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LETTER

Water shortage risks from perennial crop expansion in California's Central Valley

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Abstract

California's Central Valley is one of the world's most productive agricultural regions. Its high-value fruit, vegetable, and nut crops rely on surface water imports from a vast network of reservoirs and canals as well as groundwater, which has been substantially overdrafted to support irrigation. The region has undergone a shift to perennial (tree and vine) crops in recent decades, which has increased water demand amid a series of severe droughts and emerging regulations on groundwater pumping. This study quantifies the expansion of perennial crops in the Tulare Lake Basin, the southern region of the Central Valley with limited natural water availability. A gridded crop type dataset is compiled on a 1 mi^2 spatial resolution from a historical database of pesticide permits over the period 1974–2016 and validated against aggregated county-level data. This spatial dataset is then analyzed by irrigation district, the primary spatial scale at which surface water supplies are determined, to identify trends in planting decisions and agricultural water demand over time. Perennial crop acreage has nearly tripled over this period, and currently accounts for roughly 60% of planted area and 80% of annual revenue. These trends show little relationship with water availability and have been driven primarily by market demand. From this data, we focus on the increasing minimum irrigation needs each year to sustain perennial crops. Results indicate that under a range of plausible future regulations on groundwater pumping ranging from 10% to 50%, water supplies may fail to consistently meet demands, increasing losses by up to 30% of annual revenues. More broadly, the datasets developed in this work will support the development of dynamic models of the integrated water-agriculture system under uncertain climate and regulatory changes to understand the combined impacts of water supply shortages and intensifying irrigation demand.

1. Introduction

Agriculture in dry and semi-arid regions strongly depends on water availability, which often constrains crop planting decisions and agricultural expansion (Rockström *et al* 2007). Driven by rising global demand for food, many such regions have developed extensive water delivery infrastructure and/or relied on unsustainable rates of groundwater extraction. While crop choice and water use decisions are often made by individual landowners, the surrounding region also experiences the economic and environmental consequences (Pfeiffer and Lin 2012). These include hydrologic alteration caused by surface water storage and conveyance systems (Döll *et al* 2009), as well as groundwater depletion, a global challenge occurring primarily in areas of high agricultural development (Siebert *et al* 2010, Scanlon *et al* 2012, Famiglietti 2014). Groundwater overdraft leads to higher pumping costs, poorer water quality (Kang *et al* 2019), decreased well yields (Konikow and Kendy 2005), and land subsidence (Smith *et al* 2017, Jeanne *et al* 2019). These issues are exacerbated under poor governance as water users have little incentive to conserve (Ho *et al* 2016), particularly when individual