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Inspecting the Food–Water Nexus in the Ogallala Aquifer Region Using Satellite Remote Sensing Time Series

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Authors:



Yuting Zhou



Hamed Gholizadeh



G. Thomas LaVanchy  
Oklahoma State University



Emad Hasan  
Binghamton University

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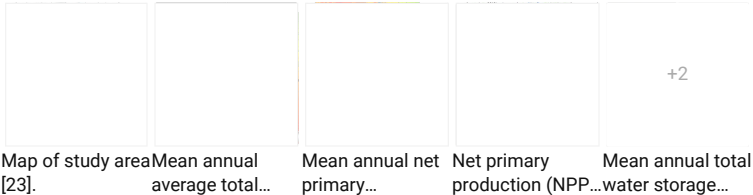
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Abstract and Figures

Agricultural production in the Great Plains provides a significant amount of food for the United States while contributing greatly to farm income in the region. However, recurrent droughts and expansion of crop production are increasing irrigation demand, leading to extensive pumping and attendant depletion of the Ogallala aquifer. In order to optimize water use, increase the sustainability of agricultural production, and identify best management practices, identification of food-water conflict hotspots in the Ogallala Aquifer Region (OAR) is necessary. We used satellite remote sensing time series of agricultural production (net primary production, NPP) and total water storage (TWS) to identify hotspots of food-water conflicts within the OAR and possible reasons behind these conflicts. Mean annual NPP (2001-2018) maps clearly showed intrusion of high NPP, aided by irrigation, into regions of historically low NPP (due to precipitation and temperature). Intrusion is particularly acute in the northern portion of OAR, where mean annual TWS (2002-2020) is high. The Oklahoma panhandle and Texas showed large decreasing TWS trends, which indicate the negative effects of current water demand for crop production on TWS. Nebraska demonstrated an increasing TWS trend even with a significant increase of NPP. A regional analysis of NPP and TWS can convey important information on current and potential conflicts in the food-water nexus and facilitate sustainable solutions. Methods developed in this study are relevant to other water-constrained agricultural production regions.



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## Article

# Inspecting the Food–Water Nexus in the Ogallala Aquifer Region Using Satellite Remote Sensing Time Series

Yuting Zhou <sup>1</sup>, Hamed Gholizadeh <sup>1</sup>, G. Thomas LaVanchy <sup>1,\*</sup> and Emad Hasan <sup>2</sup>

<sup>1</sup> Department of Geography, Oklahoma State University, Stillwater, OK 74078, USA; yuting.zhou@okstate.edu (Y.Z.), hamed.gholizadeh@okstate.edu (H.G.)

<sup>2</sup> Department of Geological Sciences and Environmental Studies, State University of New York at Binghamton, NY 13902, USA; emad.hasan@binghamton.edu

\* Correspondence: thomas.lavanchy@okstate.edu; Tel.: +1-405-744-5284

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**Abstract:** Agricultural production in the Great Plains provides a significant amount of food for United States while contributing greatly to farm income in the region. However, recurrent drought and expansion of crop production are increasing irrigation demand, leading to extensive pump and attendant depletion of the Ogallala aquifer. In order to optimize water use, increase sustainability of agricultural production, and identify best management practices, identification of food–water conflict hotspots in the Ogallala Aquifer Region (OAR) is necessary. We used satellite remote sensing time series of agricultural production (net primary production, NPP) and total water storage (TWS) to identify hotspots of food–water conflicts within the OAR and possible reasons behind these conflicts. Mean annual NPP (2001–2018) maps clearly showed intrusion of high NPP, aided by irrigation, into regions of historically low NPP (due to precipitation and temperature). Intrusion is particularly acute in the northern portion of OAR, where mean annual TWS (2002–2018) is high. The Oklahoma panhandle and Texas showed large decreasing TWS trends, which indicate the negative effects of current water demand for crop production on TWS. Nebraska demonstrated an increasing TWS trend even with a significant increase of NPP. A regional analysis of NPP and TWS can convey important information on current and potential conflicts in the food–water nexus and facilitate sustainable solutions. Methods developed in this study are relevant to other water-constrained agricultural production regions.

**Keywords:** remote sensing; Ogallala aquifer; food–energy–water (FEW) nexus

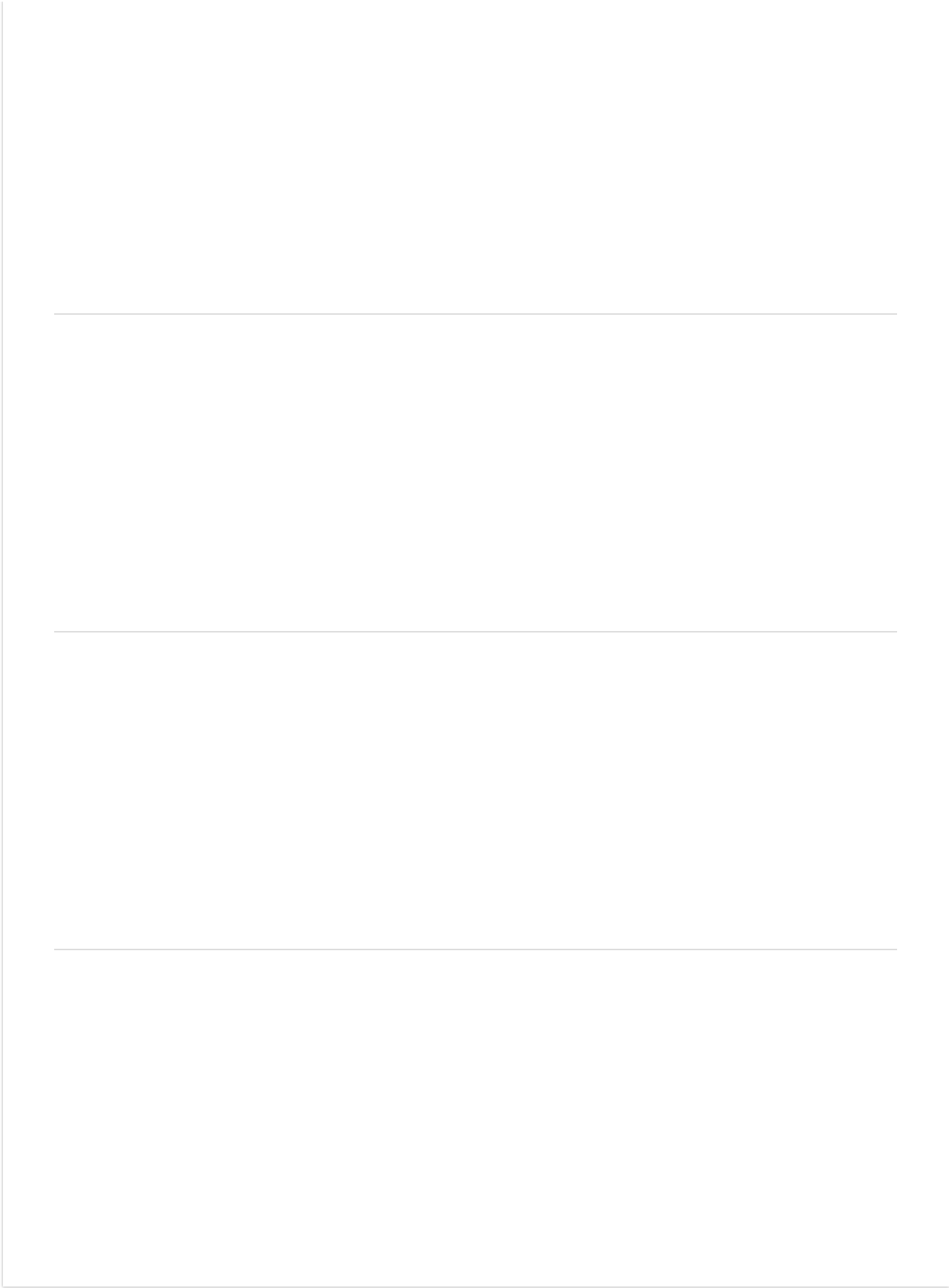
## 1. Introduction

Food, energy, and water are basic needs of each human being and thus the whole of society. These resources are also highly intertwined, resulting in the need to study them from an integrated standpoint. The food–energy–water (FEW) nexus approach has emerged as a powerful ontological tool for understanding and sustainably managing these resources [1,2]. The challenges to food, water, and energy from the continued rise of global population and associated rates of consumption are compounded by the political, economic, and social consequences of climate change. The forecast of increased threats to these resources highlights an increasing necessity to study the FEW nexus in an integrated manner. Although studies involving in situ observations are illuminative for the FEW nexus [3,4], government funding for resource monitoring is limited and faces gradual reduction and re-prioritization at the local and national level.

Remote sensing provides consistent and region-wide observations that can guide policy making and decisions in support of in situ observations. Various remote sensing products can be used to study food, energy, and water at the regional scale. For example, the U.S. Department of Agriculture







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February 2017 · IOP Conference Series Earth and Environmental Science

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Net primary production (NPP) is the difference between total photosynthesis (gross primary production, GPP) and total plant respiration in an ecosystem. NPP is a key component of the terrestrial carbon cycle and is important in global climate research. Tropical forests, distributed mainly in Central Africa, Central and South America, and Southeast Asia, are among the most important ecosystems on ... [\[Show full abstract\]](#)

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David W Hyndman · Erin Haacker · Anthony Kendall

A large imbalance between recharge and water withdrawal has caused vital regions of the High Plains Aquifer (HPA) to experience significant declines in storage. A new predevelopment map coupled with a synthesis of annual water levels demonstrates that aquifer storage has declined by approximately 410 km<sup>3</sup> since the 1930s, a 15% larger decline than previous estimates. If current rates of decline ... [\[Show full abstract\]](#)

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November 2020 · Environmental Science & Technology

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Novel low-pressure irrigation technologies have been widely adopted by farmers, allowing both reduced water and energy use. However, little is known about how the transition from legacy technologies affected water and energy use at the aquifer scale. Here, we examine the widespread adoption of low-energy precision application (LEPA) and related technologies across the Kansas High Plains Aquifer. ... [\[Show full abstract\]](#)

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