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Journal of Policy Modeling xxx (2017) xxx–xxx

Journal of Policy Modeling

www.elsevier.com/locate/jpm

The macroeconomic impact of future water scarcity An assessment of alternative scenarios

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Received 24 February 2017; accepted 9 July 2017

Abstract

In this paper we consider some of the economic implications of climate change scenarios as described in the Shared Socioeconomic Pathways (SSPs). By comparing potential water demand with estimates of (sustainable) water availability in different regions, we identify regions that are likely to be constrained in their future economic growth potential by the scarcity of water resources. We assess the macroeconomic impact of water scarcity under alternative allocation rules finding that, by assigning more water to sectors in which it has a higher value, shifting production to less water intensive sectors, and importing more water intensive goods, constrained regions can effectively neutralize these water related climate risks and adapt to a changing water environment. However, this adaptation effort is likely to imply some radical changes in water management policies.

JEL classifications: C68; F18; F43; O11; Q01; Q25; Q32; Q56

Keywords: Water; Economic growth; Shared socio-economic pathways; Computable general equilibrium; Virtual water trade

1. Introduction

Currently almost a quarter of humanity, 1.6 billion people, live in countries of physical water scarcity, and this number may double in two decades. Population growth, urbanization, and eco-

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https://doi.org/10.1016/j.jpolmod.2017.10.003
0161-8938/

Please cite this article in press as: Roson, R., & Damania, R. The macroeconomic impact of future water scarcity. An assessment of alternative scenarios. *Journal of Policy Modeling* (2017), https://doi.org/10.1016/j.jpolmod.2017.10.003

nomic expansion will heighten scarcities where water already is in short supply. Climate change, superimposed on this backdrop of water scarcity and excessive variability in many parts of the world, will perhaps magnify the challenge of managing a complex natural resource. In fact water is the primary channel through which many of the impacts of climate change will be felt — through variations in rainfall, snowmelt, storm surges, and rising seas.

This paper seeks to explore this issue in more detail by investigating some of the macroeconomic implications of possible climate and growth induced future water scarcity. In order to do so, the paper combines projections of climate impacts on water supplies, from a suite of global climate models, with a conventional computable general equilibrium that incorporates water as a factor of production and a consumption good. The analysis is based on a comparison between potential demand for water and estimated water availability in a number of climate change scenarios. The feasibility of growth scenarios are examined when there is a water supply shock.

Water availability is calculated using the Global Change Assessment Models (GCAM). Three different climatic Global Circulation Models (GCMs) are used as inputs – CCSM, FIO, and GISS – to feed a complex hydrologic model. These encompass the range of model runoff uncertainties and cover the extremes of wet, moderate and dry projections from the GCAM model ensemble. The main output of these models is an estimate of runoff and water inflows for 15 sub-regions of the world. The models suggest that the global supply of water (in aggregate) is not significantly impacted by climate change, reflecting the fact that the water cycle is a closed dynamic system. However there are vast regional variations in run-off. More countries than not will experience declines in river flow, putting major stress on irrigated agriculture (see Fig. 1 for an example of an output). Groundwater recharge, being heavily dependent on river flows, precipitation levels, and, in some regions, snowfall, is also likely to decline in these countries. Even regions which are likely to experience increases in precipitation may not see benefits. More rainfall will be partially offset by greater evaporation due to warmer temperatures. The supply side impacts are most severe in the Middle East, parts of Africa and Asia, with most of Europe and North America largely unaffected.

The analysis focuses on the consequences of changing runoff. For the purposes of this study, sustainable (renewable) water supply is defined as the total yearly runoff (where necessary integrated by water inflow) within a given region, and scenarios are considered in which this is the only available source of water. Therefore, the possible exploitation of non-renewable water resources (e.g., "fossil water") is ruled out, whereas the adoption of unconventional water supply (e.g., desalination, recycling, harvesting) is indirectly accounted for as improvements in water efficiency (fresh water needed per unit of economic activity).

A global computable general equilibrium (CGE) model is used to assess water demand, recognizing its endogenous nature. The demand for water partly depends upon economic structure and income, which are in turn endogenous to available water supplies. The conclusions of the analysis are striking and highlight further the importance of water management policies. With water in short supply, the impact depends mainly on the policy regime.

The scenarios of economic development (the SSPs) that have been proposed to define different climate change futures have ignored water availability. The analysis presented in this paper suggests that underlying assumptions of sustained economic growth, especially for developing

[1] Note that these are changes in runoff. The eventual effect depends on baseline precipitation. For instance a 100 mm decline in runoff has limited impact if baseline rainfall is 3000 mm as in Colombia rather than 300 mm as in Chad.