Water & Biofuels
A Primer

Introduction

Currently nearly one billion people lack access to safe water and 2.5 billion live without improved sanitation[1]. As water demands increase due to population growth, urbanization, and economic development and climate change results in more erratic and severe weather patterns attention on water use, its allocation, governance, and impacts (particularly in water-stressed regions) are likely to increase. The impacts of these trends will particularly be felt in the developing world—which contains important regions for biofuel production—where they directly affect human health and economic livelihood.

Water is a finite and local resource essential for agricultural and industrial production, vibrant communities, and healthy ecosystems. It has long been the case that agriculture has been the predominant consumer of water across the globe—up to 70 percent in some regions. This allocation is understandable when one considers that agriculture produces the necessities of life, such as food, fibers and—increasingly—fuel. As water demands increase, however, it is likely that water use in agriculture will come under greater scrutiny and—regardless of actual or perceived correlations—may be linked to water scarcity and availability.

In the production of biofuels, particularly feedstock production in which the bulk of water consumption occurs, access to water could become a key factor in the development of a vibrant biofuel industry. Ensuring optimal use of water—whether measured by hectare, energy produced per ton of feedstock, or a combination of these—will be increasingly important, particularly in water-stressed or water-scarce regions.

To better understand the future connection between water and biofuels, it is helpful to be familiar with the basics of water, common principles of good water governance, biofuels' water footprint, and worldwide distribution of water.

Water Basics

Water cycle

The basic water cycle in the context of agriculture production consists of evaporation and transpiration from plants and soil (evapotranspiration) into a vapor that rises and condenses in clouds before it returns to the land—or water bodies—in the form of rain, snow or hail. Precipitation can either be absorbed in the soil, percolate to aquifers, or runoff to streams, lakes, or other bodies of water.

Watersheds and ecosystems

A **watershed** is an area of land that drains all the water and rainfall to a common outlet (e.g., reservoir, bay, ocean). There can be many uses of water within a watershed—personal use, sanitation, manufacturing, energy and food production—in addition to the ecological requirements.

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[1] Water.org

An **ecosystem** is a biological environment consisting of all the organisms living in a particular area. It also encompasses nonliving physical components with which the organisms interact, including water. **Ecosystem services** are the benefits (direct and indirect) that people obtain from ecosystems.

The confinement and interdependence of water and water users or beneficiaries within a watershed and ecosystem creates a localized setting through which water is available, impacted, and impacting. This condition must be considered when governing, managing, measuring, and using water.

Climate change impacts

Climate change will directly affect the biofuels feedstock production stage of the supply chain as a result of rising sea levels—which could lead to salinization of freshwater aquifers, reduced water storage in snow and glaciers, and more frequent and severe droughts and floods—which are expected to be disproportionately felt by developing countries. Additionally, climate change will impose indirect impacts on the processing stages of the biofuels supply chain, through changes in the demand for and availability, timing and quality of water.

Measuring water

Depending on how water is viewed and accounted for in the water cycle, water use and impacts can be measured in varied ways. For example, water used for irrigation is easily measured, but the quantity used does not necessarily correspond with the actual amount of water consumed to make a product versus the quantity of water that re-enters the water cycle through evapotranspiration and—by most accounts—should not be considered part of that product's water footprint. The following definitions can aid in the measuring, modeling and reporting of water footprints in the context of different sources of water.

> **Blue water** – Fresh surface and groundwater, i.e., the water in freshwater lakes, rivers, and aquifers.
>
> **Green water** – The precipitation on land that does not run off or recharge the groundwater, but is stored in the soil or temporarily stays on top of the soil or vegetation.

It is also important to consider water boundaries and allotments when measuring the water impacts of a product along the biofuels supply chain. Life cycle assessment methodologies, developed to ensure that credible and comparable measurements are calculated, often set boundaries and establish allocation principles within a given sector or supply chain.

The local or temporal conditions under which the feedstocks are grown should also be taken into account. Water consumed in a water-scarce region or consumption that reduces water flow necessary for the health of the surrounding ecosystem is likely to result in more significant negative impacts than water consumed in regions that don't suffer water scarcity.

Water Governance

Water governance incorporates systems—political, social, economic, and administrative—to develop and manage water resources and delivery to different members of society. Elements of a strong water governance program should include mechanisms and processes through which all involved stakeholders communicate their needs, exercise their legal rights and mediate their differences to develop fair and equitable water programs.

Water governance can exist at a local (watershed) level, national level, or regional (transboundary) level. The interconnections between these different governance programs should be considered to optimize their effectiveness and integrity.

Biofuels and Water

Water is a critical input for many processes in the biofuel value chain, such as feedstock production, fermentation, distillation, and cooling during the process of converting the feedstock into biofuel. As with other agricultural crops, water impacts of biofuel production can include water consumed in the feedstock production and processing. Additionally, impacts of effluent—whether nutrient-rich agricultural runoff or processing wastewater—on receiving bodies of water needs to be considered.

Biofuels water footprint

The water footprint of a biofuel is equal to the cumulative water used during each stage of its production, processing, and refining. For virtually all forms of biofuels, the vast majority of the water footprint is at the feedstock production stage of the value chain. Water requirements for feedstock production range from approximately 500 to 2,000 liters of water per liter of ethanol produced, compared to ethanol refining facilities that consume approximately 2 to 10 liters of water per liter of ethanol produced[2].

The water impacts can also vary widely depending on the type of feedstock and where it is grown. Crops can be either rainfed—with all water requirements provided by natural precipitation and soil moisture—or irrigated, with at least some portion of water requirements met through applied water from surface or groundwater sources.

While rainfed agriculture can have negative impacts associated with water (e.g., contaminated runoff), water impacts of feedstocks are usually focused on irrigated crops.

Water consumption of different crops can be measured in a variety of ways: unit water consumed per hectare of irrigated land or per unit of crop produced are two metrics common for food and fiber crops. In terms of biofuels, it can also be—and may be best—measured in terms of water consumed per unit of energy produced from the resultant fuel.

As discussed above, while water footprint is important to understand since it measures total water use to produce a product, it does not always reflect the impact on hydrological scarcity or the risks that can result in the region where it was produced.

W*ater scarcity*

Water scarcity exists when available water is insufficient to meet the basic needs of society and the environment. It is not simply a factor of absolute quantity and can occur in both dry and moist climates. Figure 1 shows the variation of water-scarce regions—defined in terms of both physical water scarcity (availability of water for actual use) and economic water scarcity (when water may be available), but people lack access to the water they need due to insufficient infrastructure or financial capacity.

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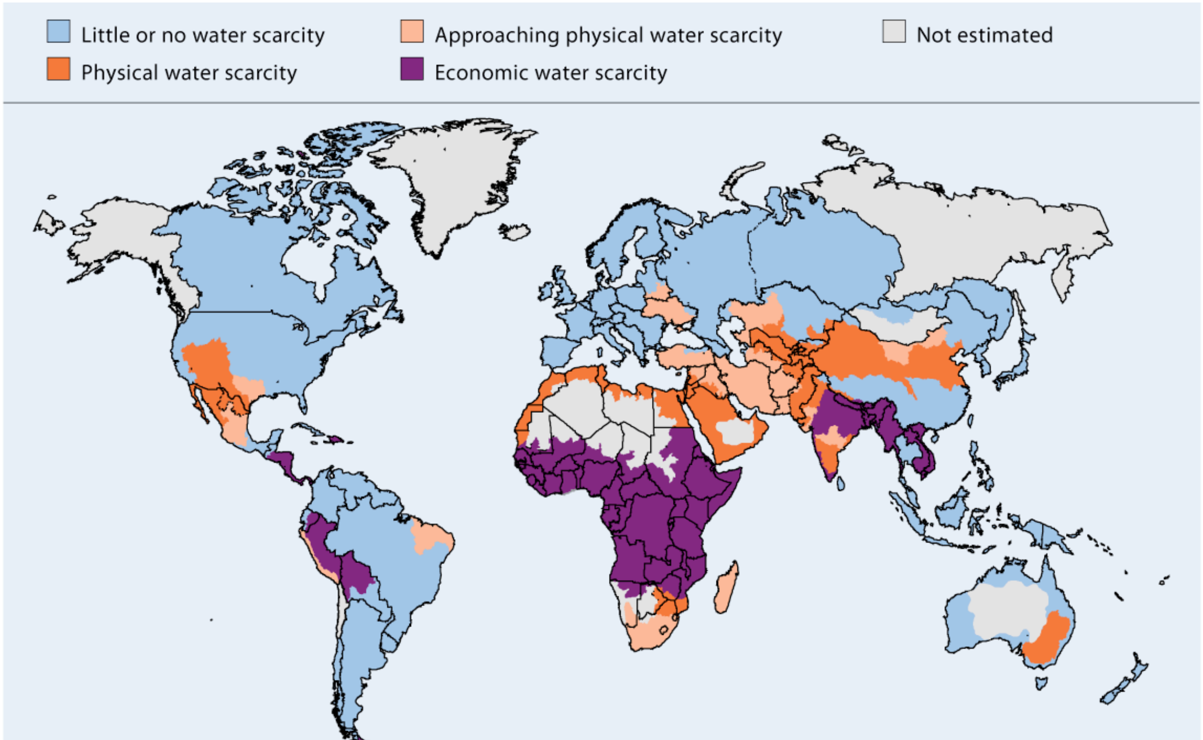
[2] Donner SD, Kucharik CJ. Corn-based ethanol production compromises goal of reducing nitrogen export by the Mississippi River, 2008.

Figure 1. Global Map: Areas of Physical and Economic Water Scarcity (2007)



Definitions and indicators

- *Little or no water scarcity*. Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.
- *Physical water scarcity (water resources development is approaching or has exceeded sustainable limits)*. More than 75% of river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition—relating water availability to water demand—implies that dry areas are not necessarily water scarce.
- *Approaching physical water scarcity*. More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.
- *Economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands)*. Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Source: International Water Management Institute analysis done for the Comprehensive Assessment of Water Management in Agriculture using the Watersim model; chapter 2.

Website Source: http://maps.grida.no/go/graphic/areas-of-physical-and-economic-water-scarcity

Regional variations

The distribution and availability of water varies significantly across different geographic and climatic regions. The severity of a water-related impact associated with agriculture production and processing will also depend on the water-availability conditions in the region in which it is grown or processed. For example, if water-thirsty crops are grown in arid areas, those crops will have a higher relative impact on the affected ecosystem and communities than if that crop were grown in a region that did not face water availability constraints. It is important to note that while irrigated agriculture can exacerbate conditions in water-scarce regions, it is not the cause. Water availability or scarcity is driven primarily by local hydrology, climate, and uses, as well as population and growth dynamics.

Conclusion

Water issues are complex. While agriculture depends on and impacts water resources, it is not the cause of global water scarcity. With this said, the biofuels industry and the communities in which it operates are likely to benefit from an improved understanding of the correlation of biofuels and water.