

# Distributing water between competing users in the Netherlands

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The Netherlands is a delta country where water is usually abundant. Large investments in water infrastructure aim to prevent flooding, maintain shipping transport routes, irrigate farmland and ensure the health of polder lands and nature. During the limited periods when water is scarce, agriculture is low on the priority list for water allocation: farmers may be restricted in expanding irrigation operations or be even temporarily forbidden from using the equipment already installed. This comes at a cost to agricultural production. Water in this context is a unique economic input that is not privately owned, not always scarce, and not always allocated according to market principles. Nonetheless, the framework of a computable general equilibrium model (CGE) can be very effective in assessing economy-wide changes from periods of water scarcity and weighing this against policy initiatives to reduce water scarcity. In this paper we explore adaptation possibilities to water scarcity from climate change with a particular focus on the challenges of interpretation of the CGE methodology for water in the context of the Netherlands.

One of the climate change scenarios that has been developed for the Netherlands predicts hotter and drier summers and a substantial drop in river discharge in summer. This is expected to lead to increased water scarcity with potentially detrimental economic and environmental effects. The summer of 2018 was one of the driest years on record and according to a recent review by Coumou et al. (2018) this hot and dry extreme weather could occur more often as part of a persistent pattern in the mid-latitude region of the globe. Global climate change exerts significant pressure on the way that we allocate our limited water resources across different water uses and user groups. In examining adaptation responses to climate change, such as updating water infrastructure, economic analysis can play an important role in reducing costs and improving efficiency (Hughes et al. 2010).

Adaptation to climate change is defined by the IPCC (2014) as “the process of adjustment to actual or expected climate and its effects”. Several types of adaptation can be distinguished. A well-known distinction is that between planned (anticipatory) and autonomous (reactive) adaptation (Smit et al. 2000). In this paper we explore market adaptation responses to water scarcity from climate change in the Netherlands by examining aspects of three studies, each of which uses a CGE model. The first (Koopman et al. 2015) uses GTAP-W (Calzadilla et al. 2010) to explore the extent of the autonomous market response. That is autonomous adaptation by economic agents that is triggered by market/price signals. The second study (Koopman et al. 2018), explores the planned adaptation of increased investment in irrigation water infrastructure in the agricultural sector, making a distinction between ground and surface water. The third study (Koopman et al. 2017) explores the planned adaptation of introducing explicit water markets between industry, agriculture and public water services.

In the first and third studies, we focus on surface water that is supplied by rivers and through precipitation. We assume that groundwater deposits are not (further) depleted i.e. that renewable groundwater is used sustainably, so the groundwater level plays no role in the analysis. In the second study we relax this assumption and assume that groundwater abstraction is limited only by irrigation infrastructure rather than physical water availability. This assumption on the availability of ground water in the second study leads to a positive impact on overall crop

growth in the Netherlands from a warmer climate, while in the first and third studies the direct impact of climate change on crop growth is negative. In all three studies there is a separate public water services sector that supplies drinking water to all sectors and households. The raw water needed to supply this sector is considered in the third study, and left out of the analysis in the first and second studies.

**Table 1:** The three studies examined, the adaptation mechanisms and the model characteristics central to the study.

<b>The study and model</b>	<b>Adaptation Mechanism</b>	<b>Water modelling characteristics</b>	<b>Assumptions on water use</b>
1st study uses model 1 (GTAP-W)	Autonomous market adaptation	Irrigation water as explicit endowment in agriculture.	Explicit water use restricted to agriculture. Additional abstraction of groundwater not allowed.
2nd study, uses model 2 (Distinction between Surface and Groundwater)	Increased investment in irrigation infrastructure	Surface and ground water as separate endowments for irrigation in agriculture.	Explicit water use restricted to agriculture. Groundwater abstraction limited only by irrigation infrastructure.
3rd study, uses model 3 (Physical water markets)	Explicit water market across multiple sectors	Water as explicit endowment in agriculture, industry and public water services. Water market allows for trading between sectors.	Explicit water use in agriculture, industry and public water services. Additional abstraction of groundwater not allowed.

All three studies find that when assessing the economic impacts of climate change it is important to look at the larger economy wide effects including the sectors that are not directly affected by the aspect of climate change under examination. In the first study for example the reduction in agricultural production from water scarcity results in rising prices for agricultural products. The increased prices for their products already partially compensate agricultural producers for their loss of output although the price increases were not uniform per crop type. The non-agricultural sectors on the other hand were not directly affected by the hot dry climate in this analysis but they were negatively affected by the reduction in Dutch consumer income and the increased price of agricultural inputs. This insight could be useful in deciding where and how much to target policies aiming to reduce negative climate impacts on particular sectors or how they might be compensated for losses due to climate change.

The same is true when estimating the effects of a planned adaptation policy as examined in studies 2 and 3. It is important to look beyond the effects on the sectors directly affected by the intervention. In the second study increasing investment in surface water irrigation infrastructure helps farmers with access to surface water to take full advantage of the warm climate to increase their output. However the reduced crop prices which accompany the increase in total crop output affect the rain fed farmers as well as irrigated farmers with only access to ground water. In the third study the implementation of water markets increase the economic efficiency of the allocation of water, and increased overall economic output. However, not all sectors benefit. Any sector participating in a water market with the manufacturing sectors further reduce their output. Even in the scenario when agriculture is not participating in a water market with the manufacturing sectors, the increased economically efficient allocation of water allows manufacturing to further increase production and in so doing increase the demand for and price of other resources (labor and capital) that are also needed in agriculture. These economy wide effects make a strong argument for the use of CGE models in assessing the impacts of water scarcity from climate change.

By examining these studies together we also make a methodological point that even in a single country such as the Netherlands interpretations of the water endowment can vary significantly. This is particularly true when

the water endowment represents both the value of the water itself and also all expertise, capital etc... required to utilize the water resulting in increased consumption of the crop and higher crop yields.

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