Water Scarcity in South Asia: A Dynamic CGE Analysis

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Introduction

The economy of South Asia faces serious challenges in water availability, which are expected to aggravate over the coming decades. There is a need for comprehensive analyses to understand these challenges and help regional decision makers develop policies to manage these challenges. In this paper, we assess the long-run economy-wide impact of potential water scarcity in South Asia within a global context. We also explore potential policies to mitigate adverse impacts of such scarcity.

Literature review

There have been several studies that have computed global water resource use (e.g. Siebert and Döll, 2010), and these have facilitated research into the interplay between water availability and agriculture (e.g. Hoekstra and Mekonnen. 2012), as well as the nexus between water and energy (e.g. IGES, 2013). However, most of these studies are missing the international trade dimension, which, as pointed out by Liu et al. (2014) may moderate the impacts of localized water scarcity. However, such studies have been largely comparative static in nature. There are studies focusing on South Asia, using disaggregated time-series datasets in dynamic econometric frameworks; Siegfried et al. (2010) quantifies the impact of climate variability and unsustainable irrigation on regional agricultural production in Andhra Pradesh, India, with forecasts on future water requirements in this region. Duflo and Pande (2007) focus on the uneven distributional effects of irrigation projects, particularly dams in India. None of these studies, however, provide a macro-economic perspective, as they are focused on specific regions or sectors.

Model description and methodology

We develop a recursive-dynamic CGE model, which is an extended version of the GDyn-E model (Golub, 2013; (Ianchovichina and Walmsley, 2012)). The Gdyn-E model treats time as a variable and incorporates features of capital accumulation, stylized representation of financial assets and associated income flows, and investment theory (Ianchovichina and Walmsley, 2012). The extensions introduced for this work serve to bring water and bio-fuels into explicit consideration. The modified model was built based on a modified version of the GTAP data base version 8, which represents the world economy in 2007. Following Taheripour et al. (2013) several modifications are made in the GTAP standard data base version 8, including: the division of agriculture into irrigated and rain-fed categories; the introduction of water as an distinct endowment; the splitting of the electricity sector into two distinct sub-sectors: one supplying hydro-power and one non-hydro. The last important modification brings biofuels into the data base. The dynamic model provides a time path of the global economy and CO2 emissions, and allows analysis of GHG mitigation policies differently affecting GDP and incentives to invest in different regions. Water conservation in the model is achieved by using more labor, capital and energy.

Experimental Design

We divide our period of analysis into five sub-periods: 2007-12, 2012-15, 2015-20, 2020-25 and 2025-30, of which the first one is historical. We employ the population baseline developed by Chappius and Walmsley (2011), which is, in turn, derived from the UN baseline. We assume that TFP (Total Factor Productivity) of all the regions in the world grows at the rate at which it did, historically, in 2007-12. The objectives of our simulations are two-fold: to develop a dynamic baseline for the period between 2007 and 2030; and to employ such a baseline to draw implications for water scarcity and water use scenarios in South Asia. We perform that latter by allowing for differing degrees of water constraint and substitutability with other factors over this baseline path. Following are the scenarios we designed, in terms of parametric and model assumptions:

1. Supply of all factors except land is unconstrained, meaning that they can all expand to meet the growth required by the baseline TFP projection. Water-Land composite is substitutable with other factors.
2. Supply of all factors except land and water is unconstrained. Water-Land composite is substitutable with other factors.
3. All factors except land and water are unconstrained. Water-Land cannot be substituted with other factors.
4. All factors except land are unconstrained. Water-Land composite cannot be substituted with other factors.

Results

Because of the constraints on land, agricultural sectors do not expand a lot in scenario 1, even more so in scenario 2. Despite that, water demand does expand – for example, to the tune of about 2% per year, during 2025-30, in India. The fuel sectors expand rapidly – this is because of two reasons; firstly, growth of non-agricultural sectors is highly energy-intensive, hence raising the demand for energy products; secondly, since water-land supply is constrained, energy, labor and capital have to expand more in order to produce all goods and services in the economy. With both scenarios 1 and 2 above, GDP growth rates were quite similar. With scenarios 3 and 4, we find that GDP growth falls by 2-3% per annum in 2012-15 and 1-2% thereafter, as water cannot expand enough and capital cannot substitute enough for it. This is shown in table 1. In scenario 4, water demand expands by 3-5% per year in India in 2020-30, given that other factors may not be substituted with water for growth. In all regions and scenarios, GDP growth increases rapidly in the beginning until 2020, but tapers down by 2030; labor supply expands quickly in the beginning but declines towards the end, because of substitution by capital and natural resources, which need to expand a lot, by as much as 6% per year, for India, irrespective of the assumption. Capital requirements are higher in scenarios where water supply is unconstrained and substitutable with other factors.

Table 1: Baseline annualized growth rates in GDP

Description	Water-Land: substitutable with other factors				Water-Land: not substitutable with other factors			
	2012-15	2015-20	2020-25	2025-30	2012-15	2015-20	2020-25	2025-30
India	7.8	5.3	3.3	2.0	4.9	3.6	2.6	2.1
Bangladesh	3.4	1.8	0.8	0.5	1.9	1.2	0.8	0.6
Rest-S-Asia	3.3	2.4	1.4	0.8	1.3	0.9	0.8	0.8
Rest-World	-0.1	-0.6	-0.9	-1.1	-0.3	-0.6	-0.9	-1.1

Preliminary Conclusions

In order to maintain growth rates observed over the period 2007-12, Countries on South Asia need expanded water supplies. Capital and natural resources have to expand rapidly as well, irrespective of whether or not they are substitutable with water and land or whether or not water/land is constrained. These have implications for huge investment in water infrastructure, in the tune of about 6% per year over the next couple of decades. We shall further expand this analysis by exploring future scenarios of climate change, yields, land supply and water use efficiency.

Potential for generating discussion

Water scarcity is a globally pressing issue in the context of agriculture as well as other industries, particularly in the context of emerging economic giants like India. In this context, while there have been many papers dealing with this issue using different methodologies for different countries/regions/sectors, there is hardly any effort to develop a global dynamic economy-wide model that can address this issue for long enough time-horizon. We have attempted this in the current paper, and are confident that this will trigger a lot of discussion among many researchers in our community, comprising those who work on climate, environment, trade, resources, agriculture, energy and water issues. In other words, this paper will be quite appealing to people working on a wide range of issues that form the core of this conference's forum.

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