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Industrialized watersheds have elevated risk and limited opportunities to mitigate risk through water trading

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ABSTRACT

Businesses are increasingly concerned about water scarcity and its financial impacts, as well as competing needs of other stakeholders and ecosystems. Industrialized watersheds may be at more serious risk from water scarcity than previously understood because industrial and municipal users have inelastic demand and a high value for water. Previous water risk assessments have failed to sufficiently capture these economic aspects of water risk. We illustrate how hydro-economic modeling can be used to improve water risk assessments at a basin scale and we apply the methodology to the industrialized Brazos River Basin (85% municipal and industrial withdrawals) and consider implications for The Dow Chemical Company's Freeport Operations in Texas, US. Brazos water right holders pay only operating and maintenance costs for water during normal periods; however, when shortages occur, leasing stored water or reducing production may be the only mitigation option in the short-run. Modeling of water shortages and the theoretical cost of leasing water under nine combined

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scenarios of demand growth and climate change suggests that water lease prices to industry could increase by 9–13X. At best, a more developed water rights and storage lease market could result in lower lease prices (2–3X); however, given that transactions would be limited it is more likely that prices would still increase by 4–13X. These results suggest that markets are unlikely to be a robust solution for the Brazos because, in contrast to other watersheds in the Western US, there is little reliable water to trade from low value users (agricultural) to high value users (industry and municipalities). Looking at demand trends across the contiguous US as an indicator of water risk, 2% of watersheds have municipal and industrial demands that outstrip total surface and ground water supplies and in these watersheds industry has historically paid higher lease prices for water. This study provides new ways for businesses to characterize water risk and forecast water prices that uncovers hidden water risk and highlights the positive but diminished mitigating effects of water markets in a highly industrialized basin.

1. Introduction

Businesses are increasingly using a variety of tools to report and manage their impacts and dependencies on water resources. As of 2012, 76% of the 250 largest businesses are reporting on water and 44% report plans to reduce water use [1]. Developing strategic plans for water presents new challenges to businesses. Currently, there are a variety of tools to help businesses assess water risk across sites, through their value chain, and within their supply chain [2–5]. Yet, these tools do not provide information on the economic value of water to the business or to other stakeholders. This means that businesses may underestimate risk or mis-characterize risk, especially in highly developed or industrialized river basins. A number of businesses have begun to make efforts to better understand the value of water and the approaches have been varied [6]. For example, Puma estimated the cost to society of water used in their supply chain and reported it in their Environmental Profit and Loss Account and Hitachi assessed the financial and social costs and benefits of a new water supply and treatment plant [7]. Here we demonstrate the use of basin-scale hydro-economic modeling to characterize water risk, forecast water prices, and assess market solutions. We apply this approach to inform business strategies for future scenarios of climate change and water demand at The Dow Chemical Company's largest facility in Freeport, TX at the mouth of the Brazos River.

Water is a unique resource that provides both private (e.g., bottled drinking water) and public (e.g., recreation) goods and services. As a result, markets do not provide good information on the value of water nor do they result in optimal allocation of water [8,9]. Hydro-economic models, or linked hydrological and economic models, therefore have been important tools to evaluate water policy and management decisions over the last 25 years [8]. Hydro-economic models vary in their particular design and complexity. However, the models are typically designed to represent spatially distributed water resource systems, infrastructure, and water demand by different types of users. Harou et al. [10] and Booker et al. [8] provide comprehensive and recent reviews of hydro-economic models and their applications. Although these models have been primarily used by governments, they may be of great use to businesses that want to better understand future trends in water shortages, economic losses, and prices at a basin scale in order to develop new water strategies and solutions.

Historic trends in economic development led to an increase in total water use and a reallocation of water from agriculture to municipalities and industry (M&I) [9,11]. Now the majority of the world's river basins are classified as water scarce [12] and, on average, 70% of water use in high-income