Biofuels and the Energy-Water Nexus

Perspectives for the United States

3rd Bioenergy Studies Symposium
Turkey, May 20-21, 2021

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INTRODUCTION

This study provides an assessment on the production of biofuels, such as ethanol and biodiesel, and the energy-water nexus in the United States. Transitioning the transportation sector to low carbon sources will require the use of both electricity and sustainable biofuels. A total transition to electricity could take several decades, given the size of the transportation fleet and front-end costs. Moreover, some parts of the transportation sector, such as aviation and shipping, may rely on biofuels (e.g., biokerosene and biodiesel) for an extended period due to technology barriers to using electricity. Therefore, under most future scenarios, biofuels will continue to play an important role in reducing transportation sector greenhouse gas emissions.

Both biofuels and thermoelectricity generation have a significant water footprint associated with their production cycles [1]. As electricity and biofuels gain a larger share of the transportation fuel market, the cumulative impact on water resources must be considered [2]. As shown in **Figure 1**, water use for thermoelectric power represents the largest share of the total water withdrawal in the U.S., followed by irrigation for crops [3]. **Figure 2** shows the use of water in different stages of corn growth, whereas **Figure 3** shows the current corn production areas. Thus, with or without biofuels expansion, water supplies must be a central component for both energy and agricultural planning.

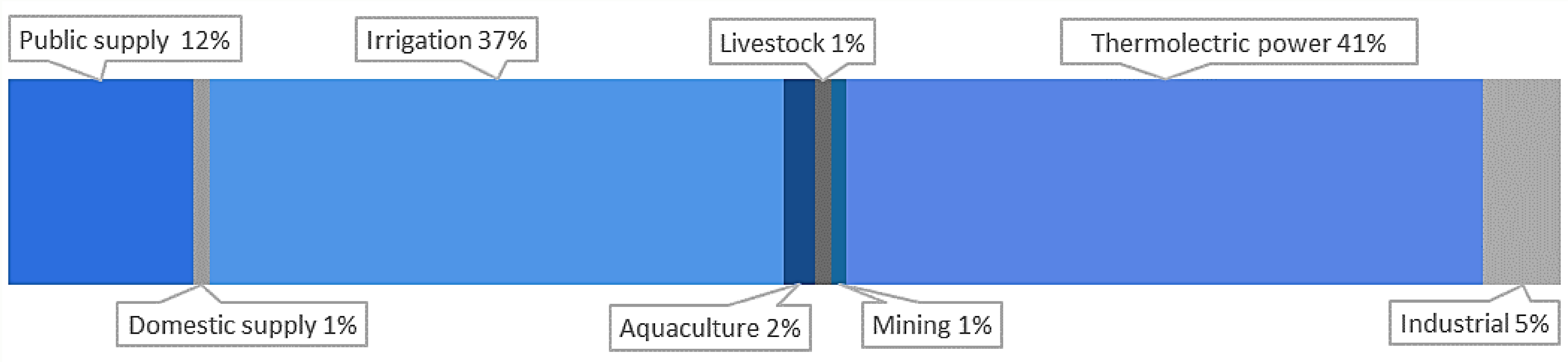

Figure 1: Total water withdrawals in the U.S. per category. **Source**: prepared by the authors, with data from USGS [3]

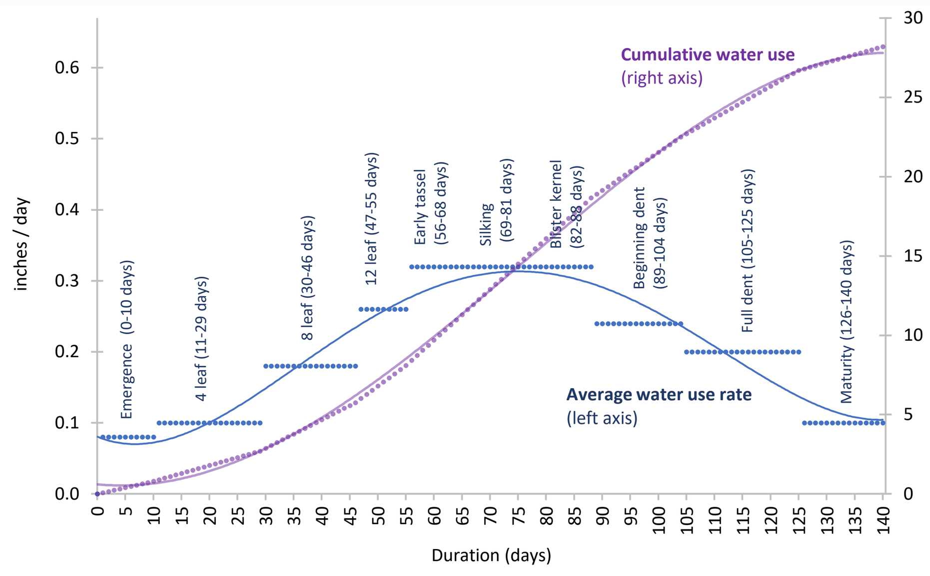

Figure 2: Daily and cumulative water required for corn production by growth stage for a long-term hybrid crop variety in South Central Nebraska. **Source**: prepared by the authors, based on data from the Clay Center [4].

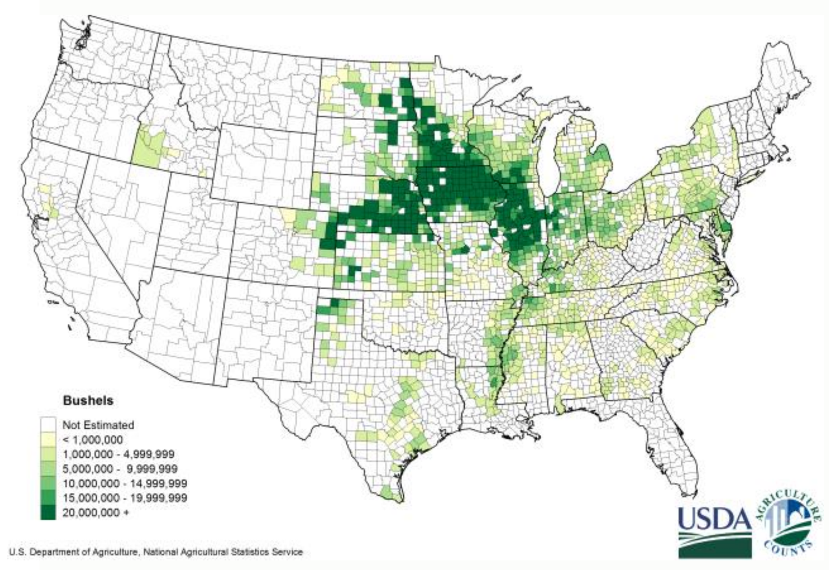

Figure 3: Production of corn for grain by county in the U.S. **Source**: USDA [5].

METHODS

This assessment was based on literature review and stakeholder consultation. We examined how some biofuel policy choices may affect water quantity in the United States and developed some corn-based ethanol production scenarios by 2030 for policy discussion, using USDA trends for corn production as a reference (Figure 4).

RESULTS AND DISCUSSION

To date, biofuel production in the U.S. has not been limited by water availability. Nonetheless, recent data suggest that feedstock crop acres have expanded into some water stressed areas and that further expansion of biofuel production could exacerbate water scarcity in some areas, if precautionary measures are not addressed. Some simulations show, however, that it is possible to expand corn-based ethanol nationwide over the next ten years, without causing an additional use of water and land resources, based on yield growth on existing acreage.

Figure 5 shows a scenario based on USDA forecast [6], in which we estimate that ethanol production (currently around 16 billion gallons per year) would not have a significant increase in the next 10 years. Some alternative simulations to increase ethanol production (without acreage expansion) by 40% and 100% in the same period are presented in Figures 6 and 7, respectively.

OBJECTIVES

To provide an overview on the main impacts of biofuels production on water resources within the U.S., with an emphasis on the corn-based ethanol market, as a technical contribution to the policy debate. The following issues were examined: i) the relationship between biofuel production and water availability; ii) trends and policy options for future biofuel production and the tradeoffs for water scarcity; and iii) considerations for policy makers who seek to reduce the future impact of biofuels on water sustainability.

FINAL CONSIDERATIONS

We recommend that policies and regulations should establish clear incentives to reduce agricultural water withdrawals in critical zones in favor of rainfed crops. Future policies should support sustainable water management and develop markets for advanced biofuels, aiming to minimize both irrigation and carbon intensity.

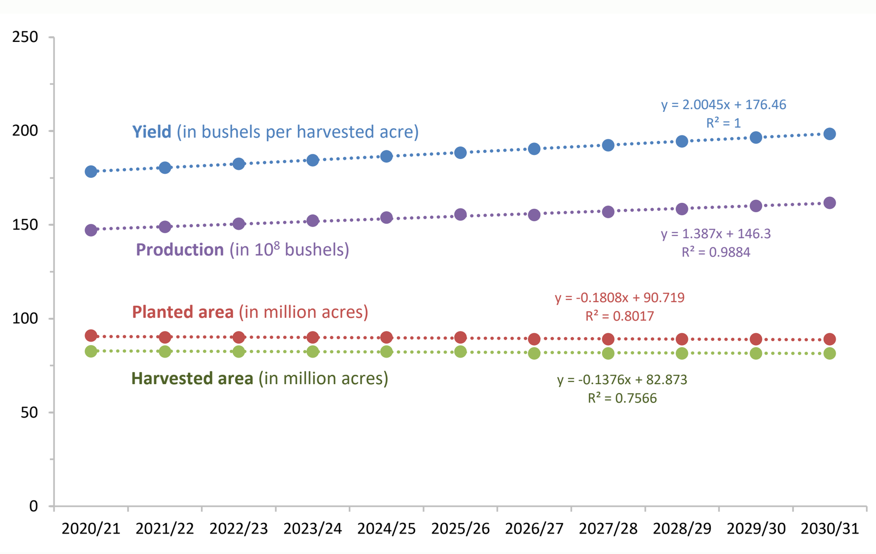

Figure 4: Official projections for corn area, production, and yield in the U.S., per crop year. **Source**: prepared by the authors, based on USDA [6].

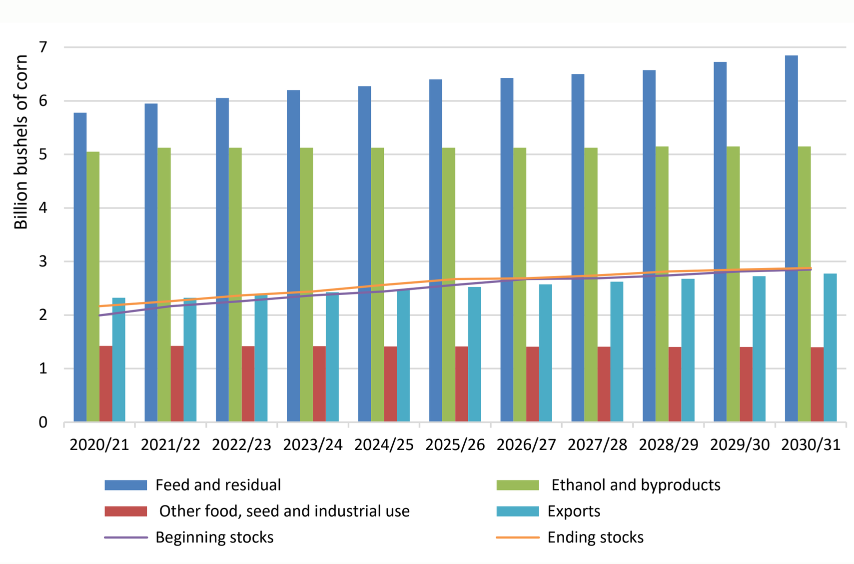

Figure 5: Official projections for corn use (column graphs) and socks (line graphs) in the U.S., per crop year. **Source**: prepared by the authors, based on USDA [6].

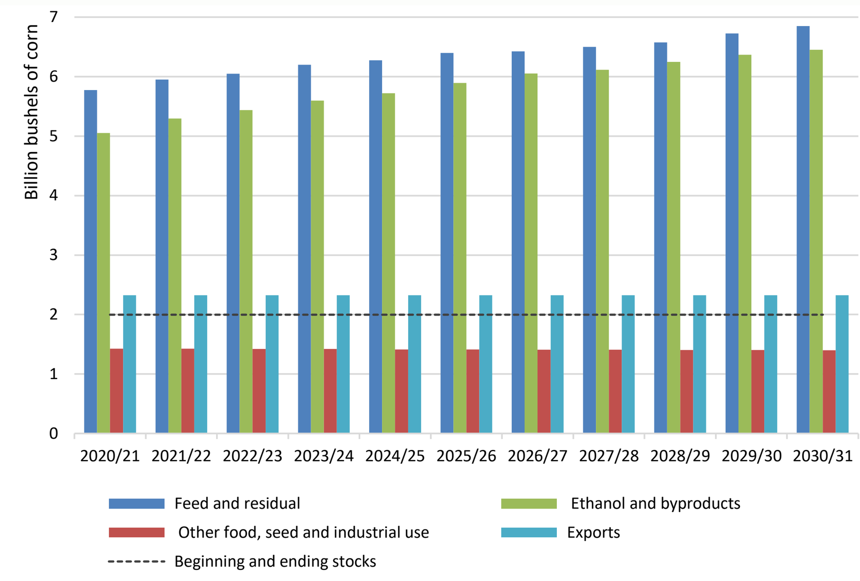

Figure 6: Ambitious corn to ethanol simulation, with adapted projections for corn use (column graphs) and socks (dashed line) in the U.S., per crop year. **Source**: prepared by the authors, adjusted from USDA [6].

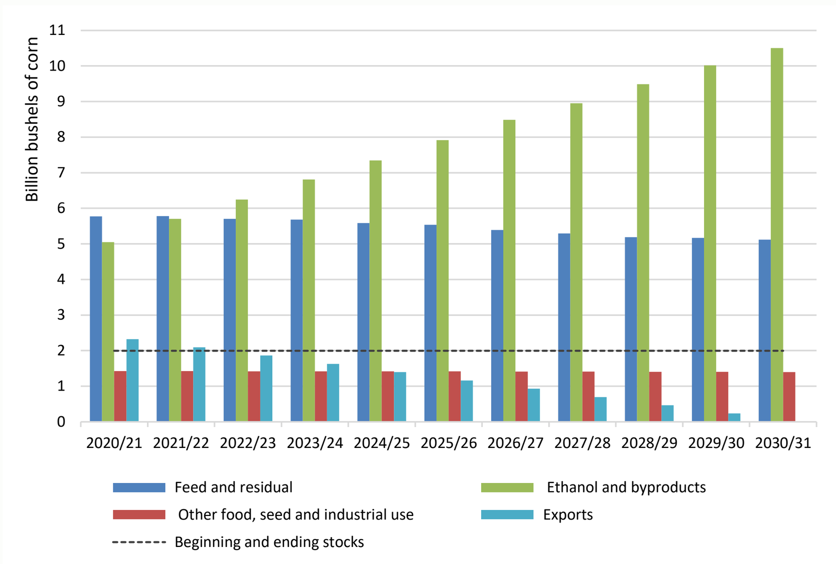

Figure 7: Very ambitious corn to ethanol simulation, with adapted projections for corn use (column graphs) and socks (dashed line) in the U.S., per crop year. Source: prepared by the authors, adjusted from USDA [6].

ACKNOWLEDGEMENTS:

The authors acknowledge POET Biorefining LLC and the Roy Family Fund for their support of the Environment and Natural Resources Program (ENRP) at the Belfer Center for Science and International Affairs, Harvard Kennedy School. The company had no role in the preparation of this paper and the opinions here shown do not necessarily represent the views of POET. The authors also thank the valuable comments made by Keith Kline from the Oak Ridge National Laboratory (ORNL) in this study.

NOTE:

The full study is available as a Belfer Center Working Paper (in press) at: www.belfercenter.org/enrp

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Credit: Corn field picture by Todd Trapani (available in open access on Pexels).