Achieving a Sustainable California Water Future Through Innovations in Science and Technology

California Council on Science and Technology
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Cover Image: 12-hr satellite precipitation accumulation estimate (mm) on March 28, 2014 (20:00 UTC) over California, produced by the G-WADI PERSIANN-CCS System of the UC Irvine Center for Hydrometeorology and Remote-sensing (CHRS)
Irrigated agriculture is one of the most critical human activities sustaining civilization. The current world population of 7 billion people is sustained in large part by irrigated agriculture. USDA statistics show that 17% of cultivated crop land in the United States is irrigated. Yet this acreage produces over 50% of total U.S. crop revenues. According to the Food and Agriculture Organization of the United Nations the approximate 3,114 million acres (ac) under rainfed agriculture, corresponding to 80% of the world’s total cultivated land, supply 60% of the world’s food, while the 684 million acres under irrigation, the remaining 20% of land under cultivation, contribute the other 40% of the food supplies. On average, irrigated crop yields are 2.3 times higher than those from rain-fed ground. These numbers demonstrate that irrigated agriculture will continue to play an important role as a significant contributor to the security of the world’s food supply.

The California Department of Food and Agriculture reported that 81,500 farmers and ranchers received $34.8 billion for their output in 2009. The state produces more than 400 different agricultural commodities, supplying nearly half of U.S.-grown fruits, nuts and vegetables. Nearly all the agricultural production in California is made possible by irrigation supplied by a vast and integrated water infrastructure.

The increased yields that have resulted from mechanization and other modern measures come at a high energy price, as the full food and supply chain claims approximately 30% of total global energy demand. Energy fuels land preparation, fertilizer production, irrigation and the sowing, harvesting and transportation of crops. The links between food and energy have become quite apparent in recent years as increases in the price of oil lead very quickly to increases in the price of food.

California's unique geography and Mediterranean climate have allowed the State to become one of the most productive agricultural regions in the world. The Sierra Nevada Mountain range, which lines the eastern edge of the State, captures and stores winter precipitation that can be then used for summer irrigation in the Central Valley. This water, combined with the Mediterranean climate permits the growing of a great number of crops. California produces over 250 different crops and leads the nation in production of 75 commodities. California is the sole U.S. producer of more than 12 different commodities including almonds, artichokes, dates, figs, raisins, kiwifruit, olives, persimmons, pistachios, prunes and walnuts. Nearly all this production requires irrigation. In an average year

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California agriculture irrigates 9 million acres and applies roughly 33.2 million (gross) acre-feet of water (net use of 25.8 MAF).\(^97\)

California’s population growth and greater awareness of environmental water requirements has increased the pressure on California agriculture to use water more efficiently and to make more water available for urban and environmental uses. Decreasing agricultural water use is difficult for several reasons. First, California agricultural water use when considered on a broad regional scale, for the most part, is very efficient. Individual fields and farms in some regions may have low efficiencies, but water that is not used on one farm or field is often used on a nearby farm or field. Secondly, for most crops, production and yield is directly related to crop water use. A decrease in applied water will often directly decrease yield. The key is management strategies that improve water use efficiency without decreasing yield.

**Innovation Opportunities**

A number of growers and interested individuals provided significant input in the discussion on the use of technology in agriculture for the purpose of improving water use efficiency. It is clear that data monitoring, data collection and reporting are common tools used among successful grower operations. Study participants provided broad geographic representation and highlighted common denominators such as the use of flow measurement and soil moisture technologies. It is clear that leading growers are achieving high water use efficiency in their day-to-day farming operations. However, it is also evident that significant opportunities exist for other growers to adopt similar strategies and technologies in the pursuit of improving agricultural water use efficiencies.

There are a number of technologies and management strategies available that benefit water use efficiencies while improving yields and production standards. These technologies and management strategies provide for better irrigation scheduling and crop-specific irrigation management that often not only optimize water use, but also save energy and decrease growers’ costs.

It is critical that both district-level and on-farm water systems take advantage of new technologies, science and equipment. Computers and communication devices allow for better information and control decision-making in near realtime. Large data sets can be continuously monitored, with alerts and record keeping forming the basis for better decision-making opportunities.

**Case Study**

*Technology Provides Improved Water Use Efficiency*

An important measure of agricultural water use is yield per unit of water or water use efficiency (WUE). An excellent example of this is found at Stamoules Produce Company, located in Mendota, CA, who adopted AirJection® Irrigation technology. This process adds about 15% air by volume to the water delivered to the root zone of plants via the subsurface drip irrigation method. This process provides much needed air to the root zone. The concept was developed by Mazzei Injector Company and through a partnership with the Center for Irrigation Technology, the process was validated and moved to commercialization.\(^98\)

Stamoules Produce has employed AirJection® Irrigation technology since 2005 on 1,500 acres of vegetables. After 8 years of use in growing honeydews, corn, peppers and cantaloupes, all crops realized an increase in yield over the farm average with cantaloupes obtaining the largest yield increase of 23%. The difference of 201 boxes of cantaloupes per acre translates to a total increase of over 1,300,000 boxes during the 8-year period on the cumulative crop area of 6,480 acres.

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The additional energy cost is estimated at $0.054 per additional box. The initial installation cost was $209,580. The added net return to the grower over the 8-year period was $3,723,000 estimated at $3.00 per box. No additional water or fertilizer was required by the fields employing AirJection® technology over conventionally farmed fields. This translated into a 23% increase in water use efficiency or the equivalent of nearly 1,500 additional acres and water under conventional drip methods. Figure 30 shows average yield differences over an eight year period on cantaloupe production between conventional and AirJection® technology. The differences were statistically significant.

**On-Farm Technology Adoption**

**Irrigation Scheduling**

Deciding when and how much water is needed for a crop is critical to the total amount of water applied to the field and what is ultimately seen as beneficial use. A number of different scheduling techniques have been developed that can use either one or a combination of soil based, plant based or weather-based measurements to determine the correct timing and amount of water. Using a more scientific approach to scheduling has generally been shown to optimize the amount of water applied while maximizing yields.

**Tailwater Return Systems**

In order to provide adequate water to the low end of the field, surface irrigation systems may require that a certain amount of water be spilled or drained off as tailwater. Tailwater return systems catch this runoff and typically pump it back to the top of the field for reuse. This approach has shown to significantly improve the applied water uniformity of surface irrigation systems. These systems are common in parts of California, but opportunities for broader use exist in other parts of the state.

**Irrigation System Improvements**

Irrigation system improvement involves modifying the irrigation method or use of hardware and software to properly apply water to the field while minimizing water losses. For example laser-leveling furrows, combining furrow and sprinkler systems, and changing from surface irrigation (flood, furrow and border check) to drip/micro systems have all proven to be effective methods. Changing from surface irrigation to pressurized systems can increase irrigation distribution uniformity and decrease applied water. However, with certain soil types and application methods, surface irrigation has been shown to be very efficient. In California there has been a trend to shift from surface irrigation to pressurized systems, particularly as growers shift from annual to permanent crops (trees/vines).

**System Audits**

Approximately 3 million acres of California farmland is currently irrigated by the drip/micro method. A significant portion of this acreage has irrigation systems that are over 10 years old. A number of recent evaluations or audits of these systems has indicated decreases in Distribution Uniformity (DU) from a design criterion of around 90%.

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99 California Water Plan Update 2013, Chapter 2: Agricultural Water use Efficiency, Table 2-1.