroprocessing and AFS-related marketing and food services becoming important drivers of rural growth and job creation in the economy.

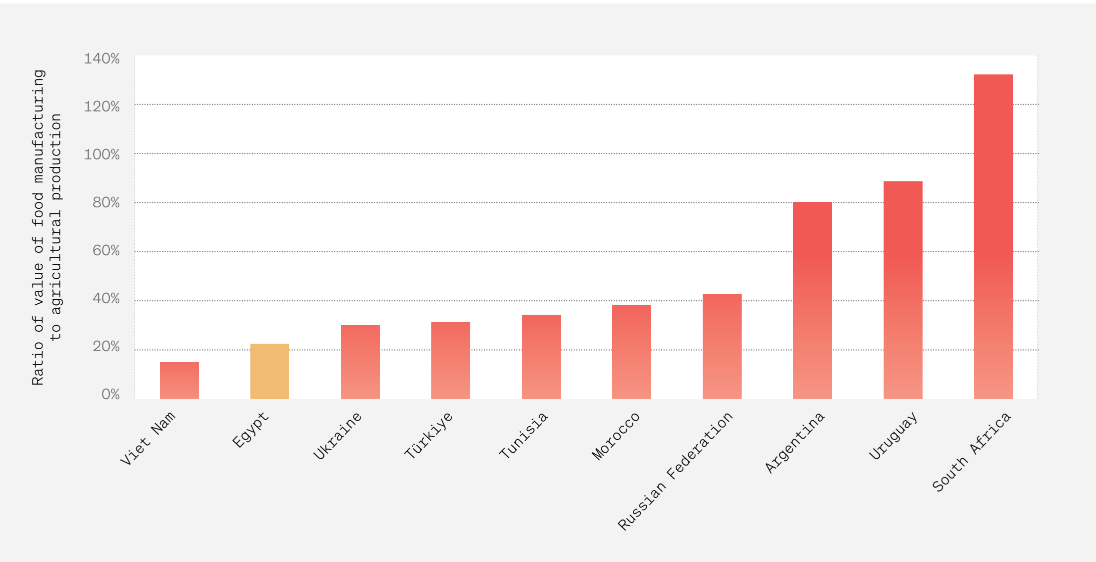


Figure 2.4
Agroprocessing sector depth in Egypt and other comparable economies (2016)

SOURCE: Authors' own elaboration based on: World Bank Group. 2022a. World Development Indicators (WDI). In: *World Bank Data*. Washington, DC. [Cited 13 September 2022]. https://data.worldbank.org/indicator

Fourth, AFS growth has been pro-poor overall, but AFS downstream activities have had greater impact on increasing earnings of the poorest. Job growth lags behind the pace at which the working age and labour force is expanding. So, the different sectors in the economy must accelerate job growth in order to absorb the growing working age population. In the period 2007–2017, the farming sector had a real increase in annual earnings of about 2.7 percent, after food services (2.8 percent), and non-AFS sectors (2.9 percent); and across the AFS and other economic sectors, the average earnings have increased in all income quintiles. Within the AFS, farming activities have increased the earnings of the first income quintile of the population by 2 percent, agroprocessing by 2.7 percent, and commerce and distribution by 3 percent. Remarkably, while farming activities have been able to increase the incomes of the poorest, they seem to have had a larger impact on the earnings of the richest quintiles (Figure 2.5). Conversely, agroprocessing, commerce and distribution have the highest impact on the earnings of the poorest, and the impact diminishes towards the richest income quintiles. Given that the farming sector will continue to be an employment source in the AFS and that the potential growth of agroprocessing also depends on the availability of consistent and quality volumes of raw material, overall jobs and income growth will be highly dependent upon on-farm productivity enhancements, as well as improvements in the overall competitiveness of the AFS.

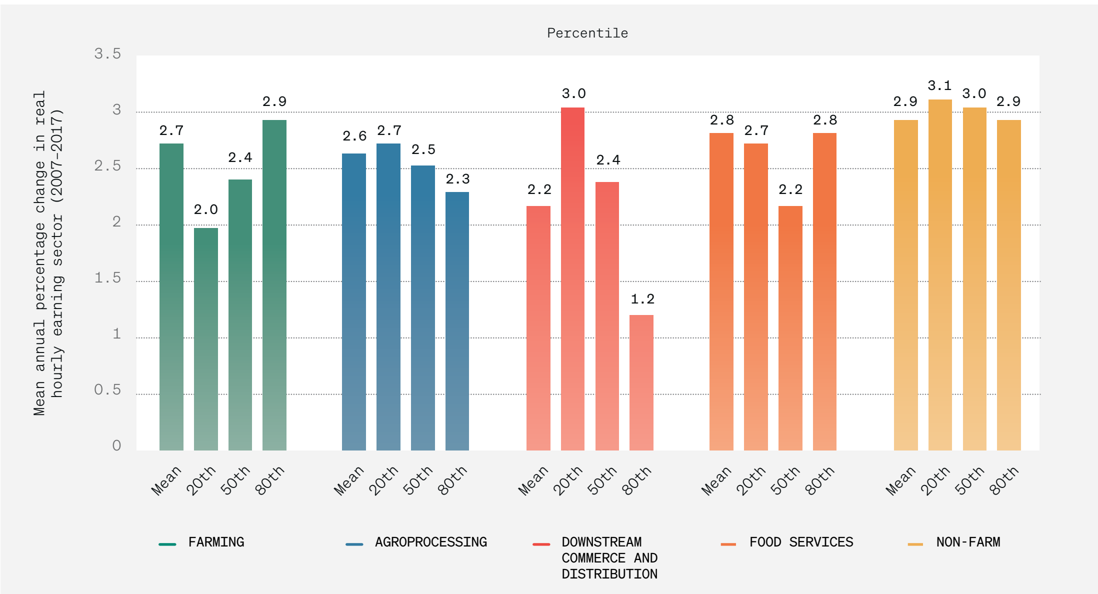


Figure 2.5
Mean annual percentage change in real hourly earnings in sector (2007-2017)

SOURCE: Yeboah, F. K. & Jayne, T. S. 2022. *Employment structure and pathways for economic transformation in Egypt.* International Development Working Paper. East Lansing, Michigan, USA, Michigan State University.

Fifth, from the resource use point of view, water and arable land are the main productive constraints for Egypt's AFS performance and sustainability. The increasing demand for food (especially protein) due to rapid population growth and rising wealth, water pollution, inefficient use of limited water resources, and climate change are deepening water scarcity in Egypt. The total demand for water in Egypt is about 114 BCM per year and available water resources from the country amount to only 59.25 BCM per year. The water deficit is covered by water recycling (about 21 BCM/year) and imports. With population growth, there has been a sharp decline in the annual freshwater resource available per capita, which has shrunk from 1972 m^3 per year in 1970 to 570 m^3per year in 2018. It is expected to fall to 390 m3 per year by 2050 (below the absolute water scarcity threshold) (Arab Republic of Egypt, 2022a). The Nile Basin faces the threat of climate change alongside water scarcity, rapidly rising pressures on water resources due to population and economic growth, and a politically complex transboundary water management system. The Grand Ethiopian Renaissance Dam is expected to result in a range of opportunities and risks. For Egypt, the dam is expected to reduce hydropower generation and impose irrigation water deficits if there is no coordination on managing multiyear droughts (Basheer *et al.*, 2023). The deterioration of water quality and water pollution due to chemicals and heavy metals in the Nile valley is a major issue affecting the capacity to produce high quality and safe food products for the untapped domestic and export markets. Moreover, the total cultivated area (arable land plus permanent crops) covers just 4 percent of the total land, or about 3.83 million hectares in 2019, and a significant part of the land in the Delta has been losing its production potential due to climate change and deteriorating soil quality. Land-use patterns and land fragmentation are also major challenges facing agriculture in the country, with nearly 85 percent of farms averaging no more than 0.6 ha per unit. Desert lands newly reclaimed for agriculture, most cultivated by larger private and institutional farms and often export-oriented, have the potential to expand the agriculture frontier. These lands predominantly use groundwater from the 2 BCM/year non-renewable sources found in Egypt's Western Desert and Sinai aquifers, which represent less than 4 percent of the current water used in agriculture.

Land productivity has remained stagnant in the last decade. Since the early 1960s, all major crops in Egypt (sugar crops and cereals) have steadily increased their yields, placing Egypt well above the North Africa and world yield averages (Figure 2.6). Maize and wheat increased from about 2.5 tonnes/ha in 1961 to about 4.9 tonnes/ha and 6.5 tonnes/ha in 2005, respectively. Sugar cane yields improved from about 90 tonnes/ha in 1961 to more than 120 tonnes/ha in 2005. However, yields of major crops have either stagnated in the last 15 years or – in most cases – slightly decreased, underperforming in comparison to the global and North African yields. This has hindered farm income growth, which – coupled with Egypt's higher than regional average population growth (around 2 percent in 2020) – has contributed to sustained high levels of poverty (28 percent in 2020), especially in rural areas and in Upper Egypt, where most people work in agriculture (about 55 percent) and where two-thirds of the extreme poor live. Major factors more broadly suppressing resource use efficiency (especially labour, land and water), yields and productivity include: (a) high land fragmentation; (b) limited capacity and skills of farmers and the agricultural labour force overall; (c) limited agrilogistics (rural roads, storage capacity, refrigerated facilities, etc.), especially in Upper Egypt; (d) limited access to financial services to enable upgrading investments; (e) increasing soil salinity and higher incidence of pests and diseases, which are also compounded by farmers' poor adoption of improved agricultural practices and technologies. Stagnant growth is also a sign that the agricultural resource base is under pressure, especially water and land, both of which are also more vulnerable to climate change and extreme weather events.

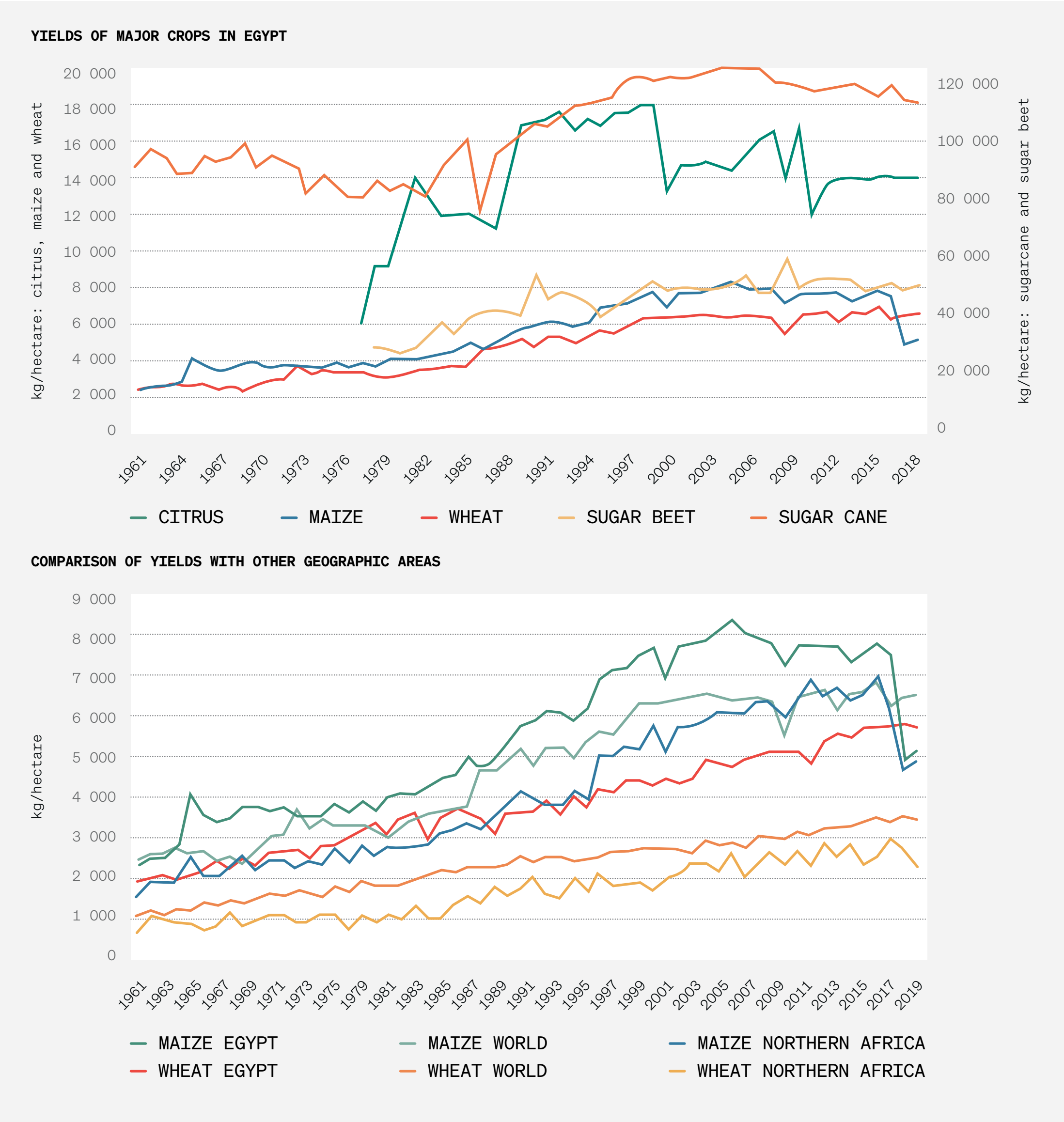


Figure 2.6
Yields of major crops in Egypt and in North Africa (1961–2019)

SOURCE: Authors' own elaboration based on: FAO. 2022a. FAOSTAT. In: *FAOSTAT*. Rome. [Cited 13 September 2022]. https://www.fao.org/faostat/en/

2.2 AGRIFOOD SYSTEM PERFORMANCE VIS-À-VIS FOUR FUNDAMENTAL OBJECTIVES

AFS systems are expected to contribute to numerous fundamental development goals beyond their direct influence on food production and food and nutrition security. The AFS is a major contributor to sustainable employment and livelihoods, and to building environmental and economic sustainability (David-Benz, *et al.*, 2022.). This section assesses the performance of Egypt's AFS from the perspective of: (a) food and nutrition security; (b) socioeconomic considerations, employment, and growth; (c) environmental sustainability and climate change; and (d) territorial balance and equity.

2.2.1 Ensuring food security and nutrition

Egypt has experienced two marked demographic trends in the last few decades that will continue to increase food consumption and shape consumer preferences towards more meat and dairy products, oilseeds, and sugar. On the one hand, Egypt has experienced rapid population growth (at 1.9 percent in 2021), which has almost doubled the country's population in the last three decades, from 56.1 million people in 1990 to nearly 104.2 million in 2021 (Figure 2.7). The rate of population growth averaged 2 percent in the last 20 years, which is slightly higher than the fast-growing NENA region (1.94 percent), and substantially higher than the average of all MICs (1.18 percent) based on WDI (World Bank Group, 2022a). While Egypt's population growth is expected to slow down in the next decade, Egypt's population will continue to grow faster than other countries in the region and the group of MIC countries, with the annual growth rate at around 1.5 percent in 2021 (Organisation for Economic Co-operation and Development, OECD, and FAO, 2022). Population growth has increased food demand while simultaneously expanding urban centres, which – through land encroachment – has diverted land away from agriculture. In the last two decades alone, it is estimated that more than 75 000 ha of the most fertile land have been lost to urban expansion in Egypt (Perez *et al.*, 2021a).

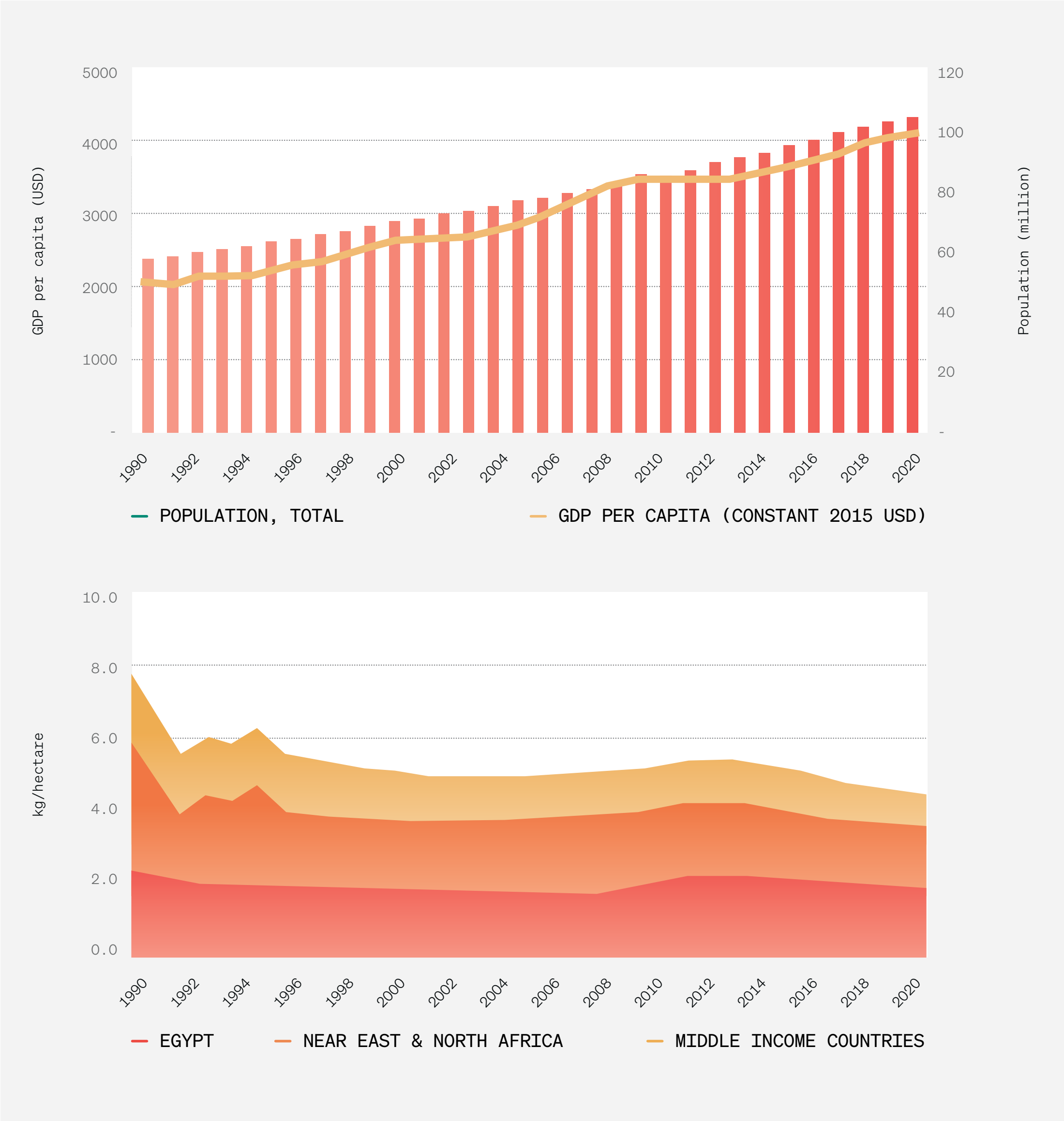


Figure 2.7
Population and income per capita growth (1990–2021)

SOURCE: Authors' own elaboration based on: World Bank Group. 2022a. World Development Indicators (WDI). In: *World Bank Data*. Washington, DC. [Cited 13 September 2022]. https://data.worldbank.org/indicator

On the other hand, Egypt's average annual income per capita (GDP per capita) has increased from about USD 2030 per person per year in 1990 to slightly more than USD 4050 in 2021, highlighting an annual average growth of 2.3 percent. The income growth is estimated to reach 4 percent in 2022 and is expected to stay within the range of 3.2–4.2 percent in the next ten years (OECD and FAO, 2022). This is higher than the projected average growth for the 2030s in the NENA region, where countries such as Jordan and the United Arab Emirates will grow by 2.7 percent and 3.1 percent per year respectively, while Saudi Arabia's per capita income is expected to grow at a much slower pace (1.6 percent per annum) (OECD and FAO, 2022). Notably, these forecasts already factor in inflation, assuming it will remain high throughout the region and especially in Egypt, where it is already 7.2 percent per annum.

A fast-growing population with increasingly higher income per capita will continue to bring demand-side pressures on the AFS. Better incomes coupled with increased education and access to information will continue to shape Egyptians' consumption patterns towards more and higher quality food products, especially in the expanding urban centres. As with other countries, increased demand for more diversified and higher value products can be an opportunity for Egyptian producers to diversify their production systems, although, given Egypt's high dependence on food imports (especially wheat, maize and rice), the pace of diversification into higher value products will largely depend on productivity growth in traditional subsectors (e.g. cereals), as well as the availability of labour and water. This is particularly true considering the government's efforts to reduce the Egypt's dependence on wheat and maize imports.

Despite Egypt's efforts to ensure national and household food security, the prevalence of undernourishment has been on the rise in the last decade. It increased from 3.8 percent in 2010–2012 to 5.1 percent in 2019–2021. This setback coincides with the reduction in the average protein supply, which retracted from about 100 grams per capita per day in 2010–2012 to 96 grams in 2017–2019, though this is at least slightly better than the 94 grams of protein consumed per capita per day 2000–2005 (Figure 2.8). This demonstrates that in times of crisis (e.g. COVID-19 pandemic, price spikes partially due to the war in Ukraine, etc.), the availability of nutritious food is often compromised, with particularly detrimental effects on the most vulnerable population, which is less able to cope with higher food prices.

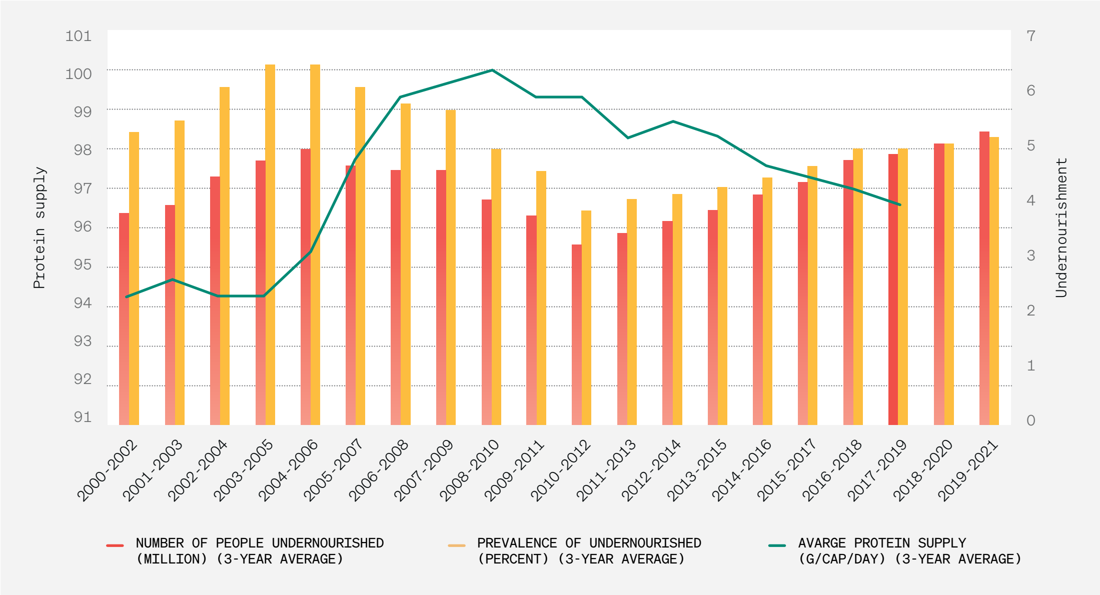


Figure 2.8
Prevalence of undernourishment and protein supply

SOURCE: Authors' own elaboration based on: FAO. 2022a. FAOSTAT. In: *FAOSTAT*. Rome. [Cited 13 September 2022]. https://www.fao.org/faostat/en/

The number of people unable to afford a healthy diet in Egypt remains very high at around 74.6 million in 2020, or 73 percent of the population; this is higher than any other country in the region except Sudan. The percentage and total number of people unable to afford a healthy diet have remained the same since 2017 (Figure 2.9), which suggests that household food security, primarily related with economic access to food (incomes and household food production capacity), is still a major problem affecting a large share of the Egyptian population. This again highlights the urgent need to increase the efficiency and growth of Egypt's agrifood system, as it has been unable to produce the quantities of main foods consumed in the country, deliver on food quality or accelerate pro-poor job growth (as will be shown in Section 2.3.2).

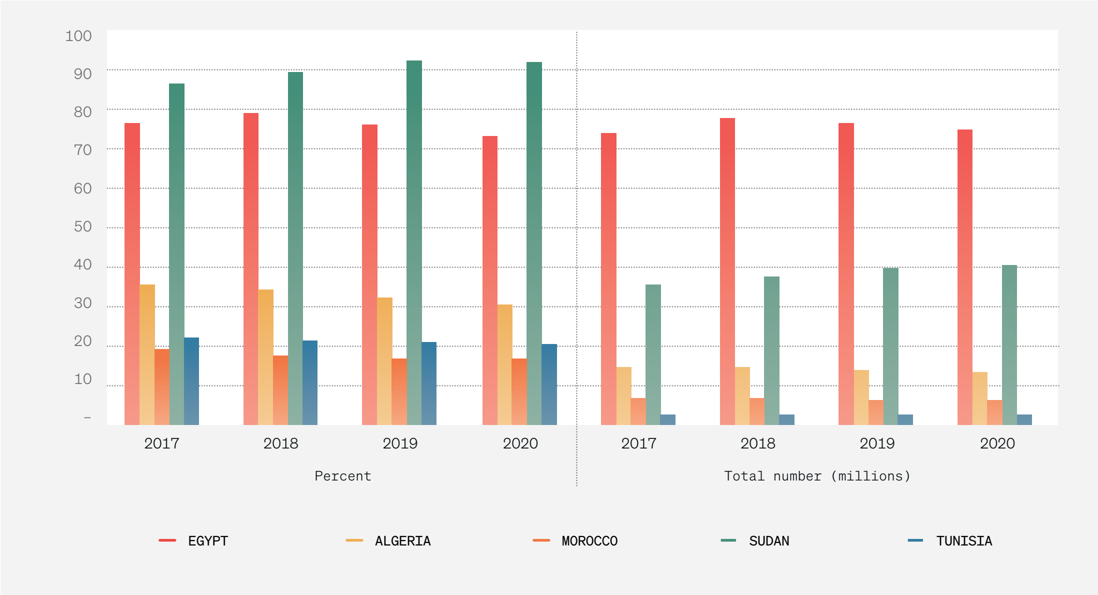


Figure 2.9
People unable to afford a healthy diet in select North African countries (2017-2020)

SOURCE: Authors' own elaboration based on: FAO, IFAD, UNICEF, WFP & WHO. 2022. *The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable.* Rome, FAO. https://doi.org/10.4060/cc0639en

Egypt ranks mid-scale on the Global Food Security Index, occupying the 62nd place among 113 nations surveyed in 2021, and 13th between the 15 NENA countries included in the ranking. Egypt's position in the region is better only than Yemen and the Syrian Arab Republic, which are affected by conflict and belong to the bottom ten countries in the global ranking.[7] In 2021, Egypt's overall score was 60.8, which is one point higher than it was in 2020 but slightly lower than in 2019, before the COVID pandemic (Figure 2.10).

7 The Global Food Security Index was constructed by Economist Impact and considers food affordability, availability, quality and safety, as well as natural resources and resilience across a set of 113 countries. It is a dynamic quantitative and qualitative benchmark constructed from 58 unique indicators that measure the drivers of food security. The overall score ranges from 0-100 and is calculated from a simple weighted average of the first three category scores (affordability, availability, and quality and safety). The natural resources and resilience category is an adjustment factor that serves to demonstrate changes to the overall score when climate-related and natural resource risks are taken into account. See: Economist Impact. 2022. Global Food Security Index 2022. London, The Economist Newspaper Limited. https://impact.economist.com/sustainability/project/food-security-index.

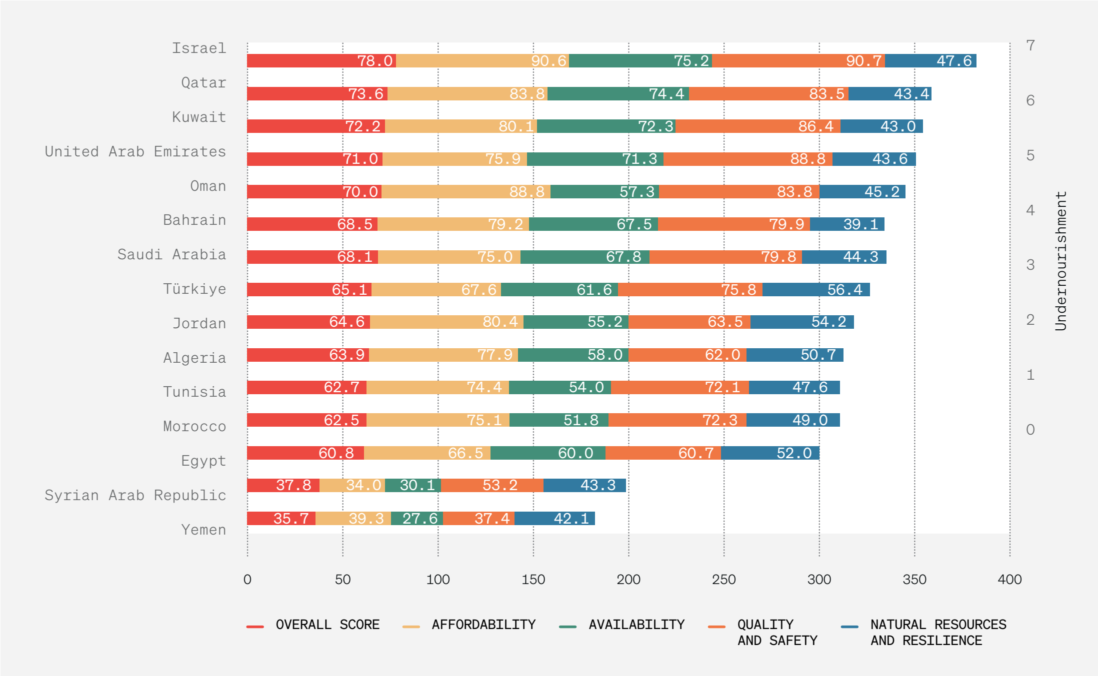


Figure 2.10
Performance of countries according to main food security drivers (2021)

SOURCE: Authors' own elaboration based on data from: Economist Impact. 2022. *Global Food Security Index 2021*. London, The Economist Newspaper Limited. https://impact.economist.com/sustainability/project/food-security-index

Food and nutrition security in Egypt have been safeguarded by the government's agriculture and social protection policies. These provide subsidies for agricultural production, from seed and fertilizer inputs to free water for irrigation, and for food consumption through Egypt's Tamween food subsidies programme (Abdalla and Al-Shawarby, 2017) (Box 2.1). The Tamween subsidies include a combination of food rations and bread allowances. Beneficiary households can use smart cards to purchase subsidized food and nonfood items from designated Tamween shops, this includes a baladi bread allowance of five loaves per person per day at very low prices (this portion of bread corresponds to about 65 percent of the average dietary energy requirement).[8] Through the programme, baladi bread reaches 71 million individuals, while ration cards cover 64.4 million individuals. Tamween's food subsidy programme is the largest social assistance programme in Egypt and has the largest share in social assistance spending. In 2021, it represented about 1.15 percent of GDP (current GDP), and more than 32 percent of total social assistance spending.

8 The average dietary energy requirement is 2328 kcal per day; the five loaves of bread amount 1625 kcal.

BOX 2.1

DIRECT AND INDIRECT SUPPORT MEASURES FOR THE AFS IN EGYPT

Subsidies to improve access to food

- **Food purchase:** support is allocated for food purchase across different government ministries, including the School Feeding Programme, run by the Ministry of Health and the Ministry of Education, but excluding purchases made under the Tamween food subsidy programme.
- **Takaful and Karama:** two programmes within the presidential agenda to provide cash transfers to underdeveloped regions in agricultural areas. These are part of social safety net efforts intended to divert policy from direct subsidies to social protection. The programmes are implemented by the Ministry of Social Security, with a yearly budget of EGP 19 000 million.
- **Tamween Programme:** includes the baladi bread and flour subsidy, as well as subsidies for specific food items distributed by the Ministry of Supply and Internal Trade (MOSIT). It is implemented by MOSIT and the General Authority for Supply Commodities (GASC), with an annual budget of EGP 87 000 million.

Subsidies to support food supply

- **Maintenance of irrigation canals:** supports the maintenance and expansion of irrigation networks, especially in the Nile Delta. It is managed by the Ministry of Water Resources and Irrigation (MWRI), with an annual budget of EGP 1100 million.
- **Farmer subsidies:** support to farmers through subsidized seeds and inputs (fertilizer and pesticides) for specific value chains, particularly wheat and maize. The subsidies are provided by the Ministry of Agriculture and Land Reclamation (MALR), with an annual budget of EGP 664 million.
- **Saiid Upper Egypt Development Subsidy:** part of a wider government effort to promote the development of Upper Egypt. It includes an indirect support to the agriculture sector through major infrastructure investments. It is managed by the Saiid Development Authority, with an annual budget of EGP 250 million.
- **Subsidized loans:** most are intended for the agriculture sector under the Agricultural Bank of Egypt (ABE). Implemented by the MALR and the ABE with a total annual budget of EGP 250 million.
- **Livestock and water resources – operational and capital expenditure:** this comprises Egypt's support towards veterinary and irrigation operations. It is implemented by the MALR, with a total budget of EGP 431 million.
- **Land reclamation:** funds land reclamation under the government's plan to reclaim 1.5 million feddan[9] of desert land for agriculture. It is managed by the MALR, the Egyptian Agricultural Authority and the General Authority for Construction and Agricultural Development, with an annual budget of EGP 135 million.
- **Emergency provisions for subsidy:** as part of its 2002/2023 budget, the GoE allocated EGP 9900 million through MOSIT to respond to increased food prices due to the war in Ukraine.

SOURCE: Author's own elaboration.

9 A feddan is an Egyptian unit of area equivalent to 0.42 ha; 2.38 feddan = one hectare.

COVID-19 pandemic and the war in Ukraine have further exacerbated food insecurity in Egypt. Global food prices have been rising since 2019 and further increased in 2020 due to supply chain disruptions caused by the COVID-19 pandemic (Baffes and Temaj, 2022). Prices continued their upward trend in 2021, when wheat prices averaged USD 280 per metric tonne during the first five months and reached USD 317 in November that year (International Grains Council, 2023). This is a major problem for Egypt as the largest importer of wheat in the world. Wheat is a key staple food in Egypt, representing 35–39 percent of the average per capita caloric consumption (Abay *et al.*, 2022). Before the war in Ukraine, Egypt's wheat imports in the 2021/2022 marketing year were estimated at 12 million metric tonnes.

Approximately 85 percent of these imports originated either from the Russian Federation (60-66 percent depending on the year) or Ukraine (20-25 percent).

Egypt's cereal import dependency has risen from 46 percent during the period of 2000 to 2002 (three-year average) to around 62 percent in the period of 2019 to 2021 (FAO, 2022a). With global wheat prices reaching as high as USD 500 per metric tonne February–April 2022, they were nearly double what was planned in the 2021/2022 budget (Ministry of Finance, MoF, 2022). As a result of these two consecutive crises – which have significantly strained Egypt's fiscal resources, given both the cost of purchasing grains and the direct implications for rising food subsidies – Egypt has been forced to tap into its foreign reserves.

Import dependence has increased not only for wheat, but also for maize and rice, and this is expected to intensify in the next decade, especially for rice (Figure 2.11). In the early 1990s, Egypt's dependence on the import of maize was around 27 percent. This has steadily increased to 59 percent in 2020 and is expected to reach 62 percent in the next decade. While 72 percent of the maize produced/imported is used for animal feed, maize is still a major cereal for food security, as it is an important ingredient in several prepared foods and influences the cost of animal protein production. Egypt has historically been self-sufficient in rice, but given rice's high use of water, the GoE has begun to control the areas of rice production. This has caused supply gaps, which have been filled with imports. In 2018, 21 percent (900 tonnes) of rice consumed in the country was imported. While this percentage has declined substantially (7 percent or 310 tonnes in 2019 and 1 percent or 70 tonnes in 2020), rice import dependence is estimated to stay in the range of 14–16 percent (680–880 tonnes) in the next decade (OECD and FAO, 2021).

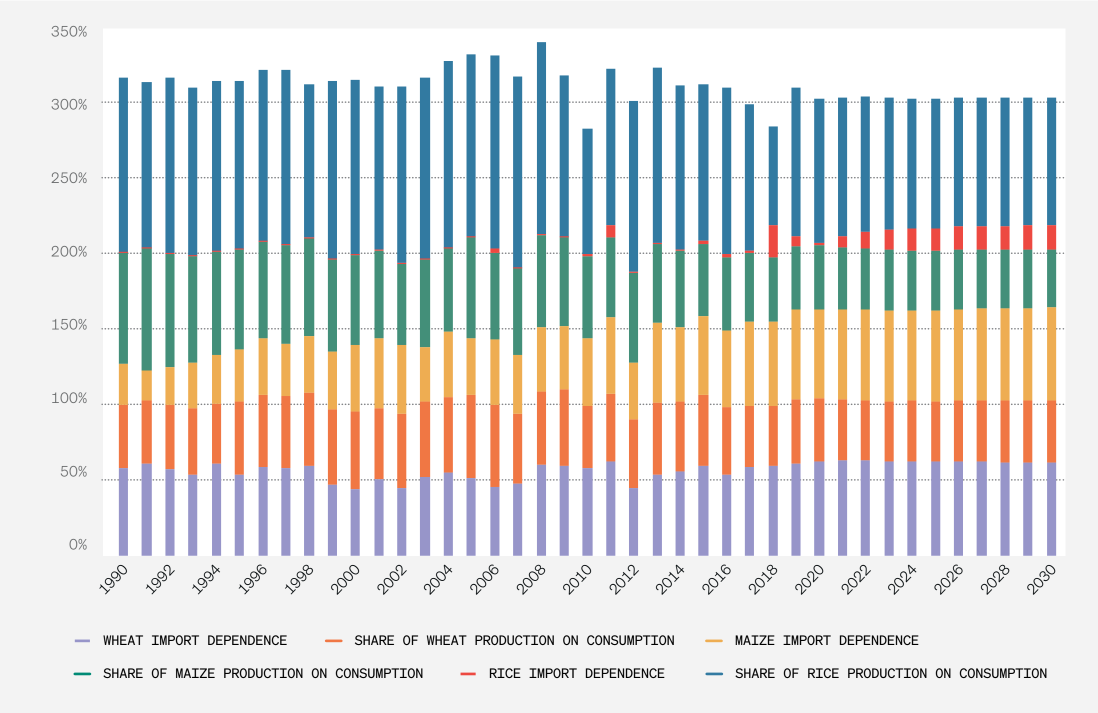


Figure 2.11
Cereal import dependence and local production capacity

SOURCE: Authors' own elaboration based on: OECD and FAO. 2022. OECD Agriculture Statistics: OECD-FAO Agricultural Outlook (Edition 2022). In: *OECDiLibrary*. Paris. [Cited 31 May 2022]. https://doi.org/10.1787/agr-data-en

To alleviate the burden of cereal import dependency and rising food prices, the GoE is making a concerted effort to increase the efficiency of value chains, reduce losses, and improve the targeting capacity of its subsidy policies. On the production side, the government is determined to increase local cereal production capacity, especially of wheat, to satisfy about 60–70 percent of the anticipated total future demand. The year-on-year inflation rate was 8.8 percent in February 2022, based on the consumer price index (Werr, 2022). In addition, the costs of important factors of production, particularly energy, fertilizers, and maize used for feed have been and will continue to be high, which will make it more difficult for crop and livestock producers to keep the same levels of production and productivity in their fields. Amid growing concerns over food reserves, the GoE implemented ad hoc policies such as banning the export of wheat, flour, lentils and beans at the beginning of the war in Ukraine. A more institutionalized instrument used by the government is the public procurement of cereals directly from farmers at controlled prices to source the large Tamween food subsidy programme. This instrument has been an important factor in improving local wheat harvests, and the incomes of poorer farmers. But these measures also have detrimental effects on dietary diversity in Egypt because they tend to increase the price of wheat for consumers of non-subsidized bread (FAO, IFAD, UNICEF and WHO, 2022).

Like other countries in the region, the per capita consumption of wheat in Egypt is among the highest in the world, at 188 kg per capita annually. This is more than double the global average and is nearly one-third of the overall food energy supply. The consumption of wheat per capita has increased from less than 178 kg per capita in the early 1990s and is expected stay in the range of 190 kg per capita per annum in the next decade (Figure 2.12). Rice has followed the same trend, increasing consumption per capita from around 30 kg in 1990 to nearly 42 kg in 2021. Maize is the only product for which the level of per capita consumption has decreased over time. Yet, its share in animal feed has substantially increased from around 52 percent of total maize use in 1990 to nearly 72 percent in 2020, and this is projected to increase to 74 percent in 2030.

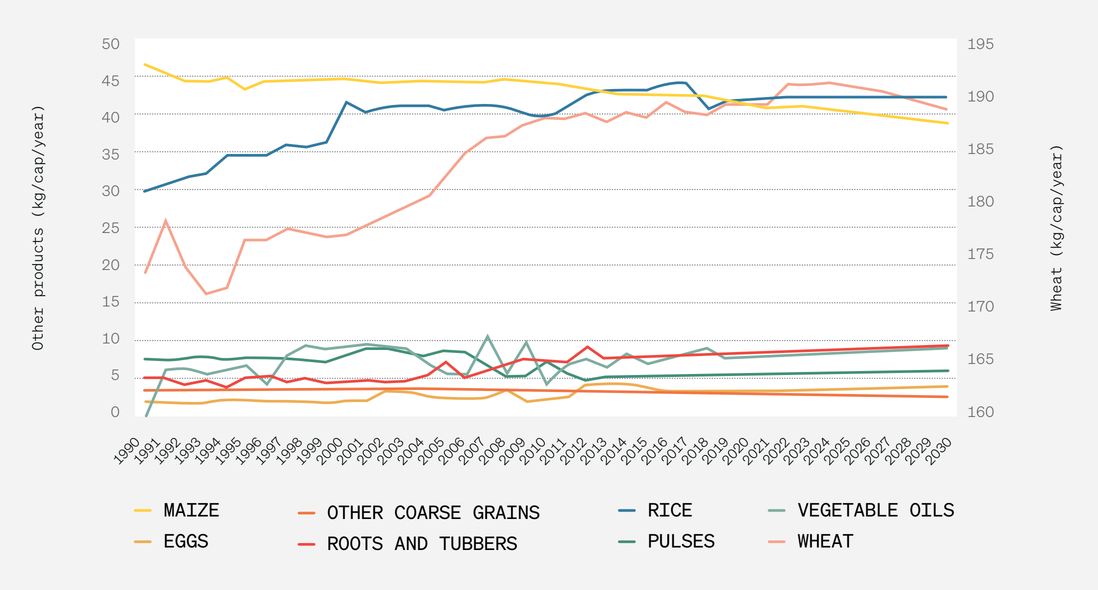


Figure 2.12
Consumption levels for different types of foods in Egypt

SOURCE: Authors' own elaboration based on: OECD and FAO. 2022. OECD Agriculture Statistics: OECD-FAO Agricultural Outlook (Edition 2022). In: *OECDiLibrary*. Paris. [Cited 31 May 2022]. https://doi.org/10.1787/agr-data-en

Food security has focused largely on food availability rather than nutritional diversity. While the government subsidy programmes have supported nutrition security, given the nature of the subsidy programmes (blanket subsidies focusing on minimum food consumption needs), they have not substantially enhanced the nutritional status of the population, especially among key beneficiaries (Box 2.1and Annex 3). While the prevalence of anemia among women of reproductive age has declined by around 7 percent over the past decade, the prevalence of obesity in adults has increased by around ten percentage points over the same period, and the percentage of stunted children under five years of age has varied from year to year (Figure 2.13). This highlights the need to both better target the subsidy programmes, and to implement supplementary nutrition programmes that can contribute to nutrition security according to certain desired outcomes. There have been ad hoc programmes in fortification and school feeding, but no nationally targeted programmes for nutrition have been established, and food policy has prioritized food accessibility and availability over food utilization.

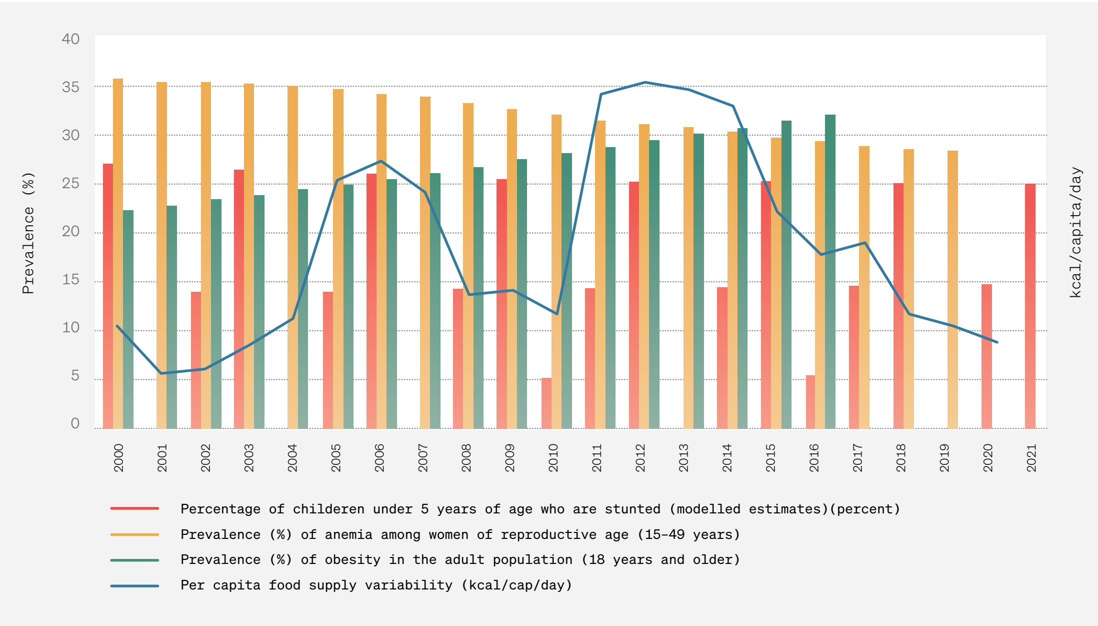


Figure 2.13
Food supply and nutrition indicators in Egypt (2020-2021)

SOURCE: Authors' own elaboration based on: FAO. 2022a. FAOSTAT. In: *FAOSTAT*. Rome. [Cited 13 September 2022]. https://www.fao.org/faostat/en/

2.2.2 Contributing to employment and growth

Sustained inclusive growth and job creation constitute a key priority for the GoE and one of the country's biggest economic challenges. Eight million Egyptians are expected to enter the labour force in the next decade, yet Egypt's job growth lags behind the pace at which the working age and labour force are expanding. Between 2007 and 2017, the labour force grew by 4.8 million, but the total number of jobs increased by only 3.3 million (Yeboah and Jayne, 2022). Hence, the share of working-age individuals employed declined by nearly 9 percent during this period. This means that without deliberate efforts to increase economic growth and job intensity, a greater number of Egyptians, especially women and youth, will be unemployed or under-employed in the informal sector in the near future.

The AFS plays a vital role in economic growth and job creation in Egypt. However, the pace of job growth in the AFS will be highly dependent on farm-level productivity growth and the pace of development of off-farm activities. Overall, the AFS employs more than 35 percent of jobs in Egypt, largely dominated by jobs in agriculture that account for the largest share of all AFS jobs (70 percent). In the period 2007–2017, farm jobs contracted by 24.3 percent, while total jobs within the AFS shrank by only 14.6 percent, given that employment in the off-farm segments of the AFS has been expanding as a percentage of the whole (Yeboah and Jayne, 2022) (Table 2.1). Farm jobs still constitute the largest share of AFS jobs; however projected declines in farm employment will boost the expansion of off-farm jobs, especially in the agroprocessing, commerce, food retail and food services subsectors. Additionally, sustained agricultural productivity growth will create demand for downstream jobs, enabling labour to move downstream into higher-paying segments of the AFS. This transition will be especially important for youth and female workers, who comprise the majority of the AFS workforce. Women are twice as likely to be engaged in farm jobs among the youth and young adults. The AFS itself will need to transform and increase its capacity to drive job creation, likely based on the expansion of AFS downstream activities, while also intensifying local value addition. The digitalization of agrifood value chains is also expected to accelerate job creation along the AFS, with particularly high potential for youth to benefit from a large share of these job opportunities.

Table 2.1

Primary employment of working age population (15-64 years) by subsectors

Survey year	Total jobs (million)	Farming		Off-farm within AFS: Agroprocessing		Off-farm within AFS: Downstream commerce and distribution		Off-farm within AFS: Food preparation away from home		Total AFS		Non-farm outside AFS	
		% of jobs	% of FTE jobs	% of jobs	% of FTE jobs	% of jobs	% of FTE jobs	% of jobs	% of FTE jobs	% of jobs	% of FTE jobs	% of jobs	% of FTE jobs
2007	22.2	32.7	29.3	4.3	4.6	2.7	3.1	1.2	1.4	40.9	38.4	59.1	61.6
2008	22.1	31.0	28.2	4.6	4.8	2.6	2.9	1.3	1.6	39.5	37.5	60.5	62.5
2009	22.4	29.3	26.6	4.2	4.4	2.8	3.1	1.4	1.6	37.7	35.8	62.3	64.2
2010	23.2	27.7	25.0	4.4	4.6	3.2	3.5	1.6	1.8	36.8	35.0	63.2	65.0
2011	22.7	28.7	26.3	3.8	3.9	3.0	3.4	1.4	1.6	36.9	35.3	63.1	64.7
2012	23.0	26.4	24.3	4.0	4.3	3.1	3.5	1.6	1.8	35.1	33.9	64.9	66.1
2013	23.4	27.3	24.8	3.8	4.1	3.4	3.8	1.6	1.9	36.1	34.6	63.9	65.4
2014	23.8	26.8	24.3	4.1	4.4	3.3	3.8	1.7	2.0	36.0	34.5	64.0	65.5
2015	24.4	25.2	23.2	4.3	4.6	3.7	4.1	2.0	2.3	35.2	34.2	64.8	65.8
2016	24.9	24.8	22.2	4.4	4.8	3.6	4.1	2.1	2.5	34.9	33.6	65.1	66.4
2017	25.5	24.4	22.4	4.8	5.2	3.9	4.3	2.0	2.3	35.1	34.2	64.9	65.8
Changes 2007 to 2016													
Change (million)		-1.04	-0.79	0.27	0.30	0.38	0.40	0.26	0.27	-0.13	0.19	3.45	3.14
% change		-24.27	-24.33	3.46	4.71	32.38	32.47	82.03	72.64	-14.57	-12.63	10.08	7.88

NOTE Farming comprises crop and livestock production. Off-farm AFS represents all pre- and post-farm value-addition activities within the agricultural value chains. Non-farm sectors encompass all other activities outside the AFS such as construction, finance, utilities. Agroprocessing involves the processing of agricultural products. Downstream commerce and distribution represent wholesale and retail of food and agricultural products. Food away from home entails food services including street food vendors and restaurants. FTE is full time equivalence. Statistics for 2007/2008 and 2016/2017 correspond to the average of job numbers and shares in each period.

SOURCE: Authors' own elaboration based on: Yeboah, F. K. & Jayne, T. S. 2022. Employment structure and pathways for economic transformation in Egypt. International Development Working Paper. East Lansing, Michigan, USA, Michigan State University.

The agricultural sector's contribution to employment is still about twice its share of GDP (20.6 percent), largely because the sector has one of the highest employment coefficients in the whole economy. It is estimated that USD 1 million of gross output (final demand) in the sector creates about 297 jobs, second to education in the services sector (320 jobs), and followed by mining services (238 jobs), public administration (270 jobs), food products (219 jobs) and construction (215 jobs) (Kamal, 2018). These subsectors are also characterized by lower labour productivity. In the case of agriculture, while the sector is a major job creator, labour productivity is one of the lowest in the whole economy, with a value added of only USD 3000 per worker per year. This contrasts with the textile subsector, for example, which generates about 150 jobs per USD 1 million in gross output, but has a much higher capacity to contribute to national output with a labour productivity of more than USD 7000 per worker per year (Figure 2.14). Whereas in agriculture, 89 percent of the jobs are generated through direct effects, a large portion of jobs created in food products (75 percent of jobs) and beverages (70 percent) are through indirect effects due to backward linkages with other sectors.

Agriculture is the primary source of intermediate inputs for the food services and beverage subsectors, and simultaneously has a high employment to output ratio. Therefore, increasing the demand for food products by USD 1 million results in the creation of 32 jobs in food products (direct effect), 150 jobs in agriculture and 14 jobs in other sectors (indirect effect).[11]

AFS and its intersectoral linkages are important drivers of growth. Egypt's economic policy has often prioritized higher value-added subsectors as drivers of economic growth. A number of these subsectors, while very productive, have limited direct and indirect multiplier effects due to limited job intensity within the subsector and weak interlinkages with other sectors in the economy. Since wages represent a large share of value added in most of these subsectors, this has an important effect on consumption and spending, and also induces growth in the economy. Prioritizing support to these sectors is desirable from a policy perspective, but must be done without compromising the support needed in sectors such as agriculture, which have lower levels of productivity, but very high job generation potential within farming activities, downstream in the AFS and in other sectors. Higher demand for food processing and textile sectors increases the demand for agriculture (farming), which in turn drives investments that could accelerate productivity growth upstream in the AFS.

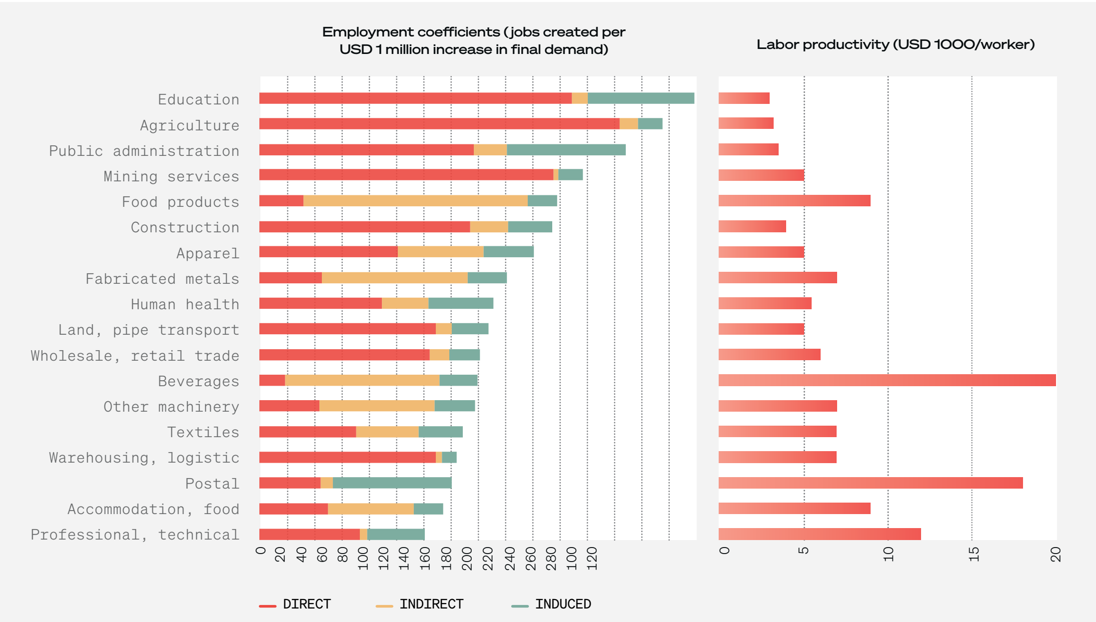


Figure 2.14

Employment multipliers and labour productivity in main economic subsectors

SOURCE: Authors' own elaboration with data from: Kamal, A. M. 2018. Which Sectors Drive Egypt's Growth and Employment? *Economics* 6(2): 57–70. https://doi.org/10.2478/eoik-2018-0019

11 The employment multiplier effects include: (a) *direct effects* related to jobs created due to activities within the subsector; (b) *indirect effects* refers to jobs created due to demand for intermediate inputs from other sectors; (c) *induced effects* refers to jobs created because of changes in consumption and demand due to higher household income and employment (Miller and Blair, 2009).

AFS growth is also relatively more pro-poor, especially in downstream AFS activities. Results show that productivity-driven agricultural growth in all crops is pro-poor and improves nutrition (Breisinger *et al.*, 2019). In the period 2007–2017, agriculture has experienced a real increase in annual earnings of about 2.7 percent, after food services (2.8 percent), and non-AFS sectors (2.9 percent) (Figure 2.14). Across the AFS and the other economic sectors, the average earnings have increased in all income quintiles. Within the AFS, while farming activities have increased the earnings of the first income quintile, agroprocessing and commerce and distribution have expanded earnings by 2.7 percent and 3 percent, respectively. Remarkably, while farming activities have been able to increase incomes for the poorest, they have in fact had a larger impact on the earnings of the highest quintiles. Conversely, agroprocessing, trade and food distribution have the highest impact on earnings of the poorest, and the impact reduces among the richest income quintiles.

2.2.3 Sustaining natural resources and addressing climate change impacts

Rapid increase in population and unsustainable production practices are placing huge pressure on natural resources. Most of Egypt's 104 million inhabitants occupy 3.5 percent of the country's land, concentrated along the Nile Valley and Delta. The population growth rate is expected to be nearly 2 percent per year, one of the highest rates in the region. Rising population and changing consumption patterns threaten the country's ability to meet its current and future food, energy, and water demands. Egypt faces serious structural constraints concerning the deteriorating water treatment facilities, distribution networks, and irrigation systems. Conventional agricultural practices, unregulated use of chemical fertilizers and polluting waste disposal practices continue to negatively impact the agricultural sector. Egypt's depleting natural resources challenge its production capacity and economic resilience. The natural resources depletion in Egypt passed from 1.36 percent of gross national income (GNI) in 1970 to 3.86 percent of GNI in 2019. This trend is well above the world average of 0.39 percent of GNI in 1970 and 1.01 percent of GNI in 2019. Egypt faces a growing ecological deficit. Egypt's total biocapacity is estimated at 0.4 global hectares (gha) per person, while its ecological footprint is much higher, estimated at 1.78 gha per person.[12] The ecological deficit grew 123 percent along the period 1970–2019 (Global Footprint Network, 2022). The CCDR indicates that the cost of environmental degradation for the country was estimated at over 3 percent of GDP in 2018 (World Bank Group, 2022b).

Egypt's water availability is lower than its demand, with agriculture being one of the main consumers. Water resources currently available for use include 55.5 BCM/year from the Nile River, 1.3 BCM/year from effective rainfall in the northern part of the Nile Delta, 2.1 BCM/year from non-renewable groundwater from Egypt's Western Desert and Sinai aquifers, and 0.35 BCM from desalination. This yields a total of 59.25 BCM/year, contrasting

12 The ecological footprint is a measure of how much area of biologically productive land and water an individual, population, or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. The footprint is usually measured in global hectares. Because trade is global, an individual or country's footprint includes land or sea from all over the world.

with the combined water needs from different sectors that total about 114 BCM/year. In order to bridge the gap, the country resorts to reusing agricultural drainage and treated wastewater, equivalent to 21 BCM, and imports the rest (Arab Republic of Egypt, 2022a). Agriculture consumes the most water, requiring 63.6 BCM/year, followed by municipalities and industrial processes (Fanack Water, 2022). Nearly all agriculture depends on irrigation water. Even the small, more humid area along the Mediterranean coast requires water harvesting or supplementary irrigation to produce reasonable yields. The irrigated area in Egypt reaches 3.8 million hectares (or 99 percent of the total arable land).

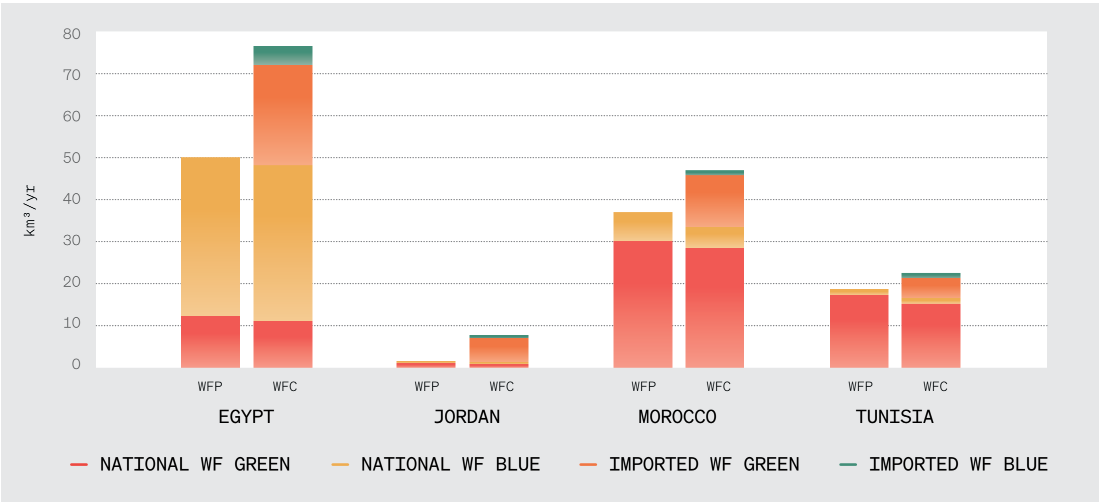


Figure 2.15
Water footprint of food production and consumption in Egypt and select NENA countries

NOTE National and imported green and blue water footprint of agricultural production and consumption in Egypt, Jordan, Morocco and Tunisia for the 2011-2015 period in km³/year.

SOURCE: Terwisscha van Scheltinga, C., de Miguel Garcia, A., Wilbers, G.-J., Heesmans, H., Dankers, R. & Smaling E. 2021. Unravelling the interplay between water and food systems in arid and semi-arid environments: the case of Egypt. *Food Security* 13: 1145-1161. https://doi.org/10.1007/s12571-021-01208-1

Egypt has the highest water footprint for food production and consumption in NENA. Its water footprint (WF) of food production is 50.2 km^3/year (76 percent blue water); the WF of food consumption is 76.2 km^3/year for (49 percent blue water) (Figure 2.15). The food produced within NENA countries has a relatively large blue WF component compared with the green water-based food imported from more water-abundant regions.[13] This is because irrigation is key to food production in the NENA region. This is especially true for Egypt, where most of the agriculture production comes from irrigated areas. Values reported for agriculture in Egypt for the 2012–2016 period are even higher: WF of food consumption is estimated at 95 km^3/year, with a very similar green/blue water pattern (El Fetyany *et al.*, 2021).

Climate change exacerbates the current environmental challenges. According to Egypt's Third National Communication (Arab Republic of Egypt, 2016b) and First Updated NDC (Arab Republic of Egypt, 2022a), both submitted to the UNFCCC, the country is highly vulnerable to the impacts of climate change, with agriculture being one of the most affected sectors in the economy. According to the CCDR (World Bank Group, 2022b), temperatures in Egypt are expected to increase between 1.5°C and 3°C by mid-century, with greater increases in the country's interior and during the growing season. Heat waves will increase in their severity, frequency, and duration, with an average of 40 additional days of extreme heat per year projected by mid-century. High temperatures and more heat waves will raise the already high evaporation rate, accelerate crop transpiration, functionally increase soil aridity, and elevate water requirements for human consumption and agriculture. The variability of the region's rainfall is projected to increase with estimates showing a 50 percent increase in variability by the year 2100, thereby impacting the Nile flow into Egypt. This change will result both in more frequent drought years and more frequent high-flow years, and it will increase the frequency and intensity of flash flooding in Egypt's coastal areas.[14] The country is also highly vulnerable to sea level rise, which results in further salinization and desertification of soils. Nearly 15 percent of the most fertile arable land in the Nile Delta, where about half of Egypt's crop production occurs, is already negatively affected by sea level rise and saltwater intrusion.

13 The water footprint of food production includes crop and livestock; the water footprint of food consumption regards the national population. Green water is water from precipitation, which is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. Blue water is sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time.

14 These projections are in line with those previously established (i.e. Perez *et al.*, 2021a), applying data from general circulation models of climate (from the Coupled Model Intercomparison Project – Phase 5) to estimate future conditions in Egypt. The results indicate that annual temperature increases for Egypt may be over 3°C (Hadley Centre Global Environmental Model) in the next 20 to 50 years, with peaks during the summer season, between June and September. Based on these models, annual rainfall is projected to decline by up to 15 mm, which is a substantial amount given that annual rainfall levels average only 42 mm over the country's agricultural areas. Besides temperature increases and rainfall reduction,the country is extremely vulnerable to see level rise.

The agrifood sector has the potential to contribute to climate change mitigation. The GoE recently submitted its first Biennial Update Report (Arab Republic of Egypt, 2018a) to the UNFCCC, with updated inventories of GHG emissions prepared according to guidelines of the Intergovernmental Panel on Climate Change (IPCC, 2014) for the period between 2005 and 2015. The GHG inventory covers four sectors: 1) energy; 2) industrial process and product use; 3) agriculture, forestry, and other land uses (AFOLU); 4) waste. Egypt's GHG emissions for 2015 totalled 325 614 gigagrams (Gg) of CO_2 equivalent ($CO2_2e$). Energy is the highest GHG-emitting sector, accounting for 64.5 percent of Egypt's total emissions for 2015 (210 171 $GgCO_2e$), followed by the AFOLU sector at 14.9 percent of national GHG emissions (48 390 $GgCO_2e$) in 2015. Agriculture sector emissions resulted mainly from enteric fermentation, manure management, field residuals burning, agriculture soil, and rice cultivation.[15] GHG emissions associated with the agrifood sector go beyond the farm level and occur along the value chain. Therefore, FAO estimates that at farm gate, land-use change, as well as pre- and post-production GHG emissions from Egypt's agrifood system reached over 30 percent of total emissions in 2015 (FAO, 2022a). In this context, Egypt's intended nationally determined contributions to climate change mitigation assessments highlight the importance of efficiency gains along the food system (Arab Republic of Egypt, 2015). This is confirmed in Egypt's First Updated NDC (Arab Republic of Egypt, 2022a). These efficiency gains can also help transition towards a more resilient food system that supports food and nutrition security.

Beyond population growth, urbanization trends and climate change impacts, water pollution aggravates water scarcity. In 2004, water per capita was 950 m^3 and by 2011 it decreased to 700 m^3 per capita, well below the UN definition of water scarcity (1000 m^3).[16] By 2025, water per capita is expected to significantly diminish to 600 m^3 per capita and further decrease to 350 m^3 per capita by 2050 (UN Environmental Programme, UNEP, 2015). Based on Egypt's Water Resources and Irrigation Strategy 2050, the country could fall below the water absolute scarcity threshold of 500 m^3 per capita by 2033 and

15 Egypt's total GHG emissions have increased by 31 percent from 2005 to 2015 with an average annual growth rate of 2.35 percent. GHG emissions from the energy, industrial process and product use, and waste sectors increased by 40 percent, 49 percent, and 34 percent respectively; while emissions from the AFOLU sector decreased by 7 percent during that time. The reduction of net GHG emissions from the AFOLU sector is associated with a decrease in the use of synthetic fertilizers and urea. One of the key elements affecting the use of fertilizers is the MALR's policy change concerning fertilizer allocations for farmers as per available financial resources/plan. Companies have reduced manufacturing or importing fertilizers in response to such MALR plans. In response, smallholder farmers complemented crop fertilization with compost due to its high content of nitrogen and lower purchase price.

16 Water scarcity is defined as the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the total demand from all sectors, including the environment, cannot be fully satisfied. Scarcity may be a social construct (i.e. a product of affluence, expectations and customary behavior) or the consequence of altered supply patterns, stemming from climate change, for example. Hydrologists typically assess scarcity by looking at the population-water equation. An area is experiencing water stress when annual water supplies drop below 1700 m^3 per person. When annual water supplies drop below 1000 m3 per person, the population faces water scarcity, and below 500 m^3 is considered absolute scarcity (Zisopoulou, 2021).

about 390 m^3 per capita by 2050 (World Bank Group, 2022b). Nonetheless, the increasing scarcity of water becomes even more critical in the face of growing water pollution, which makes the reuse of water more difficult and even dangerous unless it is pre-treated. While most of the urban wastewater is collected and treated, this is not the case in rural areas (only 10 percent collected) and industrial processes (70 percent untreated) (UN Industrial Development Organization, UNIDO, 2020).

Even if water availability remains constant, the increment of water demand for municipal use and food production will increase in the next few decades. Total water demand has been increasing rapidly from 67.6 BCM in 2000 (UNEP, 2015) to the current level of 114 BCM per year (Arab Republic of Egypt, 2022a). The potential water gap for food production and consumption is determined by expected increments in population, combined with potential effects in water availability due to climate change or infrastructure developments. A modelling framework was developed to assess Egypt's future water gap (Abdelkader *et al.,* 2018) using several scenarios with different rates of population growth, increasing in water availability by reuse and desalinization, increasing irrigation efficiency and agricultural expansion. Results show that while water availability may remain almost constant (with adequate and timely interventions), the increment of water demand for municipal use (drinking water, sanitation, industrial use) and food production will increase to almost 100 km^3/year by 2050, while the current demand is estimated at 76 km^3/year. This implies a demand increase of 50 percent, which Egypt is not on target to meet.

2.2.4 Safeguarding equity and territorial balance

A sustainable agrifood system aims at contributing to balanced territorial development by fostering stability and equity among stakeholders. A high dichotomy of rural and urban territories, paired with the current national and global challenges faced by the agrifood system, generates disproportionate pressure for rural areas and small-scale food producers to feed increasing urban populations. Smallholder farmers play a crucial role in food systems as the suppliers of food but also as main consumers, with around 24 million people (nearly a quarter of Egypt's population) involved in agriculture for their livelihood (FAO, 2020a). Besides limited land and water availability, smallholder farmers have limited capacity to add value to their products and gain a broader interaction with the market, which hampers growth in family income and families' potential contribution to regional economies. As a result, many farmers rely on second jobs to add to family income, although not many job opportunities exist in rural areas. Therefore, the poverty rate in rural areas is high. The 2030 Agenda for Sustainable Development calls for equitable territorial development, particularly for the most vulnerable populations (UN General Assembly, 2015).

Regional differences matter in value chains development across the country. Today, most of the economic activity in Egypt is in Lower Egypt (more than 71.2 percent of GDP), followed by the Suez Canal (17.5 percent of GDP) and Upper Egypt (11.3 percent of GDP). The GDP contribution of the Upper Egypt region decreased by 29 percent during the period 2012–2018 (Table 2.2). The AFS contribution to the GDP differs also by region. Of the 11.7 percent contribution made by the agriculture sector to the national GDP in the year 2015, about 7 percent of the national value added is produced by agriculture in Lower Egypt, followed by Upper Egypt and Suez, with 3.5 percent and 1.2 percent respectively. Most of the agroprocessing activity is also concentrated in Lower Egypt. Agroprocessing in Lower Egypt produces 2.9 percent of national GDP, while agroprocessing in Upper Egypt and in the Suez region each contribute only 0.4 percent to national GDP (Breisinger *et al.*, 2019). However, given the small size of the Suez regional economy, agroprocessing makes up a larger share in its regional economy compared to Upper Egypt. Within the agroprocessing sector, beverages and tobacco constitute the most important activities in Lower Egypt, followed by other food processing, grain milling, and dairy. In Upper Egypt, other food processing is followed by sugar refining and grain milling.

Table 2.2
Regional contribution to GDP and change from the period 2012/2013 to 2017/2018 (percentage)

Economic region	2012/2013	2017/2018	Change
Greater Cairo	44.5	41.9	-6%
Alexandria	14.2	18.1	27%
Delta	12.8	11.2	-13%
Lower Egypt	**71.5**	**71.2**	**-0.4%**
Suez Canal	**12.6**	**17.5**	**39%**
Southern Upper Egypt	8.2	5.9	-28%
Northern Upper Egypt	5.7	4	-30%
Central Upper Egypt	2	1.4	-30%
Upper Egypt	**15.9**	**11.3**	**-29%**

NOTE The activity of the Government of Egypt and economic bodies is excluded from the regional GDP contribution

SOURCE: Authors' own elaboration based on: Ministry of Planning and Economic Development (MPED) and United Nations Development Programme (UNDP). 2021. Egypt Human Development Report 2021. Cairo, MPED. https://egypt.un.org/en/146158-egypt-human-development-report-2021; and Arab Republic of Egypt. 2020. Results of the Fifth Economic Census 2017/2018. Cairo, CAPMAS (Central Agency for Public Mobilization and Statistics). https://censusinfo.capmas.gov.eg/Metadata-en-v4.2/index.php/catalog/405/related_materials

In addition to regional differences in the AFS' contribution to the economy, differences in consumption patterns are also relevant in the interaction of agrifood systems and territorial development. In 2015, rural households' per capita expenditure was USD 1423, compared to USD 2714 for urban households. Rural households spend 32.6 percent of total expenditures on food compared to 26.7 percent for urban households. Within food categories, spending on meat, fish, eggs, milk, and dairy make up relatively large shares of urban households' spending, whereas rural households spend relatively more of their consumption basket on cereals, roots and vegetables. The differences in consumption patterns between rural and urban households are more pronounced than the differences for households between regions (Lower Egypt, Upper Egypt, and Suez Canal) (Breisinger *et al.*, 2019).

Comparing average growth rates for the periods 2015/2016 to 2017/2018 and 2017/2018 to 2019/2020, household income grew by 16 percent in urban areas and 13 percent in rural areas. Household expenditure also grew more in urban areas, with a 19 percent increase compared to 12 percent in rural areas (MPED, 2021) (Figure 2.16).

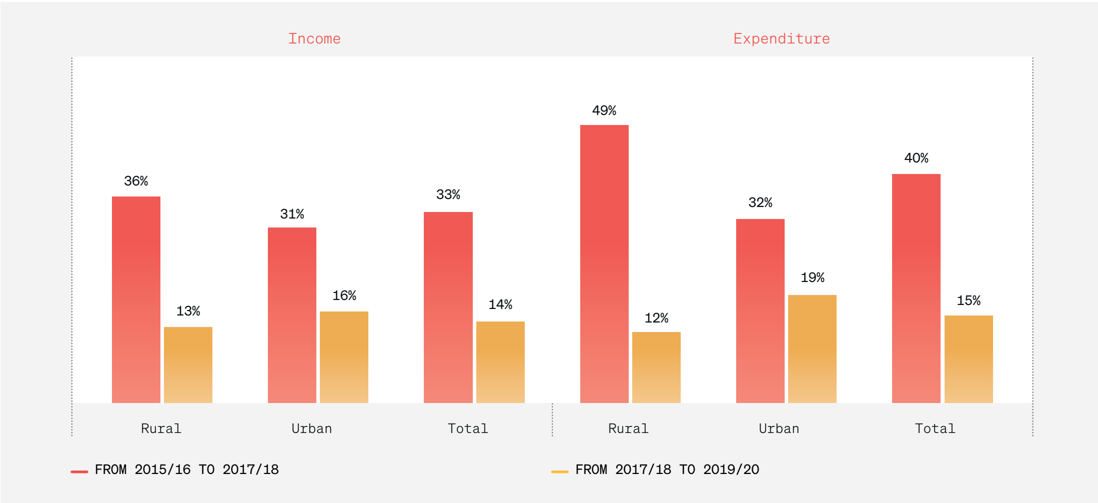


Figure 2.16
Household income and expenditure growth rates in rural and urban areas

SOURCE: MPED. 2021. Egypt's 2021 Voluntary National Review. Cairo, MPED. https://sustainabledevelopment.un.org/content/documents/279512021_VNR_Report_Egypt.pdf

Poverty and inequality are major factors of vulnerability, especially in rural areas of Egypt. During the period 1990–2020, poverty rates have been increasing overall: rising from 16.99 percent in 1990, peaking at 32 percent in 2018 before declining slightly to 29.74 percent in 2020 (Armanious, 2021; MPED, 2021, based on the National Poverty Line). Even if poverty rates have been decreasing in rural areas, the poverty gap between rural and urban population is still high. In 2019/2020, 34.78 percent of the people living in rural areas were affected by poverty, while 22.95 percent of the population in urban areas lived in poverty (MPED, 2021). While rural Upper Egypt accounts for only 25 percent of the population, it is home to more than 50 percent of the poor population in Egypt (Table 2.3). From 2015 to 2017/2018, about 15 out of 27 governorates have experienced an increase in poverty rates, affecting not only Upper Egypt but also Lower Egypt (Elshahawany, D. and Elazhary, R., 2022).

Table 2.3
Poverty rates in key economic regions, disaggregating urban and rural population in Upper and Lower Egypt

Economic region	2015	2017/2018	Change in percentage points
Total Egypt	27.8	32.5	4.7
Metropolitan	15.1	26.7	11.6
Urban Lower	9.7	14.3	4.6
Rural Lower	19.7	27.3	7.6
Urban Upper	27.4	30	2.6
Rural Upper	56.7	51.9	-4.8

SOURCE: Armanious, D. 2021. Accelerating global actions for a world without poverty: Egypt Experiences. United Nations Report. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2021/02/Final-World-without-poverty-Egypt_31-january-2021.pdf

Climate change deepens current social and economic challenges and spatial disparities. According to the CCDR, the poor are the most severely affected by the impacts of climate change, while possessing fewer resources to cope with and respond to climate change risks (World Bank Group, 2022b). It is expected that the number of people living on less than USD 4 a day (approximately the national poverty line) will increase by 0.8 percent by 2030 due to a subset of climate change impacts (effects on agriculture, health, temperature, and increase of natural disasters). Effects will not be felt equally across all regions. Upper Egypt, where about half of the poor live and rely primarily on agriculture for their income, is expected to see deeper impacts.

2.3 VISION FOR A CLIMATE RESILIENT AGRIFOOD SYSTEM

2.3.1 Regulatory context

As part of the implementation of the First Updated NDC, Egypt has made relevant progress in key areas. The government launched a comprehensive energy policy reform programme to phase-out subsidies in the electricity, oil and gas sectors; the programme is expected to be completed in fiscal year (FY) 2024/2025. Investments in renewable energy have been encouraged by the Renewable Energy Law (Decree No. 203/2014) and numerous energy efficiency programmes, leading to a reduction of electricity consumption in FY 2019/2020 compared to FY 2018/2019. Policy reforms took place with the issuance of Egypt's Waste Management Regulation Law (No. 202/2020) and the National Solid Waste Management Programme. The launch of Egypt's Sovereign Green Bonds (September 2020) listed in the London Stock Exchange at a value of USD 750 million, is the first of its kind in the NENA region, and intends to attract large investors towards green investments. Regarding climate change adaptation in strategic sectors, several projects have been implemented with financing from national and international sources, including: Sustainable Transformation for Agricultural Resilience (STAR), 2019–2029, USD 269.64 million led by the International Fund for Agricultural Development (IFAD); Promoting Resilience in Desert Environments, 2017–2026, USD 81.7 million led by IFAD; Sustainable Agriculture Investments and Livelihoods Project, 2014–2023, USD 94.67

million with financing from IFAD and other sources; Enhancing Climate Change Adaptation in the North Coast and Nile Delta Regions in Egypt, 2018–2024, USD 105.2 million, including financing from the Green Climate Fund; Adaptation to Climate Change in the Nile Delta through Integrated Coastal Zone Management, 2009–2017, USD 16.8 million, including financing from the Global Environmental Facility (GEF); and Building Resilient Food Security Systems to Benefit the Southern Egypt Region, 2013–2018, USD 6.9 million grant from the Adaptation Fund (MAPEgypt, 2023).[17]

Within the First Updated NDC, the National Climate Change Strategy 2050 is a roadmap for achieving Egypt Vision 2030 Objective 3.1 – "Meeting the challenges of climate change." The aim of the National Climate Change Strategy is to effectively address the impacts of climate change while contributing to economic growth and improving the quality of life for all citizens. The NCCS 2050 highlights the importance of preserving natural resources and ecosystems as a fundamental condition for sustainable development. The NCCS 2050 encompasses five goals covering: 1) GHG mitigation; 2) resilience building and disaster risk management; 3) improved governance; 4) research and development; 5) financing. The agrifood sector is central for climate resilience. It is able to contribute to GHG mitigation while simultaneously pursuing climate change adaptation and improved disaster risk management. The NWFE is the operationalization framework of the NCCS. The NWFE, launched at COP27, comprises nine priority projects distributed across three pillars (water, food and energy) with a total cost of USD 14.7 billion.

Agricultural development is currently led by the Sustainable Agricultural Development Strategy 2030, which was launched in 2009 and updated in 2019. SADS' main objectives are: promoting sustainable use of natural agricultural resources; increasing the productivity of both land and water units; raising the degree of food security as it pertains to the most strategic food commodities; increasing the competitiveness of agricultural products in local and international markets; improving the climate for agricultural investment; improving the livelihood of rural inhabitants and reducing rural poverty.

The National Water Resources Plan 2017–2037 relies heavily on increasing the sustainability and resilience of the agrifood sector. Pillars of the plan include the rationing of existing water resources with emphasis in reducing the waste of irrigation water, the development and reuse of agricultural and household drainage flows, protecting public health and the environment, and measures to reduce the pollution of waterways from both municipal and industrial origins. The strategy involves executing various projects 2017–2037, which will pave the way to achieve water security goals in view of a population increase to 170 million by 2050. The plan will cost EGP 900 billion over the next 20 years. The actions contemplated in the National Water Resources Plan – together with the government's strategies and policies on energy – provide a relevant framework for increased efficiency in the agrifood sector as a condition for sustainability and reduced vulnerability to climate change impacts.

17 MAPEgypt also shows other projects mapped to the agriculture sector and rural development that include an approach or activities contributing to climate resilience in the AFS, e.g.: Joint Rural Development Programme, 2014-2019, USD 21.8 million with European Union funding; and the Agricultural Innovation Project, 2020-2023, USD 8.34 million, supported by Deutsche Gesellschaft für Zusammenarbeit (GIZ).

2.3.2 Improved land use, water and energy efficiency in the face of climate change

The First Updated NDC, in line with key national strategies and plans for climate action, guides the agrifood sector priorities in terms of improving land and water management for climate action. In the frame of climate resilience commitments, this NDC includes ten priorities linked to the agrifood sector: 1) enhancing agricultural production for adaptation to climate change in the Valley and Nile Delta regions (USD 4 billion); 2) rehabilitation of agricultural areas in the northern delta affected by the repercussions of sea level rise (USD 2 billion); 3) increasing the resilience of climatically vulnerable areas by combating desertification, water harvesting and rehabilitating degraded pastures in marginal areas (USD 3.5 billion); 4) development of on-farm irrigation in the old valley and Nile Delta (USD 4 billion); 5) Supporting the establishment of early warning systems, improving agricultural weather forecasting services, modern agricultural extension, and establishing an agricultural insurance system against climate risks (USD 1.5 billion); 6) water desalination using solar energy (cross-cutting) (USD 625 million); 7) natural protection of Rosetta shoreline using the sand motor (USD 120 million); 8) rehabilitation of irrigation canals to enhance agricultural climate resilience (USD 4.5 billion); 9) scaling up solar pumping for irrigation (cross-cutting) (USD 50 million); 10) improve agricultural climate resilience by modernizing on-farm practices (cross-cutting) (USD 4 billion).

Regarding climate change mitigation commitments, the First Updated NDC also includes priorities linked to the agrifood sector. To those already specified as cross-cutting above, this NDC adds three more: 1) transition towards low carbon nitrogen fertilizer production (USD 140 million); 2) promote an eco-industrial parks concept to scale up resource efficiency through intrafirm exchanges, improvement of economic, environmental, and social performances of businesses, and creation of green industries (e.g. recycling and renewable energy), all to achieve an inclusive and sustainable industrial development; 3) expand coverage of municipal and industrial wastewater tertiary treatment infrastructure and rehabilitate existing facilities, utilize treated wastewater and grey water, and recover sewage sludge for recycling and energy use (USD 5601 million).

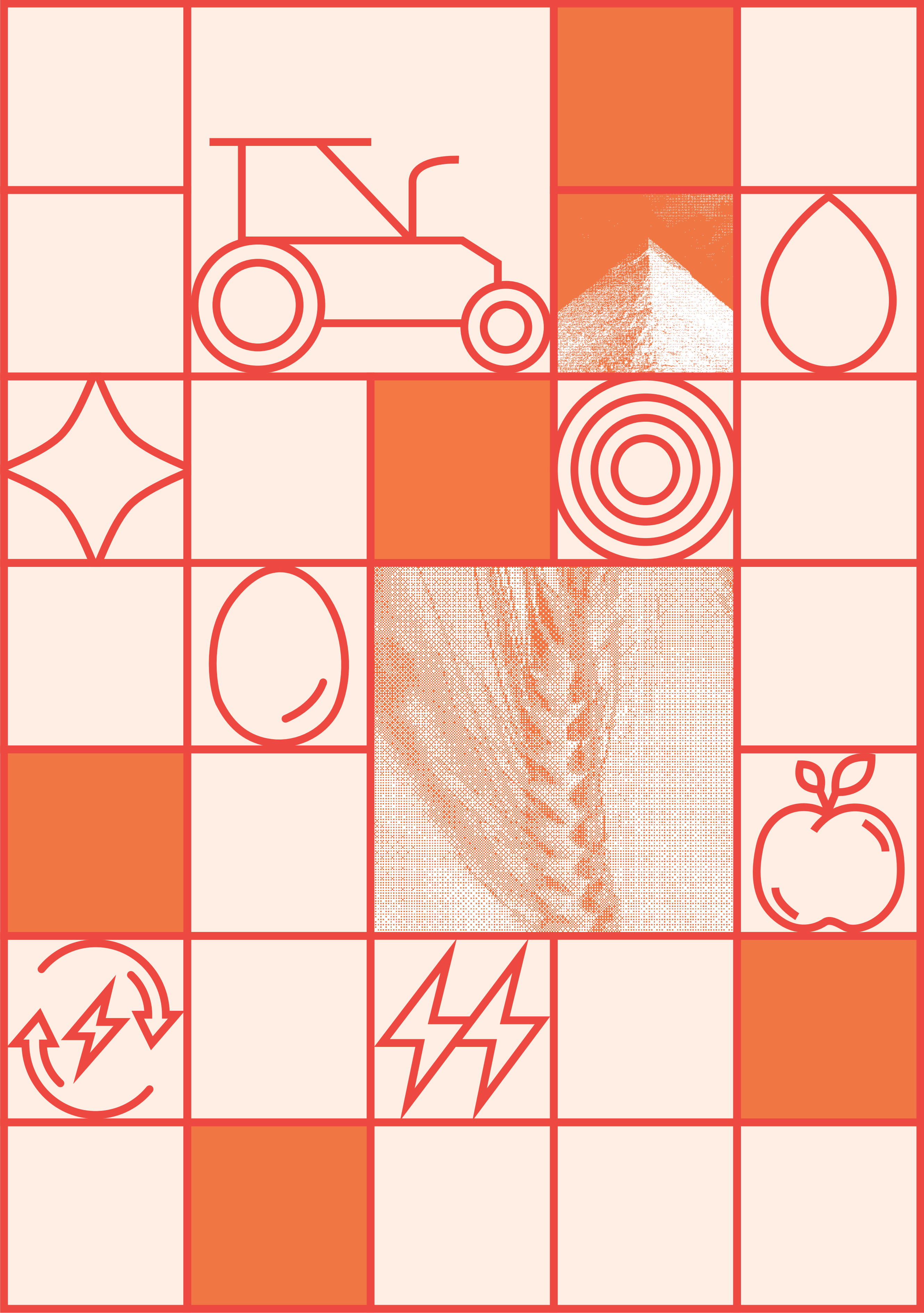
Improved land use, water and energy efficiency in the face of climate change, require an integrated approach towards building a sustainable food system. Considering Egypt's food system complexity and the intended food system outcomes, land use, water and energy are critical factors to ensure food and nutrition security. The NWFE programme intends to implement climate action in an integrated manner.

Table 2.4
Areas of intervention to address food system outcomes when executed in combination

Intervention area	Intervention	Effect	Food system outcome targeted
Production	Improving water/irrigation use and management for higher production and productivity of high-value agricultural produce	Agricultural technology gets the most (kg, USD, equity) out of every drop of water	E, I
Distribution	Reducing food loss and waste while conserving water	Policies on lowering losses and waste and better storage of stocks reduces import burden	H, E
Consumption	Nudging and pricing towards healthy foods to fight malnutrition and obesity; increasing visibility of water use difference between income groups	Consumption patterns move towards a healthier and more productive population at smaller differences between rich and poor	H
Food subsidy	Reforming food subsidy system to become more efficient and targeted to the needy (pricing vs rationing vs cash transfers)	Imports become more efficient and local processing stimulated, saving foreign exchange, while reaching those who need it most	H, I
Water footprint	Focus home production/export on high-value and water-efficient commodities. Focus import on water-consuming commodities	Agricultural policies based on markets and prices as well as green and blue water use efficiency at field and trade levels	H, E, I

NOTE H - health, E - environment, I - inclusiveness

SOURCE: Terwisscha van Scheltinga, C., de Miguel Garcia, A., Wilbers, G.-J., Heesmans, H., Dankers, R. & Smaling E. 2021. Unravelling the interplay between water and food systems in arid and semi-arid environments: the case of Egypt. Food Security 13: 1145–1161. https://doi.org/10.1007/s12571-021-01208-1

Chapter 3
Influence of agrifood policies on competitiveness and sustainability

Government involvement in the agrifood sector has been a policy priority across different administrations. Public sector policies and strategies have historically focused on desert land reclamation for agriculture, irrigation infrastructure, and agricultural and food production geared towards securing food availability, while food and agricultural input subsidies have been set to ensure food accessibility. Nevertheless, the nature of government involvement has been evolving over the last 40–50 years, especially in the last decade, when the government has intensified the transition to more targeted public support, while reducing the presence of state-owned companies and their control over private sector activity and imports and expanding the role of the private sector in driving growth and job creation in key agrifood subsectors. The first round of reforms started in the early 1970s, when the economy experienced some levels of liberalization, focusing on attracting foreign investments, alleviating restrictions over private sector activities, and offering foreign investors tax privileges and import and export permits. While this clearly resulted in more private sector involvement in the agrifood sector, local production became more exposed to international markets, which contributed to enlarging the wheat supply deficit, making Egypt a major importer of wheat.

With producers struggling to compete with imports, and rural households having difficulties coping with tight food purchase power, several rounds of reforms began in the mid-1980s, with increases in fiscal spending needed to support subsidy programmes. This period was also marked by additional structural reforms encouraged by the International Monetary Fund (IMF) and supported by the World Bank, all intended to build a more market-based economy, with less participation of the public sector, reduced agricultural input subsidies, fewer price and marketing controls for major crops, more exposure to international competition, and improvements in productivity and incomes (El-Gaafarawi, 1999; Baffes and Gautam, 1996). Trade measures also characterized this period in the late 1990's, including the establishment of guaranteed floor prices for main commodities following international prices, reduction in the maximum tariffs, and adjustments in other non-tariff barriers. An important result of these efforts was the signing of free trade agreements with the United States of America, the European Union, countries in Eastern and Southern Africa, and other Arab countries.

The last round of reforms has been taking place in the last decade, with a major focus on sustainable production of high-value export-oriented products, while also ensuring food security with imports of water-intensive food crops, especially cereals and pulses. This round of reforms has adopted a more holistic view of the agrifood sector, with the establishment of complementary development and climate change plans and strategies, including: Egypt's Vision 2030 sustainable development strategy; the Long Term Low Emission Development Strategy 2050, the NCCS and the National Strategy for Disaster Risk Reduction 2030. The reforms also include sectoral strategies such as: SADS 2030, National Water Resources Plan (2017–2037); Integrated Solid Waste Management Strategy; Integrated Sustainable Energy Strategy 2035; and the National Energy Efficiency Action Plan II (2018–2022). These lay out the main priorities to enable the Government of Egypt and the private sector to increase the competitiveness and sustainability of the agrifood value chains, while also securing fiscal sustainability.

The government has successfully regulated rice production to reduce its drain on Egypt's water supply. It has been much more challenging, however, to reduce water used in wheat production, which is usually procured by the government at prices higher than the international market to sustain the levels of domestic production (Perez *et al.,* 2021a). To reduce wheat import dependence, the current administration is providing farmers in old lands[18] with access to low-cost financing to increase water productivity, shifting from flood to pressurized irrigation, while also expanding reclaimed lands into wheat production with the use of more efficient irrigation technologies using ground water. Despite the government's long-term commitment to build a strong, open, competitive, and green economy, ad hoc policy responses are still frequent when the country faces food security and economic shocks, including devaluating the Egyptian Pound to attract foreign currency, restricting food export flows, and establishing tariffs on some food products.

18 Old lands are agricultural lands that cultivate using Nile River water. New lands refer to irrigated agriculture making use of groundwater.

3.1 PUBLIC SUPPORT TO THE AGRIFOOD SECTOR (POLICIES AND EXPENDITURE)

3.1.1 Institutional setup and agrifood policymaking

Public support in the agrifood sector is channeled through multiple layers of government institutions: the ministries and economic and service authorities as well as funds at the central level, and decentralized departments at the governorate level. At the ministry level, MALR, MOSIT, and MWRI are the main authorities tasked with supporting the agrifood sector and setting and implementing agrifood policies from production to consumption. Along with MPED, the MoF and Ministry of International Cooperation also provide policy, planning, and resource mobilization support, while the Ministry of Military Production intervenes in times of crisis to stabilize food availability and accessibility.

MALR supports farmers' cropping activities, manages quotas for inputs and finance, and guarantees output sales. The latter was partly provided by the Principal Bank for Development and Agricultural Credit, now the Agriculture Bank of Egypt. The former once had a monopoly on seed and fertilizer distribution and would procure major strategic crops at above-market prices. With the cropping activities liberalized and seed and fertilizer distribution handed over to cooperatives and private traders (except for cotton, rice and sugarcane for irrigation purposes), MALR's role has been redirected to providing overall policy guidance in the agrifood sector, while delivering research and implementing investments based on long-term strategic directions. MALR's strategy, largely driven by the government policy for increasing exports, local food production, and land and water use efficiency, has revolved around the expansion of cultivated area by reclaiming new desert lands (horizontal expansion), and accelerating yield growth in both the old and new lands (vertical expansion). These efforts are also connected with the goal of increasing value addition and exports in agrifood value chains.

While most of MALR support concentrates upstream in the agrifood system, MOSIT provides support to downstream agrifood actors. This is mainly in managing the subsidy schemes, the agrifood procurement system for the national subsidy programme and its supply chain, and the mechanisms of distributing the subsidy through ration cards and cash transfers. MOSIT remains instrumental in managing food accessibility for most Egyptians, while also guaranteeing purchase of certain strategic crops as part of the overall efforts to stabilize food security. Nevertheless, its subsidy mechanisms are evolving towards a much more limited role of subsidizing agrifood value chains, while also maintaining the ability to re-scale support in times of crises

Most of the water-related policies and expenditure are led by the MWRI, including policies related to water management and conservation, and water and hydrological research. It also oversees infrastructure investments in irrigation, water pumping and desalinization stations, and water treatment projects. The Ministry of International Cooperation has contributed actively to the AFS by negotiating international trade agreements on behalf of the sector.[19] The Ministry of Local Development supervises the decentralized

19 These include the accession of Egypt into the World Trade Organization (WTO), the Egypt-European Union Association Agreement, the Greater Arab Free Trade Area (GAFTA), the Egypt-United Kingdom Free Trade Agreement (a.k.a. United Kingdom-Egypt Association Agreement) and the Common Market for Eastern and Southern Africa (COMESA).

departments of agriculture, veterinary services, and supply and internal trade in Egypt's 27 governorates. These departments form a second layer of government institutions that, in principle, should implement policies at the decentralized level. Each ministry is linked to several economic authorities, service authorities and funds. These operate almost independently from the ministries and decentralized departments and receive separate budget allocations. Most of investment and subsidy expenditure is channelled through these authorities and funds.

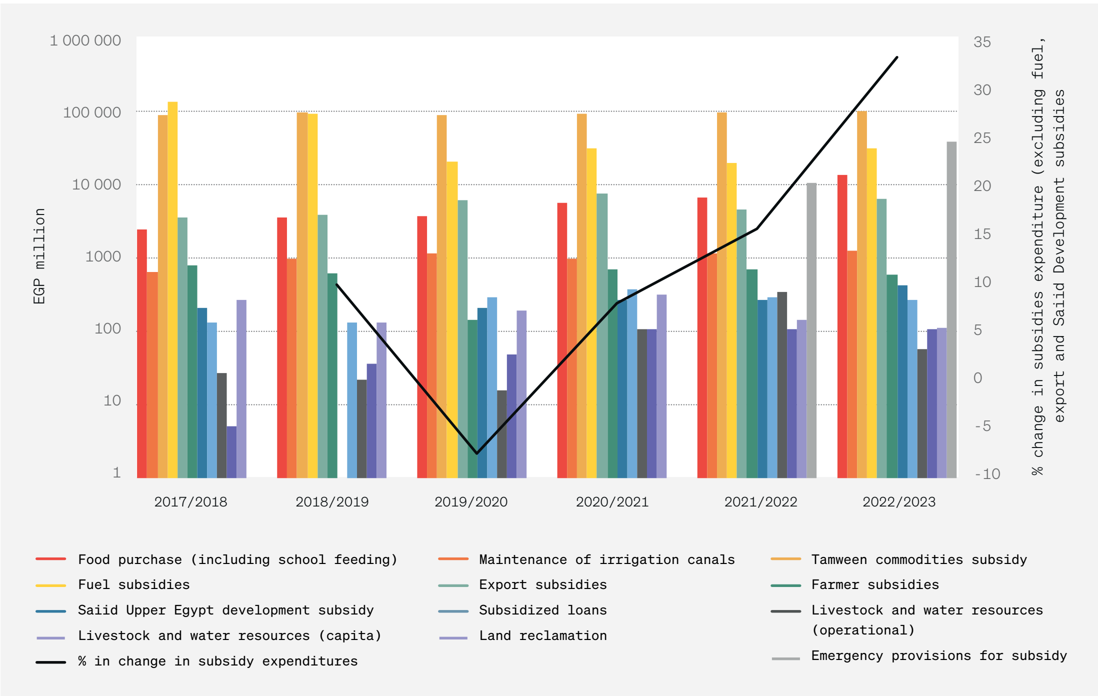
Within the agriculture and irrigation sectors, four major economic authorities implement the majority of agricultural investments. They are: the Egyptian Agricultural Authority (project management and implementation), the General Authority for Construction and Agricultural Development (mainly land reclamation and irrigation projects), the Egyptian General Survey Authority (hydrological and agri-ecological mapping), and the Lakes and Fisheries Development and Protection Agency (fisheries projects). Most of the investments have been dedicated to land reclamations, which have been on the rise in the last four fiscal years. Managing the government subsidy schemes are the Supply and Internal Trade economic authorities, including GASC, the Internal Trade Development Authority, and the General Authority for Mediation and Testing Cotton. GASC is the main driver for the implementation of the food subsidy schemes (baladi bread value chain, Tamween, cash transfers and purchase of strategic crop production).

3.1.2 Public expenditure on agrifood development

Overall, the expenditure on agrifood has been rising, with investment expenditures increasing and subsidies remaining stable except in times of crisis, when subsidies increase. This is in line with government strategies for the agrifood sector, whether supporting agricultural production through research and input subsidies or stabilizing access to food through subsidies. Nevertheless, the share of total public investment dedicated to agriculture is starkly low, only around 3 percent, roughly one-quarter the size of agriculture's contribution to the national GDP. In addition, expenditure on salaries remains high due to overstaffing; while this is less than the expenditure on subsidies, it is still higher than the expenditure on investments.

Egypt's agrifood subsidy system has multiple purposes, and has evolved over time to respond to the socioeconomic changes in the country. With the change in government policies in the 1970s and 1980s, the agrifood subsidy evolved to mirror the government policy on desert land reclamation and to ensure that food availability kept pace with the internal migration from rural areas. Given the fast population growth, which outpaced economic growth, and external economic shocks such as the financial crisis of 2008 and the global food crisis of 2011, the agrifood subsidy system remains one of the few tools available to address the impacts of these shocks and sustain social protection and stability. Even after committing to reduce subsidies under the IMF programme, Egypt had to increase expenditures on subsidies due to the COVID-19 pandemic and the war in Ukraine. Nevertheless, this tool has been at the heart of every government reform discussion, especially considering the heavy dependence of the subsidy system on high volumes of foreign currency to cover food imports.

The agrifood subsidy system, however, is a heavy burden on the government's finances. Excluding the indirect subsidies on fuel, export rebates, and Saiid Upper Egypt Development, the cost of the agrifood subsidies stood at EGP 85 billion in FY 2019/2020 (approximately USD 4.26 billion), an amount comparable with the value of profits generated in the tourism sector in 2020 (around USD 4.87 billion), one of the main sources of foreign currency in the country. The expenditure on subsidies in 2019/2020 was one of the lowest in recent years, but has substantially increased annually since then, reaching an estimated value of EGP 106 billion in 2021/2020 and an imposing EGP 140 billion in 2022/2023. This is largely explained by the increased costs of the Tamween programme and the funds needed by emergency provisions, both due to the impacts of the Ukraine war in commodity markets.



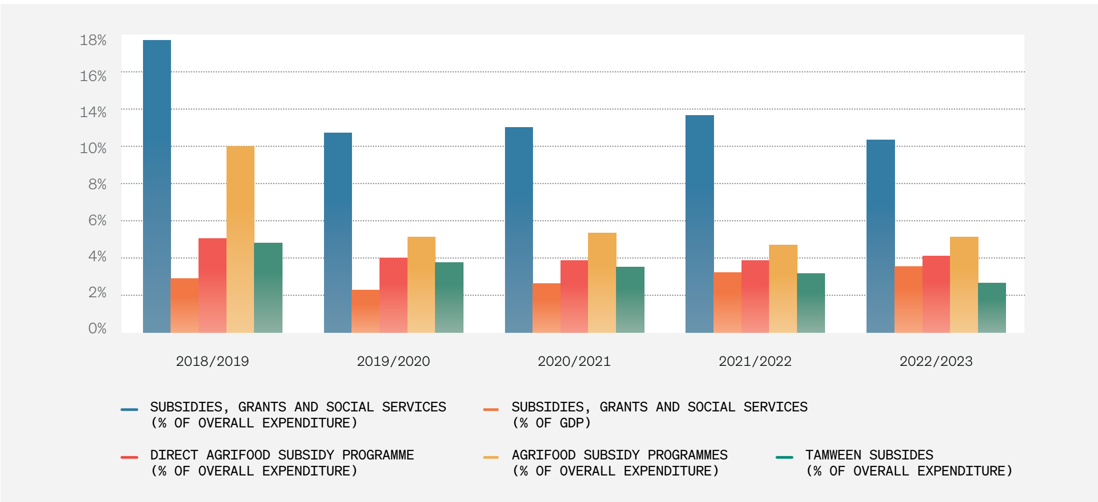
NOTE See Box 2.1 and Annex 3 for more detail on the main support measures.

Figure 3.1
Fiscal expenditures on agrifood subsidies

SOURCE: Authors' own elaboration based on: MoF. 2022. General Budget 2021/2022. Cairo, Ministry of Finance.

Macroeconomic pressures and the advent of digitization into government services have energized the need for reforms in agrifood government expenditure modalities. These reforms are to be based on the government's goals for the agrifood sector, whether for agrifood export expansion, food sovereignty, or social protection goals. The preference has always been for in-kind transfers as they provided the raison d'etre for certain government institutions. Yet, government subsidy policies are evolving towards targeted cash transfers, whether in the form of cash transfer to the poorest (under the Tamween, Takful and Karamah programmes), and to farmers, or export rebates to exporters and investors. The elimination of food subsidies would adversely impact the poor, but this can be offset by targeting these reforms to non-poor households, and also by combining a smaller Tamween food subsidy programme with cash transfers to the most vulnerable households (Breisinger *et al*., 2021).

Evolving towards more targeted and growth-energizing instruments may – in principle – bring a number of fiscal, economic, and environmental benefits to the country. These include savings in expenditure stemming from the reduction in overconsumption of subsidized commodities and services; reduced dependence on imported commodities; more flexibility for targeted individuals on how to utilize the subsidies; improved environmental sustainability due to fewer price incentives for production of water-intensive food commodities; and increased fiscal capacity to invest in research and development, extension and scaling up adoption of climate-smart technologies intended to help Egypt's AFS achieve its adaptation and mitigation goals.[20]



NOTE Excluding financial and loan repayment expenditure.

Figure 3.2
Importance of subsidies and social services in overall government expenditure

SOURCE: Authors' own elaboration based on: MoF. 2022. General Budget 2021/2022. Cairo, Ministry of Finance.

20 Note that if cash transfers are financed by higher fiscal deficit, the deceleration of economic growth will tend to reduce welfare gains for the poor and lead to welfare losses for the non-poor (Breisinger *et al*., 2021).

One of the core challenges in Egypt's fiscal spending on agrifood has been efficiency. While there have been many studies on the efficiency of these subsidy programmes, those discussions are rarely held in the context of their efficacy in the agricultural sector.[21] Similar to expenditure on subsidies, which are mostly channelled through the economic authorities to procure commodities and transfer cash, expenditure on agrifood through the ministries and local departments are highly inefficient, with salaries taking the largest share by far. Salary expenditures on agricultural research projects, for example, represented 71 percent of the projects' budgets, while only 13 percent was dedicated to cover expenses on goods, and services for research; and 11 percent on non-financial investments (mostly infrastructure and equipment).[22] Expenditure on goods and services is very low compared to expenditures on staff, which renders frontline staff unable to serve farmers effectively for lack of fuel, equipment, tools, etc. Spending on staff accounts for more than 90 percent of all governorates' resources allocated to the agricultural and veterinary departments.

3.2 PUBLIC AND PRIVATE INVESTMENTS FOR AGRIFOOD SUSTAINABILITY

Egypt's AFS sector handled impacts of the COVID-19 pandemic and economic slowdown relatively well, performing better than other sectors in the economy. With the current levels of investments in AFS adaptation strategies, the sector is unlikely to thrive under the worrying climate change threats. The competitiveness and economic and environmental sustainability of Egypt's AFS largely depends on three main aspects. First, on the country's capacity to accelerate R&D, focusing on adaptation technologies. Second, on farmers' and other value chain actors' adoption of such technologies by having access to training and extension, information, and financial services. Third, on the government's ability to reform its production and consumption subsidies, which are currently creating incentives for more production than is ideal and for consumption of low-value and unhealthy commodities (especially cereals), while also limiting the country's fiscal capacity to make transformational investments along the AFS.

Under its Vision 2030, the GoE has put in place several plans to address the persistent challenges related to water and land scarcity and climate change. SADS 2030 focuses on technology adoption to increase production and increase water use efficiency, and the NCCS provides a multisectoral framework to promote the sound management of soil, arable land and water, while encouraging the use of high-yielding inputs. These policies seek to

21 That said, some studies have produced important findings, including: (a) small aggregate regressive welfare gains from removing food subsidies, better targeting of subsidies is recommended (Löfgren and El-Said, 2001); (b) regressive welfare changes when switching from food subsidies to cash transfers (Helmy *et al.*, 2019); and (c) welfare of poor households would be enhanced by a smaller, but better targeted food subsidy programme if the cost savings from reforms are used for investments (Breisinger *et al.*, 2021).

22 GoE investments are categorized as financial and non-financial investments. The latter refers to investments in infrastructure, equipment, and other types of assets.

tackle long-standing problems associated with water scarcity and climate change by improving crop productivity, enhancing resilience, and reducing food losses, but their implementation is still slow and the relevant GoE institutions have had difficulties funding programmes to deliver on these plans. For example, as part of its mandate, MALR has been focusing on supporting land reclamation, accelerating yield growth of key field and horticulture crops, development of livestock and fishery production, and water rationing. Yet it has had difficulties funding research and extension programmes to generate technological solutions for climate change adaptation and resilience, and is experiencing challenges that restrict its ability to create financial and regulatory instruments that would enable the scaling up of climate-resilient green technologies along the agrifood system.

The GoE is willing to reform social programmes by reducing subsidies and scaling up targeted cash transfer programmes. These reforms are key not only to sustainably enhance the welfare of the poor (Breisinger *et al.*, 2021), and eliminate perverse incentives for inefficient use of scarce production factors, but also to boost fiscal spending on public goods (R&D, extension, digitalization, market systems, agrologistics, etc.) towards a more climate-resilient and greener AFS. The GoE has also implemented some successful instruments that are dealing with water scarcity and climate change threats. One is the establishment of the production quota for rice. In 2022, the total quota was 724 000 feddan for flooded areas, 200 000 feddan for water efficient systems, and 150 feddan for lands affected by salinity. The GoE is also investing in desalination plants, groundwater extraction facilities, and wastewater treatment plants. Nearly 60 desalination plants were already in operation in the beginning of 2021, and 39 other plants were planned to open by the end of 2021. These initiatives align with MWRI's 2037 National Water Resources Plan, which focuses on rationing water use, improving water quality, expanding water resources, and fostering climate-resilient water management.

The GoE plans to contribute about 72 percent of funding needed for SADS 2030, around EGP 49.3 billion over the next seven years. The remaining amount is expected to come from the private sector, which is crucial to boost innovation and efficiency along the AFS. Private sector investment in the AFS is the cornerstone for accelerating adaptation and greening the AFS. Yet, there are worrying trends in private investment in the sector in the last two decades. In real terms, the value of gross fixed capital formation (GFCF) reduced substantially from a three-year annual average of USD 2.06 billion 2001–2003 to USD 1.36 billion 2015–2017 (Table 3.1). It has now recovered to the levels seen in the early 2000s, but this was made possible only recently (i.e. 2018–2020), with a GFCF of USD 2.02 billion. What is more concerning is the fact that the GFCF in the sector as a share of total GFCF has reduced from 10.4 percent in 2001 to nearly 2.6 percent in 2020. Similarly, the GFCF in the sector as a share of agricultural value added has reduced from 13.77 percent in 2001 to nearly 4.1 percent in 2020. Despite the apparent reinvigoration of the private sector as key investors in the sector, GFCF in the sector has clearly lagged behind the growth in GFCF in the whole economy. At the very least, one can assume the sector has not received the levels of needed investments, including what is necessary for climate adaptation and mitigation.

Table 3.1

Trends on gross fixed capital formation (GFCF) in agriculture in Egypt

Year	Value of GFCF (USD million 2015)	GFCF annual growth (%)	Agriculture orientation index	Share of agriculture sector GFCF in total GFCF (%)	GFCF as share of agriculture value added (%)
2001	2068	-	0.87	10.39	13.77
2002	2303	11.38	0.82	9.65	13.51
2003	1814	(21.22)	0.66	8.06	11.26
2004	1250	(31.09)	0.41	5.33	6.29
2005	1008	(19.38)	0.26	3.60	4.47
2006	1546	53.35	0.35	4.95	6.59
2007	1596	3.24	0.27	4.64	5.44
2008	1336	(16.28)	0.21	3.47	4.71
2009	1160	(13.18)	0.16	6.00	3.05
2010	763	(34.21)	0.13	1.75	2.53
2011	725	(5.03)	0.12	1.71	2.06
2012	1445	99.44	0.30	3.42	4.46
2013	1271	(12.08)	0.31	3.48	4.00
2014	1110	(12.67)	0.25	2.85	3.13
2015	1260	13.57	0.25	2.90	3.48
2016	1276	1.21	0.25	3.00	3.83
2017	1543	20.97	0.28	3.20	4.25
2018	2260	46.47	0.30	3.35	4.97
2019	2018	(10.73)	0.23	2.56	4.17
2020	1770	(12.27)	0.23	2.60	4.21

SOURCE: Authors' own elaboration based on: FAO. 2022a. FAOSTAT. In: FAOSTAT. Rome. [Cited 13 September 2022]. www.fao.org/faostat/en/

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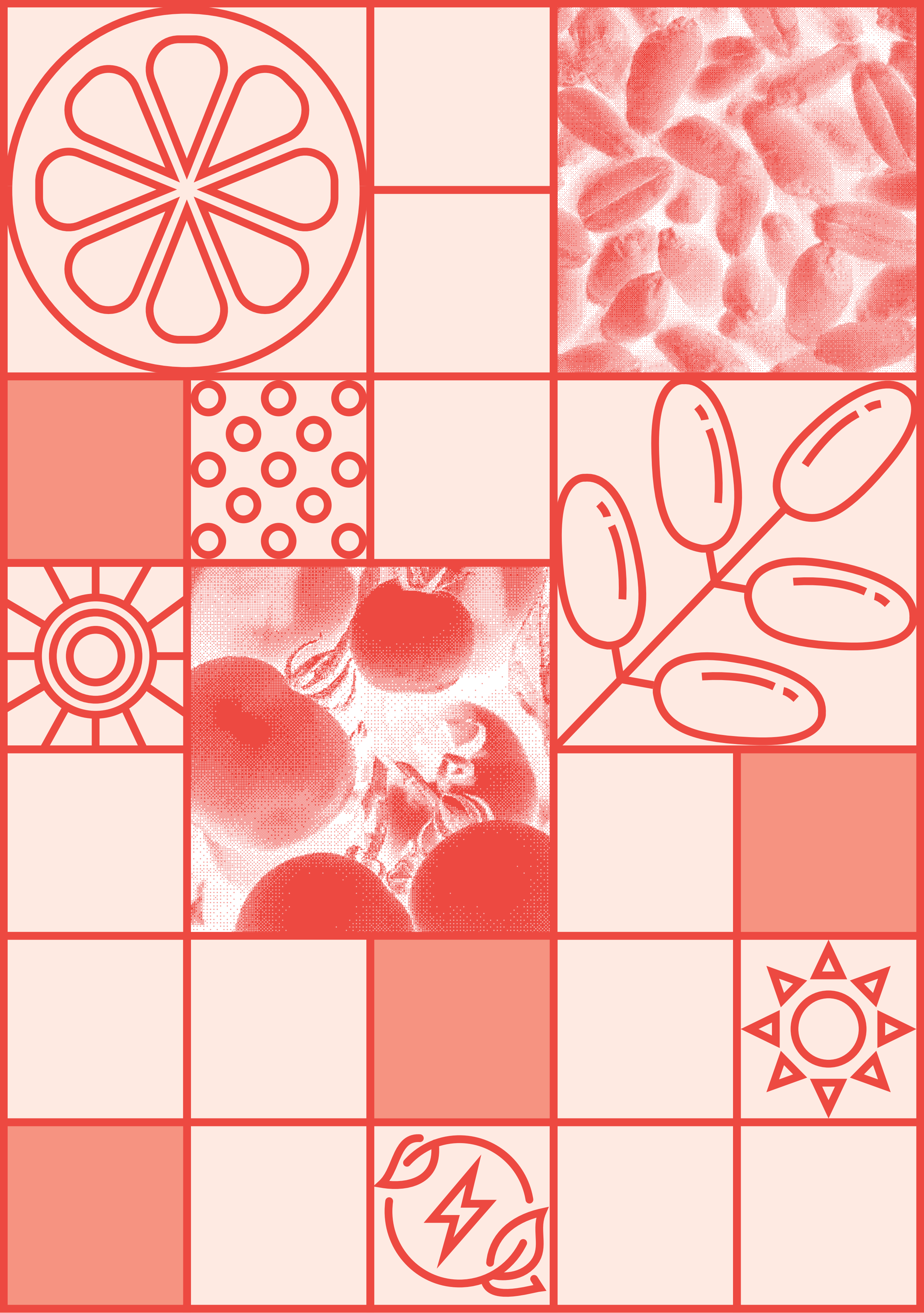


Chapter 4
Scaling up climate smart technologies in key subsectors

Egypt's AFS faces structural challenges, exacerbated by climate change. Agriculture has experienced performance issues in the last two decades, reflected in the stagnation of the yields of major crops, underperforming other similar countries. The limited land and water resources are under pressure. This is further exacerbated by climate change impacts – with particular attention to higher temperatures, changes in rainfall patterns and sea level rise – as well as their influence in the frequency and intensity of extreme weather events and the occurrence of pests and diseases. Climate change will impact the AFS heavily, making it one of the most affected sectors in the economy, and put a significant strain on national and household food security and the livelihoods of the Egyptian population, especially of the most vulnerable.

Climate action is crucial for AFS's sustainable transformation and CSA technologies are key to building resilience against the impacts of climate change and reducing the sector's environmental footprint. Mainstreaming adaptable and tested CSA technologies and involving small, medium and large actors along the agrifood value chains, can foster the sustainable transformation of key value chains and the AFS as a whole. CSA technologies are diverse and specific to the conditions of different production systems, although there is growing convergence among stakeholders on where and how CSA can make the highest impact. While there are obvious environmental benefits from the large-scale adoption of CSA technologies, there are also significant market opportunities for CSA technologies in Egypt, which – compared to business-as-usual (BaU) scenarios – can yield greater benefits for farmers of all sizes, consumers, and other actors along the AFS in both the short and long term.

4.1 PRIORITIZATION OF SUBSECTORS AND CLIMATE-SMART AGRICULTURE TECHNOLOGIES

Step 1 of the AFS analytical framework supported the delimitation of AFS goals and subsectors. The validation of AFS goals and selection of subsectors were based on criteria agreed with key stakeholders. The criteria included: (a) economic relevance; (b) possibility to increase productivity, while improving environmental sustainability; (c) relevance for food and nutrition security; and (d) climate change adaptation and mitigation potential. For this stage, the main inputs applied were the AFS rapid assessment in the context of a changing climate, the AFS expenditure analysis, and priorities indicated in key national strategies and plans. Particular attention was given to the NSRFP, with the lens of climate change adaptation and mitigation in the AFS provided by the NCCS, First Updated NDC and NWFE programme. Consultations with decision-makers were conducted to confirm selection of the subsectors for in-depth assessment.

The four value chains targeted in this study are dairy, dates, maize, and wheat. Besides fulfilling the priority criteria, the selected value chains offer the possibility to analyse a number of performance and sustainability issues that reflect key challenges and opportunities faced by other agrifood value chains. On the aggregate, maize and wheat have a high impact on water and land resources, given the large extensions of land used by these crops and the level of water consumption and waste. Although wheat is a winter crop, and thus consumes relatively less water than summer crops, the quantity of water used to produce wheat at suboptimal water productivity levels is significant. Maize and wheat are also highly affected by high temperatures and heat waves, precipitation pattern changes, salinization, and the increased outbreaks of pests and diseases, which are directly linked to climate change. As currently managed, the dairy value chain has significant negative environmental impacts, both directly through its contribution to GHG emissions and water pollution, and indirectly through the intensive use of fertilizers and water in feed production. Enteric fermentation and poor manure management are main contributors to the environmental footprint of the subsector. Whereas the date palm value chain is one of the most climate-resilient and least water-intensive crops in Egypt, this subsector still uses a large quantity of water, which could be minimized through the use of more efficient irrigation and soil management technologies. The value chain is also affected by important pests whose control requires the use of pesticides, and high yields can only be achieved with heavy use of fertilizers (Table 4.1).

Table 4.1

Production indicators (area, yield, volume and water footprint) for the selected subsectors

Product	Old lands[a]			New lands				
	Area (feddan)	Yields (tonnes/ feddan)	Production (tonnes)	Area (feddan)	Yields (tonnes/ feddan)	Production (tonnes)	Water use (m^3/ feddan)	Water footprint (m^3/feddan)
Maize[b]								
Nile Delta	1 020 476	3.55	3 621 670	70 300	3.44	242 113	2 609	746
Middle Egypt	570 871	3.05	1 740 701	23 569	2.79	65 729	3 081	1 055
Upper Egypt	412 526	3.23	1 330 644	30 374	2.17	65 826	3 363	1 247
Total	**2 003 874**	**3.34**	**6 693 016**	**124 243**	**3.01**	**373 669**	**3 017**	**951**
Wheat								
Lower Egypt	1 661 018	2.67	4 437 288	144 273	2.46	354 213	1 826	712
Middle Egypt	579 915	2.63	1 526 637	47 804	2.53	121 158	2 027	784
Upper Egypt	534 388	2.93	1 564 250	129 084	2.50	322 871	2 425	893
Outside the Nile valley	–	–	–	306 166	2.53	775 343	–	–
Total	**2 775 321**	**2.71**	**7 528 175**	**627 327**	**2.51**	**1 573 585**	**2 097**	**803**
Dates[c]								
Lower Egypt	11 975	139	677 911	3 393	104	31 768	–	–
Middle Egypt	17 749	127.10	335 179	20 261	139.67	133 397	–	–
Upper Egypt	5 181	85.77	190 883	22 545	85.04	39 694	–	–
Outside the Nile valley	-	-	-	53 022	86.06	301 771	–	–
Total	**34 905**	**123.48**	**1 203 973**	**99 221**	**99.04**	**506 630**	**11 875**[e]	**850**
Dairy[d]								
Raw milk, buffalo	1 310 469	1 334	1 747 641	–	–	–	–	–
Raw milk, cattle	1 418 352	2 306	3 270 010	–	–	–	–	–
Raw milk, sheep/ goats	976 141	74	71 844	–	–	–	–	–
Total	**3 704 962**		**5 089 495**	–	–	–	–	–

NOTES (a) Data for dairy corresponds to the whole country with no differentiation between old and new lands. Most of the dairy cattle are located in old lands (FAO, 2018). (b) Data for maize correspond to the average for years 2015-2019 (Swelam *et al.*, 2022). (c) The yield unit for dates is kg per tree. The numbers on date palm producing fruits in old lands is 5.1 million and in new lands 9.7 million. (d) The yields of milk are kg per animal per annum. There is no differentiation between the yields of milk for old and new lands. (e) The water use for dates was calculated based on the average FAOSTAT yield for 2020 (13.97 tonnes/feddan) and the water footprint as stated in the table.

SOURCE: Authors' own elaboration based on data from: 1) FAO 2022a. FAOSTAT. In: *FAOSTAT*. Rome. [Cited 13 September 2022]. www.fao.org/faostat/en/; 2) Agriculture Economic Affairs at MALR; and 3) Swelam, A., Farag, A., Ramasamy, S. & Ghandour, A. 2022. Effect of Climate Variability on Water Footprint of Some Grain Crops under Different Agro-Climatic Regions of Egypt. *Atmosphere* 13(8):1180. https://doi.org/10.3390/atmos13081180

Step 2 of the AFS analytical framework supported the definition of key uncertainties, main trends, and priority climate-smart technologies. There is consensus that critical climate change impacts in Egypt's agrifood sector overall and the four subsectors selected for in-depth assessment derive primarily from higher temperatures, heat waves, rising sea level and growing incidence of pests and diseases. These factors have a significant effect on key resources for the AFS – land, water and energy – and ultimately on the system's capacity to produce, process, distribute, commercialize and consume food products, as confirmed by the First Updated NDC, the CCDR (World Bank Group, 2022b), FAO (AbdelMonem *et al.*, 2022) and various studies from IFPRI (Perez *et al.*, 2021a, 2021b and 2021c). Therefore, the identification of CSA technologies addresses the main climate change impacts and responds to the country's priorities indicated in the NSRP, First Updated NDC and NWFE.

Research points towards a variety of CSA technologies that have the potential to enhance the climate resilience of Egypt's main agrifood value chains. These technologies can generate substantial gains in terms of land, water and energy efficiency, as well as on diversification into higher value subsectors, increasing rural incomes and reducing the environmental footprint. Two rounds of consultations with farmers, traders, processors, researchers, academia and government experts and decision-makers, informed the prioritization of CSA technologies. The first round was a perception assessment conducted in 2021, which studied the adoption potential of different CSA technologies in Egypt according to four conditions: 1) the actor's willingness to apply the CSA technologies in the face of climate change threats; 2) affordability of adopting the technologies; 3) perceived expected return on investment; and 4) likely barriers to adoption. The survey collected feedback from 32 respondents, including researchers, extensionists, processors, and farmers (Nganga *et al.*, 2021). The second round was a consultation workshop in March 2022 in Cairo, which stimulated more in-depth discussion on the main CSA options for the target value chains. In addition, the authors held meetings with experts in MALR (including representatives of MALR's Agricultural Economics Research Institute and its Agriculture Economic Affairs office), farmers cultivating new lands, the Agricultural Export Council (including its dates committee), FAO Egypt, and researchers.

Consultations with Egypt's agrifood value chain stakeholders highlighted the importance of focusing on a set of CSA strategies. The selected CSA technologies respond to the most relevant climate change impacts on the AFS in Egypt, which are particularly acute for the four selected subsectors in all production areas and along the value chain. The CSA strategies are: (a) varietal and breed improvement, with particular attention to higher temperatures, heat waves, reduced water availability and increased salinity; (b) soil moisture and fertility management; (c) irrigation water use efficiency, with a focus on pressurized irrigation technologies (drip and sprinkler) in old lands; (d) improved fertilizer use efficiency; and (e) post-harvest loss reduction. In most cases, the financial analysis assessed technological packages with potential to achieve higher combined impact. The stakeholders' feedback was key to confirm the selection of subsectors and CSA technologies that are subject to a detailed technical, economic and financial analysis to support the definition of policy options for scaling up adoption. The assessment of CSA technologies considers the incremental costs and benefits of the CSA technology package versus the conventional technology (business-as-usual, BaU) scenario. For each subsector, Table 4.2 summarizes the BaU and CSA technology scenarios applied in the assessment, including the sources of information used in the assumptions. Annex 2 provides a full description of the models included in the assessment and the sources of information.

Table 4.2
Summary of target CSA technologies and their potential impact by subsector

Business-as-usual technology (BaU)	CSA technology package	Climate change adaptation strategy
Maize		
Full tillage and flood irrigation	Canal lining, mulching, reduced tillage & improved cultivar	Varietal improvement, soil management & higher irrigation efficiency
Full tillage and flood irrigation	Canal lining, fixed-furrow irrigation (FFI), mulching & improved cultivar	Varietal improvement, soil management & higher irrigation efficiency
Full tillage and flood irrigation	Surface drip irrigation with nitrogen, phosphorus, and potassium (NPK) nanofertilizers & improved cultivar	Varietal improvement, soil management and higher irrigation efficiency
Full tillage and flood irrigation	Subsurface drip irrigation, with semi-mechanical method (15 cm depth & 1 m of lateral spacing)	Higher irrigation efficiency
Conventional production & storage	Improved production and storage with application of nano-silica and better storage conditions	Post-harvest loss reduction
Wheat		
Rainfed farming with full tillage	Contour tillage and water harvesting (rainfed)	Soil management & higher irrigation efficiency
Full tillage and flood irrigation	Mechanized raised bed	Soil management & higher irrigation efficiency
Conventional land levelling and flood irrigation	Laser land levelling, sprinkler irrigation and deficit irrigation (60%)	Soil management & higher irrigation efficiency
Full tillage and flood irrigation	Subsurface drip irrigation with application of nanosilica to manage salinity and improve nutrient up-take	Soil management & higher irrigation efficiency
Full tillage and flood irrigation	Wide ridges with drip irrigation and conservation tillage	Soil management & higher irrigation efficiency
Conventional production & storage	Improved production and storage with application of nano-silica and better storage conditions (hermetic polyethylene bags)	Post-harvest loss reduction
Date palms cv. Medjool		
Bubbler irrigation system with conventional NPK fertilization (500, 250, 250 g/tree)	Renovation of the date orchard and bubbler irrigation sys-tem with nanotechnology NPK fertilization (500, 250, 250 g/tree)	Orchard renovation, soil management with an improved fertilization technique
Bubbler irrigation system, no mulching and application 100% of irrigation water requirement	Renovation of the date orchard, adoption of subsurface drip irrigation and mulching, with application of 70% of irrigation water requirement	Orchard renovation, soil management & higher irrigation efficiency
Dairy		
Conventional breeds & management	Improved breeds & management (feeding & housing)	Livestock breeding, feeding and hous-ing improvement

SOURCE: Authors' own elaboration.

The prioritization of CSA packages selected for the in-depth assessment took into consideration the availability of robust financial and economic information. There are many relevant CSA technologies applicable at different stages of the value chain for selected subsectors, however, due to limitations in information to fulfil the scope of the study, only the list presented in Table 4.2 was retained for the in-depth technical, financial and economic analysis. Nevertheless, the list of CSA packages assessed in this study is comprehensive and provides relevant insights to back-up investment priorities and policy solutions that benefit the private stakeholders, with particular attention to those most at risk, and society as a whole. The selected CSA packages are in line with FAO's overview of technologies with the highest potential for scaling up by small-scale farmers, and other AFS stakeholders in the context of Egypt (AbdelMonem *et al.*, 2022). These CSA technologies have multiple benefits in terms of the three pillars considered in the CSA approach: 1) sustainably increase agricultural productivity and incomes; 2) build resilience of people and the food system; 3) reduce or remove GHG emissions where possible.

4.2 ASSESSMENT OF ALTERNATIVE CLIMATE SMART TECHNOLOGIES

Step 3 of the CSA analytical framework comprised a quantitative and qualitative analysis of the different best-bet CSA options. A technical, financial and economic analysis was performed for each CSA alternative. Given that the CSA alternative is contrasted with the BaU system, technical, financial and economic models were developed for the business-as-usual and CSA scenarios. Due to interest in assessing adoption potential, the analysis takes into consideration incremental performance indicators that allow a comparison of both scenarios. The key performance indicators considered in the assessment follow the priorities marked by the First Updated NDC and the NWFE. So, at this stage, the technical assessment of the proposed models includes estimates of four environmental performance indicators: 1) water use efficiency: net productivity gain in kg/m3; 2) energy efficiency: net change in kilowatts per hour (KWh), per feddan, per season; 3) land-use efficiency: potential gain (in feddan per season); and 4) GHG balance: incremental tonnes of CO_2 equivalent (tCO_2e) per feddan per season. The financial analysis covers all basic indicators, such as: initial investment cost (EGP per feddan); incremental NPV (EGP per feddan at 12 percent); incremental IRR (percent); payback period (PBP); benefit-cost ratio; SVB; and SVC. Based on the models, socioeconomic data was gathered and assessed to: (a) build the economic assessment of CSA options at scale (EIRR, ENPV, SVC and SVB); and (b) delimitate minimum conditions for scaling up.

The following sections provide a summary of the technical, environmental and financial assessment of CSA technology packages by subsector. For each subsector, there is a description of the context and key challenges in the face of a changing climate that constitute the basis for the CSA solutions proposed. It also includes the results of key environmental and financial performance indicators for the CSA options assessed. A complete description of each model and parameters used is included in Annex 2. These CSA profiles include a list of minimum criteria to support adoption, with particular attention to small-scale producers.

4.2.1 Maize

Maize is a major annual crop in Egypt, an important component of the country's crop rotations along the Nile basin. Maize plays an important role in the economy and livelihoods of the rural population. In terms of area produced, it is the second most common field crop in the country after wheat, with an annual harvested area of 2.32 million feddan in 2019/2020, and a total production of 7.58 million tonnes (Table 4.1). Maize production is widespread along irrigated areas in Egypt. Despite the steady increase in the maize cultivated area in the last decades, maize's yields have stagnated and even experienced a slight reduction in the past decade (Salama *et al.*, 2021). In 2019/2020, the maize yield was 3.3 tonnes/feddan (7.58 tonnes/ha), slightly lower than the average yield of 3.36 tonnes/feddan (7.82 tonnes/ha) in 2009/2010. Under the prevailing climate change conditions, the yields of maize are expected to shrink as much as 19 percent by 2050, making it the field crop with the highest negative impact in the country (Perez *et al.*, 2021b). As a summer cereal crop, maize's water and land-use efficiency is a major issue. The crop consumes around 950 m^3 of water per tonne, and generates a WF net return of EGP 0.72/m^3. This return is much lower than any other field and vegetable crop year-round, except for soybean and sunflower (El-Marsafawy and Mohamed, 2021). Estimates of maize post-harvest losses range from 10 percent to 30 percent (Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation – COMCEC, 2016), which represents an important impact in terms of efficiency in the use of water, land, energy, labour and other key production inputs.

Five CSA technology options were assessed for maize and compared with the BaU scenario related to each technology option. The first two CSA options include technologies such as canal lining, improved irrigation, reduced tillage, and mulching. These seek to improve soil fertility and moisture, leading to increased yields and higher water productivity (from 0.7 to 1.36 kg/m^3 in CSA) and energy savings (up to an equivalent of 701 kWh/feddan/season). Two other CSA packages propose the application of more efficient irrigation systems, comparing surface drip irrigation (SDI) plus nanofertilizers and subsurface drip irrigation (SSDI) with flooded irrigation, which is massively used in Egypt. Both options generate positive effects in terms of water productivity (increasing from 0.7 kg/m^3 to a range of 1.02 to 1.27 kg/m^3) and energy efficiency (reaching an equivalent reduction of up to 2464 kWh/feddan/season). The SSDI system provides higher efficiency gains compared to SDI, however SSDI requires a much larger initial investment. The post-harvest loss reduction option considers the application of nanosilica at the production stage, and the improvement of storage conditions to reduce maize losses by 5 percentage points. This CSA package is capable of increasing water productivity (from 0.7 to 0.97 kg/m^3) and energy efficiency (a reduction of 1994 kWh/feddan/season), considering the effect of nanotechnology at production and post-harvest stages. All CSA packages lead to a reduction in GHG emissions and to greater land-use efficiency. Potential land-use gain estimates derive from increased efficiency and investment capacity (higher net revenues) per CSA package application (assessed in an area of 2.38 feddan – one hectare), based on the level of production in the BaU system (Table 4.3).

Table 4.3
Impact of CSA technologies adoption on key environmental indicators in maize subsector

	Indicator			
CSA option	Water use efficiency: net productivity gain in kg/m³	Energy efficiency: net change in kWh/ feddan/season	Land-use efficiency: potential gain (feddan/season)	GHG balance (tCO_2e/ feddan/season)
Canal lining, mulching and reduced tillage	Increased efficiency: from 0.7 to 1.2 kg/m³	-701	0.07	-0.87
Canal lining, mulching and FFI	Increased efficiency: from 0.7 to 1.36 kg/m³	-646	0.10	-0.86
Surface drip irrigation with nanofertilizers	Increased efficiency: from 0.7 to 1.02 kg/m³	-1736	0.14	-1.28
Subsurface drip irrigation	Increased efficiency: from 0.7 to 1.27 kg/m³	-2465	1.00	-1.02
Post-harvest loss reduction	Increased efficiency: from 0.7 to 0.97 kg/m³	-1994	0.18	-1.43

SOURCE: Authors' own elaboration.

From the perspective of CSA adoption potential, the financial indicators show attractive incentives for adoption by value chain actors (farmers, traders, etc.). The IRR derived from the net incremental financial benefits of adopting these CSA technologies ranges from 12 percent in the reduced tillage package to 16 percent in FFI, SDI and SSDI for a period of 20 years. The levels of investment per feddan are much higher in SDI, SSDI and post-harvest loss reduction packages, which explains the slightly lower benefit-cost ratio (1.49, 1.49 and 1.47, respectively). The NPV ranges from EGP 116 per feddan in the reduced tillage package to around EGP 2240 in SDI and EGP 19 648 per feddan in SSDI. The reduced tillage package had a negligible NPV of EGP 116 per feddan, but it does not account for economic gains in terms of increased water, energy and land-use efficiency, as well as its capacity to mitigate GHG emissions (Table 4.4).

Table 4.4
Financial feasibility of CSA technology options in maize production and post-harvest

Indicators	Canal lining, mulching and reduced tillage	Canal lining, mulching and FFI	Surface drip irrigation	Subsurface drip irrigation	Post-harvest loss reduction
Period of analysis	20 years	20 years	20 years	20 years	20 years
Unit of production in the model	14.7 ha: 35 feddan (Mesqa)	14.7 ha: 35 feddan (Mesqa)	1 ha: 2.3 feddan	1 ha: 2.3 feddan	1 ha: 2.3 feddan
Incremental initial invest-ment cost (EGP/ feddan)	8 371	8 371	10 561	84 190	14 940
Incremental NPV (EGP/ feddan at 12%)	116	1759	2 240	19 648	1 326
Incremental IRR (%)	12%	16%	16%	16%	14%
PBP (years)	1.99	1.88	1.58	4.97	2.51
Benefit-cost ratio	1.59	1.61	1.49	1.49	1.47
Switching value for benefits	-59%	-61%	-49%	-49%	-47%
Switching value for costs	37%	38%	33%	33%	32%

SOURCE: Authors' own elaboration.

4.2.2 Wheat

Wheat is the most important winter crop in Egypt with a total harvested land area of nearly 3.4 feddan (7.67 ha) in the 2019/2020 growing season. Total wheat production reached 9.1 million tonnes in the 2019/2020 season, and around 9.84 million tonnes in 2020/2021. Some of the major production areas are located in Lower Egypt. In recent years, Egypt has successfully introduced a substantial amount of desert reclaimed land into wheat production. In 2019/2020, this represented around 18 percent (627 330 feddan) of the total harvested land, and increased to 20.3 percent in 2020/2021 season. The yields of new lands (2.51 tonnes/feddan), however, are still lower than that of old lands (2.71 tonnes/feddan), apparently due to the poorer soil fertility and moisture retention capacity (MALR, 2022). While the average wheat yield has increased substantially in the last few decades from about 1.08 tonnes/feddan in 1961 to 2.79 tonnes/feddan in 2019 (FAO, 2022b), yield growth plateaued in the last decade or so. Under predicted climate change conditions, wheat yield is only expected to decrease up to 0.6 percent by 2050 (Perez *et al.*, 2021b). Increased productivity is crucial for the sustainability and competitiveness of this subsector, particularly if the GoE alleviates price protection policies. As a winter crop, wheat's water footprint is lower than maize at around 803 m^3/tonne, and it generates substantially higher WF net returns (EGP 1.32/m^3). However, wheat is still one of the crops with the lowest return in the country (El-Marsafawy and Mohamed, 2021). As in the case of maize, post-harvest loss reduction (estimated at 10 percent) may significantly contribute to savings in terms of water, energy and land use.

An array of six CSA technology packages were analysed for wheat and compared with the BaU scenario related to each technology option. The first two CSA packages generate significant improvements in terms of soil fertility and moisture. One of the models proposes contour tillage and water harvesting, in areas with very limited access to water for irrigation, and the other corresponds to the application of mechanized raised bed (MRB) technology. These CSA options produced increased yields and higher water efficiency (reduced runoff in the case of contour tillage and water harvesting, and increased water productivity from 1.12 to 1.57 kg/m^3 for MRB) and energy savings (up to an equivalent of 1765 kWh/feddan/season in the case of contour tillage and water harvesting). Three other CSA packages propose the application of more efficient irrigation systems, sprinkler irrigation (including land levelling and deficient irrigation regime), SDI with nanosilica and SDI in wide ridges with reduced tillage. These generate positive effects in terms of water productivity (from 1.12 kg/m3 in BaU to a range of 1.98 to 2.1 kg/m3 in the CSA scenario) and energy efficiency (reaching an equivalent reduction of up to 1203 kWh/feddan/season). The post-harvest loss reduction package considered the application of nanosilica starting at the production stage, and the use of hermetic polyethylene bags (barrier film 140 micron) and other storage improvements to reduce wheat losses by 10 percentage points. This CSA package, including improved post-harvest technology, is capable of increasing water productivity (up to 1.88 kg/m^3) and energy efficiency (a reduction of 1495 kWh/feddan/season). All CSA packages lead to a reduction in GHG emissions and to greater land-use efficiency. Potential land-use gain estimates derive from increased efficiency and investment capacity (higher net revenues) per CSA package application (assessed in an area of 2.38 feddan – one hectare), based on the level of production in the BaU system (Table 4.5 below).

Table 4.5

Impact of CSA technology adoption on key environmental indicators in wheat subsector

CSA option	Indicator: Water use efficiency: net productivity gain in kg/m³	Energy efficiency: net change in kWh/ feddan/season	Land-use efficiency: potential gain (feddan/season)	GHG balance (tCO_2e/ feddan/season)
Contour tillage and water harvesting (rainfed)	Increased soil moisture retention capacity 35 to 95 mm. Reduced runoff from 100 to 10 mm	-1765	0.22	-1.97
Mechanized raised beds	From 1.12 to 1.57 kg/m³	-865	0.3	-0.77
Laser land levelling, sprinkler irrigation and deficit irrigation	From 1.12 to 1.98 kg/m³	-1174	0.52	-1.04
Surface drip irrigation with application of nanosilica	From 1.12 to 2 kg/m³	-1203	0.27	-0.26
Wide ridges with drip irrigation and conservation tillage	From 1.12 to 2.1 kg/m³	-1152	0.79	-1.39
Reduction of post-harvest losses	From 1.12 to 1.88 kg/m³	-1495	0.18	-1.36

SOURCE: Authors' own elaboration.

Financial indicators for the six technology options show attractive incentives for adoption by wheat producers and traders. The IRR derived from the net incremental financial benefits of adopting these CSA technologies ranges from 14.6 percent in the post-harvest model to 33.5 percent in SDI together with the application of nanosilica, for a period of 20 years. The levels of initial investment per feddan are much higher in SDI in wide ridges and conservation tillage, but this is also the solution with the highest NPV (EGP 37 310 per feddan) and benefit-cost ratio (1.9), as well as the second highest IRR (30.5 percent). The incremental NPV ranges from EGP 2262 per 2.3 feddan in the post-harvest package, to around EGP 37 310 per feddan in the wide ridges with SDI irrigation and conservation tillage model (Table 4.6).

Table 4.6

Financial feasibility of CSA technology options in wheat production and post-harvest

Indicators	Contour tillage and water harvesting (rainfed)	Mechanized raised beds	Laser land levelling, sprinkler irrigation and deficit irrigation	SDI with application of nanosilica	Wide ridges with drip irrigation and conservation tillage	Reduction of post-harvest losses
Period of analysis	20 years	20 years	20 years	20 years	20 years	20 years
Unit of production in the model	2.3 feddan	2.3 feddan	2.3 feddan	2.3 feddan	2.3 feddan	2.3 feddan
Incremental initial invest-ment cost (EGP/ feddan)	11 205	22 410	28 675	10 014	32 424	14 940
Incremental NPV (EGP/ feddan at 12%)	9485	10 330	19 012	13 501	37 311	2262
Incremental IRR (%)	25.8%	19.7%	23.0%	33.5%	30.5%	14.6%
PBP (years)	1.1	3.1	3.0	1.8	2.9	2.2
Benefit-cost ratio	1.6	1.6	1.7	1.5	1.9	1.4
Switching value for benefits	-62%	-59%	-67%	-51%	-92%	-36%
Switching value for costs	38%	37%	40%	34%	48%	26%

SOURCE: Authors' own elaboration.

4.2.3 Date palm

Egypt is the world's most important producer of dates with a total production of 1.7 million tonnes per annum. Dates are well adapted to Egypt's arid conditions, where both water scarcity and the inefficient use of water greatly affect productivity. Cultivation of dates may happen with limited water resources, yet competitive levels of productivity and high product quality can only be attained when water requirements are met through irrigation. The current levels of production could be achieved with 50 percent less water by using modern irrigation systems. Egypt has rapidly expanded date palm production into new reclaimed lands using ground water for irrigation (99 200 feddan in 2020, almost three times the area in old lands). These lands primarily use improved irrigation, however the average yield in new lands (nearly 100 kg/tree) are still lower than in old land plantations (123 kg/tree). The water footprint for dates is higher than wheat at around 850 m^3/tonne, but generates much higher net returns (EGP 2.1/m^3) (El-Marsafawy and Mohamed, 2021). Dates are also highly responsive to fertilizers. The overuse of fertilizers is leading to low nutrient use efficiency and water contamination. Loss of NPK may be as high as 40–70 percent, 80–90 percent, and 50–90 percent respectively. Nanofertilizers have emerged as an attractive alternative to improve uptake of nutrients by roots, increasing fertilizer efficiency in date palm by 50–70 percent (Shalaby *et al.*, 2022). The Medjool cultivar (Phoenix dactylifera) produces the best quality dates, mostly for export. Medjool cultivars are mainly located on farms in the Governorates of Giza, especially in the Bahariya Oasis, New Valley, Minya and Luxor.

Two CSA technologies were assessed to substantially reduce the quantity of water and fertilizers used in date palm cultivation, while also securing higher fruit quality and yields. The first CSA package is irrigated date palm using NPK nanofertilizers (500, 250, 250 g/tree), which was compared with irrigated date palm with conventional fertilizers. In both scenarios, the initial investment costs include the renovation of the date palm orchard and bubbler irrigation system (BIS). This improved package leads to increased yield by 12 percent, increased fertilizer absorption efficiency by 20–30 percent, and reduced NPK doses by up to 50 percent. These benefits generate higher water productivity (from 1.05 to 1.18 kg/m^3) and energy savings (up to 987 kWh per feddan). The second CSA package considered the renovation of the date palm orchard using cv. Medjool, and a transition to SSDI at 70 percent of irrigation water requirement along with mulching. This was compared to the BaU scenario, which used the same cultivar but with BIS at 100 percent of irrigation water requirement and without mulching. Compared with the BaU scenario, this CSA option leads to increased yields by 15 percent, paired with higher water productivity (from 1.05 to 1.72 kg/m^3) and energy efficiency (energy savings up to 926 kWh per feddan). Both CSA packages lead to a reduction in GHG emissions and improved land-use efficiency. Potential land-use gain estimates derive from increased efficiency and investment capacity (higher net revenues) per CSA package application (assessed in an area of 2.38 feddan – one hectare), based on the level of production in the BaU system (Table 4.7).

Table 4.7
Impact of CSA technology adoption on key environmental indicators in date palm

CSA package	Indicator: Water use efficiency: net productivity gain in kg/m³	Energy efficiency: net change in kWh/ feddan/season	Land-use efficiency: potential gain (feddan/season)	GHG balance (tCO_2e/ feddan/season)
Date palms cv. Medjool, BIS with NPK nanofertilizers (500, 250, 250 g/tree)	Increased from 1.05 kg/m3 to 1.18 kg/m3	-987	0.12	-0.60
Date palms (Medjool cv.), irrigated with subsurface drip irrigation at 70% water requirement plus mulching	Increased from 0.7 kg/m3 to 1.72 kg/m3	-926	0.15	-0.66

SOURCE: Authors' own elaboration.

The financial indicators of the two CSA packages studied for dates show attractive incentives for adoption. The IRR derived from the net incremental financial benefits of adopting these CSA technologies was 19.7 percent in the case of nanofertilizers and 20.4 percent in SSDI for a period of 20 years. Regarding the initial investment, both BaU and CSA scenarios take into consideration the renovation of the date orchards. One of the CSA models integrated an improved irrigation system from BIS to SSDI. The NPV ranges from EGP 75 220 for the nanofertilizer technology to EGP 82 050 for the SSDI package (Table 4.8).

Table 4.8
Financial feasibility of CSA technology options in date production

Indicators	Date palms (nanofertilizers)	Date palms (SSDI + mulching)
Period of analysis	20 years	20 years
Unit of production in the model	1 feddan	1 feddan
Incremental initial investment cost (EGP/feddan)	Same initial investments considered in the BaU and CSA scenarios (renovation of date palm orchard and BIS)	17 542
Incremental NPV (EGP/feddan at 12%)	75 233	82 048
Incremental IRR (%)	19.7%	20.4%
PBP (years)	6.8	6.8
Benefit-cost ratio	37.7	7.9
SVB	-3 669%	694%
SVC	97%	87%

SOURCE: Authors' own elaboration.

4.2.4 Dairy

The dairy sector in Egypt produces more than 5 million tonnes of fresh milk that is consumed locally with low exporting activities. Dairy products include fresh milk, ultra-high temperature (UHT) milk, yoghurt, cheese, ghee and other products. Egypt imports more than 166 000 tonnes of baby milk and dehydrated milk that are extensively used in processing. About 90 percent of milk production is dominated by small-scale producers, while the remaining 10 percent is produced by large-scale companies. The household dairy producers are linked to local markets or to collectors, while the commercial producers are mostly linked directly to dairy processors. Most of the cattle livestock is located in Lower Egypt. Dairy activities have so far had low response to investment, due to the current characteristics and performance of this value chain (World Bank Group, 2021a). Milk production and productivity has been stagnant, and producers have been unable to increase the quality of milk, which is preventing the expansion of processing activities. One major factor discouraging efforts to improve milk quality is the limited response of milk prices to different levels of quality. These result in informality along milk market channels, through which more than 70 percent of milk production is commercialized. Heat stress is one of the main climate change threats to dairy cattle productivity, along with the impacts in availability and quality of feeding. Therefore, be it through limited production of feed at the farm or higher input prices, dairy farmers will face increasing challenges in terms of animal feeding.

One main climate-smart technology package considered for dairy farming was the improvement of breeds and management practices. This CSA option proposes the use of adapted cattle crossbreeds,[23] enhanced feeding and better animal housing conditions. Besides enhancing the balance mix of animal feeding, it integrates CSA technologies in the farm production of fodder. The CSA package considered for feed production at the dairy farm includes maize intercropped with clover (barseen), both used for fodder (in the case of maize also for concentrate). In terms of irrigation, the improved model incorporates canal lining and fixed-furrow irrigation (compared to flooded irrigation without mulching). This CSA technology option led to increased productivity and environmental benefits. The CSA package leads to increased yield (almost 10 percent increase), water productivity (from 0.7 to 1.36 kg of maize grain per m^3) and energy efficiency (up to a reduction of 646 kWh per feddan). It also leads to a reduction in GHG emissions and improved land-use efficiency. Potential land-use gain estimates derive from increased efficiency and investment capacity (higher net revenues) per CSA package application (assessed in an area of 2.38 feddan – one hectare), based on the level of production in the BaU system (see Table 4.9).

23 Even though this model represents dairy producers who also have some buffalos in their production systems, it focuses on dairy production activities related to cattle.

Table 4.9

Impact of adoption of dairy CSA technology on main environmental indicators

CSA package	Indicator: Water use efficiency: net productivity gain in kg/m³	Energy use efficiency: net productivity gain (kg/kWh)	Land-use efficiency: potential gain (feddan/model)	GHG balance: BaU vs CSA (tCO_2e per unit per year)
Improved breed (cross breed) and management	From 0.7 to 1.36 kg/m³ (feeding, based on maize grain and barseen); a net reduction of 1238 m³ per feddan	-646	0.10	-1.59

SOURCE: Authors' own elaboration.

Application of the CSA package also shows attractive financial incentives for adoption. The IRR derived from the net incremental financial benefits of adopting improved breed and management practices is around 25 percent for a period of 20 years. The initial investment of the CSA package includes improved breeding and animal housing, as well as other investments related to the integration of CSA technologies in fodder production (corresponding to improved irrigation through canal lining, FFI, and intercropping maize with barseem). The NPV was USD 24 300 for a period of 20 years, considering an initial investment of EGP 26 300 (Table 4.10).

Table 4.10

Assessment of financial feasibility of CSA technology options in dairy

Indicators	Improved breed (cross breed), feeding and management
Period of analysis	20 years
Unit of production in the model	1 feddan
Incremental initial investment cost (EGP/feddan)	26 323
Incremental NPV (EGP/feddan at 12%)	24 297
Incremental IRR (%)	18.8%
PBP (years)	1.0
Benefit-cost ratio	1.6
SVB	-61%
SVC	38%

SOURCE: Authors' own elaboration.

4.3 ECONOMIC PERFORMANCE AND SCALING UP POTENTIAL OF CLIMATE-SMART AGRICULTURE TECHNOLOGIES

Step 4 of the CSA analytical framework comprises assessing the scale-up potential of CSA technologies and defining policy options. This step is informed by the quantitative (i.e. economic and financial analysis, EFA) and qualitative evaluation of barriers and opportunities for adoption at scale. The EFA of CSA packages at larger scale requires an incremental cost and benefit assessment from the perspective of stakeholders and the whole society. The economic analysis builds on the financial assessment of CSA and BaU models. Then, it integrates externalities and appraises the incremental net benefits distribution by applying economic values. The analysis includes the economic valuation of environmental benefits generated by the application of the CSA packages, such as water, land and energy efficiency, as well as the net reduction of GHG emissions (Annex 1). The economic analysis uses a 20-year timespan and a discount rate of 10 percent. The delimitation of CSA scale-up potential is based on conservative assumptions, which are corroborated with secondary sources of information (mainly academic papers) reviewed during the previous steps of the CSA analytical framework. It takes into consideration the minimum requirements for adoption, evaluated per CSA option (Annex 2), as well as challenges and opportunities identified in the global assessment of Egypt's ASF (Chapter 2) and the policy framework analysis (Chapter 3). To complement the EFA, the assessment takes into consideration estimates of two macroeconomic indicators: job creation potential (direct and indirect along the value chain) and contribution to food and nutrition security (in terms of reducing the production/consumption gap).

Assuming around 25 percent of the area already used for maize (as identified by Ouda *et al.*, 2016), under flooded irrigation, Egypt could potentially convert around 404 500 feddan from conventional maize farming to climate-smart technologies. This requires an incremental initial investment of about EGP 5.1 billion, and has the potential to generate an incremental ENPV of EGP 6.5 billion over a period of 20 years. The EIRR ranges from 18 percent in SSDI to 35 percent in SDI with nanofertilizers. Applying the proposed technologies in the area with potential for scaling up would also generate a total of 27 200 more jobs along the value chain, and increase food and nutrition security, with a reduction of the production/consumption gap by around 6 percent in aggregate for all five CSA technologies.

Assuming 25 percent of the area already used for wheat (as identified by Atta *et al.*, 2022), the potential exists to apply CSA technologies in nearly 850 000 feddan. This requires an incremental initial investment of about EGP 15.88 billion, and may generate an incremental ENPV of EGP 24.8 billion in 20 years. The EIRR ranges from 22 percent in MRB to 44 percent in SDI with application of nanosilica. These technologies, applied in the area with potential for scaling up, would generate 124 815 more jobs along the value chain, and increase food and nutrition security by reducing the production/consumption gap by around 15 percent in aggregate for all the six CSA options.

In dates and dairy, considering 25 percent of the total surface of dates in the country (based on FAOSTAT estimate for 2020), and 25 percent of the herd estimates (as articulated in El-Eraky *et al.*, 2022), there is potential to scale up adoption of CSA technologies in over 30 000 feddan of date palms and nearly 280 000 feddan of fodder production (437 000 milk cows). This requires an incremental initial investment of about EGP 0.27 billion for dates and EGP 7.4 billion for dairy. Scaling up CSA technologies may generate an incremental ENPV of EGP 4.5 billion for date production and EGP 9.7 billion for dairy, over a period of 20 years. The EIRR is 21 percent in improved dairy breeding and management, and ranges from 21 to 23 percent for date palm CSA options (nanofertilizers and SSDI plus mulching). In addition, these technologies have the potential to generate more direct and indirect jobs: 17 200 for dairy and 1588 for dates, along their respective value chains. Because date production in Egypt is higher than local consumption, the surplus is exported. Based on the increased yield of first grade Medjool dates generated by the CSA packages, Egypt could potentially increase its date export quantity by 24 percent. In the case of fresh cow milk, the proposed CSA technologies could reduce the production/consumption gap by up to 63.7 percent.

Table 4.11

Economic feasibility of CSA technology options in Egypt (20 years of assessment, applying a 10 percent discount rate and low carbon price*)

CSA technology options	Scale-up potential (feddan)	Investment required for scaling up (Thousand EGP)	Incremental ENPV of large scale adoption (Thousand EGP)*	Incremental EIRR*	Job creation potential** along the value chain (number of jobs)	Food and nutrition (% reduction of the production/ consumption gap)
			Maize			
Canal lining, mulching and reduced tillage	121 341	1 015 797	1 250 429	27%	2490	-0.2%
Canal lining, FFI and mulching	121 341	1 015 797	1 521 776	30%	3414	-0.3%
Surface drip irrigation and nanofertilizers	121 341	1 281 484	2 416 872	35%	12 701	-1.1%
Subsurface drip irrigation with a semi-mechanical method	20 223	1 702 607	950 597	18%	6668	-3.4%
Improved post-harvest technologies through application of nanosilica and improved storage	20 223	302 133	349 271	25%	1962	-1.1%
Maize total	**404 469**	**5 124 086**	**6 488 945**		**27 234**	**-6.0%**
			Wheat			
Contour tillage and water harvesting (rainfed)	255 000	2 857 227	7 789 007	43%	20 240	-1.1%
Mechanized raised beds	255 000	5 714 454	5 324 098	22%	27 953	-1.5%
Laser land levelling, sprinkler irrigation and deficit irrigation	85 000	2 437 348	3 033 269	27%	16 044	-2.6%
Surface drip irrigation with application of nanosilica	85 000	851 229	2 047 085	44%	20 353	-3.3%
Wide ridges with surface drip irrigation and conservation tillage	85 000	2 756 047	5 272 389	35%	24 499	-4.0%
Reduction of post-harvest losses	85 000	1 269 879	1 314 662	23%	15 726	-3.1%
Wheat total	**850 000**	**15,886,185**	**24 780 510**		**124,815**	**-15.6%**
			Dates			
Irrigation with nano NPK	15 129	–	2 095 785	21%	712	11% increase in exports***
Renovated date orchard, subsurface drip irrigation and mulching	15 129	265 389	2 404 488	23%	816	13% increase in exports***
Dates total	**30 258**	**265 389**	**4 500 273**		**1588**	**24% increase in exports*****
			Dairy			
improved breeds and management	279 520	7 357 783	9 734 105	19%	17 213	-63.7%
Dairy total	**279 520**	**7 357 783**	**9 734 105**		**17 213**	**-63.7%**

SOURCE: Authors' own elaboration based on:

*The incremental ENPV is based on the shadow price of carbon – USD 2021 – from: World Bank Group. 2017. Guidance note on shadow price of carbon in economic analysis. Washington, DC, World Bank. https://thedocs.worldbank.org/en/doc/911381516303509498-0020022018/original/2017ShadowPriceofCarbonGuidanceNoteFINALCLEARED.pdf. This FAO study applies the low value of the carbon price range, adjusted per the 2021 Consumer Price Index for the United States.

** Job creation potential estimate based on the employment multiplier of a percentage increase in output for one feddan due to higher water productivity. Employment multipliers are taken from: Osman, R., Ferrari, E., Mainar, A., Jiménez, S. 2021. Can the Nile Generate Output, Income and Employment in Egypt? A Mixed Multiplier Analysis. New Medit. DOI: 10.30682/nm2101a. The output increase (in percentage) comes from the technical assessment of each CSA option in comparison to the BaU system.

*** Domestic production of dates is higher than national consumption. Therefore, the assessment presents the export potential by considering the yield increase of first grade Medjool dates under CSA production, compared to conventional production.

CSA makes a broad contribution to the sustainability of the AFS and therefore to food and nutrition security. CSA seeks to enhance climate resilience and sustainability in the AFS by tackling three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing GHG emissions where possible. The proposed CSA technologies generate positive direct and indirect effects over the pillars of food and nutrition security – food availability, access, utilization and stability. CSA adds to food availability through higher efficiency in the use of inputs and increased yields that lead to increased net revenues and employment opportunities for stakeholders along the value chain. This, in turn, contributes to household food access. Higher water, energy and land-use efficiency from applying CSA technologies is relevant for food utilization and stability of all FNS dimensions in the long run. Regarding this last aspect, efficiency gains and increased net revenues could also support livelihoods diversification strategies. Smallholder farmers could be encouraged to dedicate such gains to other subsectors and AFS activities that generate at least the same environmental, financial and economic benefits.

Technical, financial and economic indicators are compelling but key barriers must be overcome to facilitate adoption. There are two broad typologies of barriers that impede CSA adoption. The first relates to the physical means or resources required to practice CSA (e.g. land, human resources, equipment, infrastructure and finances). The second, non-physical barriers relate to the institutional, cultural, policy and regulatory environments; information, knowledge and skills; technologies and innovations; and governance among others (James *et al.*, 2015). The following sections go deeper into the facilitation of CSA adoption in Egypt's AFS and priorities for policy action.

4.4 FACILITATING THE ADOPTION OF BEST-BET CLIMATE-SMART AGRICULTURE TECHNOLOGIES

The uptake of promising climate-smart technologies has been remarkably slow in Egypt given numerous factors that hinder their adoption. In other countries, scaling up private investment in CSA technologies required adjustments in the policy and regulatory framework and, in most cases, financial incentives through a diverse set of instruments. Many OECD countries, for example, have adjusted their public support programmes to scale up investments in green, environmentally friendly, and climate-responsive technologies. Other countries have used matching grants and guarantees to co-finance climate-smart investments (World Bank Group, 2021b). Egypt has made strides in developing its Vision 2030 and plans for fostering climate-responsive investments and green growth along the AFS. However, it is essential that a business enabling environment, supportive policy framework, and financial incentives are created to mitigate risks, reduce costs, and increase the uptake, mainstreaming and ultimately the impact of CSA technologies. Egypt must make bold efforts to address major bottlenecks, including:

a. Investment capacity: initial costs of CSA technologies are often an impediment for quicker adoption, and this is intensified by inadequate access to affordable financing.

b. Cost management: increased labour and other costs in early years of adoption constitute a critical barrier for adoption, especially for smallholders.

c. Change in household dynamics: specific time and cost requirements associated with CSA technologies may discourage adoption as they may affect labour requirements from household members, often resulting in an increased burden for women.

d. Risk management: substantial risks are often associated with CSA technologies due to the uncertainties of climate dynamics, and the absence of weather-based or yield-based instruments (or any other for dairy) to support farmers in risk management further hampers CSA adoption.

e. Information and knowledge gaps: information systems on CSA are not adequately developed and inadequate extension of existing systems limit dissemination of skills and technologies to farmers.

f. Limited digitalization: low digitalization of production and other value chain activities prevent the adoption of soil and water management, livestock feeding, processing, and market access technologies and systems.

g. Undeveloped carbon market: participation in the global carbon market requires documentation of value chain-specific emission factors and activity data for computing emissions in a way that is verifiable and compliant with IPCC guidelines.

The financial performance of available CSA technologies is also a central factor for adoption. This study has demonstrated attractive IRRs and NPVs for most of the assessed technologies, confirming the business case for these investments. Nevertheless, decision-makers must consider the heterogeneity between different types and scales of farms, and the varied impact that CSA investments have on the target population or household. Land fragmentation is a major problem in Egypt (average landholding is 2.5 feddan/farm), making it more difficult for smallholders to adopt CSA options, especially those that have relatively high investment and fixed costs. Land size and income levels are key determinants of whether a CSA technology is adopted and if farmers will reap enough benefits from CSA (Sitko *et al*., 2019). For example, it has been found that some wheat loss reducing technologies in Tunisia would only be economically attractive for farmers with larger cultivation areas (Anriquez *et al*., 2021). The same study shows that the net incremental benefits of some loss-reducing post-harvest technologies (plastic crates) is so limited that farmers prefer the use of palm crates as the technology that maximizes their benefits. A study covering Viet Nam, Nicaragua and Uganda found significant variation on farm-profitability of CSA practices depending on crop typologies, input access and prices, household types and local context (Lan *et al.,* 2018). In the specific case of Viet Nam, the appeal of CSA technologies was heterogeneous among Viet Nam farmers in terms of their income groups, and land size, and varying profitability per hectare. Sugarcane and coconut cultivation in areas no longer suitable for irrigated rice was only suitable for farmers in higher income groups.

It is important to strengthen horizontal linkages that will help small-scale value chain firms benefit by economies of scale to reduce costs and increase returns on CSA investments. Through participation in groups of farmers and business associations, farmers may increase their access to higher value markets, directly affecting returns on investment. Collective action may also play an important role on value chain actors' access to financial services, which are key to support private sector investments in CSA technologies. Larger value chain actors are usually able to access financing from the formal financial sector, but smallholders' access to finance are more limited. Egypt has been using and intends to continue expanding public instruments to enable access to finance for smaller farmers. However, these programmes are slow to focus on the poorest, and are not specific enough to incentivize the climate-smart investments. The GoE is now promoting the large-scale transition from flooded to pressurized irrigation in old lands, and is facilitating smallholders' access to low-cost financing. These efforts need to be expanded and target the subsectors with the highest value addition potential. The GoE should also consider matching grants and partial credit guarantees to further accelerate CSA adoption.

Chapter 5
Implications for policy reform and investments

The AFS in Egypt is at the crossroads, facing major global crises while in great need of accelerating productivity growth and value addition along agrifood value chains. The agrifood sector is a central pillar in the Egyptian economy and crucial for social stability. It is a major contributor to the GDP, employment, rural livelihoods, and an important source of foreign currency. However, the AFS has experienced major performance issues in the last two decades, as the yields of major crops have stagnated and, in most cases, slightly decreased, underperforming population growth and the global and regional yield averages. Major causes include the relatively low use efficiency of key resources such as land and water, high land fragmentation, increasing soil salinity, and higher incidence of pests and diseases, all linked to climate change threats. Conventional agricultural technologies are unlikely to improve performance of the sector and even maintain its current levels of productivity and efficiency on the face of climate change.

Aiming at AFS's long-term growth and sustainability, this study analysed some of the implications of water scarcity and climate change for key subsectors and the AFS as whole. It also considered the main climate-smart investment opportunities to inform evidence-based results-oriented decision-making in the face of climate-related uncertainties. The study adopted the guiding principles of the World Bank's GRID framework, which promotes a more sustainable pathway to recover from multiple shocks affecting the country, but which also requires forward-looking transformative policy reforms (World Bank Group, 2021b). It also portrays the AFS beyond its production capacity, namely: as a sector that contributes to multiple objectives, including economic growth, employment and poverty reduction, while also playing a key role in food and nutrition security. The analytical work incorporated literature review, stakeholder engagement, expert interviews, and quantitative economic and financial modeling to assess the potential impact of CSA options, their economic feasibility, and potential to scale up. The CSA technologies studied are attuned to the conditions and needs of the AFS in Egypt, and were prioritized to have the greatest synergies in achieving 'triple-wins' in terms of increasing productivity and incomes, strengthening people and the AFS' resilience to climate change, and climate change mitigation.

Analysis of the 15 CSA adaptation options studied for dairy, dates, maize and wheat suggests there is a variety of technologies that offer impact potential. These technologies – which include varietal and breed improvement, soil moisture and fertility management, irrigation water use efficiency, improved fertilizer use efficiency, and post-harvest loss reduction – were found to substantially increase water, land, and energy use efficiency and to mitigate GHG emissions compared to conventional systems. The expressive net incremental financial benefits that most of the target CSA investment options offer, as reflected in IRRs and NPVs, highlight the strong business case for adopting CSA technologies, not only because value chain investors benefit directly from these technologies, but so does the country as a whole.

5.1 CONCLUSIONS AND BROAD POLICY PRIORITIES

Based on this study, it is possible to summarize eight broad policy options that are indispensable for the sustainable transformation of the AFS in Egypt, increasing climate-resilience, and fast-tracking green and inclusive growth. Because scaling up adoption of CSA technologies is an important element to achieve these policy goals, these are at the core of the policy options offered below.

1. Egypt should intensify the conversion from staple cereal crops to higher-value subsectors, as well as the development of downstream AFS activities. The sustainable production of high-value products, agroprocessing, trade, and marketing and food services must become the key drivers of sustainable rural growth and job creation in the economy.
2. Output growth, driven primarily by higher water, land and energy efficiency, must continue to expand to support growth in the non-farming segment of the AFS. Agriculture's total factor productivity growth must

also intensify to increase earnings in agricultural jobs (especially for youth and female workers, who constitute the majority of the AFS workforce), and support pro-poor job growth in the non-farm sector, both within and outside the AFS.

3. CSA technologies provide the opportunity for generating 'triple-wins' by increasing agricultural productivity, strengthening AFS' climate-resilience, and contributing to climate change mitigation. This study put forward various CSA options that should be considered to intensify climate change adaptation and mitigation in the dairy, dates, maize and wheat value chains, and beyond.

4. In addition to the strong business case for CSA, scaling up CSA technology adoption may have substantial impacts on food and nutrition security by increasing incomes for farmers and rural households, allowing crop diversification towards more nutritious and climate-resilient crops and generating employment along the agrifood value chains.

5. Policymaking to promote large-scale adoption of promising CSA options must focus on measures that overcome key barriers to the adoption of these technologies. Such desired measures include collective actions to reduce costs and increase access to finance for smallholders, develop supply chains to increase access to technologies, inclusive access to affordable finance; etc.

6. Market-driven agriculture and a conducive business environment for CSA adoption are essential to maximize gains from the private and public perspective. Strengthening agricultural markets and increasing smallholders' access to markets must be prioritized, so increased agrifood production has a greater impact along the AFS and in the wider economy.

7. Egypt's price support incentives to promote local wheat harvests have detrimental impacts on dietary diversity, while tending to increase prices for consumers of non-subsidized bread. In addition, bread and flour subsidies have promoted higher bread consumption per capita (and higher bread waste), and a larger share of wheat-based products in the food supply. Egypt must repurpose these food availability-driven instruments towards greater efficiency and value addition programmes that increase households' access to diverse food.

5.2 INVESTMENT PRIORITIES IN THE SHORT, MEDIUM AND LONG TERM

Based on the broad policy options above, the matrixes detail a number of policy actions and investment options that are key to enabling Egypt's transition towards a more resilient, inclusive and sustainable AFS. The tables also suggest the time horizon (short, medium, and long term) when these proposals can be realistically implemented, based on their level of priority for policymakers and current context (e.g. shocks, political debate, etc.). Each action includes the readiness level for implementation according to technical (T), financial (F), and institutional (I) considerations. The colour-coded classification reflects the views of the authors and consulted stakeholders about the feasibility of implementing these actions based on Egypt's preparedness: high feasibility (H) is indicated in yellow; medium feasibility (M) in orange; low feasibility (L) in red.

Table 5.1
Short- and medium-term policy actions

Policy area	Public action	Feasibility T	Feasibility F	Feasibility I	Contribution to GRID objectives
Growth and trade promotion	Accelerate adaptation actions to improve water resources management through: (a) **sustainable utilization of groundwater** (modern technologies in monitoring and controlling groundwater aquifers); (b) **improving irrigation efficiency** in old and new lands; and (c) scaling up the use of modern efficient **soil management technologies.**	H	H	H	Green, resilient and inclusive
Growth and trade promotion	Intensify support to CSA **investments specifically focused on farm-level productivity and output**, this includes development of input markets (improved breeds, crop varieties, seedlings production, etc.), but also increasing adoption readiness of small-holder farmers through training and financing.	H	M	H	Green, resilient and inclusive
Growth and trade promotion	Facilitate access to technical assistance, training, and finance to scale up climate-smart investments in the **production and value addition of non-traditional higher-value products**, with a focus on smallholders, youth and women.	H	H	H	Green, resilient and inclusive
Growth and trade promotion	Capitalize on the use of **digital technologies to make the AFS more efficient, inclusive, and environmentally sustainable** (better access to agronomic, weather, and price data; improve access to input/output markets).	H	H	M	Inclusive
Job creation and poverty reduction	Intensify efforts to **increase value addition in key subsectors, such as dates, dairy, MAPs, fruits and vegetables.** Complement support to alleviate the costs of private investments in agroprocessing with efforts to secure high quality raw material upstream.	H	H	H	Resilient and inclusive
Job creation and poverty reduction	Create targeted programmes to **improve access to financial services for smallholders, youth and women.** Using finance technology products, expanding the lending capacity of the ABE and private banks, and creating risk-reduction mechanisms (insurance, matching grants, partial guarantees).	H	M	M	Resilient and inclusive
Job creation and poverty reduction	**Increase financial inclusion** by targeting groups that are often at the margin of financial markets, with training on financial literacy, business development, supporting their participation in producer organizations, and provision of matching grants for investment.	M	M	M	Green, resilient and inclusive
Job creation and poverty reduction	In line with recent revisions in cooperative laws, **support cooperatives and farmers organizations** to play a better role on providing services, product aggregation, and increasing access to finance/markets for its members (organizational training, post-harvest and storage facilities, access to finance, etc.).*	H	M	M	Green, resilient and inclusive
Climate resilience and green growth	**Expand resource allocation to MALR and ARC** to intensify the generation of key context-specific CSA technologies and cultivation practices, while expanding **extension to small-scale farmers** (new breeds for dairy, saline resistant varieties for cereals and fruits, heat tolerant varieties for fruits and crops, soil preparation and irrigation modalities, etc.)	H	M	M	Green, resilient and inclusive
Climate resilience and green growth	Improve **integrated weather forecasting and communication systems** (early warning system) to help producers prepare for adverse climatic events. This includes establishing 120 weather stations throughout the country, developing a communication strategy, and building the capacity of technical staff.	H	H	M	Resilient and inclusive
Climate resilience and green growth	**Promote nanofertilizers** to reduce quantity of fertilizers used and GHG emissions in the cultivation of dates, cereals and other crops. This includes creating programmes for testing and promoting these technologies and improve supply chains of nanofertilizers in the country.	H	H	H	Resilient and inclusive

Subsector specific actions	The government's credit programme to support farmers' transition out of flood irrigation should focus on technologies such as **surface and especially subsurface drip irrigation**, together with moisture sensors and climate-smart soil management practices in dates, maize, and wheat production.	M	M	M	Resilient and inclusive
	Mechanized raised bed and laser levelling have great potential to improve water and soil use efficiency. To promote this: increase access to finance and the capacity of cooperatives and associations to invest in machineries to serve members.**	H	H	H	Green, resilient and inclusive
	MALR should **prioritize the promotion of practices that are complementary to irrigation equipment**, including smart irrigation scheduling, permanent raised beds, mulching and manure, limited tillage and other conservation practices, etc.).	H	M	H	Resilient and inclusive
	Food loss reduction in cereal crops, fruits and vegetables should be seen as yield enhancing strategy. **Nanosilica and improved storage for maize, and hermetic polyethylene bags** for wheat should be promoted as a key loss-reduction strategy.	H	H	H	Resilient and inclusive
	Expand investments in joint grain storage facilities at district level to enable better storage and management of grain stocks.	H	M	M	Resilient and inclusive
	Expand access to credit and incentives for investment in milk collection centres at the level of producers' associations, and testing equipment, refrigerated storage, and transport for dairy farmers.	H	H	H	Resilient and inclusive

NOTE The government role is always that of policymaker and financer, except for: here*, where it is policymaker, convener and financer; and here**, where it is only financer.

SOURCE: Authors' own elaboration.

Table 5.2
Long-term policy actions

Policy area	Public actions	Government role	Feasibility T	Feasibility F	Feasibility I	Contribution to GRID objectives
Growth and trade promotion	**Repurpose market price support policies** in favour of more investments in public goods such as: R&D in CSA technologies; agricultural training and extension; food safety and quality systems; surveillance, inspection and control; and market information systems.	Policymaker and financer	M	L	L	Green, resilient and inclusive
	Establish a policy framework to promote investments in agriculture, with a focus on high-value crops, CSA adop-tion, and value addition.	Policymaker	M	L	L	Green, resilient and inclusive
	Incentivize private investments in sustainable/green growth through: (a) legal and regulatory framework con-ducive to private investments; (b) transparent policy environment; (c) public-private dialogue; (d) efficient public services (permits, certificates, testing, etc.), and agrilogistics.	Policymaker and financer	M	M	M	Inclusive
	Expand exports of high-value products (fruits and vege-tables, dates, dairy, MAPs, etc.) by increasing the adop-tion of CSA technologies, diversifying exports into prod-ucts with more added value, and focusing on high-value markets.	Policymaker and financer	H	H	M	Inclusive
Job creation and poverty reduction	Following the example of other countries (Ghana, India, Indonesia, and Kenya) expand the **use of digital solutions to enable a credit rating system for farmers,** off-takers and other value chain actors to increase access to financial services	Policymaker and marketmaker	H	M	M	Green, resilient and inclusive
Climate resilience and ecosystem sustainability	Put in place a targeted programme to **scale up the adoption of CSA technologies,** focusing on key aspects of production and vulnerable territories (e.g. Upper Egypt) that need to diversify out of cereals and sugar crops.	Policymaker, financer and marketmaker	H	M	M	Green, resilient and inclusive
	Reduce GoE support to subsectors with highest GHG and **establish mechanisms to incentivize the adoption of carbon-neutral practices** and mitigation co-benefits (e.g. matching grants for energy efficient technologies, and for groups of farmers to invest in CSA equipment, etc.).	Policymaker and marketmaker	M	M	L	Resilient and inclusive
	As part of the NDCs, review/revise the sectorial policies and laws guiding the efforts of climate-adaptation and mitigation, and **setup strong institutional and technical capacity in MALR, MWE (Ministry of Water and Environment)** to design, plan, implement, monitor, and report.	Policymaker	M	M	M	Resilient and inclusive
	Strengthen institutional capacity to **establish and implement a water rationalization framework** to better manage the use of water resources through different instruments.	Policymaker and financer	M	H	L	Resilient and inclusive
Subsector specific actions	**Develop market-based policy instruments to reduce the environmental footprint** and increase climate-resilience of high emission value chains. This includes the use of quotas and taxes associated with emissions (and not with output) in dairy, poultry, cereals, sugar crops, etc.	Policymaker and financer	L	L	L	Green, resilient and inclusive
	Scale up breeding improvement in the dairy subsector together with enhancements in feeding practices, herd management, and milk quality.	Policymaker and financer	M	M	M	Resilient and inclusive

SOURCE: Authors' own elaboration.

References

Abay, K., Abdelfattah, L., Breisinger, C., Glauber, J. & Laborde, D. 2022. The Russia-Ukraine crisis poses a serious food security threat for Egypt. In: IFPRI. Washington, DC, *IFPRI*. [Cited 1 May 2023]. www.ifpri.org/blog/russia-ukraine-crisis-poses-serious-food-security-threat-egypt

Abdalla, M. & Al-Shawarby, S. 2017. The Tamween Food Subsidy System in Egypt: Evolution and Recent Implementation Reforms. In: Alderman, H., Gentilini, U. & Ruslan, Y. 2018. The 1.5 *Billion People Question: Food, Vouchers, or Cash Transfers?*, pp. 107–150. Washington, DC, World Bank. https://doi.org/10.1596/978-1-4648-1087-9_ch3

Abdelkader, A., Elshorbagy, A., Tuninetti, M., Laio, F., Ridolfi, L. Fahmy, H. & Hoekstra, A. Y. 2018. National water, food, and trade modeling framework: The case of Egypt. *Science of the Total Environment* 639: 485–496. www.sciencedirect.com/science/article/pii/S0048969718318461

Abd El-Latif, Kh.M., Ainer, N.G., Eid, T.A.A. & Osman, E.A.M. 2017. Effect of irrigation and mulching practices on maize crop and some water relations (Egypt). *Annals of Agricultural Sciences, Moshtohor,* 55(4): 1027–1036. www.researchgate.net/publication/326625996_Effect_of_irrigation_and_mulching_practices_on_maize_crop_and_some_water_relations

AbdelMonem, M., Wong, T., Elbadawy, O., Faurès, J., Tawfic, M., Abouzeid, F. & Matteoli, F. 2022. *Towards climate-smart agriculture in Egypt – Scaling up sustainable practices for enhancing agrifood system resilience and adaptive capacity.* Cairo, FAO. https://doi.org/10.4060/cc2917en

Abd El-Rhaman, G. 2009. Water use efficiency of Wheat under Drip Irrigation Systems at Al-Maghara Area, North Sinai, Egypt. *Journal of Soil Sciences and Agricultural Engineering* 34(3): 2537–2546. https://jssae.journals.ekb.eg/article_90464.html

Abdelraouf, R. E. & El-Habbasha, E. S. 2014. Wheat production in the arid regions by using drip irrigation system. *International Journal of Advanced Research* 2(3): 84-96. www.journalijar.com/article/1090/wheat-production-in-the-arid-regions-by-using-drip-irrigation-system-/

Abouziena, H., Abd-Elmotty, Z. & Sahab, A. 2011. Using Polyculture for Combating Desertification in Egypt. Case Study. *International Journal of Water Resources & Arid Environments* 1(15): 334–341. www.psipw.org/index.php?option=com_content&view=article&id=306&Itemid=162&lang=en

Alary, V., Corniaux, C., Aboul-Naga, A. A. M., Galal, S. *et al.* 2016. *Atlas of the traditional milk sector around greater Cairo in Egypt*. Montpellier, France, CIRAD, APRI, ICARDA, Cairo University & Ain Shams University. https://agritrop.cirad.fr/584660/1/Atlas_finale_BR1_end.pdf

Ali, A., Xia, C., Jia, C. & Faisal, M. 2020. Investment profitability and economic efficiency of the drip irrigation system: Evidence from Egypt. *Irrigation and Drainage* 69(5): 1033–1050. https://doi.org/10.1002/ird.2511

Alnaim, A. A., Mohamed, M. S., Mohammed, M. & Munir, M. 2022. Effects of Automated Irrigation Systems and Water Regimes on Soil Properties, Water Productivity, Yield and Fruit Quality of Date Palm. *Agriculture* 12(3): 343. https://doi.org/10.3390/agriculture12030343

Alnashar, S. B. H., Elashmawy, F. I. M. & Youssef, J. 2020. *Egypt Economic Monitor: From Crisis to Economic Transformation – Unlocking Egypt's Productivity and Job-Creation Potential* (English). Washington, DC, World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/256581604587810889/

Al-Wahabi, H. S., Ben Salah, M. & Al-Raisi, Y. 2018. Date Palm Production and Water Productivity Under Subsurface Drip Irrigation System. Presentation at the Sixth International Date Palm Conference, Abu Dhabi, United Arab Emirates, 19–21 March 2018. https://repo.mel.cgiar.org/handle/20.500.11766/9855

Anriquez, G., Foster, W., Ortega, J., & Santos Rocha, J. 2021. In search of economically significant food losses: Evidence from Tunisia and Egypt. *Food Policy* 98. https://doi.org/10.1016/j.foodpol.2020.101912

Arab Republic of Egypt. 2009. *Sustainable Agricultural Development Strategy Towards 2030*. Cairo, MALR. https://andp.unescwa.org/sites/default/files/2020-09/Sustainable%20Agriculture%20Development%20Srategy%20Towards%202030.pdf

Arab Republic of Egypt. 2015. *Egyptian Intended Nationally Determined Contribution*. Cairo, Egyptian Environmental Affairs Agency. https://faolex.fao.org/docs/pdf/egy186133E.pdf

Arab Republic of Egypt. 2016a. *Egypt Vision 2030: Sustainable Development Strategy.* Cairo, MALR. https://arabdevelopmentportal.com/sites/default/files/publication/sds_egypt_vision_2030.pdf

Arab Republic of Egypt. 2016b. *Egypt Third National Communication under the United Nations Framework Convention on Climate Change*. Cairo, Egyptian Environmental Affairs Agency. https://unfccc.int/sites/default/files/resource/TNC%20report.pdf

Arab Republic of Egypt. 2016. Renewable Energy Targets. In: *NREA* (New and Renewable Energy Authority). Cairo, Ministry of Electricity and Renewable Energy, New and Renewable Energy Authority. [Cited 1 May 2023]. http://nrea.gov.eg/test/en/About/Strategy

Arab Republic of Egypt. 2017. *National Strategy for Disaster Risk Reduction 2030*. Cairo, The Cabinet of Egypt Information and Decision Support Centre, Crisis Management and DRR Sector. www.preventionweb.net/files/57333_egyptiannationalstrategyfordrrengli.pdf

Arab Republic of Egypt. 2017. *Water Security for all: National Water Resource Plan 2017–2037.* Cairo, MWRI. https://unece.org/fileadmin/DAM/env/documents/2017/WAT/12Dec_20-21_TunisWS/2.3_Egypt_Adapting_extreme_weather_events.pdf

Arab Republic of Egypt. 2018a. *Egypt's First Biennial Update Report to the United Nations Framework Convention on Climate Change.* Cairo, Egyptian Environmental Affairs Agency.

Arab Republic of Egypt. 2018. *Second National Energy Efficiency Action Plan (NEEAP)*. Cairo, Egyptian Environmental Affairs Agency. https://sustainableenergyegypt.com/wp-content/uploads/2020/07/The-National-Energy-Efficency-Action-Plan-II.pdf

Arab Republic of Egypt. 2020. *Results of the Fifth Economic Census 2017/2018*. Cairo, CAPMAS (Central Agency for Public Mobilization and Statistics). https://censusinfo.capmas.gov.eg/Metadata-en-v4.2/index.php/catalog/405/related_materials

Arab Republic of Egypt. 2021. *Egypt's Water Resources and Irrigation Strategy 2050*. Cairo, Ministry of Irrigation and Water Resources.

Arab Republic of Egypt. 2022a. *Egypt's First Updated Nationally Determined Contributions (NDC)*. Cairo, Egyptian Environmental Affairs Agency (EEAA). https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf

Arab Republic of Egypt. 2022. *Egypt's Country Platform for the Nexus Water Food Energy (NWFE) Programme*. Cairo, Ministry of International Cooperation. https://moic.gov.eg/page/nwfe

Arab Republic of Egypt. 2022. *Egypt National Climate Change Strategy (NCCS) 2050*. Cairo, Egyptian Environmental Affairs Agency. www.eeaa.gov.eg/Uploads/Topics/Files/20221206130720583.pdf

Armanious, D. M. 2021. *Accelerating global actions for a world without poverty: Egypt Experiences*. United Nations Report. Cairo, UN. www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2021/02/Final-World-without-poverty-Egypt_31-january-2021.pdf

Atallah, S., Shaikh, A. & El-Ktany, E. M. 2015. Some Factors affecting Profitability of Dairy Farms. *Alexandria Journal of Veterinary Sciences* 45: 119–126. https://applications.emro.who.int/imemrf/Alex_J_Vet_Sci/Alex_J_Vet_Sci_2015_45_April_119_126.pdf

Atta, S. K., Mashaal, M. S., Eleshmawiy, K. & Sobih, S. H. 2022. The economics of wheat production under different irrigation systems in the West of Nubariya region. *Egyptian Journal of Agricultural Research* 100: 250–259. https//doi.org/10.21608/ejar.2022.128555.1217

Ayman, M., Metwally, S., Mancy, M & Abd alhafez, A. 2020. Influence of Nano Silica in wheat plant grown in salt-affected soil. *Journal of Productivity and Development* 25(3): 279–296. https://doi.org/10.21608/JPD.2020.120786

Badawy, A., Elmahdi, A., El-Hafez, S. A. & Ibrahim, A. 2022. Water Profitability Analysis to Improve Food Security and Climate Resilience. *Climate* 2022(2), 17. https://doi.org/10.3390/cli10020017

Baffes, J. & Gautam, M. 1996. Price Responsiveness, Efficiency, and the Impact of Structural Adjustment on Egyptian Crop Producers. World Development 24(4): 765-771. https://doi.org/10.1016/0305-750X(95)00164-8

Baffes, J. & Temaj, K. 2022. Food prices continued their two-year-long upward trajectory. In: *World Bank Blogs*. Washington, DC. [Cited 1 May 2023]. https://blogs.worldbank.org/opendata/food-prices-continued-their-two-year-long-upward-trajectory

Basheer, M., Nechifor, V., Calzadilla, A., Gebrechorkos, S., Pritchard, D., Forsythe, N., Gonzalez, J.M. *et al.*, 2023. Cooperative adaptive management of the Nile River with climate and socio-economic uncertainties. *Nature Climate Change*. Volume 13, January 2023, 48–57. www.nature.com/articles/s41558-022-01556-6

Breisinger, C., Raouf, M., Thurlow, J. & Wiebelt, M. 2019. *Beyond the business case for agricultural value chain development: An economywide approach applied to Egypt.* MENA RP Working Paper 18. Washington, DC and Cairo, Egypt, IFPRI. https://doi.org/10.2499/p15738coll2.133192

Breisinger, C., Kassim, Y., Kurdi, S., Randriamamonjy, J. & Thurlow, J. 2021. *Food subsidies and cash transfers in Egypt: Evaluating general equilibrium benefits and trade-offs.* MENA RP Working Paper 34. Washington, DC, IFPRI. https://doi.org/10.2499/p15738coll2.134427

CAPMAS (Central Agency for Public Mobilization and Statistics). 2019. Bulletin of Production and Foreign Trade of Agricultural Commodities in El-Agami, 2021. Dimensions of the food gap in major crops. In: *Egyptian Institute for Studies*. Cairo, Egypt. [Cited 13 September 2022]. https://en.eipss-eg.org/egypt-dimensions-of-the-gap-in-major-food-crops

COMCEC (Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation). 2016. *Selected Case Studies from the Member Countries and Recommendations for Reducing Post-harvest Losses.* Ankara, COMCEC. www.comcec.org/wp-content/uploads/2021/07/8-AGR-PRE-3.pdf

CVF (Climate Vulnerable Forum) & V20 (Vulnerable Twenty Group). 2022. *Climate Vulnerability Monitor, 3rd Edition: A Planet on Fire.* McKinnon, M., Lissner, T., Romanello, M., Baarsch, F., Schaeffer, M., Ahmed S. & Rosas, A. eds. Geneva, Switzerland and Rotterdam, The Netherlands, CVF and V20. https://drive.google.com/file/d/1ZKX50D8EpQBx1EuR5IKfn_59XQVVC8I-/view

de Ferranti, D., Perry, G. E., Foster, W., Lederman, D., & Valdés, E. 2005. *Beyond the City: The Rural Contribution to Development.* World Bank Latin American and Caribbean Studies. Washington, DC, World Bank. http://hdl.handle.net/10986/7328

David-Benz, H., Sirdey, N., Deshons, A., Orbell C. & Herlant, P. 2022. *Conceptual framework and method for national and territorial assessments* – Catalysing the sustainable and inclusive transformation of food systems. Rome; Montpellier, France; Brussels. FAO, CIRAD and European Union. https://doi.org/10.4060/cb8603en

DCarbon Egypt. 2019. *Egypt Low Emissions Development Strategy (LEDS): Objectives, Pillars and Main Features.* https://enterprise.press/wp-content/uploads/2022/08/ppt.leds_.pdf

Dhehibi, B., Swelam, A., Dessalegn, B., Salem, S. A. & AbdAllah, E. 2017. *Adoption of Mechanized Raised Bed Technology for Sustainable Farming System in Sharkia and Assiut Governorates. Technical Report.* Amman, ICARDA. https://repo.mel.cgiar.org/handle/20.500.11766/7976

Dhehibi, B., Salah, M. B., Frija, A., Aw-Hassan, A., El-Ouhibi, H. & Al-Raisi, Y. M. 2018. Economic and Technical Evaluation of Different Irrigation Systems for Date Palm Farming System in the GCC Countries: Case of Oman. *Environment and Natural Resources Research* 8(3). https://doi.org/10.5539/enrr.v8n3p55

Economist Impact. 2022. *Global Food Security Index 2022.* London, The Economist Newspaper Limited. https://impact.economist.com/sustainability/project/food-security-index

Eid, A. R., Mohamed, M. H., Pipars, S. K. & Bakry, B. A. 2014. Impact of laser land levelling on water productivity of wheat under deficit irrigation conditions. *Current Research in Agricultural Sciences, Conscientia Beam,* 1(2): 53–64. https://ideas.repec.org/a/pkp/criasc/v1y2014i2p53-64id59.html

El-Agami, D. 2021. Egypt: Dimensions of the gap in major food crops. In: *Egyptian Institute for Studies*. Cairo Egypt. [Cited 1 May 2022]. https://en.eipss-eg.org/egypt-dimensions-of-the-gap-in-major-food-crops/

El Bakouri, Z., Meziani, R., Mazri, M. A., Chitt, M. A., Bouamri, R. & Jaiti, F. 2021. Estimation of the Production Cost of Date Fruits of Cultivar Majhoul (Phoenix dactylifera L.) and Evaluation of the Moroccan Competitiveness towards the Major Exporting Regions of the World. *Agricultural Sciences* 12(11): 1342–1351. https://doi.org/10.4236/as.2021.1211086

El-Enbaby, H., Figueroa, J. L., ElDidi, H. & Breisinger, C. 2016. *The role of agriculture and the agro-processing industry for development in Egypt: An overview.* MENA RP Working Paper 3. Washington, DC and Cairo, Egypt: IFPRI. https://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/131007

El-Eraky, M., Rabab, J., Ismat, B., Hussein, S. 2022. Trends in milk production in Egypt. *Egyptian Journal of Agricultural Economics* 32. https://meae.journals.ekb.eg/article_257352_f7e1bd8c32a974e08bee1f811cf58467.pdf

El Fetyany, M., Farag, H., Abd, S.H. 2021. Assessment of national water footprint versus water availability –Case study for Egypt. *Alexandria Engineering Journal* 69(4): 3577–3585. www.researchgate.net/publication/349644983_Assessment_of_national_water_footprint_versus_water_availability_-Case_study_for_Egypt

El-Haggan Group. 2022. *Date palm production data*. Shared with World Bank and FAO during May 2022 joint mission. Unpublished.

El-Halim, A. 2015. Water Saving Under Fixed-Furrow Surface Irrigation in Clay Soil of the Middle Nile Delta of Egypt. *WIT Transactions on Ecology and the Environment* 200: 343–352. https://doi.org/10.2495/WS150291

El-Marsafawy, S. & Mohamed, A. 2021. Water footprint of Egyptian crops and its economics. *Alexandria Engineering Journal* 60(5): 4711–4721. https://doi.org/10.1016/j.aej.2021.03.019

El-Naggar, M., Abdelsalam, N. R., Fouda, M. M. G. Mackled, M. I., Al-Jaddadi, M. A. M., Ali, H. M., Siddiqui, M. H. & Kandil, E. E. 2020. Soil application of Nano Silica and Maize Yield and its Insecticidal Activity Against Some Stored Insects after the Post-Harvest. *Nanomaterials* 10(4), 739. https://doi.org/10.3390/nano10040739

Elshahawany, D. & Elazhary, R. 2022. *Government Spending and Regional Poverty Alleviation: Evidence from Egypt.* Working Papers 1609, Economic Research Forum, revised 20 Nov 2022. Cairo. https://ideas.repec.org/p/erg/wpaper/1609.html

Egypt Ministry of Planning, Monitoring and Administrative Reform. 2016. Sustainable Development Strategy: Egypt vision 2030. Cairo. https ://www.arabdevelopmentportal.com/sites/default/files/publication/sds_egypt_vision_2030.pdf

Fanack Water. 2018. Water Use in Egypt. In: *Fanack Water*. The Hague, the Netherlands. [Cited 15 June 2022]. https://water.fanack.com/egypt/water-use

FAO (Food and Agriculture Organization of the United Nations). 2018. *ASL2050 Livestock production systems spotlight – Egypt*. Rome, FAO. www.fao.org/documents/card/en/c/I8477EN

FAO. 2019. *Palm Dates Value Chain Development in Egypt.* Rome, FAO. www.fao.org/3/ca9013en/CA9013EN.pdf

FAO. 2020a. *On-farm Irrigation Development Project in the Old Lands (OFIDO). Technical Assessment – Final Report.* Rome, FAO. https://www.fao.org/documents/card/en/c/cb0484en

FAO. 2021. *Climate-smart agriculture case studies 2021 – Projects from around the world.* Rome, FAO. https://doi.org/10.4060/cb5359en

FAO. 2022a. FAOSTAT. In: *FAOSTAT*. Rome. [Cited 13 September 2022]. www.fao.org/faostat/en

FAO. 2022b. FAOSTAT: Crops and livestock products. In: *FAOSTAT*. Rome. [Cited September 13 2022]. www.fao.org/faostat/en/#data/QCL

FAO. 2022c. FAOSTAT: Food Balances (2010–2019). In: *FAOSTAT*. Rome. [Cited September 13 2022]. www.fao.org/faostat/en/#data/FBS

FAO. 2023. Economic and Policy Analysis of Climate Change. In: *FAO*. Rome. [Cited 16 January 2023]. www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en

FAO, IFAD, UNICEF, WFP & WHO. 2022. *The State of Food Security and Nutrition in the World 2022*. Repurposing food and agricultural policies to make healthy diets more affordable. Rome, FAO. https://doi.org/10.4060/cc0639en

Gaafarawi, I. 1999. *Structural Adjustment in Egypt: The Case of Agriculture.* Leeds, UK, University of Leeds. PhD dissertation.

Global Footprint Network. 2022. Country Trends: Egypt. In: *Global Footprint Network*. Oakland, CA, USA. [Cited 13 September 2022]. https://data.footprintnetwork.org/#/countryTrends?cn=59&type=BCpc,EFCpc

Hatab, A. A., Amuakwa-Mensah, F. & Lagerkvist, C. 2022. Who moves and who gains from internal migration in Egypt? Evidence from two waves of a labor market panel survey. *Habitat International* 124, 102573. https://doi.org/10.1016/j.habitatint.2022.102573.

Helmy, I., Ghoneim, H. & Siddig, K. 2019. Implementing Cash Transfer Programs in Egypt Differently: An Economic Impact Analysis. Presented at the GTAP 22nd Annual Conference on Global Economic Analysis, 19–21 June 2019. Warsaw, Poland. www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5751

IFAD (International Fund for Agricultural Development). 2019. Irrigation: Sustainable Transformation for Agricultural Resilience [STAR] in Upper Egypt. *Egypt 2000002202: STAR Project Design Mission: June – July 2019*. Rome, IFAD. www.ifad.org/en/-/document/egypt-2000002202-star-project-design-mission-june-july-2019

IFC (International Finance Corporation). 2020. *Creating Markets in Egypt. Realizing the full potential of a productive private sector*. Country Private Sector Diagnostic. Washington, DC, IFC. www.ifc.org/wps/wcm/connect/af513599-08b4-45a4-b346-1a44de58cda6/CPSD-Egypt.pdf?MOD=AJPERES&CVID=npT1-BJ

IFPRI (International Food Policy Research Institute). 2019. Social Accounting Matrix (SAM) for Egypt. In: *Harvard Dataverse*. Cambridge, Massachusetts, USA, Harvard. [Cited 13 September 2022]. https://dataverse.harvard.edu/datasetxhtml?persistentId=doi:10.7910/DVN/FSCI03

IRENA (International Renewable Energy Agency). 2018. *Renewable Energy Outlook Egypt: Executive Summary.* Abu Dhabi, IRENA (International Renewable Energy Agency). www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En_summary.pdf?la=en&hash=58DBAA614BE0675F66D3B4A2AC68833FF78700A0

James, B., Henry, M., Emmanuel, T. & Solomon, B. 2015. B*arriers to scaling up/out climate smart agriculture and strategies to enhance adoption in Africa*. Accra, FARA. https://library.faraafrica.org/2021/01/19/barriers-to-scaling-up-out-climate-smart-agriculture-and-strategies-to-enhance-adoption-in-africa-2/

Johnston, B. F., & Mellor, J. W. 1961. The Role of Agriculture in Economic Development. T*he American Economic Review* 51(4): 566–593. www.jstor.org/stable/1812786

Kamal, A. M. 2018. Which Sectors Drive Egypt's Growth and Employment? *Economics* 6(2): 57–70. https://doi.org/10.2478/eoik-2018-0019

Lan, L., Sain, G., Czaplicki, S., Guerten, N., Shikuku, K. M., Grosjean, G. & Läderach, P. 2018. Farm-level and community aggregate economic impacts of adopting climate smart agricultural practices in three mega environments. *PLOS ONE* 13(11): e0207700. https://doi.org/10.1371/journal.pone.0207700

Löfgren, H. & El-Said, M. 2001. Food subsidies in Egypt: reform options, distribution and welfare. *Food Policy* 26(1): 65–83. https://doi.org/10.1016/S0306-9192(00)00030-0

MAPEgypt. 2023. Monitoring Agricultural and Rural Development in Egypt. In: *MAPEgypt*. Washington, DC. [Cited 16 January 2023]. https://mapegypt.org/#/en?_k=pj16ym

MALR Economic Affairs Sector. 2022. Production costs and revenues of main crops for the period 2019/2020 (excel worksheets). Shared with World Bank and FAO during May 2022 joint mission. Unpublished.

Mansour, H. A., Jiandong, H., Pibars, S. K., Feng, B. H. & Changmei, L. 2019. Effect of pipes installation by modified machine for subsurface drip irrigation system on maize crop yield costs. *Agricultural Engineering International (CIGR Journal)* 21(2): 98–107. https://cigrjournal.org/index.php/Ejounral/article/view/5424

Matouk, M., El-Kohly, M., Tharwat, A. & El-Azia, A. A. 2017. Safe storage of Egyptian wheat grain using different types of hermetic polyethylene bags. Journal of Soil Sciences and Agricultural Engineering 8(6): 317–322. https://doi.org/10.21608/JSSAE.2017.37500

Meselhy, A. A. E., Youssef, M. F. A. & El-Kot, A. 2021. Manufacturing of machine for planting on wide ridges without tillage in desert soils. I*nternational Journal of Applied Agricultural Sciences* 7(1): 16–37. www.sciencepublishinggroup.com/journal/paperinfo?journalid=343&doi=10.11648/j.ijaas.20210701.12

Miller, R. E. & Blair, P. D. 2009. *Input-output analysis: foundations and extensions.* Cambridge, UK, Cambridge University Press.

MoF (Ministry of Finance). 2022. *General Budget 2021/2022*. Cairo, Ministry of Finance. https://mof.gov.eg/ar/archive/stateGeneralBudget/5fd9d731f0a7ba0007ee0ce7/%D8%A7%D9%84%D8%A8%D9%8A%D8%A7%D9%86%D8%A7%D8%AA%20%D8%A7%D9%84%D9%85%D8%A7%D9%84%D9%8A%D8%A9

Mohammed, M. E. A., Alhajhoj, M. R., Ali-Dinar, H. M. & Munir, M. 2020. Impact of a Novel Water-Saving Subsurface Irrigation System on Water Productivity, Photosynthetic Characteristics, Yield, and Fruit Quality of Date Palm under Arid Conditions. *Agronomy* 19(9), 1265. https://doi.org/10.3390/agronomy10091265

Moneim, Doaa A. 2022. Egypt-ICF2022: From pledges to implementation. In: *Ahramonline*. Cairo. [Cited 13 September 2022]. https://english.ahram.org.eg/NewsContent/50/1201/476046/AlAhram-Weekly/Egypt/EgyptICF-From-pledges-to-implementation.aspx

Morsy, A. S. M. & Awadalla, A. O. 2021. Response to two yellow maize hybrids to amino acids, mineral NPK and Nano-fertilizers under Toshka District conditions. *Alexandria Science Exchange Journal* 42(2): 327–340. https://doi.org/10.21608/ASEJAIQJSAE.2021.168889

Moursy, M. A. M., El-Fetyany, M., Meleha, A. M. I. & El-Bialy, M. A. 2022. Productivity and profitability of modern irrigation methods through the application of on-farm drip irrigation on some crops in the Northern Nile Delta of Egypt. *Alexandria Engineering Journal* 62: 349–356. www.sciencedirect.com/science/article/pii/S1110016822004598?via%3Dihub

MPED (Ministry of Planning and Economic Development). 2021. *Egypt's 2021 Voluntary National Review.* Cairo, MPED. https://sustainabledevelopment.un.org/content/documents/279512021_VNR_Report_Egypt.pdf

MPED. 2022. The Ministry of Planning and Economic Development and the United Nations in Egypt Signed a Declaration of Intent to Strengthen the Implementation of Egypt's National Structural Reform Programme 2021–2024. In: *MPED*. Cairo. [Cited 14 June 2022]. https://mped.gov.eg/singlenews?id=1166&type=previous&lang=en

MPED and UNDP (United Nations Development Programme). 2021. *Egypt Human Development Report 2021.* Cairo, MPED. https://egypt.un.org/en/146158-egypt-human-development-report-2021

Nganga, L., Abdelrahman, H. & Abdelnabby, M. 2021. *Climate-smart agriculture investment plan for Egypt.* Document prepared for the World Bank. Unpublished.

OECD (Organisation for Economic Co-operation and Development) & FAO. 2022. OECD Agriculture Statistics: OECD-FAO Agricultural Outlook (Edition 2022). In: *OECDiLibrary*. Paris. [Cited 31 May 2022]. https://doi.org/10.1787/agr-data-en

Osman, M. A., Alary, V., Khalil, M., Elbeltagy, A. R. Tourrand, J. F. & Moulin, C.-H. 2017. Adaptability and suitability of local cattle breeds in Egypt: Farmers and actors' perceptions and practices of the cattle value chain. *Revue d'Élevage et de Mélevage et de Médecine Vétérinaire des Pays Tropicaux* 69(3): 95–103. https://hdl.handle.net/20.500.11766/6767

Osman, R., Ferrari, E., Mainar-Causapé, A. & Jiménez Calvo, S. 2021. Can the Nile Generate Output, Income and Employment in Egypt? *A Mixed Multiplier Analysis. New Medit, Mediterranean Journal of Economics, Agriculture and Environment*. https://newmedit.iamb.it/bup/wp-content/uploads/2020/12/NEW-MEDIT-2021-N.1-01-Can-the-Nile-generate-output.pdf

Ouda, S., Farag, H., Taha, A. & Noreldin, T. 2016. Assessment of drip irrigation system for maize to reduce food, water and energy insecurity in Egypt. Fourth African Regional Conferences on Irrigation and Drainage (ARCID), 26–28 April 2016, Aswan, Egypt. www.researchgate.net/publication/301765638

Oxford Business Group. 2022. How Egypt plans to expand agricultural output. In: *Oxford Business Group. London*, Oxford Business Group. [Cited 13 September 2022]. https://oxfordbusinessgroup.com/overview/fertile-lands-new-initiatives-increase-availability-arable-land-boost-crop-productivity-and-ensure

Perez, N. D., Kassim, Y., Ringler, C., Thomas, T. S. & ElDidi, H. 2021a. *Climate Change Adaptation Strategies for Egypt's Agricultural Sector.* MENA Regional Program Policy Note 18. Washington, DC, IFPRI. https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/134321/filename/134535.pdf

Perez, N. D., Kassim, Y., Ringler, C., Thomas, T. S., ElDidi, H. & Breisinger, C. 2021b. *Climate-resilience policies and investments for Egypt's agriculture sector: Sustaining productivity and food security.* Washington, DC, IFPRI. https://doi.org/10.2499/9780896294189

Perez, N. D., Kassim, Y., Ringler, C., Thomas, T. S. & ElDidi, H. 2021c. C*limate Change and Egypt's Agriculture*. MENA Regional Program Policy Note 17. Washington, DC, IFPRI. https://doi.org/10.2499/p15738coll2.134318

Rady, A. M. S., Attia, M. F. A., Kholif, A. E., Sallam, S. M. A. & Vargas-Bello-Pérez, E. 2022. Improving Fodder Yields and Nutritive Value of Some Forage Grasses as Animal Feeds through Intercropping with Egyptian Clover (Trifolium alexandrinum L.). *Agronomy* 12(10), 2589. https://doi.org/10.3390/agronomy12102589

Ramadan, E. K. & El-Tahawy, A. S. 2014. Effect of Calving Season on the Economic and Production Efficiency of Dairy Production Breeds. *International Journal of Biological, Agricultural, Food and Biotechnological Engineering* 8(7). www.researchgate.net/publication/281586651_Effect_of_Calving_Season_on_the_Economic_and_Production_Efficiency_of_Dairy_Production_Breeds

Randriamamonjy, J., Raouf, M. & Thurlow, J. in collaboration with CAPMAS (Central Agency for Public Mobilization and Statistics). 2019. *First Regionalized Social Accounting Matrix for Egypt. A 2015 Nexus Project Social Accounting Matrix. Cairo, General Department of National Accounts at the Central Agency for Public.* Washington, DC, and Cairo, IFPRI. https://doi.org/10.2499/p15738coll2.133402

Roshydy, Kh. A. & Refaai, M. M. 2016. Effect of nanotechnology fertilization on growth and fruiting of Zaghloul date palms. *Journal of Plant Production* 7(1): 93–98. https://jpp.journals.ekb.eg/article_43478_824fd0ecb557d4e1639b508f9da3c96c.pdf

Salama, H. S. A., Nawar, A. I., Khalil, H. E. & Shaalan, A. M. 2021. Improvement of Maize Productivity and N Use Efficiency in a No-Tillage Irrigated Farming System: Effect of Cropping Sequence and Fertilization Management. *Plants* 10(7), 1459. https://doi.org/10.3390/plants10071459

Salem, H. E. Y., Ibrahim, S. A. & Hefny, R. M. 2021. An economic study of date palm production in the North of Sinai Governorate. *Sinai Journal of Applied Sciences* 10(2): 205–218. https://doi.org/10.21608/SINJAS.2021.85163.1031

Shabani, F., Cacho, O. & Kumar, L. 2016. Effects of climate change on economic feasibility of future date palm production: An integrated assessment in Iran. *Human and Ecological Risk Assessment* 22(5): 1268–1287. www.tandfonline.com/doi/abs/10.1080/10807039.2016.1162089?journalCode=bher20

Shalaby, T. A., Bayoumi, Y., Eid, Y., Elbasiouny, H., Elbehiry, F., Prokisch, J., El-Ramady, H. & Ling, W. 2022. Can Nanofertilizers Mitigate Multiple Environmental Stresses for Higher Crop Productivity? *Sustainability*, 14(6), 3480. https://doi.org/10.3390/su14063480

Shimizu, K., Abdel-Gawad, K., Safina, S. Kubota, A., Ishikawa, N., Mohamed, A. & Cao, W. 2015. Possibility of Intercropping Maize and Berseem in the Nile Delta, Egypt. *Tropical Agriculture and Development* 59(4): 221–223. https://doi.org/10.11248/jsta.59.221

Sime, G., Aune, J. B. & Mohammed, H. 2015. Agronomic and economic response of tillage and water conservation management in maize, central rift valley in Ethiopia. *Soil & Tillage Research* 148: Pages 20–30. https://www.sciencedirect.com/science/article/pii/S0167198714002669

Sitko, N. J., Veljanoska, S. & Ignaciuk, A. 2019. E*conomics of Climate-Smart Agriculture: Considerations for Economic and Financial Analyses of Climate-Smart Agriculture Projects.* Washington, DC, World Bank Group. https://documents.worldbank.org/curated/en/744811563536732346

Soliman, I. & Mashhour, A. 2014. *Techno-economic factors affecting genetic investment in dairy cattle in Egypt.* MPRA Paper 6677. Munich, Germany, University Library of Munich. https://ideas.repec.org/p/pra/mprapa/66777.html

Sova, C. A., Grosjean, G., Baedeker, T., Nguyen, T. N., Wallner, M., Nowak, A., Corner-Dolloff, C., Girvetz, E., Laderach, P. & Lizarazo, M. 2018. *Bringing the Concept of Climate-Smart Agriculture to Life: Insights from CSA Country Profiles Across Africa, Asia, and Latin America.* Washington, DC, World Bank. https://hdl.handle.net/10986/31064

Swelam, A., Farag, A., Ramasamy, S. & Ghandour, A. 2022. Effect of Climate Variability on Water Footprint of Some Grain Crops under Different Agro-Climatic Regions of Egypt. *Atmosphere* 13(8), 1180. https://doi.org/10.3390/atmos13081180

Terwisscha van Scheltinga, C., de Miguel Garcia, A., Wilbers, G.-J., Heesmans, H., Dankers, R. & Smaling E. 2021. Unravelling the interplay between water and food systems in arid and semi-arid environments: the case of Egypt. *Food Security* 13: 1145–1161. https://doi.org/10.1007/s12571-021-01208-1

Tsegay, A., Kidane, A., Tesfay, G., Kahsay, G. Abrha, B. & Aune, J. B. 2018. Reduced tillage and intercropping as a means to increase yield and financial return. M*omona Ethiopian Journal of Science* 10(2): 221–239. www.ajol.info/index.php/mejs/article/view/183441

UNEP (United Nations Development Programme). 2015. *Green Economy Scoping Study: Egypt.* Nairobi, UNEP. https://d1bf23g64f8xve.cloudfront.net/sites/default/files/downloads/resource//Green_Economy_Scoping_Study_Egypt_UNEP.pdf

UNIDO (UN Industrial Development Organization). 2020. *Project Document: Inclusive Green Growth in Egypt*. Cairo, UNIDO. https://open.unido.org/projects/EG/projects/170146?_ga=2.220442458.376596949.1557660449-652774733.1526911941

UN General Assembly. 2015. *Transforming our World: The 2030 Agenda for Sustainable Development A/RES/70/1.* New York City, USA, UN. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

University of Notre Dame. 2020. Notre Dame Global Adaption Index (ND-Gain). In: *University of Notre Dame*. Notre Dame, Indiana, USA. [Cited 13 September 2022]. https://gain.nd.edu/our-work/country-index

USDA (United States Department of Agriculture). 2022. Egypt: Grain and Feed Annual. Attaché Report (GAIN). In: *USDA Foreign Agricultural Service.* Washington, DC. [Cited 13 September 2022]. www.fas.usda.gov/data/egypt-grain-and-feed-annual-6

USDA. 2022. North Africa – Crop Production Maps. In: *USDA Foreign Agricultural Service*. Washington, DC. [Cited 13 September 2022]. https://ipad.fas.usda.gov/rssiws/al/na_cropprod.aspx

Verbist, J. 2020. Mechanized raised bed (MRB) technology in a wheat based production system. In: *WOCAT Database on Sustainable Land Management*. Bern, WOCAT. [Cited 13 September 2022]. https://qcat.wocat.net/en/wocat/technologies/view/technologies_5804/

Wassif, O. M. & Meselhy, A. A. 2022. Effect of contour tillage system and water harvesting method on mitigation of soil water erosion hazards. *Journal of Xi'an Shiyou University, Natural Sciences Edition* 65(04). https://xianshiyoudaxuexuebao.com/detail.php?id=DOI:10.17605/OSF.IO/Y3KRF

Werr, P. 2022. Egypt's February headline inflation accelerates to 8.8%. In: *Reuters*. Cairo. [Cited 13 September 2022]. www.reuters.com/world/middle-east/egypts-feb-headline-inflation-quickens-88-capmas-2022-03-10

World Bank Group. 2017. *Guidance note on shadow price of carbon in economic analysis.* Washington, DC, World Bank. https://thedocs.worldbank.org/en/doc/911381516303509498-0020022018/

World Bank Group. 2021a. *Accelerating the transformation of Egypt's agrifood system: Impact of investments in selected value-chains.* Report No: AUS0002438. Washington, DC, World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/259611625118209081

World Bank Group. 2021b. *Green, Resilient, and Inclusive Development.* Washington, DC, World Bank. https://openknowledge.worldbank.org/handle/10986/36322

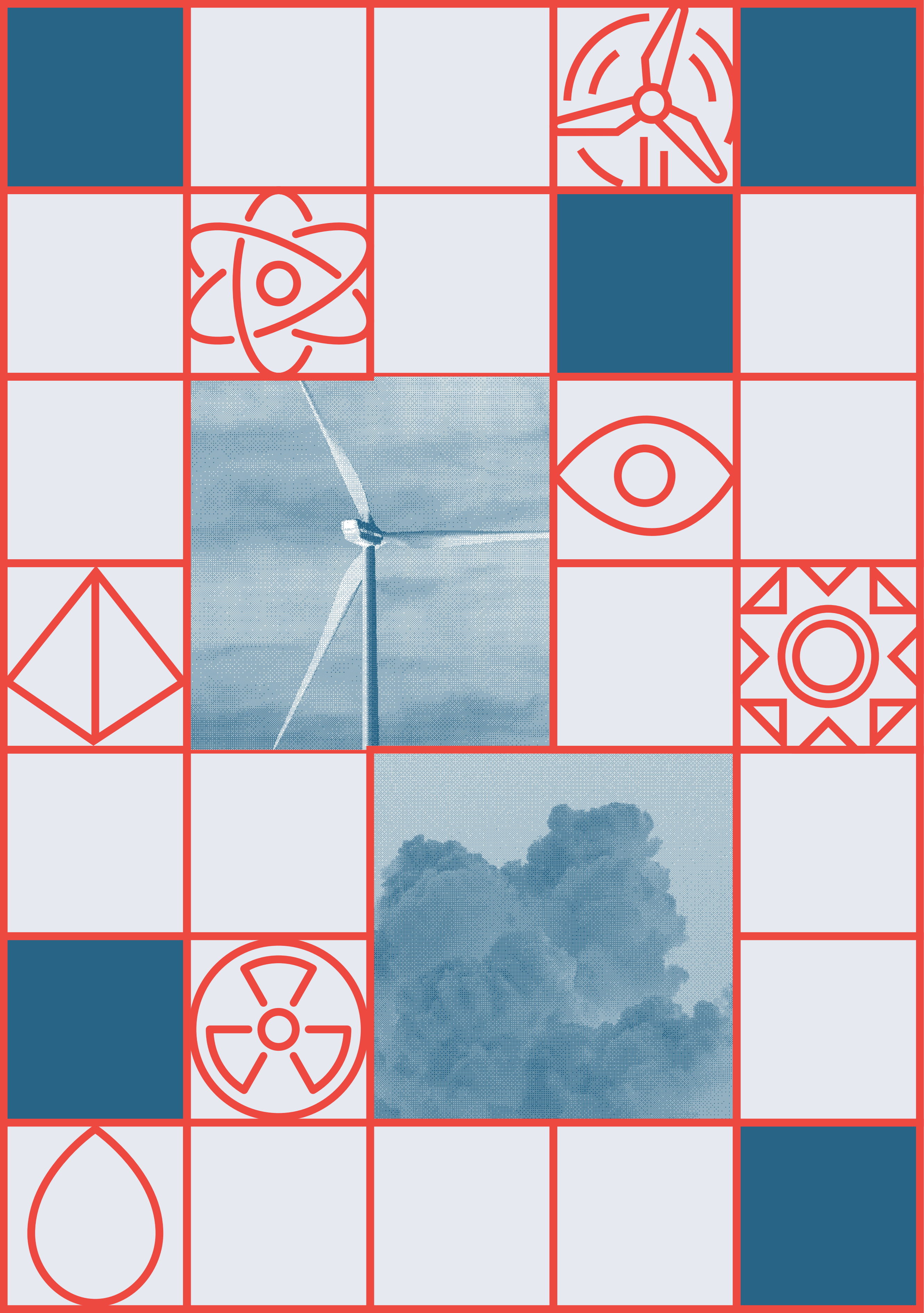
World Bank Group. 2022a. World Development Indicators (WDI). In: *World Bank Data.* Washington, DC. [Cited 13 September 2022]. https://data.worldbank.org/indicator

World Bank Group. 2022b. *Egypt Country Climate and Development Report.* CCDR Series. Washington, DC, World Bank. https://openknowledge.worldbank.org/handle/10986/38245

Yeboah, F. K. & Jayne, T. S. 2022. *Employment structure and pathways for economic transformation in Egypt*. International Development Working Paper. East Lansing, Michigan, USA, Michigan State University.

Yigezu, Y. A., Moustafa, M. A., Mohye, M. M., Ibrahim, S. E., Ghanem, W. M., Niane, A.-A., Abbas, E., Sabry, S. R. S. & Halila, H. 2021. Food losses and wastage along the wheat value chain in Egypt and their implications on food and energy security, natural resources, and the environment. *Sustainability* 13(18): 10011. https://hdl.handle.net/2.500.11766/66173

Zisopoulou, K. & Panagoulia, D. 2021. An In-Depth Analysis of Physical Blue and Green Water Scarcity in Agriculture in Terms of Causes and Events and Perceived Amenability to Economic Interpretation. Water 13(2), 1693. https://doi.org/10.3390/w13121693



Annexes

Annex I
Methodologies for the identification and prioritization of climate-smart agriculture options

Annex 2
Profiles of climate-smart agriculture and business-as-usual scenarios

Annex 3
Support measures in Egypt's agrifood system

You can consult the annexes at the following link:
https://www.fao.org/3/CC8718EN/Annexes.pdf

Highly vulnerable to the effects of climate change, Egypt is facing increasingly severe and frequent heat waves, raising the already high evaporation rate, accelerating crop transpiration, increasing soil aridity and elevating water requirements for both human and agricultural consumption in a country where water is scarce. The forecasted spike in rainfall variability will affect flow of the Nile River, increasing both drought and high-flow years. While Egypt must produce more food for its rapidly growing population and confront high levels of child malnutrition, agricultural performance is slowing due to inefficient use of land, labour, water and energy along with environmental degradation and limited access to new technology, all of which favour increased incidence of pests and disease. Having analysed climate smart agriculture (CSA) technologies in four of Egypt's most important value chains – dairy, dates, maize and wheat – the authors demonstrate that CSA practices, technologies and policies can increase agricultural productivity and incomes, strengthen resilience to climate change, improve AFS sustainability and contribute to food and nutrition security. These important, evidence-based findings have bearing well beyond Egypt's borders. This publication is part of the Country Investment Highlights series under the FAO Investment Centre's Knowledge for Investment (K4I) programme.

ISBN 978-92-5-138384-1

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CC8718EN/1/11.23