Water Wise
Are we getting enough crop per drop?

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The Key Challenge
Agriculture consumes far more water than any other human activity, linking the challenges of water sustainability and food security.

To evaluate the effectiveness with which water resources are used, we assess water productivity, edible energy produced (kcal) per unit of water evaporated (liter).

Water Productivity is Highly Variable
Water productivity, calculated as the sum of all kilocalories produced by 16 crops divided by the sum of water consumed by those crops, is shown for precipitation-limited areas: P + PET. Data for both rained (a) and irrigated (b) systems are centered at 1.5 kcal L⁻¹, close to the median water productivity reported (1.3 kcal L⁻¹) and irrigated (1.8 kcal L⁻¹) systems, so that areas of low water productivity are shown in red and areas of high water productivity are shown in green. In climates that are water potentially limited, we find that, among the 16 crops analyzed in this study, median water productivity differs by “5 kcal L⁻¹” among crops.

Increasing Water Productivity is Possible; The Impacts are Substantial
The range of crop water productivity is driven as much by management and soil as by climate, suggesting that farmers have substantial leeway to improve water productivity. For irrigated crops, the effect of climate on water productivity ranges from 2.8 – 4.8 kcal L⁻¹ while the effect of management and soil ranges from 1.0 – 4.7 kcal L⁻¹. In irrigated systems (b), climate effects range from 2.1 – 3.7 kcal L⁻¹ and management effects range from 1.6 – 4.6 kcal L⁻¹.

Water Use is Disproportionate
In areas where water is scarce and water productivity is low, increasing water productivity can relax pressure on the system. In contrast, if water is scarce and water productivity is high, increasing sustainability will require structural changes such as decreasing cropland and growing higher value crops, the income from which could then be used to import food from regions with less water scarcity. Our findings indicate substantial potential for increasing agricultural productivity without increasing water use.

Even a modest increase of water productivity to the 20th percentile in precipitation-limited regions could (a) increase caloric output on rained cropland by enough to provide food to “150 million people annually” (120 trillion kilocalories) without increasing water consumption and (b) reduce water consumption on irrigated cropland by enough to meet the annual domestic water demand of 1.4 billion people (“50 km³”).

Water Consumption Across Climate Zones
To feed the world, agriculture must be adapted across climate zones. The majority (93%) of water consumed by crops originates as rainfall on cropland (a). Irrigation water (b) provides only 1.7% of water, primarily in arid climates. Climate zones, most arid at the bottom and most humid at the top, are based on P/PET (insert map). Climate zones are evenly distributed in climate space.

Global distribution of water consumption by 16 staple food crops (a) and water consumption by those crops on irrigated cropland (b). Land that is not cultivated with those crops is shown in gray. The color categories for water consumption are log scaled to illustrate the wide range of water use. Volumes are distributed over 5° grid cells, an area of approximately 5,200 hectares.

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Water Consumption by Crops

Annual Water Consumption by Crops