The Poverty and Distributional Impacts of Water Quality
A CGE-Micro Analysis for Egypt

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Introduction

Exposure to contaminated food and water-borne diseases are common in Egypt. Deteriorating water quality has been an obstacle to the development of agricultural sector, where "[c]ontamination rates have reached unacceptable levels in some agricultural areas and have had negative effects on the ability of these areas to produce safe food acceptable to local inhabitants and suitable to export", (MALR, 2009, p. 45). The Ministry of Water Resources and Irrigation (MWRI) estimates annual cost of using low quality water to be 1.8% of GDP (MWRI, 2005a).

Deteriorating water quality is likely to have significant adverse impacts on low-income household groups and farmers. Poorer households and farmers are more dependent on water with low quality. They are also more vulnerable to, and less adaptable to, variations in water quality measures. This study captures the poverty and distributional impacts of changes in water quality through several transmission channels: direct impacts due to contaminated water use and indirect impacts on food security due to productivity and production loss as well as higher prices which can be imputed to a worsening of water quality for agricultural uses (among other factors).

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It analyses the multi-sectoral and distributional impacts of variations in water quality in Egypt. First, the direct and indirect impacts of changes in water quality are quantified using a national-level CGE. Second, a micro model is used to measure how these changes are transmitted into various household/farmer groups through changes in price and labour market (e.g., wages or employment level) and how they affect poverty, inequality and income distribution. Using data from recent household and labour force surveys allows us to evaluate the distributional implications for different income groups and various crop farmers.

Data and Model

The CGE model is a variant of STAGE 2 (McDonald & Thierfelder, 2015) that encompasses the characteristics of the Egyptian agricultural and irrigation systems. The model is calibrated to an updated version of 2008/09 Egypt SAM (Osman *et al.*, 2015a and 2015b).

The SAM is updated to the most recent Supply-Use and Input-Output Tables 2012-13. It includes 102 accounts: 54 activities (23 of which are agricultural activities), 16 commodities, 19 factors, 5 institutions, 4 tax instruments, trade margins, savings/investment and rest of the world. The database distinguishes irrigated land from rain-fed land. For the former, water and irrigated land are segmented by irrigation season, i.e., winter, summer, *Nili*[3] and year-round, and by type of water, i.e., Nile water and groundwater. There are 16 water/land production factors for irrigated agriculture.

Furthermore, the SAM is augmented with multiple representative household types. The micro model is estimated based on the most recent household survey data for Egypt (i.e. Harmonized Household Income and Expenditure Surveys (HHIES) 2015)) (OAMDI, Harmonized Household Income and Expenditure Surveys (HHIES), 2017); and the most recent labour force survey data for Egypt (i.e. Harmonized Labor Force Surveys (HLFS) 2016), (OAMDI, Harmonized Labor Force Surveys (HLFS), 2017).

Water quality indicators are incorporated using satellite accounts, allowing for modelling various agronomic features; e.g. water/land salinity, soil fertility and agricultural productivity, (Osman, Ferrari, & McDonald, 2019).

[3] Before building the Aswan High Dam in 1970, the term *Nili* has been historically used referring to the Nile flood period from September to November.

The production activities have a 5-level nested constant elasticity of substitution (CES) structure (Figure 1). Intermediate inputs are combined using Leontief input-output coefficients. CES production technologies define aggregate value added from labour, capital and various types of irrigation water and land across irrigation seasons.

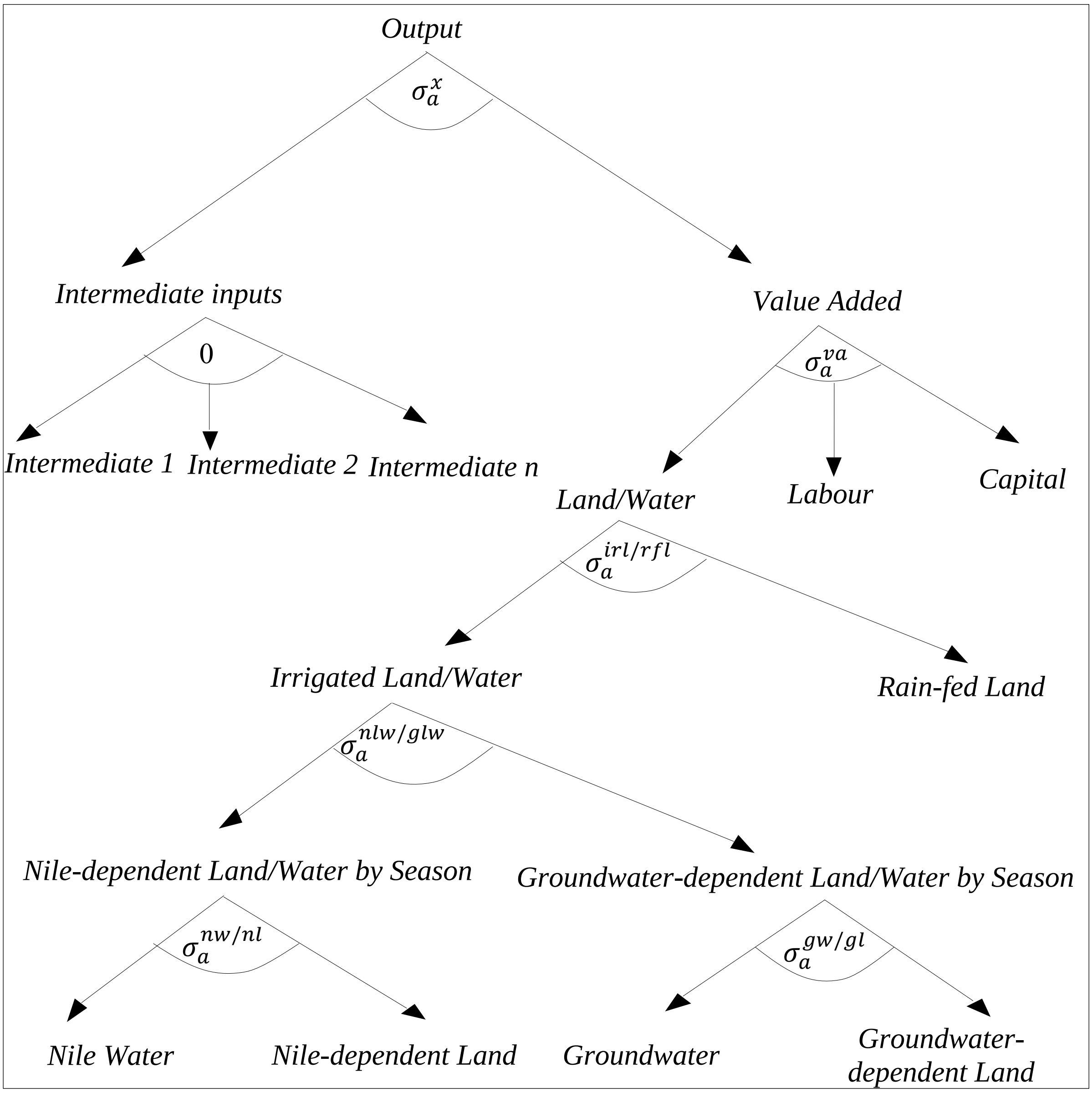

Figure 1: Agricultural Production Flows in the Model
Note: Here and thereafter, elasticity of substitution between Irrigated Land/Water and Rain-fed Land is $\sigma_a^{irl/rfl}$; between Nile-dependent Land/Water and Groundwater-dependent Land/Water is $\sigma_a^{nlw/glw}$; between Nile Water and Nile-dependent Land is $\sigma_a^{nw/nl}$; and between Groundwater and Groundwater-dependent Land is $\sigma_a^{gw/gl}$.

Source: Osman *et al.* (2016).

For Nile-dependent and groundwater-dependent activities, water and land are fully employed but season-specific, with fixed physical supply constraints for water and land (in thousands of feddan). Water and land supplies are fixed for each irrigation season, but flexible across agricultural activities within each season providing distinct seasonal water and land prices. The model solves for water and land seasonal prices that ensure efficient allocation of water and land across crops cultivated in the same season.

Keywords Water, Water Pollution, Irrigation Efficiency, Agricultural Productivity, Poverty and Income Distribution, Egypt, Computable General Equilibrium (CGE) Models.

JEL code Q25, Q53, Q15, D24, I32, O55, C68

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