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CALIFORNIA AGRICULTURAL WATER USE: KEY BACKGROUND INFORMATION

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INTRODUCTION

Water plays a substantial and vital role in California's agricultural sector. Given the long-term challenges facing California water and the short-term crisis imposed by the ongoing severe drought, policy makers, journalists, researchers, and the public have been clamoring for up-to-date data and information on agricultural production and water use. We offer here a short primer on these issues and will be producing more detailed assessments in the coming weeks and months.

Perhaps the most important characteristic of California's agricultural water-use information is how poor it is. There are large uncertainties regarding agricultural water use due to a lack of consistent measurement and reporting, time lags in releasing information, and confusion about definitions. Data on agricultural production and water use are not collected at all, or are collected by individual irrigation districts, counties, and a variety of state and federal agencies using a range of tools from voluntary reporting at the field level to remote sensing from satellites. Additional estimates of water use come not from actual observations or reporting but from model estimates and other techniques for projecting use. In order to truly understand the risks and opportunities for water use in California, more and better data are needed.

WATER TERMINOLOGY

This report uses several terms to describe agricultural water use, including water use, applied water, water intensity, and economic productivity. These are described in more detail, below:

- ***Water use*** refers to water taken from a source and used for agricultural purposes, such as crop irrigation, frost protection, and leaching salts from soil. It includes conveyance losses, i.e., seepage or evaporation from reservoirs and canals, that occur as water is moved from the source to the agricultural field. Here, the term "water use' includes both consumptive and non-consumptive uses.
- ***Applied water*** is a subcategory of agricultural water use that refers specifically to water that is applied over the land surface by various application techniques to meet individual crop water requirements. It does not include conveyance losses. It also includes both consumptive and non-consumptive water use.
- ***Water intensity*** refers to the amount of water applied to a crop per acre of irrigated land, as measured by the average depth of water applied to the crop.
- ***Economic productivity of water*** refers to the economic value produced per acre-foot of water applied to the crop, as measured in dollars per acre-foot.

Agricultural water use can be further divided into consumptive and non-consumptive water use. The term ***consumptive use*** or ***consumption*** typically refers to water that is unavailable for reuse in the basin from which it was extracted, due to evaporation from soils and standing water, plant transpiration, incorporation into plant biomass, seepage to a saline sink, or contamination. It is sometimes referred to as irretrievable or irrecoverable loss as well as net water use. ***Non-consumptive use***, on the other hand, refers to water available for reuse within the basin from which it was extracted, such as through return flows. Non-consumptive use is sometimes referred to as recoverable loss. This water often has elevated levels of salts and other pollutants.

AGRICULTURAL WATER USE

For many years, the California Department of Water Resources (DWR) has generated estimates of agricultural water use that are used in long-term planning efforts by the state and captured in the state's water plan update (Bulletin 160). ***These estimates are not actual observations or measured use,*** but are modeled based on a combination of irrigated area, crop type and associated water requirements, and weather, and given that these factors change on an annual basis, show considerable annual variability. These data indicate that agricultural water use has generally ranged from 30 to 37 million acre-feet per year since the mid-1960s (Figure 1). Agricultural water use was relatively low (27 million acre-feet) in 1998 due to an El Nino that brought cool temperatures and wet weather during the spring months and relatively high in hotter, drier years when irrigation demands increase[1]. The data also suggest that overall agricultural water use has increased slightly since the early 2000s, although variability and uncertainty make it difficult to draw robust conclusions. It is of note that newer estimates using updated techniques, also produced by DWR and described in Orang et al. (2013), suggest that agricultural water use may be 20% to 30% higher than previous estimates but with the same general trends, highlighting the challenges in evaluating agricultural water use trends in California.

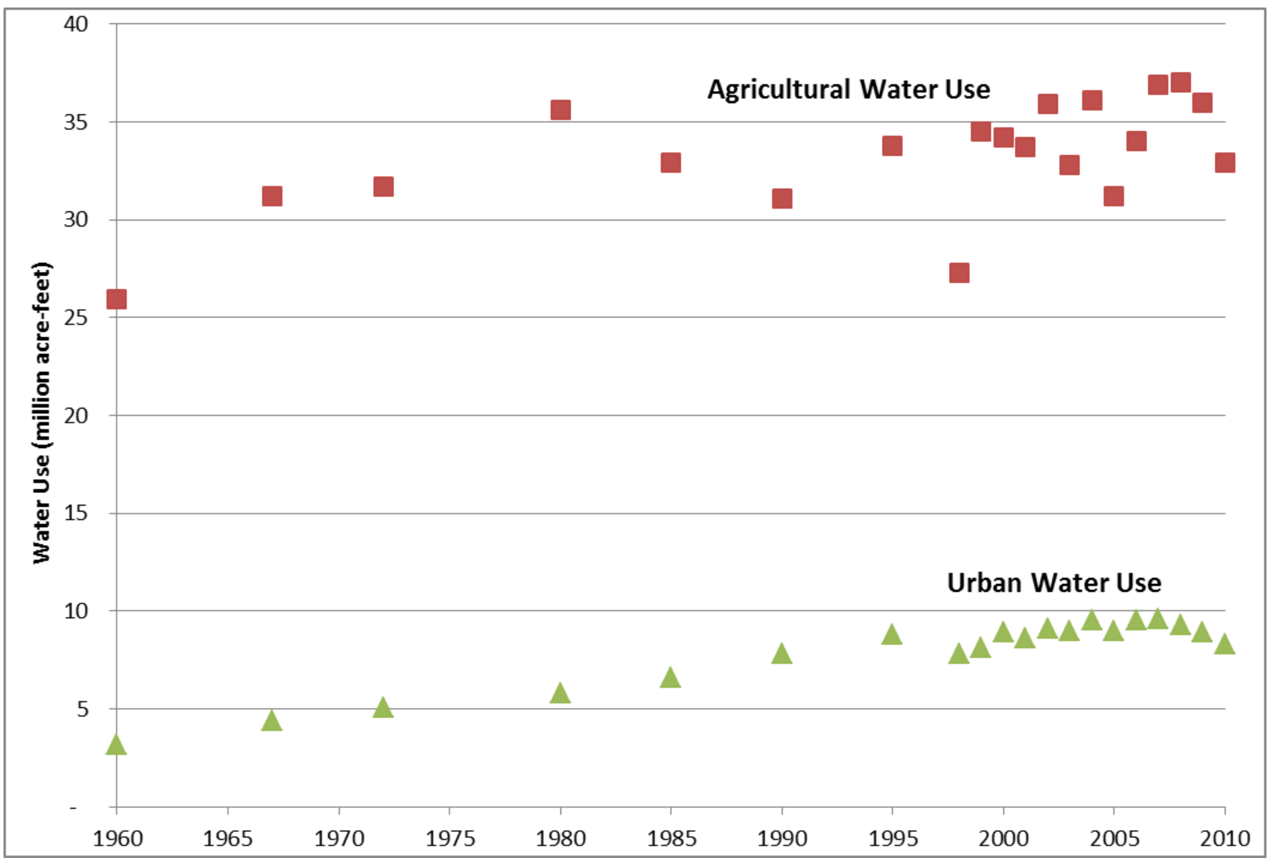

Figure 1. Agricultural and urban water use in California, 1960 – 2010.

Note: These estimates include conveyance losses that occur as water is moved from the source to the end use.
Sources: DWR (1964, 1970, 1974, 1983, 1987, 1993, and 2014)

APPLIED WATER FOR CALIFORNIA CROPS

California produces a highly diverse array of agricultural products in varying amounts and with different water requirements. These crops are commonly grouped into 20 crop categories (Appendix). Figure 2 shows the applied water by crop type in 2010, the most recent year for which water data are available. In 2010, the single largest user of water was alfalfa, with an estimated 5.2 million acre-feet of applied water. A large and growing amount of water was also applied to almonds and pistachios, which together used 3.8 million acre-feet of water, 54% higher than in 2000. Irrigated pasture and rice represent the third and fourth largest water user, respectively, in California.

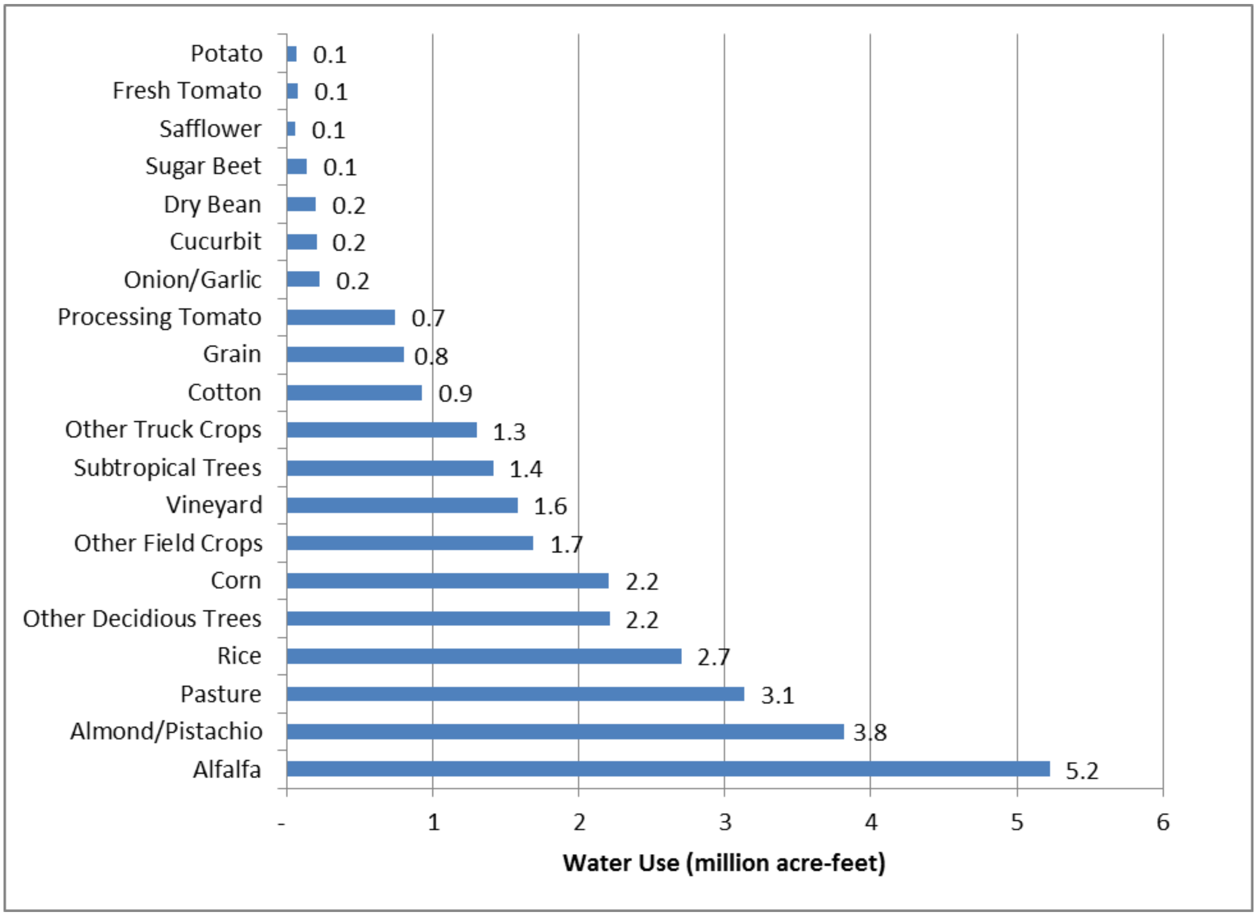

Figure 2. Applied water for California crops in 2010

Source: DWR (2014)

WATER INTENSITY OF CALIFORNIA CROPS

Figure 3 provides information on the water intensity of California crops, as measured by the average depth of water applied to a crop. Water intensity is a function of the plant water requirements and weather conditions in the areas those crops are grown, with crops requiring less water under cool, wet conditions and more water under hot, dry conditions. Here, we show a range of water intensity across California for 1998 through 2010 (DWR 2014). Rice and alfalfa, for example, are the most water-intensive crops grown in California, requiring 5.1 feet and 4.9 feet of water, respectively. At 4.2 feet, pasture is also relatively high. By contrast, grains and safflower are much more water thrifty, requiring 1.5 and 1.4 feet, respectively. Wine and table grapes are also fairly low, average 1.6 feet of water, while almonds and pistachios require an average of 4.0 feet.

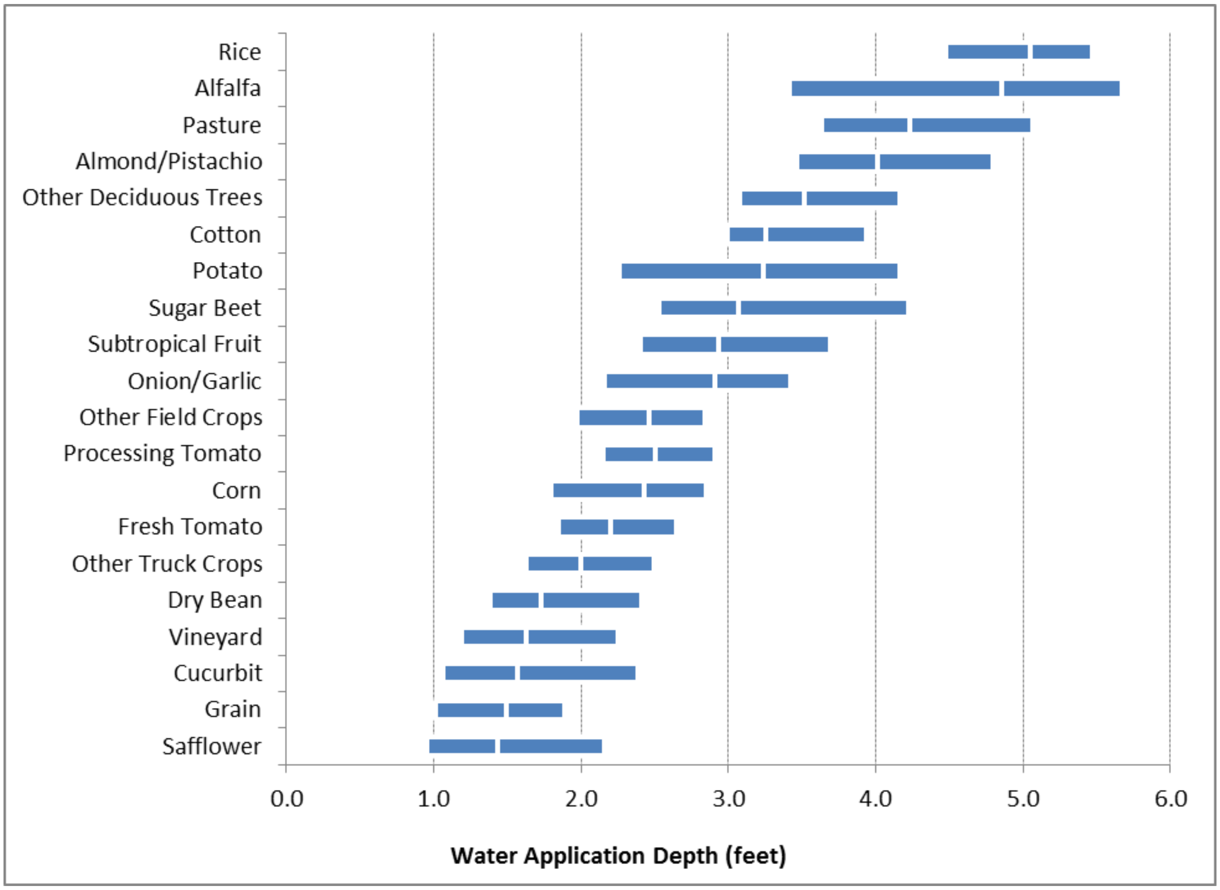

Figure 3. Water intensity of California crops, as measured by water application depth

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Note: The range shown reflects the first and third quartile of the water application depth for the period 1998-2010, and the white line within that range reflects the median application depth during that period.
Source: DWR 2014

ECONOMIC PRODUCTIVITY OF WATER

Farmers make decisions about crop types based on a wide variety of factors, ranging from soil quality to market and economic conditions to water availability to the kinds of equipment in their barns. It is worthwhile, therefore, to look at some of these in the context of water. A key measure of agricultural production is the "economic productivity" of water use – the economic value produced per unit of water applied to the crop. Figure 4 shows the gross revenue (as measured by total farm gate value) for crop production in California per acre-foot of water between 2000 and 2010. All values have been adjusted for inflation and are shown in year 2014 dollars. During this period, the overall economic productivity of water increased from $660 to $910 per acre-foot. This trend was driven by several factors, including a shift toward higher-value crops, which has increased economic returns, and the increased adoption of more-efficient irrigation technologies and practices, which has reduced the volume of applied water. For example, the total and percentage of cropland using flood irrigation has steadily declined, replaced by precision drip and micro-sprinkler irrigation systems (Tindula et al. 2013).

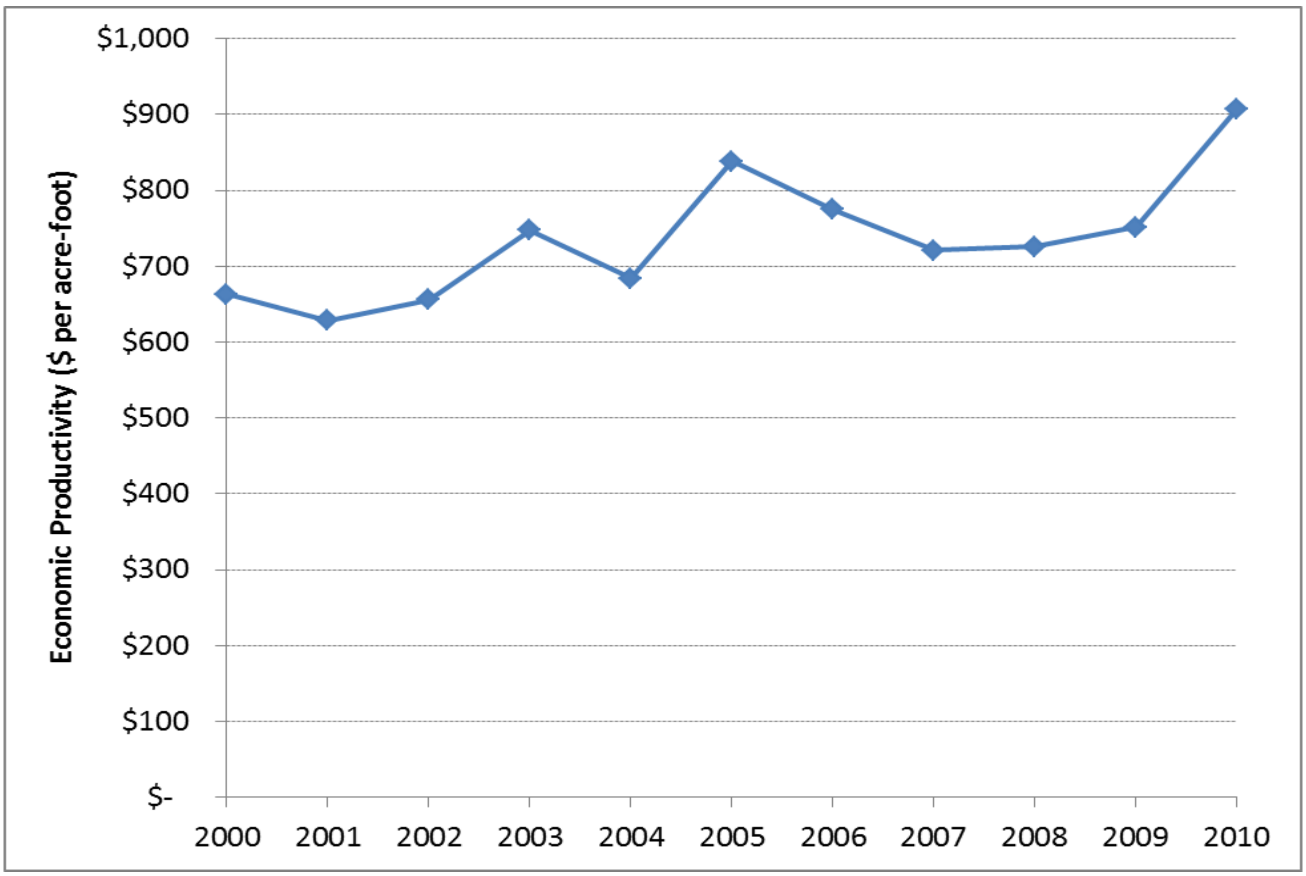

Figure 4. Economic productivity of water in California, 2000-2010

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Note: All values are shown in year 2014 dollars.

Source: Crop production values are based on figures from the U.S. Department of Agriculture (USDA-NASS 2015). Water use values for 2000-2010 are based on DWR Statewide Water Balances data (DWR 2014)

The economic productivity of water varies by crop type (Figure 5). For example, the total value of almonds and pistachios grown in California in 2010 was $4.4 billion, generating $1,200 in revenue per acre-foot of water applied. The economic productivity of onions/garlic and tomatoes was also relatively high, generating $2,200 and $1,700, respectively, for every acre-foot of water applied. By contrast, the value of rice was $1.0 billion (equivalent to $370 per acre-foot of water applied), and the value of alfalfa was $910 million (equivalent to $170 per acre-foot of water). It is of note that these values do not reflect the role that some crops play in supporting other industries. For example, alfalfa supports the state's beef and dairy industry and the value it produces; likewise, almonds support several industries and are now used in beauty and food products, e.g., almond butter and almond milk.

We note that while these values provide some insight into choices that farmers make, agricultural decisions cannot be made based only on economic productivity numbers. No one would propose, for example, that only vineyards be planted because of its high value per unit water or that no field crops be grown in California.

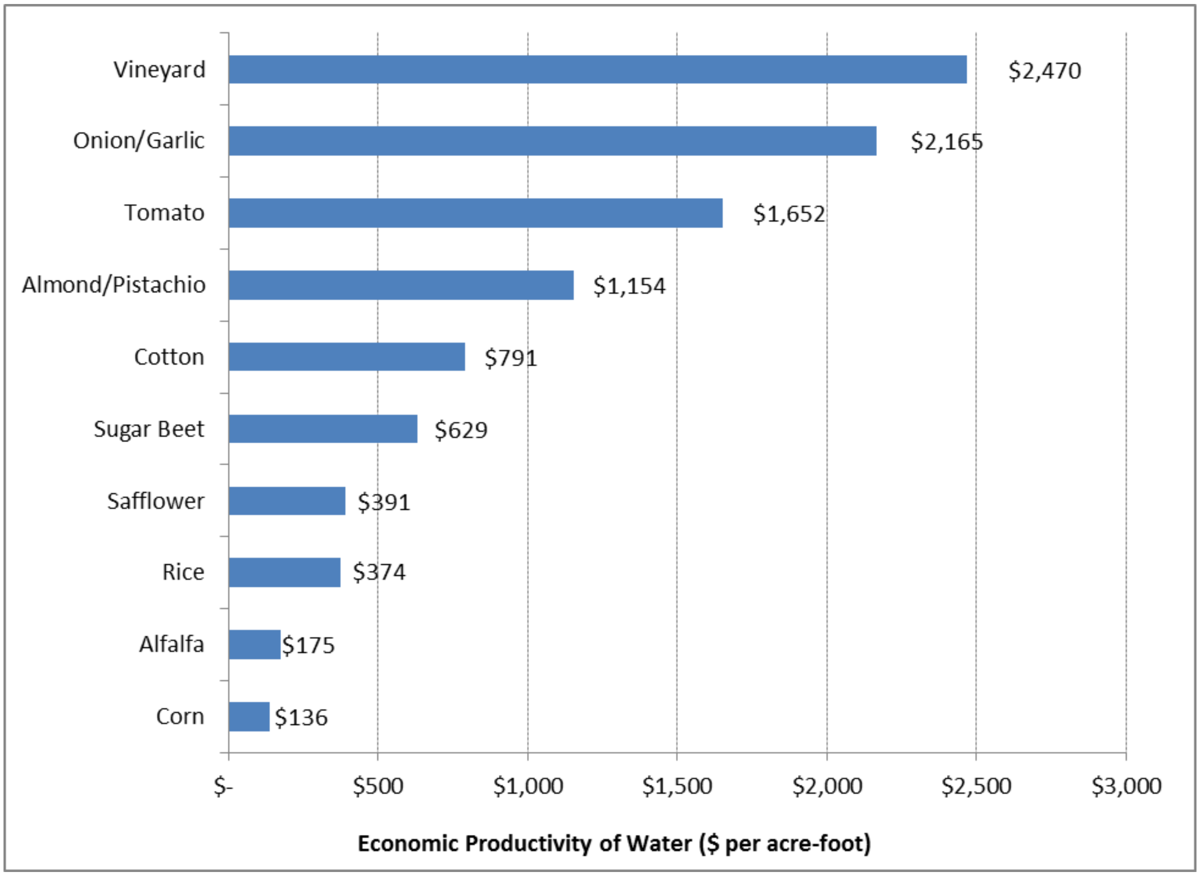

Figure 5. Economic productivity of water in 2010 for select crops grown in California.

Note: All values are shown in year 2014 dollars. All values are rounded to two significant figures.
Source: Crop production values are based on figures from the U.S. Department of Agriculture (NASS-CA 2015). Water use values for 2010 are based on DWR Statewide Water Balances data (DWR 2014)

CONCLUSIONS

California agriculture uses an estimated 80% of the state's developed water supply. As the state enters the fourth year of a severe and intensifying drought, this simple fact has shined a spotlight on the state's agricultural sector and its use of water. Indeed, some point to the large volume of water used for certain crops as an indication of widespread waste and inefficiency.

The reality is far more complex. Growing crops uses a lot of water, and the agricultural sector's use of water in California is consistent with global water use (of which about 70% is used for agriculture). To better understand agricultural water use and associated trends, we must look beyond total water use and consider other metrics, such as the water intensity of crops and the economic productivity of water. These metrics often show a much more complex story.

But even these fall short. In particular, they do not provide sufficient information to evaluate how efficiently water is being used across the state. The Pacific Institute and others have explored the potential for improving water-use efficiency in the agricultural sector (CALFED 2000 and 2006, Cooley et al. 2009), and more detailed analyses of the opportunities in this sector are needed as a means of reducing agriculture's vulnerability to water supply constraints and improve its long-term sustainability.

APPENDIX

DWR Crop Category	Crop
Grain	Wheat, barley, oats, miscellaneous grain and hay, and mixed grain and hay
Rice	Rice and wild rice
Cotton	Cotton
Sugar Beet	Sugar beets
Corn	Corn (field and sweet)
Dry Bean	Beans (dry)
Safflower	Safflower
Other Field Crops	Flax, hops, grain sorghum, sudan, castor beans, miscellaneous fields, sunflowers, hybrid sorghum/sudan, millet, and sugar cane
Alfalfa	Alfalfa and alfalfa mixtures
Pasture	Clover, mixed pasture, native pastures, induced high water table native pasture, miscellaneous grasses, turf farms, bermuda grass, rye grass, and klein grass
Processing Tomato	Tomatoes processed for canning, sauces, etc.
Fresh Tomato	Tomatoes for market
Cucurbit	Melons, squash, and cucumbers
Onion/Garlic	Onions and garlic
Potato	Potatoes
Other Truck Crops	Artichokes, asparagus, green beans, carrots, celery, lettuce, peas, spinach, flowers nursery and tree farms, bush berries, strawberries, peppers, broccoli, cabbage, cauliflower, and brussel sprouts
Almond/Pistachio	Almonds and pistachios
Other Deciduous Trees	Apples, apricots, cherries, peaches, nectarines, pears, plums, prunes, figs, walnuts, and miscellaneous deciduous
Subtropical Trees	Grapefruit, lemons, oranges, dates, avocados, olives, kiwis, jojoba, eucalyptus, and miscellaneous subtropical fruit
Vineyard	Table grapes, wine grapes, and raisin grapes

Source: DWR (2014)

ENDNOTES

[1] An acre-foot is a quantity of water that would flood an acre of land one foot deep, or 325,851 gallons.

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