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THE MULTIPLE BENEFITS OF WATER EFFICIENCY FOR CALIFORNIA AGRICULTURE

California farmers have made progress in updating and modernizing irrigation practices, but despite past efforts, great untapped potential remains to use water more efficiently. Water efficiency – defined as measures that reduce water use while maintaining the benefits water provides – has been shown to be a cost-effective and flexible tool to adapt to drought as well as to address longstanding water challenges in California. Moreover, today's investments in efficiency will provide a competitive advantage in the future and ensure the ongoing strength of the agriculture sector in California.

Water-efficiency improvements offer multiple benefits. Some of the water saved represents new supply that can be dedicated to other uses, and efficiency improvements that do not produce new supply provide other important co-benefits (Gleick et al. 2011). They can, for example, help farmers maintain and even improve crop yields and quality; protect water quality; reduce fertilizer, water, and energy costs; and boost profits. This paper and infographic describe some of these benefits. We conclude that an improved understanding of these benefits, and the strategies to achieve them, expand the portfolio of policies that can be applied to solve key issues of concern in California, including water-supply reliability, conflicts among water users, the risks of droughts, worsening water quality, and ecological degradation.

WATER TERMINOLOGY

The water literature is rife with confusing and sometimes misleading terms about "water use" and "water efficiency." It is important to clarify the uses of these terms, as different meanings can lead to different conclusions about water-management options. Here, we focus on definitions relevant to the agricultural sector, though similar terms are used broadly across all sectors.

- **Water withdrawals** refer to water taken from rivers, streams, and groundwater aquifers. These withdrawals can be divided into two categories: consumptive and non-consumptive uses.

- **Consumptive use** refers to water that is unavailable for reuse in the basin from which it was extracted due to evaporation, incorporation into plant biomass, transfer to another basin, seepage to a saline sink, or contamination. These are sometimes referred to as **irrecoverable losses**.

- **Non-consumptive use** refers to water that is available for reuse within the basin from which it was extracted, for example through return flows. This water, also referred to as **recoverable losses**, usually has elevated levels of salts and other pollutants.

Water use can be further divided into beneficial and non-beneficial uses. Beneficial uses in agriculture include those that contribute to crop production and quality, including crop transpiration and water used to leach salts from the root zone. Non-beneficial uses include those that do not contribute to crop production, such as unproductive transpiration from weeds; evaporation from reservoirs, canals, sprinklers, soil, and plant surfaces; and return flows that are not captured and reused. Beneficial use can be either consumptive or non-consumptive. Likewise, non-beneficial use can be either consumptive or non-consumptive (Table 1).

Table 1. Examples of beneficial and non-beneficial consumptive and non-consumptive uses

	Consumptive Use	Non-Consumptive Use[1]
Beneficial Use	-Crop evapotranspiration -Evaporation for cooling -Evaporation for frost protection	-Water for leaching
Non- Beneficial Use	-Phreatophyte evapotranspiration[2] -Weed evapotranspiration -Spray evaporation -Evaporation from soil -Reservoir and canal evaporation	-Excess deep percolation -Excess surface runoff -Operational spill

Notes:

(1) These represent non-consumptive uses if the water can be captured and reused, e.g., it does not flow into a saline sink.

(2) The evapotranspiration of phreatophytes, or deep-rooted riparian vegetation, is not defined as beneficial in this figure, but may provide important ecological services and therefore could be considered beneficial in some cases.

Source: Heerman and Soloman 2007

MULTIPLE BENEFITS OF WATER CONSERVATION AND EFFICIENCY

Water-efficiency improvements can reduce both consumptive and non-consumptive water uses. By definition, the goal of efficiency improvements is to maintain crop production levels. In doing so, crop transpiration rates are maintained. The emphasis is placed on reducing non-beneficial uses of water, such as unproductive evaporation from sprinkler spray or bare soil or transpiration from weeds. Reductions in consumptive use are especially valuable because they create “new supply” that is available for other uses. But there are also compelling reasons to seek reductions in total water withdrawals.

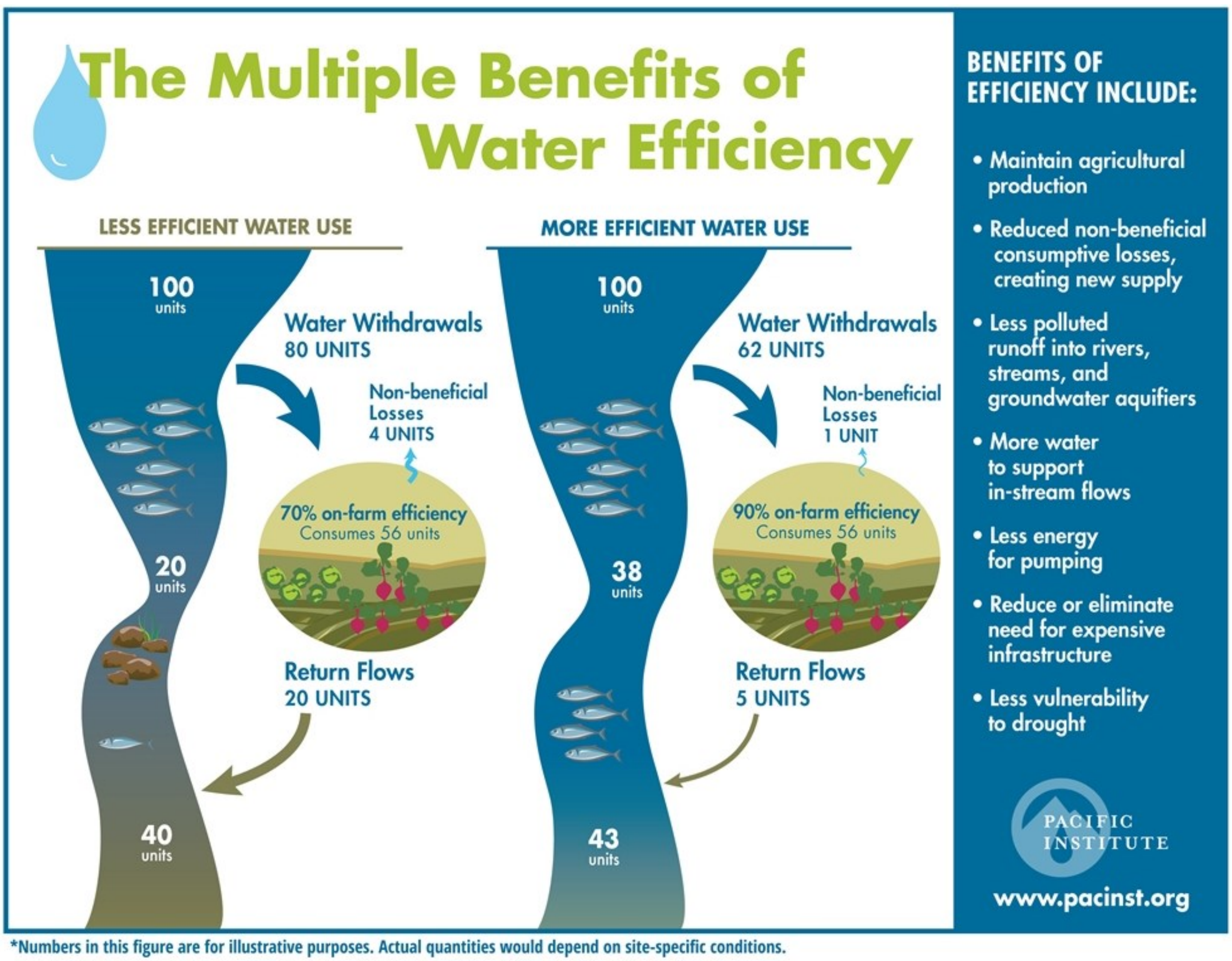
From the farmer’s perspective, reducing water withdrawals can provide a number of important benefits. In particular, it reduces the cost to purchase water and, if the farmer is using groundwater, reduces energy costs to pump and apply that water. Many farmers have also found that reducing water withdrawals allows them to apply chemicals more effectively, reducing total chemical use and associated costs. Moreover, studies suggest that improving water management through irrigation scheduling and efficient irrigation technologies can improve crop quality and/or yield, thereby increasing farm revenue. Finally, reductions in applied water improve the reliability of existing supplies and reduce vulnerability to drought and other water-supply constraints.

Reducing water withdrawals provides benefits beyond the farm boundaries, including water-quality improvements, instream flow augmentation, and less need for capital-intensive infrastructure. These benefits are described in detail in Gleick et al. (2011) and are summarized in Figure 1 and below:

- **Water Quality.** Runoff from agricultural lands often contains pesticides, fertilizers, salts, and fine sediments from surface erosion. These pollutants can contaminate surface and groundwater sources, increasing treatment costs for downstream users and degrading fish and wildlife habitat. Efficiency improvements that reduce excessive water use and withdrawals can reduce these water-quality problems.

- **Instream Flows.** The withdrawal of surface water reduces the amount of water left in a stream (also referred to as instream flows) between where the water is extracted and where some of it may be returned. Moreover, while return flows may eventually flow back to a stream via surface runoff or groundwater percolation, there is a lag time between when the water is withdrawn and when it flows back into the river. Instream flows serve many purposes, e.g., maintaining suitable water temperatures and water chemistry; flushing waste products and pollutants; and allowing and supporting fish passages and migrations. By reducing water withdrawals, efficiency can help maintain instream flows that are essential for stream health and function.

Figure 1. Multiple benefits of water efficiency



Note: See full-sized image at http://bit.ly/1nZ1N4U

- **Fish and Wildlife.** Diversions from waterways can pose a direct threat to fish and wildlife populations. For example, water diversions, especially the large pumps for California's State Water Project and Central Valley Project, kill fish on the intake screens and at the fish diversion facility. Efficiency improvements that reduce total water demands can reduce these adverse fish and wildlife impacts.

- **Energy Use.** Capturing and conveying water to agricultural users often requires an input of energy. For example, conveying surface water to farmers in the Tulare Lake hydrologic region requires up to 970 kilowatt-hour (kWh) per acre-foot.[1] Likewise, pumping groundwater requires energy. As a result, reducing water withdrawals can save energy (and associated energy costs) and reduce related greenhouse-gas emissions. While some efficiency improvements, e.g., drip irrigation, may increase on-farm energy use, total energy use may be lower because less water must be pumped to the farm.

- **Soil Salinity.** Irrigation water and fertilizers contain salts and their application increases soil salinity. Reducing the quantity of water applied to the field – and total fertilizer use – can reduce salt accumulation, thereby reducing the risk of further loss of arable land.

- **Capital-Intensive Infrastructure.** Building and siting new infrastructure to provide new supply is time-consuming, expensive, and politically controversial. Water savings achieved through efficiency improvements can reduce or delay the need for heavy capital investment in new infrastructure to capture, store, and distribute water.

- **Vulnerability to Drought.** California has a variable climate and is prone to droughts. Moreover, continued population and economic growth place additional strains on the available water supplies. Reducing water withdrawals permits the retention of water in reservoirs, improves the reliability of existing supplies, and reduces vulnerability to future drought and water shortages.

SUMMARY

Water-efficiency strategies provide important benefits to farmers, ecosystems, and society. Some of the water saved represents new supply that can be dedicated to other uses. But there are also compelling reasons to seek reductions in total water withdrawals, e.g., allowing farmers to maintain and even improve crop yields and quality; protecting water quality; reducing fertilizer, water, and energy costs; and boosting profits. The multiple benefits associated with reducing both consumptive *and* non-consumptive water uses argues for a comprehensive approach for promoting water-efficiency improvements that allows us to address complex and interrelated water management challenges in California, including water-supply reliability, conflicts among water users, the risks of droughts, worsening water quality, and ecological degradation.

[1] Based on State Water Project energy requirements from CEC (2005). We estimate the upper range on energy intensity at Wheeler Ridge.

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