



Cachuma Resource
Conservation District



Strategic Actions for Enhancing Local Agricultural Water Efficiency in Santa Barbara County

Prepared for Cachuma Resource Conservation District
by Katy Mamen and Lucas Patzek on behalf of Ag Innovations
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Cachuma Resource Conservation District

Cachuma Resource Conservation District (CRCD) supports the efforts of farmers, ranchers, public land managers and schools to benefit our soil, water, habitat and climate. Our dedicated and experienced team provides education, technical assistance and large-scale planning. We work closely with many local, state and federal government agencies, non-profit organizations, private landowners and public land managers on an array of programs that balance economic and environmental goals. We help bring funding and collaboration to local projects and help farmers, ranchers and landowners navigate the laws and permits that may be required.



Ag Innovations is a nonprofit, nonpartisan organization dedicated to helping stakeholders solve problems in the food system through effective collaboration. Since 1999, Ag Innovations has been designing, organizing, facilitating, and managing multi-stakeholder efforts to improve the performance of the food system for producers, consumers, and participants in local, regional, and global food supply chains. These efforts focus on both policy changes and direct improvements on farms, processing sites, and food outlets. Ag Innovations combines deep expertise in the challenges of the global food system, from production through to food access, with an approach to problem solving that gives groups the tools they need to deliver outcomes in meetings, conferences, and multi-stakeholder collaborations.

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Executive Summary

In 2016-2017, Ag Innovations carried out a project investigating existing and potential agricultural water management practices in Santa Barbara County, with a particular emphasis on south Santa Barbara County. Data was collected in a variety of ways, including interviews, a situation assessment, a survey of Santa Barbara County growers, a focus group to solicit growers' feedback on preliminary survey findings, a convening of key stakeholders to review and advance action strategies, and ongoing technical and socioeconomic guidance from the project steering committee.

This report identifies a set of strategic actions that represent, at this time, the best opportunities for additional gains in efficient agricultural water use in Santa Barbara County. These actions, summarized on page 7, meet the following guiding criteria.

GUIDING CRITERIA FOR STRATEGIC ACTIONS

POTENTIAL FOR MEANINGFUL REDUCTIONS IN APPLIED WATER	NOT YET WIDELY ADOPTED	LIKELY TO BE ACCEPTED BY AGRICULTURAL COMMUNITY
NET BENEFIT TO AGRICULTURAL OPERATIONS	COST-EFFECTIVE	NOT LIKELY TO CAUSE UNINTENDED ECOLOGICAL OR HEALTH IMPACTS

PRIORITY ACTIONS FOR IMPROVED AGRICULTURAL WATER MANAGEMENT IN SANTA BARBARA COUNTY

1. OPTIMIZE IRRIGATION SCHEDULING

- a. Increase the adoption of technologies for smart irrigation scheduling by launching a coordinated program to provide free or low-cost tools to farms throughout the county. Couple these with training on irrigation scheduling best practices.
- b. Provide irrigation scheduling best practices training for farm operators, managers, and irrigation staff, offering incentives for participation when able.
- c. Make data more useful for irrigation scheduling.

2. PROVIDE WIDESPREAD AND REGULAR IRRIGATION SYSTEM ASSESSMENTS AND MEANINGFUL FOLLOW-UP SUPPORT

- a. Significantly increase the number and impact of agricultural irrigation system assessments across Santa Barbara County, particularly targeting water district customers and small- to mid-scale farms.
- b. Enhance and coordinate decision support tools to increase adoption of irrigation management best practices.

3. INCREASE WATER AVAILABILITY THROUGH ENHANCED CAPTURE, INFILTRATION, AND RETENTION

- a. Develop soil health research and education opportunities.
- b. Provide technical and permitting assistance for earthworks projects for increased water capture.
- c. Facilitate soil health technical assistance and cost-sharing.
- d. Expand outreach to, and engagement of, the agricultural community in sustainable groundwater management and governance discussions.

4. CLOSE THE TECHNICAL ASSISTANCE COLLABORATION GAP

- a. Create an agricultural water support network based on the shared value that good water use efficiency and stewardship should be employed in all agricultural operations and that everyone should have access to the best water technologies and practices.
- b. Coordinate strategic outreach to achieve shared outcomes.

ACRONYMS

AWUE Agricultural Water Use Efficiency

CDFA California Department of Food and Agriculture

CIMIS California Irrigation Management Information System

CRCD Cachuma Resource Conservation District

DWR Department of Water Resources

EWMPs efficient water management practices

EQIP Environmental Quality Incentives Program

MAD management allowed depletion

MIL Mobile Irrigation Lab

NRCS Natural Resources Conservation Service

PG&E Pacific Gas & Electric

RCD Resource Conservation District

SCE Southern California Edison

SGMA Sustainable Groundwater Management Act

SWEEP State Water Efficiency and Enhancement Program

1. Introduction

With grant funding from the California Department of Water Resources Water Use Efficiency Grants Program and the Santa Barbara County Water Agency, the Cachuma Resource Conservation District (CRCD) initiated a project focused on agricultural water use in Santa Barbara County in partnership with Ag Innovations, Goleta Water District, and Carpinteria Valley Water District.

The objectives of the project were to:

- » Conduct a strategic analysis of efficient on-farm water management practices;
- » Document existing participation levels and implementation barriers to efficient water management practices (EWMPs);
- » Build community awareness and knowledge of innovative EWMPs;
- » Develop an action plan for increasing adoption of EWMPs; and
- » Transfer results to regional and statewide partners.

The geographic scope of the project included Santa Barbara County, with a special focus on the Goleta and Carpinteria Valley agricultural regions. These areas of south Santa Barbara County are of special interest because of their partial reliance on State Water Project water imported from outside of the county. Water deliveries to these areas were significantly curtailed during the recent drought.

This strategic action plan details key findings from the project, including adoption of existing practices, key barriers faced by the agricultural community, and a set of proposed cost-effective programs and tools that will result in real reductions in reliance on applied water over the near-term.

2. Methods

Data collection methods for this project included individual interviews, a situation assessment, an online survey, and focus group discussions.

Complete methods and key survey findings are found in the appendix.

TELEPHONE INTERVIEWS were conducted with 21 regional experts in agriculture and water management between April 21, 2016, and July 1, 2016. Concurrently, existing statistics and reports were reviewed to develop a deeper understanding of regional trends and issues related to agriculture and water management in Goleta and Carpinteria Valley, and Santa Barbara County as a whole.

These research activities provided the information for a **SITUATION ASSESSMENT**, and informed the design of a questionnaire targeting the region's growers (the term "growers" is used synonymously in this report with "farmers").

A questionnaire consisting of 37 questions was developed and sent as an **ONLINE SURVEY** to growers in Santa Barbara County. The target population was farm owners and managers, excluding animal operations. Given the project's

special interest in south Santa Barbara County, additional outreach was focused there. 150 individuals completed the survey. The purpose of this survey was to identify important farm characteristics and management methods, major barriers to and opportunities for increasing on-farm water use efficiency, and key strategies for deploying appropriate forms of technical and financial support to increase on-farm water use efficiency in Santa Barbara County. The survey was launched on October 3, 2016, and was closed on October 31, 2016.

Two structured **FOCUS GROUPS** with growers and key agricultural stakeholders were designed based on an initial analysis of survey results, guidance from the project steering committee, and existing literature and water-related plans. The first focus group was aimed at soliciting grower feedback on initial survey results. It was held on October 17, 2016, in Goleta as part of a Cachuma Resource Conservation District

workshop and involved 20 growers from the county. The second was aimed at more deeply assessing key opportunities and barriers to the increasing agricultural water use efficiency, and to refine a set of proposed actions. It was held on June 22, 2017, at Rancho San Julian and included 27 agricultural leaders from the county.

Take the Santa Barbara County
AGRICULTURAL WATER MANAGEMENT SURVEY
by October 31, 2016 and get
\$40 FOR WATER USE EFFICIENCY SUPPLIES

Cachuma Resource Conservation District

Participating stores:

- AQUA-FLO SUPPLY**
- Cal-Coast Irrigation, Inc.**
- ALL AROUND Landscape Supply**

➔ www.rcdsantabarbara.org/survey
Your confidential participation will help bring water management technical support and funding to Santa Barbara County growers

Postcard promoting participation in the survey.

3. Drought and Its Impacts on Santa Barbara County Agriculture

Agriculture is the most important industry to Santa Barbara’s economy, with a value of \$1.5 billion in agricultural production.

Agriculture contributes a total of 25,370 jobs and \$2.8 billion to the local economy when multiplier effects are taken into account.¹ Primary agricultural products in Santa Barbara County in 2016 were strawberries, wine grapes, broccoli, cut flowers, nursery products, head lettuce, avocados, cauliflower, raspberries, and celery.

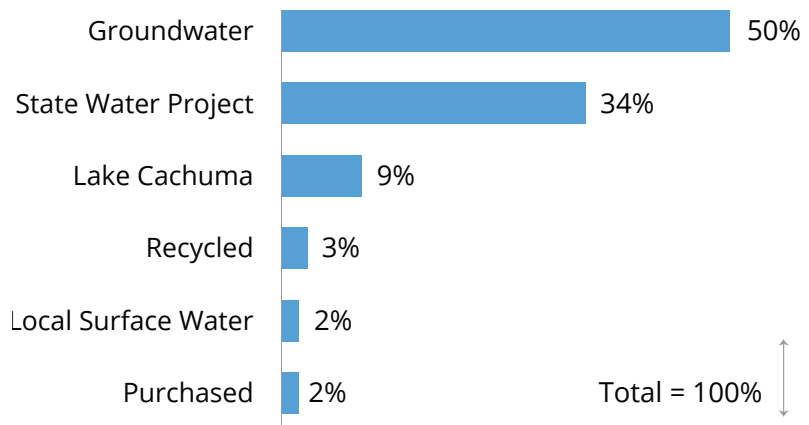
Water availability and affordability are prime concerns among growers in the county. This is a region that is particularly vulnerable to drought conditions. As of August 2017, Santa Barbara County persists as part of the 9% of the state that remains in drought.² Its unique geography provided a “rain shadow” effect that resulted in less precipitation for Lake Cachuma, a key source of local water, which stood at less than half capacity.³ In addition, the rainfall that was received fell with an intensity that, combined with the steep topography, meant that little water was infiltrated to recharge groundwater supplies.

Santa Barbara County depends on groundwater as a major source of its water supply. See Figure 1. The health of Santa Barbara’s groundwater basins vary geographically, and their response to the drought has also varied (see the 2014 County of Santa Barbara Groundwater Basins Status

Report for more detail). At this time, only one basin, Santa Maria Valley, is ranked as a high priority basin,⁴ indicating the poor health of the basin. Others, including Goleta, Santa Ynez, Cuyama Valley, and San Antonio Creek Valley are ranked as medium priority groundwater basins. Several, including Carpinteria Valley, Foothill, Montecito, and Santa Barbara, are ranked very low priority. High and medium priority basins must comply with California’s Sustainable Groundwater Management Act (SGMA). The Goleta Basin is adjudicated and is therefore specifically exempt from SGMA, but other high and medium priority basins must develop a SGMA-compliant Groundwater Sustainability Plan and manage groundwater according to this plan.

Between 2015 and 2016, Santa Barbara County’s reliance on water imported from

FIGURE 1: SANTA BARBARA COUNTY SOURCES OF WATER 2016



Source: The Network of Santa Barbara County Water Providers.

outside the county increased from 13% to 34% of the total supply. Lake Cachuma went from supplying 25% to 9% of the total water used in-county. The share of groundwater decreased slightly from 57% to 50% of the total supply.⁵ Compounding Santa Barbara’s water shortage, increasing temperatures have caused evapotranspiration rates to rise, leading to increased water needs for plantings.

The 5-year drought affected agriculture significantly, from cattle to avocados and wine grapes. Avocado acreage was reduced 11% between 2014 and 2015, with some growers stumping trees in response to the drought. Production was affected directly by a decrease in water supply, as well as indirectly through water quality decline. Overall, 1/3 of growers we surveyed had stumped trees or fallowed land within the last two years. 44% reported a decline in water quality as a result of the drought, most notably salt build-up.

Growers surveyed were asked how they would likely modify their management practices if they continue to experience dry weather. Many growers reported that they would make significant changes to their management practices under these conditions (see Figure 2).

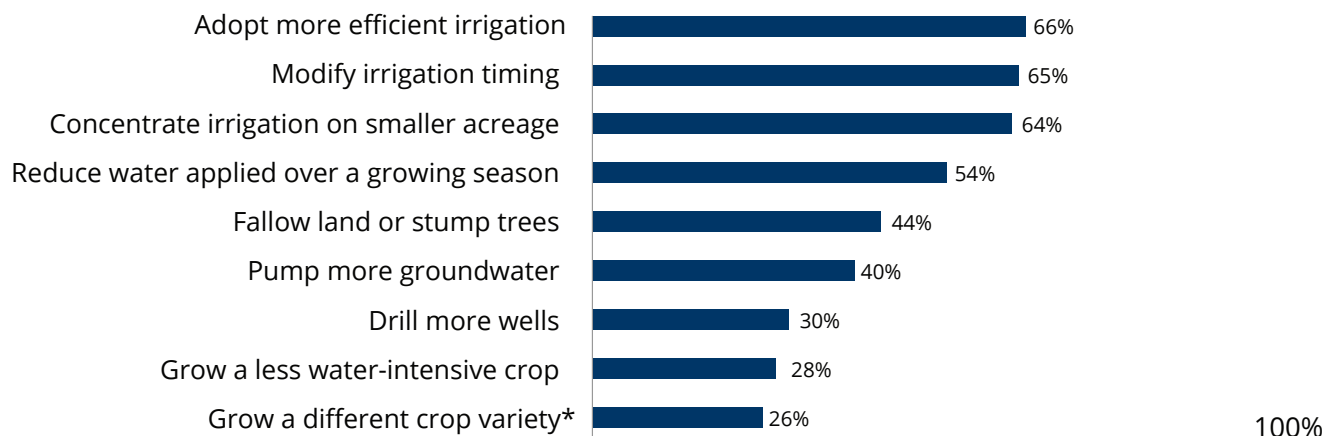


Some [avocado] trees are very stressed— lost all their leaves due to salt buildup in the soil that hasn’t been washed out by rainfall.

— SURVEY RESPONDENT

FIGURE 2: MANAGEMENT PRACTICES CONSIDERED BY GROWERS

Management practices growers would “likely” or “very likely” make to manage risk if Santa Barbara County continues to experience decreased water availability (by percent of respondents)



**e.g., a different variety of avocado to withstand higher salt levels*

4. Existing Agricultural Water Use Efficiency Practices in Santa Barbara County

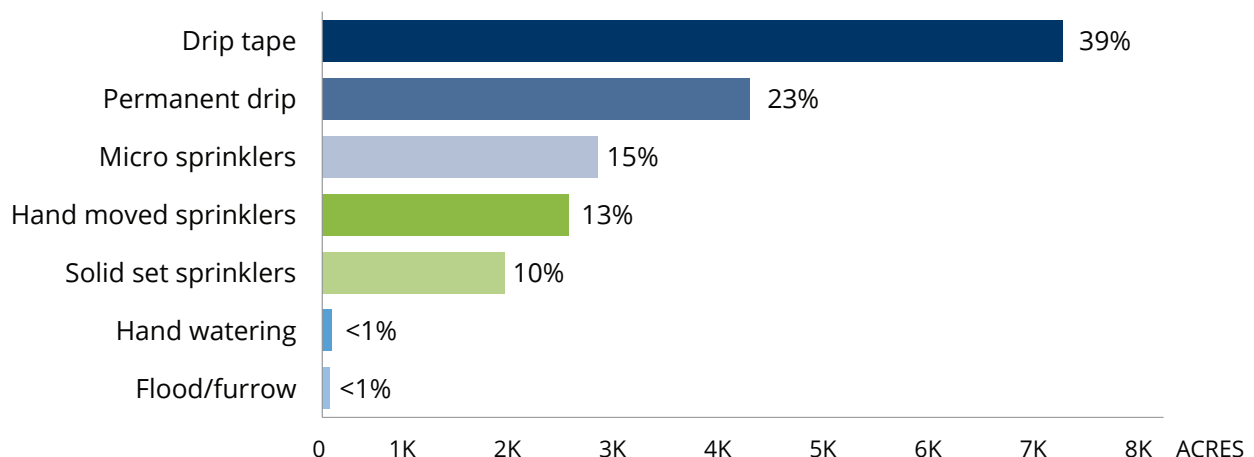
Santa Barbara growers have a high rate of adoption of irrigation technologies. 76% of farmland surveyed is irrigated using micro-sprinklers, permanent drip, or drip tape.

Survey respondents managed a total of 30,559 acres on their primary Santa Barbara County farms, including 17,975 irrigated acres (59% of the total acreage surveyed). As shown in Figure 3, 76% of this farmland is irrigated using micro sprinklers, permanent drip, or drip tape. Very few farms (constituting fewer than 1% of total irrigated acres) are irrigated using flood or hand watering methods.

The survey results confirm the general understanding that there is a high adoption rate of efficient drip and micro sprinkler technologies on Santa Barbara County farms, but the type of irrigation system favored depends in part on the source of water

used. Those irrigating with only or mostly groundwater are the dominant users of permanent drip (83% of total acres using this system), drip tape (95%), hand moved sprinkler (90%), and solid set sprinkler (86%) systems, while growers using only or mostly surface water have a lower rate of adoption of these irrigation technologies. Of the total farmland acres irrigated using micro sprinkler (also called micro spray) systems, nearly half irrigate only or mostly with groundwater (44% of total acres using this system) and half with surface water (51%). Those irrigating with only or mostly groundwater use drip tape on 42% and permanent drip on 21% of all their acres. Growers irrigating with only or mostly surface

FIGURE 3: IRRIGATED ACREAGE SURVEYED BY IRRIGATION PRACTICE





water primarily favor the use of micro spray systems, applying water using this technique on 35% of their acres, while permanent drip is a distant second choice, used on only 6% of their irrigated acres.

Variations in irrigation practice by crop type are outlined in Figure 4. Avocado and lemon growers primarily use micro sprinkler and permanent drip systems for irrigation (81% of avocados and 95% of lemons). These irrigation systems are also used on 77% of all wine grape and 31% of all cut flower acres. Vegetable, cut flower, and berry growers favor drip tape over other irrigation systems, with 38-44% of total acres, by crop type, under this type of irrigation. About one third of vegetable and berry acres are irrigated with hand-moved sprinklers,

while this method is used on only 8% of wine grape, 3% of cut flower, and 1% of avocado acres. Flood or furrow irrigation is a practice employed exclusively by cut flower and avocado growers, but on only 8% and 1% of their acres respectively. Not irrigating is fairly common for berries (24% of acres), cut flowers (14%), and avocados (13%).

A wide variety of additional specific water efficiency measures are already in place on Santa Barbara farms in the categories of irrigation system design, irrigation system maintenance, irrigation scheduling, and soil moisture management practices. These are summarized in Figure 5 on the following page and explained further below.

FIGURE 4: IRRIGATION METHODS BY CROP TYPE

Percent of Santa Barbara County farmland acres irrigated by different methods

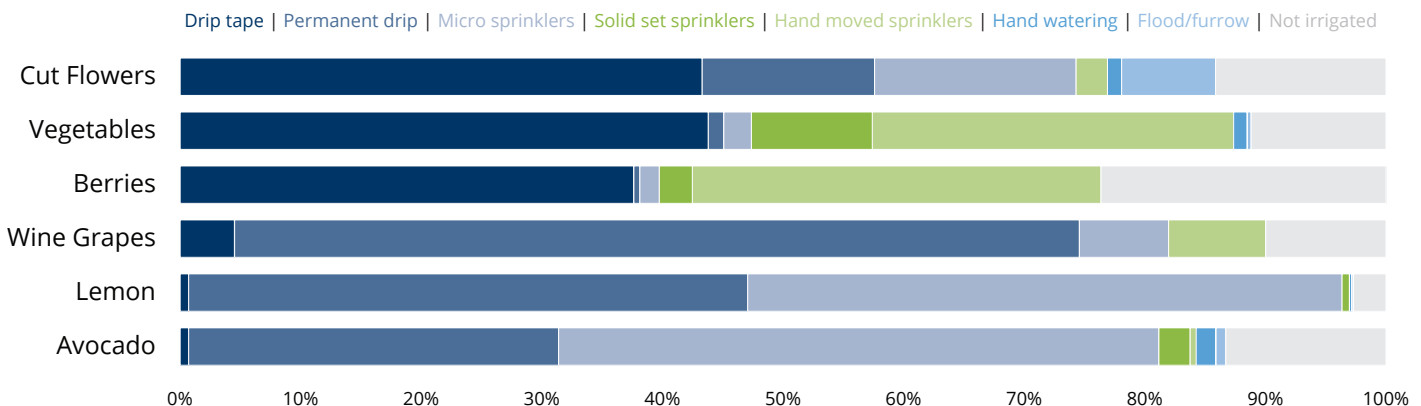
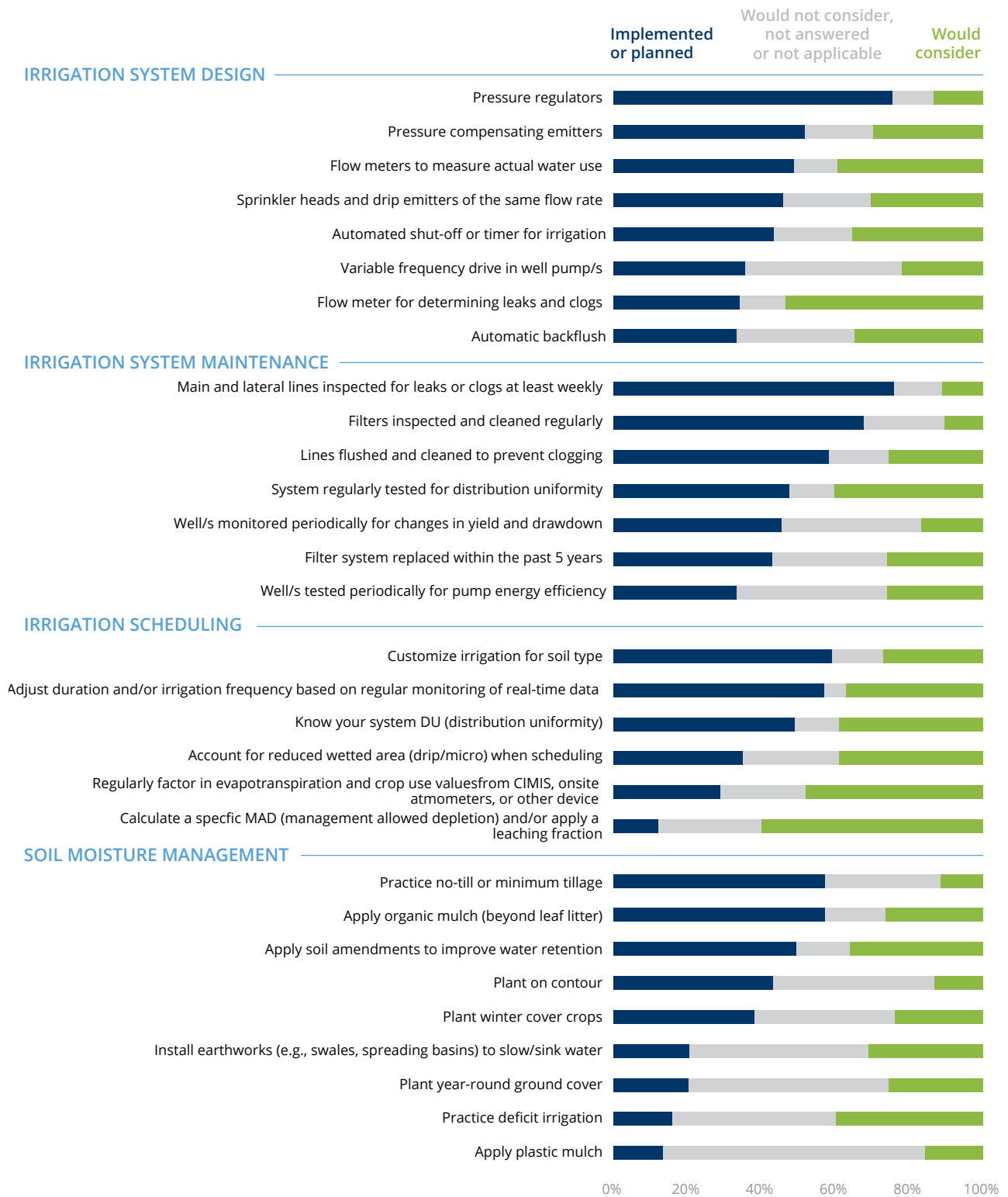


FIGURE 5: IRRIGATION PRACTICES ADOPTED OR PLANNED ON FARMS IN SANTA BARBARA COUNTY



IRRIGATION SYSTEM DESIGN

The agricultural water management survey we conducted evaluated the use of best practices in irrigation system design. Several efficiency measures were included in the design of existing farm irrigation systems in Santa Barbara County. Pressure regulators are the most commonly adopted technology, having been implemented or planned by 76% of all respondents. Growers using only or mostly surface water already have a high adoption rate (77%) of both pressure regulators and pressure compensating emitters—important measures to increase efficiency by uniformly distributing irrigation water—while only 53% of groundwater users have adopted the use of pressure compensating emitters. Consequently, growers on groundwater would be more effective targets of outreach and education. Lemon growers have the highest rate of adoption of pressure regulators (96% have implemented or plan to implement), followed by growers of wine grapes (84%), cut flowers (83%), and avocados (82%). Pressure compensating emitters was one of the top three practices already adopted by growers of wine grapes (90%), cut flowers (67%), lemons (59%), and avocados (50%), and there is a high level of interest in considering this technology among those who have not yet adopted it.

IRRIGATION SYSTEM MAINTENANCE PRACTICES

The survey also assessed practices for adequately maintaining irrigation systems, an important aspect of eliminating water waste. Growers using only or mostly groundwater have a higher rate of adoption of all irrigation system maintenance practices compared with those using only or mostly surface water. Compared with surface water users, groundwater users are nearly twice as likely to have adopted the practice of regularly testing their irrigation system for distribution uniformity, replacing their filter system within

the past 5 years, and flushing and cleaning their lines to prevent clogging. 74% of groundwater-dependent growers have adopted the practice of periodically monitoring their wells for changes in water yield and drawdown, and the remaining 26% would consider this practice. 55% of groundwater dependent growers have adopted the practice of periodically testing their wells for pump energy efficiency; another 38% would consider this practice.

For all crop types, there is an opportunity to increase awareness and improve adoption of irrigation system maintenance best practices. There is generally a higher rate of adoption of the following three maintenance practices compared with the other practices: inspecting main and lateral lines for leaks or clogs at least weekly, flushing and cleaning lines to prevent clogging, and regularly inspecting and cleaning filters. These are the top three most commonly adopted maintenance practices among avocado, lemon, and cut flower growers, and also widely adopted by wine grape, berry, and vegetable growers (see Appendix Table G). There is a high level of interest in considering the other two practices that are not related to wells: replacing filter systems within the past 5 years and regularly testing the system for distribution uniformity by monitoring water delivery and pressure differences within a block. These latter two practices have a 25-53% adoption rate, depending on the crop type (see Appendix Table G for more detail).

The survey found that the larger the size of the farm, the higher the adoption rate for key irrigation system maintenance practices (additional detail is provided in Appendix Table H). While large farms (>100 acres) have a 50% or greater adoption rate for all seven practices, small farms (≤ 15 acres) have a 50% or greater adoption rate for only two of the practices, and mid-sized (16-100 acres) farms for five. Among mid-sized and large farms there is a significant opportunity to conduct outreach about testing wells for energy efficiency.

IRRIGATION SCHEDULING

The grower survey assessed adoption of irrigation scheduling practices. Irrigation scheduling—practices to establish the optimal duration and frequency of watering—was identified as an area where significant additional water efficiency gains could be made. 64% of respondents irrigate on a set schedule, which means they do not modify the duration or frequency of irrigation according to plant needs. The greatest difference between adoption rates for large farms versus small was observed for the practice of calculating a specific management allowed depletion (MAD) and/or applying a leaching fraction (30% of large farms vs. 4% of small farms), and the practice of regularly factoring in evapotranspiration and crop use values from CIMIS, onsite atmometers, or other device (50% of large farms vs 17% of small farms). See Appendix Table I. These are the two practices that groundwater users are also substantially more likely to adopt than surface water users. Groundwater users are 30-40% more likely than surface water users to customize irrigation on a soil type basis, and know their system distribution uniformity. In general, for those practices not already adopted, there was a strong willingness to consider them.

37% of all respondents modify their irrigation duration and/or frequency at least weekly, followed by 25% doing so seasonally, 18% at least monthly, and 17% daily. Very few respondents (1.5% of the total) never modify their irrigation over the course of a year. Source of irrigation water only influences the daily and monthly practices. Compared with surface water users, groundwater users are nearly twice as likely to modify their irrigation duration and/or frequency daily, and were about half as likely to do so at least monthly. Irrigation varies by farm size. About one third of large farms modify their irrigation schedule on a weekly or seasonal basis, while about half as many do so on a daily or monthly basis. Both

small and mid-sized farms are twice as likely to modify their irrigation schedule on a weekly basis as compared with a monthly or seasonal basis. Mid-sized farms are about twice as likely to modify their practices on a daily basis as compared with small or large farms. Growers of all crop types, except vegetables, favor modifying their practices weekly. Vegetable growers favor modifying their irrigation schedule daily. About one third of growers of perennial crops – avocado, lemon, and wine grapes – modify their irrigation schedule on either a monthly or seasonal basis. Cut flower and vegetable growers are the most likely to make only seasonal modifications (about one quarter of growers). Appendix Section 3.7 provides more detail on irrigation scheduling practices in Santa Barbara County.

SOIL MOISTURE MANAGEMENT

The two most commonly adopted soil moisture management practices (adopted by 57% of all respondents) are no-till or minimum tillage and the application of organic mulch beyond natural leaf litter, while the two least commonly adopted practices are deficit irrigation and applying plastic mulch. There is a high level of interest among respondents in learning about deficit irrigation, while the application of plastic mulch would not be considered by 46% of respondents, likely because the production systems will not easily accommodate plastic ground covers. Applying plastic mulch is a practice that has been adopted by 52% of vegetable and 75% of berry growers surveyed. Planting of winter cover crops has been adopted by 88% of berry, 79% of wine grape, and 62% of vegetable growers. There is also a high rate of adoption of applying organic mulch beyond natural leaf litter by berry (75%), lemon (68%), avocado (67%), and cut flower (64%) growers, although the frequency and extent of application were not evaluated.

5. Top Opportunities for Future Agricultural Water Use Efficiency and Stewardship Gains

Our findings identify several key opportunities that can help agriculture in Santa Barbara County decrease its reliance on uncertain and/or expensive water supplies, improve economic viability, and enhance its contributions to environmental stewardship.

PRIORITY OPPORTUNITIES FOR IMPROVED AGRICULTURAL WATER MANAGEMENT IN SANTA BARBARA COUNTY

**OPTIMIZE IRRIGATION
SCHEDULING**

**FOSTER THE REGULAR
ASSESSMENT OF IRRIGATION
SYSTEM FUNCTIONING COUPLED
WITH TARGETED FOLLOW-UP
SUPPORT**

**ENHANCE THE USE OF CULTURAL
PRACTICES ALIGNED WITH LOCAL
ECOLOGICAL CONDITIONS**

**IMPROVE THE COORDINATION
OF THE TECHNICAL SUPPORT
COMMUNITY**

5.1 OPTIMIZED IRRIGATION SCHEDULING

Meaningful gains in agricultural water use efficiency can be made by improving irrigation scheduling to better match the needs of the crop day-to-day.

As described previously, almost two-thirds of all growers surveyed irrigate on a set schedule. 43% of growers surveyed modified their irrigation frequency or duration monthly or seasonally, suggesting a likely poor match between plant water requirements and volume of applied water. Only 24% factor evapotranspiration or crop coefficients into their decision making.

37% have not been, but would consider, adjusting irrigation duration or frequency based on regular monitoring of real-time data such as depth of moisture after irrigation, suggesting a meaningful opportunity for improvements to be made. (Practices that growers would consider are listed in green in Figure 5.) 39% of respondents would consider accounting for reduced wetted area when scheduling irrigation in drip and micro-spray systems. Almost half would consider regularly factoring in evapotranspiration and crop use values from CIMIS, onsite atmometers or other devices. 60% would consider calculating a specific management allowed depletion (MAD) or applying a leaching fraction as a management practice (only 12% currently do this or plan to do this).

“

The management — scheduling — is where we are going to save water... someone has to make the decision every time. It's work for someone to do.

— INTERVIEWEE

“

The combination of having evapotranspiration data, flow meters, and soil moisture probes gives you a great data set for decision-making.

— FOCUS GROUP PARTICIPANT

“

The big thing growers need to know is scheduling—how often and for how long to turn on the pump; what duration between irrigation sets.

— INTERVIEWEE



USE OF SYSTEM COMPONENTS THAT PROVIDE DATA FOR IRRIGATION SCHEDULING

Several technologies exist that contribute to improving measurement of water use and irrigation efficiency. Reducing costs of monitoring and measuring is essential. As one engineer interviewed put it, “water conservation is a function of measuring, which is a function of incentives.” The survey identified three specific technologies with significant potential to enhance growers’ irrigation scheduling practices: automated shut-off components, flow meters, and soil moisture sensors.

The top three irrigation system design technologies or practices that survey respondents would consider implementing are the same regardless of whether the respondent is a surface water user or groundwater user: flow meters for determining leaks and clogs, flow meters to measure actual water use, and automated shut-offs or timers for irrigation.

Automated shut-offs

Anecdotal reports suggest that irrigation equipment workers are often juggling numerous tasks, sometimes on multiple sites, resulting in possible delays in turning off the irrigation water. Less than half (43%) of growers surveyed use automated shut-off valves, and 35% of those surveyed would consider employing this technology.

Flow meters

Flow meters can help growers understand their water use patterns and also, importantly, to identify possible leaks and clogs in the irrigation system. Our grower survey revealed that flow meters are the single most widely desired best management practice of all those listed in the survey. 71% of all respondents would consider using flow meters for the purposes of finding

clogs or leaks, to measure actual water use, or for both. Growers primarily on groundwater have nearly double the adoption rate of flow meters than those exclusively or mostly reliant on surface water, suggesting a particular opportunity to target growers on delivered water. In addition, interest is highest among avocado growers but is also high for growers of lemons, wine grapes, and vegetables.

In addition to flow meters, other tools such as Powwow Energy’s Pump Monitor product, which measures and provides proprietary data on water usage and energy savings using power meters, can help agricultural irrigators understand their water use.

Soil moisture sensors

Relatively few operations—about one third—use digital sensors, tensiometers, or plant-based moisture monitoring devices to determine soil moisture levels. 73% use manual feel as a method for determining soil moisture levels, and only about a third of those use this in conjunction with a more quantitative approach. An opportunity exists to support irrigation decision-makers in better understanding irrigation needs and matching water volume with plant requirements in order to eliminate waste.



Every time growers turn their sprinklers on, they should walk the grove, see what's happening. Lots of people don't do that. Lots of farms are managed by different companies, running around turning water on and off. They don't check.

— INTERVIEWEE

MOBILE IRRIGATION LAB

The Cachuma Resource Conservation District operates the mobile irrigation lab with funding from the Santa Barbara County Water Agency. The Mobile Irrigation Lab provides on-site irrigation system evaluations including Distribution Uniformity (DU), a general survey (estimating seasonal evapotranspiration, effective rainfall, leaching, and average irrigation water requirements), energy efficiency evaluation and water quality metrics (including pH, electrical conductivity, nitrate, etc.) allowing calculations of total dissolved solids and leaching fraction in irrigation water. The MIL also provides recommendations on system design, maintenance, and operation, as well as site specific irrigation scheduling recommendations. Some engineering assistance may be offered to support implementation of recommendations.

BEHAVIORAL CHANGE

The technologies listed previously are important tools in irrigation management, but the use of the tools needs to be coupled with knowledge about how to integrate available data into irrigation decision-making. For example, irrigators must be skilled in calculating their total irrigation run time based on their specific conditions and system design. Commodity organizations, technical support providers, and others can collaborate to develop, conduct outreach, and to implement these opportunities.



*What's the next level of efficiency?
It's not so much about technology as it is
about management. You can't manage
something you can't measure.*

— INTERVIEWEE



5.2 WIDESPREAD AND REGULAR ASSESSMENT OF IRRIGATION SYSTEMS AND FOLLOW-UP SUPPORT

Throughout the data collection and analysis phases of this project, the performance of existing irrigation systems emerged as an important area for improvement. Distribution uniformity is a key indicator of irrigation system performance. The uniformity of water application by an irrigation system within a field or block has a major effect on the overall efficiency of the system and poor distribution uniformity ultimately causes water waste and crop under-performance.

Only 49% of growers surveyed are aware of the distribution uniformity of their irrigation systems. 40% of survey respondents are interested in regularly testing the system for distribution uniformity by monitoring water delivery and pressure differences within a block, with the biggest opportunity being on small and mid-scale farms. Providing growers with assistance in assessing their distribution uniformity and other aspects of their irrigation system performance is a critical ongoing need. Because growers using only or mostly groundwater have a higher rate of adoption of all irrigation system maintenance practices evaluated compared with those using only or mostly surface water, an opportunity exists to conduct targeted outreach to water district customers to increase adoption of best practices.

In addition, at least a quarter of growers surveyed would consider the following new management practices: testing wells periodically for efficiency, replacing filter systems periodically, and flushing lines to prevent clogging. These measures are among those that tend to be recommended by the

Mobile Irrigation Lab (MIL). Respondents cited one-on-one farm evaluations as the most useful way of learning about efficient water management practices.



We will have limited impact by promoting any component or technology. They have the technologies, they're just using them improperly. We've done a poor job as an industry in seeing the value in a closer look at operations.

— INTERVIEWEE



We are finding that you can have the best system but if you have a problem and send someone out there and they put drip parts in backwards, the efficiency goes to heck. We're learning that after a few years of installation, and DU either goes up or down, it may mean problems with the system and you need an audit and maintenance program.

— INTERVIEWEE



Lack of field staff training is a big issue. The farm owner might say they're doing lots of conservation but the person in field making the decisions may not be.

— INTERVIEWEE

5.3 MORE ATTENTION TO CULTURAL PRACTICES

Land and surface management practices that capture and infiltrate rainwater (e.g., retention basins, cover cropping), and practices that build soil organic matter and tilth (e.g., keeping soil covered, minimizing disturbance such as tillage, maximizing plantings, and diversifying plantings through cover cropping and rotations) demonstrate significant potential to offset surface and groundwater use. For example, increasing organic matter by 1% in the top 6" of soil will result in 27,000 more gallons per acre per year of available soil water.⁶ Building organic matter and thus soil health has the added benefits of enhancing crop yields and nutrient retention, sequestering carbon, improving water quality, recharging groundwater, supporting flood control objectives, reducing disease and pest issues, and enhancing drought resilience. The value of cultural practices for land and surface management can be under-acknowledged in the technology-oriented water management field.

As one interviewee noted, "California doesn't have a water problem, it has a water storage problem." Agricultural soils can be seen as water reservoirs because the capacity of healthy soils to retain water and make it available to plants is significant. As such, building soil organic matter and tilth, protecting evaporative losses from soil surface, and fostering infiltration

rather than runoff are powerful approaches to help agriculture use less water while increasing productivity and reducing costs. The agricultural community is considered a critical partner in achieving sustainable groundwater and other water management goals due to the potential for improved groundwater recharge on farms and enhanced water quality through better land management.

Among growers in Santa Barbara County, there is a meaningful level of openness to, and interest in, practices that provide these outcomes. Almost half of all growers were interested in the application of soil amendments such as compost to increase the water-holding capacity of the soil. Our survey indicated that 32% of growers believe they can capture more water from precipitation than they are currently, with an additional 13% being uncertain about their ability. There is particular optimism among vegetable and perennial

“

I see lemon orchards that have put in a conservation crop down the middle of their lemons... across the road, I see larger groves who haven't done that.

— INTERVIEWEE

“

“We have a water storage problem, not a water problem. Anything that enhances storage infiltration, agriculture should be a huge proponent for because when urban users are mandated to cut back watering and they see someone running sprinklers, it becomes a real irritant with our urban neighbors. Anything we can do to promote storage is good.”

— FOCUS GROUP PARTICIPANT

vine and tree crop growers, as well as in larger operations (see Appendix Section 3.4 for additional details).

About one-third of respondents would also consider applying soil amendments and mulch to improve water retention and soil health, installing earthworks to slow, spread, and sink water, and applying organic mulch or ground cover (which offers added benefits such as weed abatement and enhanced yields). Interest in these practices does vary somewhat by crop type (see Appendix, Section A3.10). Finally, 56% of survey respondents did not know the approximate soil organic matter content on

a representative block or field. While many will have a more qualitative interpretation of soil health, this finding suggests a potential opportunity to raise more awareness among growers about soil water storage practices.

The type of soil moisture management practice that a grower would consider depends in part on the type of crop grown. Avocado, lemon, and cut flower growers have the greatest interest in deficit irrigation and applying soil amendments to improve water retention. About half of wine grape growers would consider applying organic mulch and installing earthworks to slow and infiltrate surface water.

5.4 A WELL-COORDINATED TECHNICAL SUPPORT COMMUNITY

New tools for irrigation efficiency are emerging all the time and growers receive their information about water management from a wide variety of sources. The proliferation of information and options around water management is causing some confusion for growers. In fact, half of all growers surveyed reported that the number and/or breadth of sources of technical advice were somewhat of or a significant barrier to their ability to move forward in adopting agricultural water use efficiency (AWUE) practices. Additionally, 41% feel that too much choice in technologies and brands was a moderate or significant barrier.

Outreach to growers was identified as a critical gap. Survey respondents' awareness of key assistance programs is low. More than half of growers surveyed are not aware of the State Water Efficiency and Enhancement Program (SWEEP) or the Natural Resource Conservation

Service's (USDA-NRCS) Environmental Quality Incentives Program, and almost half are not aware of the services of the Mobile Irrigation Lab. At least 20 percent of survey respondents would like to participate in one or more of these programs.



Santa Barbara County has a wide variety and large number of organizations, companies, agencies, and processes with the stated objective of supporting agricultural water stewardship in order to meet a range of goals, including food security, health of the agriculture industry, economic development, and environmental conservation. These include:

GROUNDWATER MANAGEMENT AGENCIES

are forming in response to the Sustainable Groundwater Management Act to bring stakeholders together around common goals, but only in limited geographies based on the severity of groundwater basin conditions.

Stakeholders collaborated to create the **SANTA BARBARA INTEGRATED REGIONAL WATER MANAGEMENT PLAN**, in which an identified priority is fostering measures to increase conservation and efficiency of water use.

THE AGRICULTURE ELEMENT OF THE COUNTY GENERAL PLAN includes water conservation as a priority and identifies the County as a provider of technical and financial incentives.

THE COUNTY'S ENERGY AND CLIMATE ACTION PLAN (Sections AG 2, AG 4, AG5, AG6, and WE1) lists agricultural water conservation and irrigation efficiency as priorities and calls on the Agricultural Commissioner and Planning and Development to pursue funding to support implementation of voluntary measures via organizations like the RCD and UC Cooperative Extension.

THE SANTA BARBARA FOOD ACTION PLAN includes a goal (Goal 16) to promote and incentivize the use of best management practices on farms, ranches, and food system businesses in Santa Barbara County.

WATER DISTRICTS, including Goleta Water District and Carpinteria Valley Water District, implement programs supporting agricultural water conservation and use efficiency objectives.

THE SANTA BARBARA CONSERVATION BLUEPRINT acknowledges agricultural (and urban) water use efficiency as a key ingredient of resilience.

Commodity groups, nonprofits, and others are also taking action on agriculture and water. Several of these initiatives include efforts to build more communication and coordination, however significant gaps in coordinating water-related technical assistance remain. The number and diversity of water management practices and technologies, the number and diversity of assistance providers, the number of stand-alone planning processes that include water management goals, and the low level of coordinated outreach all combine to indicate the importance of strong collaboration among those who provide assistance to agriculture.

6. Strategic Actions to Achieve Agricultural Water Management Improvements in Santa Barbara County

The four key areas of opportunity described previously point to a set of strategic actions that represent, at this time, the greatest opportunities for additional gains in efficient agricultural water management.

These include actions that:

- » Have potential to contribute to meaningful reductions in applied water;
- » Are not yet widely adopted;
- » Are likely to be accepted by the agricultural community;
- » Constitute a net benefit to agricultural operations;
- » Are cost-effective; and
- » Are not likely to produce unintended ecological or health impacts.

Below, these actions are described and preliminary action steps are proposed. Some of the challenges associated with the actions are listed. However, this is not a comprehensive list but rather captures concerns that were raised by growers over the course of the project.



6.1 OPTIMIZE IRRIGATION SCHEDULING

TARGET OUTCOMES

Best practices for irrigation scheduling are widely adopted on Santa Barbara County farms. Specifically, the number of farms irrigating on a set schedule is halved in 5 years (from 2016 levels) and the percentage of growers who determine irrigation needs by factoring in evapotranspiration or crop coefficients is doubled in the same time frame.

ACTION 1.1

Increase the adoption of technologies for irrigation scheduling (in particular automatic shut-offs, flow meters, and soil moisture sensors) by launching a coordinated program to provide free or low-cost tools to operations throughout the county. Couple these with training on irrigation scheduling best practices (see Action 1.2 below).

ACTION STEPS

- » Consider an equipment loan program through the RCD or another local organization.
- » Consider providing financial incentives to reduce costs of critical technologies such as automatic shut-offs, flow meters, and soil moisture sensors. Impact can be enhanced by providing these in conjunction with training in irrigation scheduling best practices.

CHALLENGES

- » Some industry concern exists about the privacy of water use data collected using flow meters, and the possibility of flow meters becoming a regulatory requirement in overdrafted groundwater basins under the Sustainable Groundwater Management Act. However, while there is some possibility that well monitoring may become mandatory, this appears to be independent of existence of flow meters on farms and ranches.
- » Flow meters may require calibration and awareness about proper use.
- » Adequate funding for program implementation and incentives remains an obstacle.

ACTION 1.2

Provide irrigation scheduling best practices training to farm operators, managers, and irrigation staff, offering incentives for participation when able.

ACTION STEPS

- » Provide trainings, ideally on a demonstration site using grower-to-grower sharing, about data and tools to support scheduling. Considerations:
 - To the extent possible, make it easy for irrigators to participate in trainings by delivering them where growers are already convening rather than organizing stand-alone events that require added time and commitment.
 - Ensure that trainings target irrigation field staff and contract irrigators.
 - Deficit irrigation should be a topic covered in trainings given grower interest in this technique. The survey showed that 40% of growers, particularly of lemons, avocados, and wine grapes, would consider deficit irrigation techniques.
 - The training for landscape professionals provided by Green Gardens Group may be a good model to expand for this audience.
 - Explore collaborations with commodity organizations, technical support providers, and others to develop, conduct outreach for, and implement these opportunities.
- » Provide Irrigated Lands Regulatory Program education credits when possible.

ACTION 1.3

Make data more useful for irrigation scheduling. Aggregate the best data sources and tools for tailoring water use to crop need on a daily basis and make these accessible to agricultural irrigators. Create simplified interfaces to facilitate use.

ACTION STEPS

- » Develop and promote a mobile app or web interface that provides growers with irrigation recommendations based on evapotranspiration and crop coefficients, and provides text alerts with recommended irrigation schedules.
 - Industry representatives recommended asking growers for no more than 2-3 data points such as crop type and date of planting for annuals.
 - Other variables to consider include water holding capacity by soil type, plant water requirements, water budgets, and distribution uniformity.
 - One example of a related web interface for landscape applications to reference is Santa Barbara's Landscape Watering Calculator, available at <http://waterwisesb.org/calculator>.
- » Promote commercial software platforms that integrate field sensor data with management recommendations, and that have been recommended for use by local experts. Take steps to ensure that these are accessible to farm operations of all scales.

6.2 PROVIDE WIDESPREAD AND REGULAR IRRIGATION SYSTEM ASSESSMENTS COUPLED WITH FOLLOW-UP SUPPORT

TARGET OUTCOMES

Farms, particularly those with known or suspected irrigation system or implementation challenges, are receiving regular irrigation system evaluations to ensure optimal performance and efficiency.

Distribution uniformity is being assessed as a key indicator of system performance and is a metric known by farm operators.

Technical advisors are following irrigation system evaluations with targeted advice and robust support to implement recommended system maintenance and upgrades.

There is widespread awareness among Santa Barbara County growers about irrigation system evaluation services offered, including those of the Mobile Irrigation Lab.



ACTION 2.1

Significantly increase the number and impact of agricultural irrigation system assessments across Santa Barbara County, particularly targeting water district customers and small- to mid-scale farms. Through these assessments, deliver recommendations for system and management improvements, and provide follow-up implementation support.

ACTION STEPS

- » Increase the value of Mobile Irrigation Lab (MIL) services by expanding the MIL's follow-up, providing technical and financial support for implementation of recommended practices. See below for specifics on enhancing added value of the MIL through collaborations.
- » Promote MIL services through enhanced targeted outreach to growers and irrigation managers. The MIL should investigate partnerships with private and public farm advisors to more broadly encourage distribution uniformity (DU) assessments and irrigation system evaluations, utilizing photography and video to demonstrate poor DU. Specific actions might include:
 - Evaluating opportunities to target MIL outreach where it may be most needed.
 - Implementing a new orchard program, providing incentives to focus on distribution uniformity in new orchards or blocks where it can have a more meaningful impact.
 - Providing more education about the importance of good distribution uniformity and irrigation efficiency to growers around the county, either directly or in collaboration with other respected agricultural advisors.

CHALLENGES

- » An increase in funding is necessary to support the ongoing and enhanced provision of irrigation assessments.
- » RCD capacity has been identified as an issue requiring attention before successfully implementing these actions.
- » Effective outreach to growers has been a challenge. New and targeted outreach strategies would benefit MIL effectiveness.

ACTION 2.2

Enhance and coordinate decision support tools to increase adoption of irrigation management best practices.

ACTION STEPS

- » Create a coordinated and easily accessible package for growers that combines services by multiple providers to make it simpler for the end user to identify irrigation inefficiencies and make cost-effective upgrades. This could include the following elements (interested parties are listed in parentheses; others may exist):
 - Pump test and provision of incentives for variable frequency drives on ag pumps and pump replacements (SCE or PG&E);
 - Imagery and integration of forecast and evapotranspiration (Powwow Energy);
 - Irrigation system assessments (RDC), site specifics (Hortau and others), and follow-up support (multiple providers); and
 - Cost-share funding for water efficiency practices (USDA-NRCS, CDFA).
- » Partnerships with commodity groups can increase effectiveness of outreach and customization of services by crop type.

The Cachuma RCD or other respected local partner could initiate a program to coordinate these elements and communicate to growers in a clear and straightforward way.

- » Create an online portal to support growers in bringing together all info in one place and make it accessible to all growers.
- » Provide cost-share for irrigation efficiency components such as pressure compensating emitters and the irrigation scheduling components listed in the irrigation scheduling recommendations above.

CHALLENGES

- » The effective collaboration among public and private actors may be hindered by competition, insufficient motivation, and other factors.
- » Lead organizations may require added capacity and funding for carrying out proposed actions and programs.



What's never been done is the integration... in a way that the farmer feels like it makes sense to them. They don't have time to put the puzzle pieces together.

— FOCUS GROUP PARTICIPANT

6.3 INCREASE WATER AVAILABILITY THROUGH ENHANCED WATER CAPTURE, INFILTRATION, AND RETENTION

TARGET OUTCOMES

Irrigation water efficiency is optimized through healthy soils. Specifically, growers of all scales are implementing cultural practices that build soil health for optimal water retention, protect soil surface to reduce evaporative losses and erosion, and enhance the capture, infiltration, and retention of water in agricultural soils.

ACTION 3.1

Develop soil health research and education opportunities.

ACTION STEPS

- » Investigate opportunities for peer-to-peer demonstration and applied research programs focused on enhancing soil health in local agricultural systems.
- » Deliver information to growers about best management practices and available incentive programs such as the State Water Efficiency and Enhancement Program (SWEEP), administered by the California Department of Food and Agriculture.
- » Expand one-on-one technical and financial assistance programs, such as those managed by Resource Conservation Districts and USDA-NRCS.



ACTION 3.2

Provide technical and permitting assistance for earthworks projects for water capture.

ACTION STEPS

- » Provide technical support and streamlined permitting to facilitate growers implementing land management activities that, in alignment with sustainable groundwater management goals, improve water retention and infiltration. These may include a patchwork of small-scale retention basins and swales, planting on contour, keyline design, and possibly small ponds, particularly in groundwater infiltration areas.
- » Where possible, farm and conservation advocates may collaborate with the regulatory community to advance coordinated permitting programs.

CHALLENGES

- » *Site specificity:* There is no one-size-fits-all solution in the realm of earthworks or land management for water retention—design will vary with site characteristics such as slope and soil type. A technical support partner could help landowners overcome the knowledge gap and create effective designs.
- » *Permitting challenges for earthworks:* More substantial earthworks projects that impound water or move more significant amounts of soil require permits (sometimes multiple permits from different agencies), which is an obstacle to advancing these multi-benefit solutions at the farm scale but may be overcome by coordinated permitting.

ACTION 3.3

Facilitate soil health technical assistance and cost-sharing.

ACTION STEPS

- » Supply direct technical support, cost-share program information (e.g., State Water Efficiency and Enhancement Program), demonstration projects, and shared case studies and communications materials to increase adoption of water retention measures such as mulching and minimizing exposed soil.
- » Collaborate with groundwater recharge advocates to support implementation.

CHALLENGES

- » *Labor costs:* On some ranches, particularly on steeper terrain, mulching and seed broadcasting for cover cropping must be done by hand and is thus labor intensive. The cost of labor is reportedly one challenge to the more widespread application of mulch. Innovative approaches to addressing this challenge such as engaging the local community in mulching work parties could be explored. More communication about the benefits of mulching may also be helpful.
- » Additional challenges, such as the availability of good quality mulch and food safety regulations addressing compost use, are also important to assess.

ACTION 3.4

Expand outreach to, and engagement of, the agricultural community in sustainable groundwater management and governance discussions.

ACTION STEPS

- » Identify opportunities for growers to support groundwater management goals through increasing water capture, retention, and infiltration on farms located in ideal groundwater recharge areas.
- » Ensure agricultural representation and discussion of cultural practices in Groundwater Sustainability Agencies.



6.4 CLOSE THE TECHNICAL ASSISTANCE COLLABORATION GAP

TARGET OUTCOMES

All growers and irrigation contractors are aware of, and have access to, agricultural water technical advisors (spanning approaches from irrigation technologies to cultural practices for enhanced water management).

There is a meaningful increase in coordinated efforts among public and private agricultural water advisors to effectively share and advance emerging water efficiency and stewardship practices and technologies.

ACTION 4.1

Create an agricultural water support network based on the shared value that good water use efficiency and stewardship should be employed in all agricultural operations and that everyone should have access to the best water technologies and practices.

ACTION STEPS

- » A local, trusted organization, such as the Cachuma Resource Conservation District, should investigate the creation of an agricultural water support network that includes all interested public and private technical support advisors working with the Santa Barbara agricultural community. Such a network could be a powerful way to:
 - Identify shared goals;
 - Discuss successes and challenges;
 - Share and coordinate activities and services;
 - Inform each other about emerging studies, technologies and approaches; and
 - Provide input and support for each other's efforts.

CHALLENGES

- » Staff capacity and funding to advance these actions remains necessary to ensure success of this area of opportunity.

ACTION 4.2

Coordinate strategic outreach to achieve shared outcomes.

ACTION STEPS

- » Reach out to growers through their trusted farm advisors, including pest control advisors, crop consultants, and irrigation equipment suppliers. These types of professional service providers are important targets for outreach alongside direct outreach to growers themselves.
- » Provide tailored outreach to small-scale operations that lack the resources to effectively source and implement water management best practices. Implement outreach, messaging, and technical support opportunities that specifically target small farms.

CHALLENGES

- » Creating an effective framework for collaboration that addresses competition among technical assistance providers will take particular attention.

7. Barriers to Adoption of Agricultural Water Use Efficiency Measures

A large number of varied obstacles hinder growers' abilities to implement new water use efficiency and stewardship measures.

Our survey asked growers about the most significant barriers they face in their efforts to increase water use efficiency (see Table 1). A large number of significant obstacles were reported. Barriers that are specific to particular technologies and practices are explained in greater detail under the areas of opportunity listed above.

In general, costs, including equipment and labor costs, are barriers to all growers, but equipment and supply costs are one of the top three

significant barriers for all crop types, while labor cost is only in the top three for berry growers. Wine grape, cut flower, and avocado growers are particularly sensitive about the risk of a new water management practice or technology to their crop yield or quality, with 37% of these growers considering this a significant risk. Paperwork and regulatory requirements are a barrier to the adoption of new practices or technologies across all crop types. How these requirements are defined may vary.



TABLE 1: BARRIERS TO ADOPTION OF EFFICIENT AGRICULTURAL WATER MANAGEMENT PRACTICES IN SANTA BARBARA COUNTY

*Percentages of respondents growing by crop type who identify barriers as “significant” or “somewhat significant.”
The graded shading scale represents the most prevalent barriers (darkest) to the least prevalent (lightest).
The top 3 “significant” barriers (4 if a tie) or each crop type are indicated by an asterisk.*

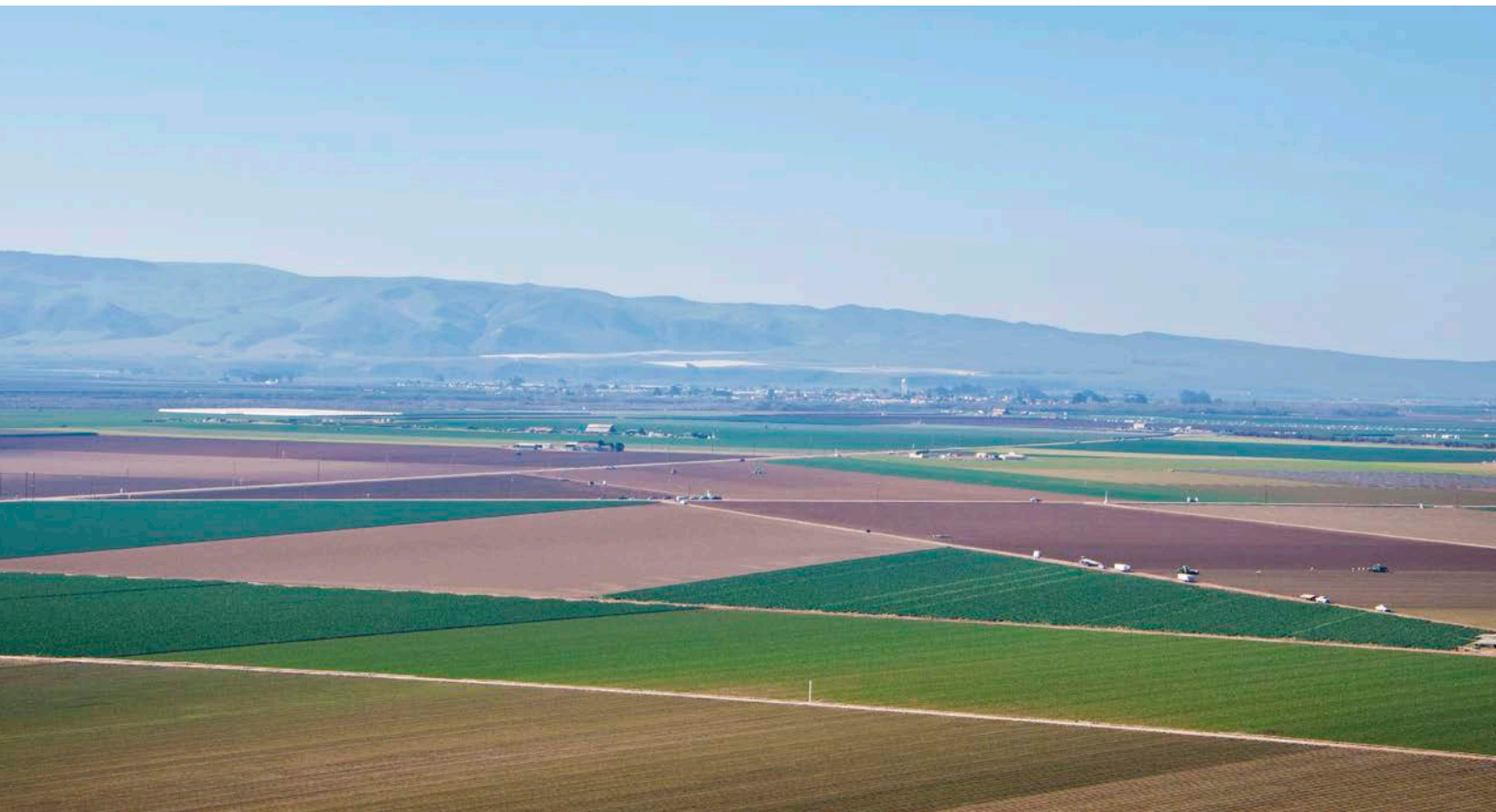
	Avocado	Lemon	Wine grapes	Berries	Vegetables	Cut flowers
Equipment/supply costs	* 82%	* 71%	* 79%	* 86%	* 79%	* 64%
Labor costs	80%	73%	58%	* 71%	80%	64%
Insufficient labor availability	55%	50%	37%	43%	58%	50%
Lack of adequate skills or knowledge on the farm	42%	35%	53%	29%	58%	27%
Uncertainty about effectiveness of practices	77%	55%	63%	71%	74%	40%
Risk to crop yield or quality	73%	57%	* 84%	50%	58%	* 82%
Compatibility with other aspects of the operation	43%	43%	47%	29%	55%	56%
Too much choice in technologies/brands	42%	35%	47%	43%	20%	30%
Lack of access to adequate technical advice/support	59%	52%	58%	29%	63%	45%
Too many sources of technical advice; uncertainty about best option	62%	45%	47%	57%	42%	64%
Changes in water prices	57%	* 53%	47%	* 57%	55%	* 70%
Paperwork requirements	* 69%	57%	* 61%	57%	* 63%	73%
Regulatory requirements	* 63%	* 58%	72%	83%	* 76%	* 70%

8. Conclusion

While growers in Santa Barbara County have a high rate of adoption of efficient irrigation systems, many opportunities still exist to secure further gains in agricultural water use efficiency.

Agriculture is an important economic engine in Santa Barbara County as well as being integral to the character and landscape of the county. Everyone has a stake in the long-term viability and health of agriculture in Santa Barbara County, whether their primary interest is economic viability, food security, or ecosystem services provided by open space and agriculture. The availability of future water supplies is a significant threat to the agricultural sector. Conversely, the places where agricultural water use is inefficient imperils the county's broader water security.

Improved irrigation scheduling, irrigation system evaluation and maintenance, and improvements in on-farm water retention and infiltration represent the most important focal points for future technical and financial support. In addition, the enhanced coordination and collaboration across the full spectrum of technical and financial support providers is needed to most effectively implement further change.



SNAPSHOT: Goleta Water District

Goleta is home to a thriving agriculture sector. The leading agricultural product in Goleta is avocados, followed by lemons and ornamentals. Growers already have a very high adoption rate of efficient drip and micro sprinkler technologies (approximately 85% of farms), however, as more broadly throughout the county, there is room for improvement in system management and maintenance. Water availability has been a significant factor limiting the expansion of avocados and lemons in this region. In addition, Goleta agriculture has a strong interface with residential areas, both urban agriculture and rural farms.⁷

REPRESENTATIVENESS OF SURVEY RESPONDENTS IN THE GOLETA WATER DISTRICT

There are 124 agricultural customers in Goleta Water District (urban agricultural and Goleta West Conduit agricultural customers combined).⁸ Of these, 28 (23%) were represented in the agricultural water management survey. For avocados, the survey represents between 461 and 2,035 acres of the total 2,636 acres of avocados in Goleta Water District (respondents indicated a size range rather than specific acreage value). The survey covers between 180 and 782 acres of a total 845 acres of lemons grown.

FIGURE 6: GOLETA WATER DISTRICT ACREAGE BY CROP

Low, medium, and high acreage estimates for crop types actively managed by respondents having a water line connection with the Goleta Water District

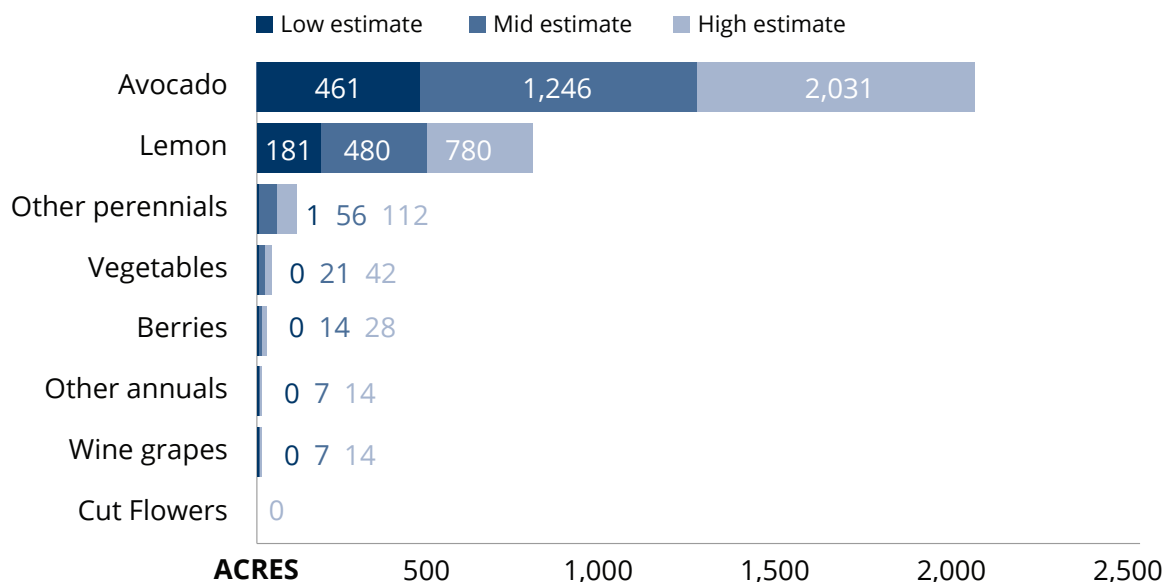
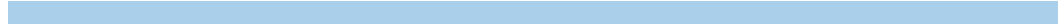


FIGURE 7: GOLETA WATER DISTRICT CUSTOMERS - KEY FACTS

97% identify the **cost of equipment and supplies** as a significant or somewhat of a barrier to greater adoption of efficient water management practices



85% are interested in installing solar power



79% are interested in using municipal recycled water for irrigation if adequate quality and rate



77% would consider factoring in Management Allowed Depletion to calculate irrigation needs



At least 66% would consider using a flow meter



63% would consider testing for distribution uniformity on a regular basis



60% would consider factoring in evapotranspiration rates to calculate irrigation needs



60% expressed interest in participating in an incentive program to replace ailing pumps



52% would consider practicing deficit irrigation



42% would consider applying organic soil amendments to improve water retention



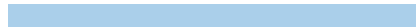
40% would consider using an automatic backflush



39% modify the frequency and duration of their irrigation monthly or less



33% would consider using an automated shut-off



31% would like to participate in the Mobile Irrigation Lab (42% are not aware of the program)



29% of growers see an opportunity to capture more water from rainfall events (18% are uncertain)



26% expressed interest in Goleta's Water Savings Incentive Program (33% are not aware of the program)



100%

SNAPSHOT: Carpinteria Valley Water District

Avocados are by far the biggest crop in Carpinteria Valley in terms of acreage (1,849 acres in 2015); avocados are grown both on the valley floor and on hillsides, and make up 20% of all avocado production in Santa Barbara County. The second most extensive crop is ornamental flowers, accounting for 785 acres of open land and greenhouse production. Greenhouses have become prevalent in the valley for the production of chrysanthemums, orchids, other cut flowers and bedding plants. Carpinteria Valley is considered “California’s flower basket.”⁹ The multi-million dollar cut flower industry includes over 30 nurseries and is responsible for over half of the county’s flower production. Fairly recently, there has been an increase in the production of exotic fruits, such as cherimoyas, white sapotes, and passion fruit.

REPRESENTATIVENESS OF SURVEY RESPONDENTS IN CARPINTERIA VALLEY WATER DISTRICT

There are 406¹⁰ agricultural accounts in Carpinteria Valley Water District, covering a total of 3,167 acres. Of these, 39 operations (10%) were represented in the agricultural water management survey. The survey provided a range of acres for each crop. For avocados, the survey represents between 167 and 833 acres of the total 1,849 acres of avocados in Carpinteria Valley Water District. The survey represents between 16 and 147 acres of a total 785 acres of ornamentals, and between 1 and 84 acres of a total 207 acres of lemons.

FIGURE 8: CARPINTERIA VALLEY WATER DISTRICT ACREAGE BY CROP

Low, medium, and high acreage estimates for crop types actively managed by respondents having a water line connection with the Carpinteria Valley Water District

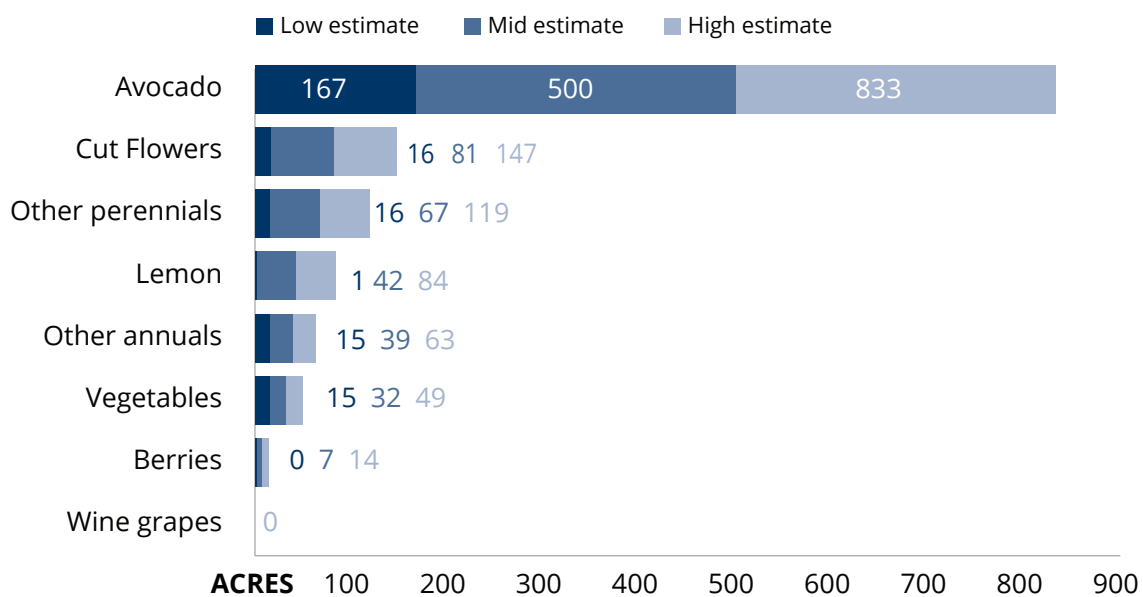


FIGURE 9: CARPINTERIA VALLEY WATER DISTRICT CUSTOMERS - KEY FACTS

80% identify **uncertainty about effectiveness of practices** as a significant or somewhat of a barrier to greater adoption of efficient water management practices. Equipment and labor costs are also significant barriers



85% are interested in installing solar power



67% are interested in using municipal recycled water for irrigation if adequate quality and rate (23% are unsure)



53% would consider factoring in Management Allowed Depletion to calculate irrigation needs



51% would consider factoring in evapotranspiration rates to calculate irrigation needs



50% would consider using a flow meter



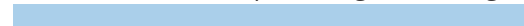
45% expressed interest in participating in an incentive program to replace ailing pumps



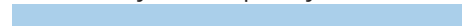
44% would consider applying organic soil amendments to improve water retention



42% would consider practicing deficit irrigation



37% modify the frequency and duration of their irrigation monthly or less



35% would consider using pressure compensating emitters



35% would consider using an automatic backflush



33% would consider using an automated shut-off



29% would consider testing for distribution uniformity on a regular basis



16% would like to participate in the Mobile Irrigation Lab (48% are not aware of the program)



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Appendix:

Santa Barbara County Agricultural Water Management Survey Report

By: Katy Mamen, Lucas Patzek, and Tessa Opalach

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This report outlines the methods and selected findings of the Agricultural Water Management Survey carried out in Santa Barbara County in October 2016. The action plan was developed using information collected through expert interviews, an online survey, and focus groups. In order to develop a general understanding of trends, opportunities, and challenges related to agricultural water use efficiency in the region, experts were interviewed and a review was conducted of published statistics and reports. An online survey of the county's growers was designed using the information from these initial research activities. Two focus groups with growers and agriculture support specialists were conducted to further refine recommendations for actions to increase agricultural water use efficiency, and to clarify the key challenges that growers face in advancing efficient agricultural water management practices.

1. RESEARCH METHODS

1.1 EXPERT INTERVIEWS AND SITUATION ASSESSMENT

Telephone interviews were conducted with 21 experts between April 21 and July 1, 2016. A semi-structured interview guide was used, which included 31 questions, although the specific questions asked during each interview varied depending on the sector or expertise of the interviewee. Interviews generally lasted 60 minutes. Interviewees were content specialists in the agriculture and water sectors, and included representatives of research and technical support organizations, agriculture interest groups, and water supply and management agencies. The interviewees were selected with guidance from the steering committee, and most were from Santa Barbara County, although some were selected from nearby areas, such as California's Central Valley or San Diego, in order to obtain a broader understanding of water management tools and strategies in use. Follow-up interviews were conducted with a handful of interviewee-experts to further explore outstanding questions. While interviews were being conducted, relevant published statistics and research reports were reviewed, and these two activities informed the development of the situation assessment.

1.2 ONLINE SURVEY

Guided by the results of the interviews and situation assessment, and with input from the steering committee, a questionnaire consisting of 37 questions was developed and deployed using the internet-based survey tool, Survey Monkey, to farm owners, managers, or other individuals actively involved in irrigation management decisions on farms in Santa Barbara County. The survey was launched on October 3, 2016, and was closed on October 31, 2016. The same questionnaire was sent to four different survey populations, herein called Tiers.

Survey Populations

Tier 1 was a population of 788 individuals having pesticide permits and/or organic certifications registered with the Agriculture Commissioner's Office of Santa Barbara County. A personalized link was emailed to this survey population. Tier 2 was a population of 393 agricultural customers of the Carpinteria Valley Water District, and a generic Tier 2 link was emailed to this survey population. Tier 3 was a population of 124 agricultural customers of the Goleta Water District, and a generic Tier 3 link was emailed to this survey population. While Tier 2 and 3 respondents could not be individually identified, they could be identified as customers of one of the two water districts. Tier 4 was a population of an unknown number of other Santa Barbara County farm operators not already identified in one of the other tiers, and a generic Tier 4 link was used for this survey. Tier 4 respondents learned of this survey through several targeted outreach campaigns described below.

Survey Delivery

Tier 1-3 survey populations were targeted by email beginning October 3, 2016. Emails included a letter introducing the survey and describing a \$40 gift certificate incentive offered to all survey respondents. The gift certificates were redeemable for water efficiency products, drip irrigation products, and all controllers and controller components at three local stores, including All-Around Landscape (Carpinteria and Santa Ynez store locations), AquaFlo (Goleta store location) and Cal-Coast Irrigation (Buellton and Santa Maria store locations). Tier 1 emails were sent by the project leader, while Tier 2 emails were sent by Carpinteria Valley Water District staff, and Tier 3 emails were sent by Goleta Water District staff. The Carpinteria Valley Water District also mailed a postcard advertising the survey to their customers. Follow-up reminders were emailed by the project leader to the Tier 1 population each Monday in the month of October until October 28, 2016. One email reminder was sent to Tier 2 and 3 populations on October 24, 2016, by each respective water district. Phone calls were also made to Tier 1 non-respondents having addresses in Carpinteria Valley (150 individuals) and Goleta (82 individuals) 14 days prior to the closure of the survey. Each individual was contacted once by phone, unless a request was made to call again at another time or if a return call was made to the project team. If the individual who was called requested another survey link, a generic (Tier 4) survey link was provided to them.

A variety of outreach strategies were used to target the Tier 4 survey population. First, the Santa Barbara County Ag Advisory Committee made an announcement about the survey at their monthly meeting on October 5, 2016, and provided flyers and postcards to meeting participants. Second, the California Avocado Commission announced the survey in its e-newsletter sent on October 17, 2016. Lastly, flyers and postcards were distributed through the offices of the Agricultural Commissioner, Cachuma Resource Conservation District, and Santa Barbara County Farm Bureau, as well as local irrigation supply stores (i.e., All-Around Landscape Supply in Santa Ynez and Carpinteria, AquaFlo in Goleta, and Cal-Coast Irrigation in Santa Maria and Buellton) and agricultural packers, distributors, and support providers (IndexFresh, Mission Produce, Wonderful Citrus, Oxnard Lemon, Saticoy, Sunkist, and West Pak).

Response Rate

There were 150 total respondents, including 99 Tier 1 respondents, 13 Tier 2 respondents, 29 Tier 3 respondents, and 9 Tier 4 respondents. The Tier 1 response rate was 13.4%, excluding 51 incorrect email accounts. The Tier 2 response rate was 3.3%, the Tier 3 response rate was 23.4%, and the Tier 4 response rate cannot be calculated because the number of growers reached is unknown. The actual response rate for Tiers 1-3 is most likely higher than stated above as some individuals were included in multiple tiers, but only responded to one. A large portion of the total acreage of several important crops was captured in this survey, as described below.

The eligibility of some non-respondents in the Carpinteria Valley and Goleta areas was determined during follow-up phone call reminders. If the individual contacted was no longer actively managing irrigation on the farm because of retirement, death, or another reason, the project team attempted to identify a current irrigation manager. If an alternative manager could not be identified, that email address was determined to be ineligible. If the name and email address for the current manager was identified, they were added to the survey. The reasons provided during the follow-up reminder phone calls for not responding to the survey included no longer working in the farming industry and having too little time to fill out the survey due to it being a busy time of year. A few individuals described having survey fatigue or distrusting the intention of the survey.

1.3 FOCUS GROUPS

Two structured focus groups were held with growers and key agricultural stakeholders, the first on October 17, 2016, and the second on June 22, 2017. The first was held to solicit feedback on initial survey findings (the survey was still open at this time), and it involved 20 growers from Santa Barbara County. It was held at Glen Annie Golf Club in Goleta as part of the Cachuma Resource Conservation District's 3-hour long workshop "Agricultural Assistance for Santa Barbara County Growers and Farmers." The second focus group was held to evaluate tools and techniques growers can employ to reduce dependency on uncertain water supplies by improving their management of existing and future water supplies, and to build alignment and partnerships to guide implementation of best practices. It involved 27 agricultural leaders, including 11 growers, 4 technical assistance providers, 2 packer-shippers, 3 water suppliers, 2 staff from the County of Santa Barbara, and 5 other agriculture industry representatives. It was a 4-hour long convening entitled "Tools and Strategies for Agricultural Water Use Efficiency" held at Rancho San Julian.

2. CHARACTERIZATION OF SURVEY RESPONDENTS

150 growers around Santa Barbara County completed the survey, representing 12% of all farms with cropland in the county. The average farm size represented is 142 acres, and farms range in size from 1 acre to 2,850 acres in size.¹ 64% of respondents have one agricultural operation; 19% have two; 18% have three or more. Respondents operate a total of 397 farms in the county, however they were asked to complete the survey for the largest farm they operate, so data for 150 farms is included in survey results. Regarding ownership status, 75% of respondents own their farms, 59% directly manage the operation, and 9% lease. In total, survey respondents operate 17,913 acres—or 14%—of Santa Barbara County cropland. Although a significant proportion (21%) of survey respondents were representing small farms of 1-9 acres, this is a smaller proportion of the total number relative to other size classes (see Figure A).

The survey covered many important crops in Santa Barbara County.² 45% of respondents grow avocados, 15% grow lemons, 14% grow vegetable row crops, 13% grow wine grapes, 8% grow cut flowers, and 5% grow berries. 15% grow other annuals, including beans, wheat, orchids, and basil. 22% grow other perennial crops, including cherimoyas, apples, olives, coffee, and jujube. Of the responding avocado growers, 28% also produce lemons, 22% produce another perennial crop, and 13% produce cut flowers, but very few avocado growers (only 3-4%) produce either wine grapes or cut flowers as an additional crop. However, 75% of responding cut flower growers produce avocados as a second crop. None of the responding berry growers produce avocados, lemons, or wine grapes, but 63% of the berry growers also produce vegetables. Avocado, lemon, and berry growers are particularly well-represented in the survey population, with approximately half of all acreage of these crops covered by the survey. 40% of respondents operate at least some certified organic acreage.

1 Small farms were defined as those that are ≤15 acres in size, mid-sized farms as those that are >15 acres and ≤100 acres, and large farms as those that are > 100 acres. Acreages were taken from the responses to the field "# total acres in the farm you responded for in this survey" in question 27. The total acreage was greater for this field compared with the field "# of farmland acres in Santa Barbara County," suggesting that some respondents may have read this field as asking for the total farmland acres that they actively manage.

2 Responses were categorized by crop type by evaluating whether a production acreage range was provided for a given crop type. For instance, all respondents selecting any acreage range value for avocados were considered an avocado grower. Because there were only 8 berry growers responding to this survey, this crop type category was excluded from most analyses.

FIGURE A: SIZE DISTRIBUTION OF FARMS SURVEYED COMPARED WITH TOTAL SANTA BARBARA COUNTY FARMS BY SIZE CATEGORY³

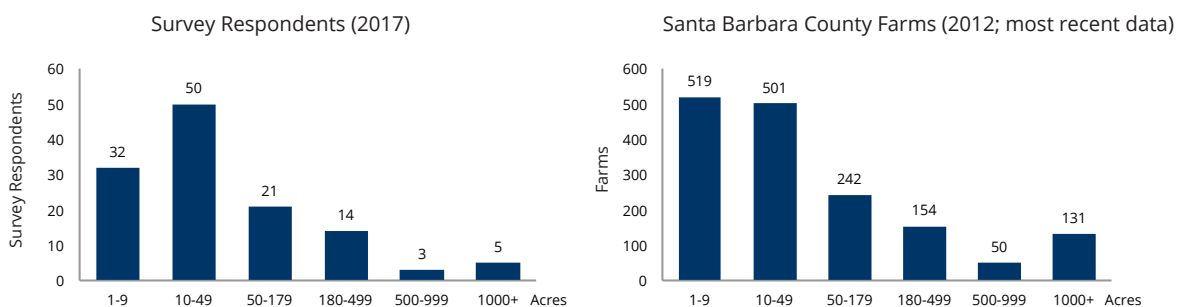


TABLE A: NUMBER OF FARMLAND ACRES AND INDIVIDUAL FARMS ACTIVELY MANAGED BY RESPONDENTS IN SANTA BARBARA COUNTY BY WATER LINE CONNECTION⁴

	All respondents		Carpinteria Valley Water District		Goleta Valley Water District	
	Total	Min-Max (Mean)	Total	Min-Max (Mean)	Total	Min-Max (Mean)
# of farmland acres in Santa Barbara County	17,9134	1-2,850 (1,421)	636	1-55 (18)	3,471	1-1,800 (139)
# of individual farms in Santa Barbara County	16,716	1-3,000 (146)	630	1-55 (20)	1,277	1-340 (56)

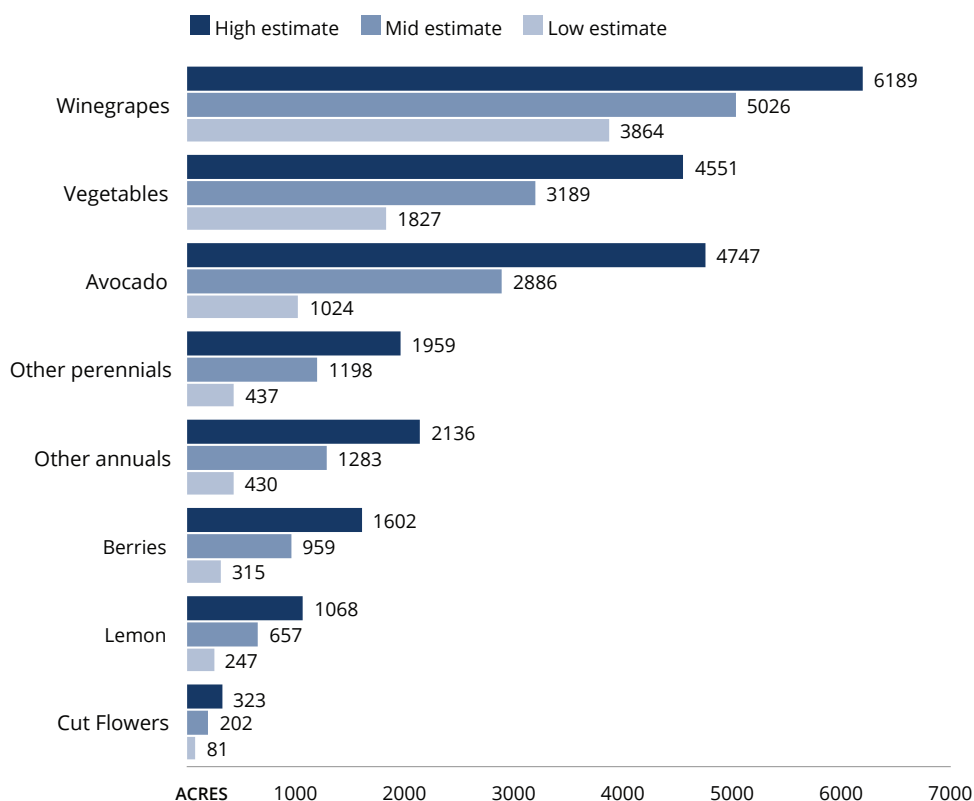
TABLE B: NUMBER OF ACRES OF DIFFERENT CROP TYPES ACTIVELY MANAGED BY RESPONDENTS IN SANTA BARBARA COUNTY BY WATER LINE CONNECTION

Crop type	Total acres - Mid estimate		
	All respondents	Carpinteria Valley Water District	Goleta Water District
Wine grapes	5,026	-	7
Vegetables	3,189	32	21
Avocado	2,886	500	1,246
Other perennials	1,198	67	56
Other annuals	1,283	39	7
Berries	959	7	14
Lemon	657	42	480
Cut Flowers	202	81	-
Total	15,400	769	1,832

3 USDA NASS. (2014). 2012 Census of Agriculture, Volume 1, Chapter 2: County Level Data. Table 8. Farms, Land in Farms, Value of Land and Buildings, and Land Use: 2012 and 2007. Retrieved from https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1_Chapter_2_County_Level/California/st06_2_008_008.pdf

4 Estimating the acreages of crops grown by the respondents is made difficult by the fact that respondents were asked to select an acre range for different crop types, the range categories being: 0.1-14, 15-49, 50-99, 100-499, 500+ acres. A low, medium, and high acreage estimate was calculated for each crop type by multiplying the minimum, mean, and maximum values of a range category by the number of respondents specifying production of a specific crop type in that range, and summing across all range categories for that crop type. The sum of medium acreage estimates is 15,400 acres, which is relatively close to the total number of farmland acres the respondents actively managed in Santa Barbara County (16,716 acres), and will therefore be used as the closest approximation of crop acreages captured by the survey.

FIGURE B: HIGH, MEDIUM AND LOW ACREAGE ESTIMATES FOR CROP TYPES ACTIVELY MANAGED BY ALL RESPONDENTS



3. ADDITIONAL SURVEY DATA AND ANALYSIS

Selected survey findings are reported throughout the main report. Additional data and analysis from the survey provide a more complete picture of agricultural water management in Santa Barbara County and are provided below. Berries are omitted from several of the following tables because of the low number of survey respondents who grow berries.

3.1 IRRIGATION WATER SOURCES

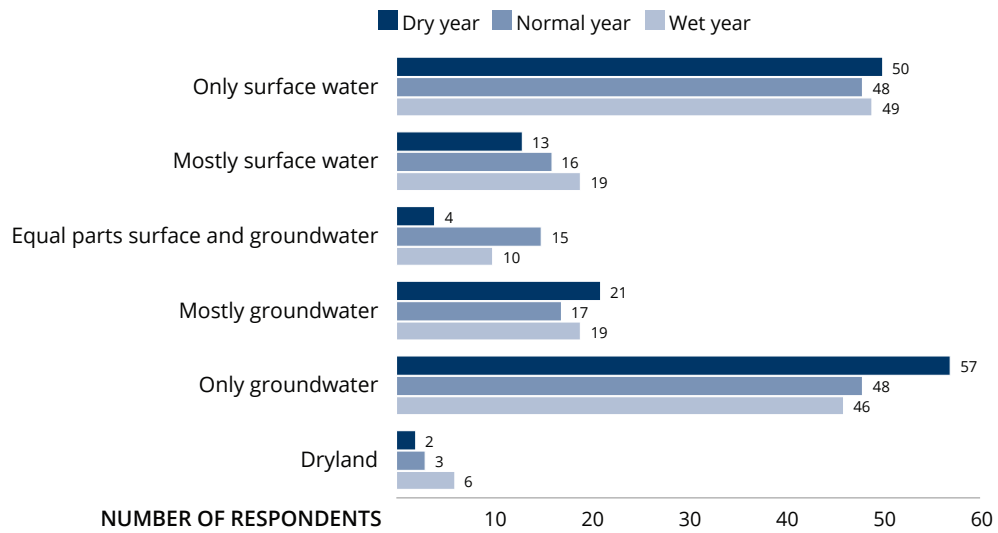
In a normal year, nearly half of the respondents (65) are only or mostly dependent on groundwater, and about half of the respondents (64) are only or mostly dependent on surface water.⁵ Reliance on only or mostly groundwater increases by 20% in a dry year over a wet or normal year, while reliance on only or mostly surface water decreases by 7% in a dry year over a wet year. This indicates that fewer than 10% of growers reduce their reliance on surface water in a dry year, either due to allotments being curtailed or the cost burden becoming too great, while the shift toward greater groundwater reliance is almost twice as large in a dry year compared with the shift away from surface water reliance. Only 2% of respondents are dryland farmers in a normal year. In a wet year, the number of growers who dryland farm doubles compared with a dry year, but this is still a tiny number compared with number of growers reliant on irrigation.

⁵ Growers only or mostly dependent on surface water (i.e., surface water users) were determined by merging responses for “only surface water (including utility/water district water)” and those for “mostly surface water (including utility water), some groundwater” in a normal year. Growers only or mostly dependent on groundwater (i.e., groundwater users) were determined by merging responses for “groundwater only” and those for “mostly groundwater, some surface water (including utility water)” in a normal year.

TABLE C: IRRIGATION WATER SOURCES USED BY SURVEY RESPONDENTS

	% of Respondents (# of Respondents)		
	Dry year	Normal year	Wet year
Only surface water	34% (50)	33% (48)	33% (49)
Mostly surface water	9% (13)	11% (16)	13% (19)
Equal parts surface and groundwater	3% (4)	10% (15)	7% (10)
Mostly groundwater	14% (21)	12% (17)	13% (19)
Only groundwater	39% (57)	33% (48)	31% (46)
Dryland	1% (2)	2% (3)	4% (6)

FIGURE C: IRRIGATION WATER SOURCES IN A TYPICAL WET, NORMAL, AND DRY YEAR



3.2 IRRIGATION METHODS

TABLE D: IRRIGATION METHODS BY WATER SOURCE

	% of acres by water source (# of acres)		
	Only or mostly surface water	Only or mostly groundwater	Any water source
Flood/furrow	1% (30)	<1% (21)	<1% (71)
Hand watering	1% (33)	<1% (1)	<1% (87)
Solid set sprinklers	2% (63)	9% (1,502)	6% (1,737)
Hand moved sprinklers	5% (188)	13% (2,119)	8% (2,348)
Micro sprinklers	35% (1,326)	7% (1,150)	9% (2,624)
Permanent drip	6% (240)	21% (3,378)	13% (4,067)
Drip tape	2% (78)	42% (6,657)	23% (7,041)
Not irrigated	48% (1,808)	7% (1,177)	41% (12,583)
Total acres	3,767	16,005	30,558

FIGURE D: ACRES IRRIGATED BY DIFFERENT METHODS BY SOURCE OF IRRIGATION WATER

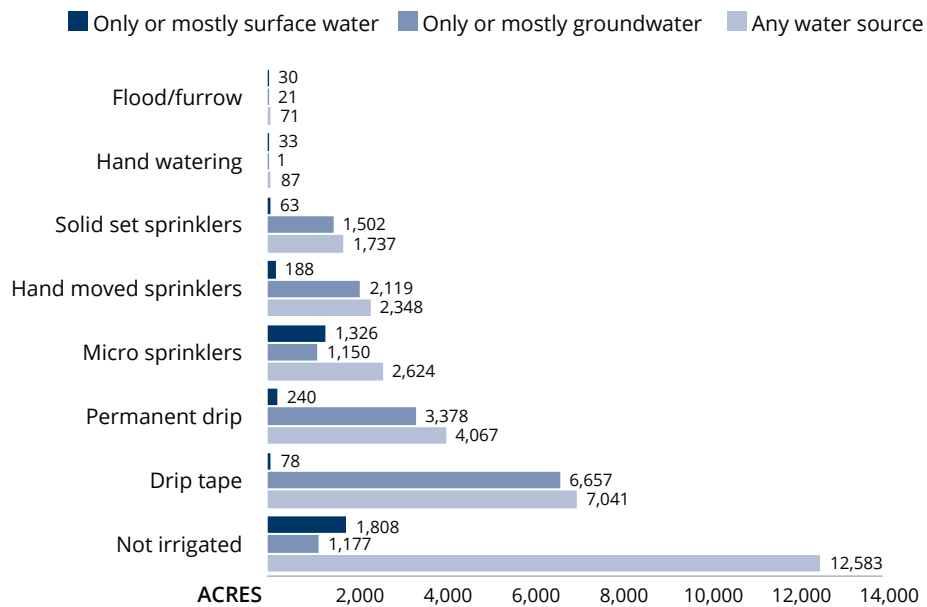
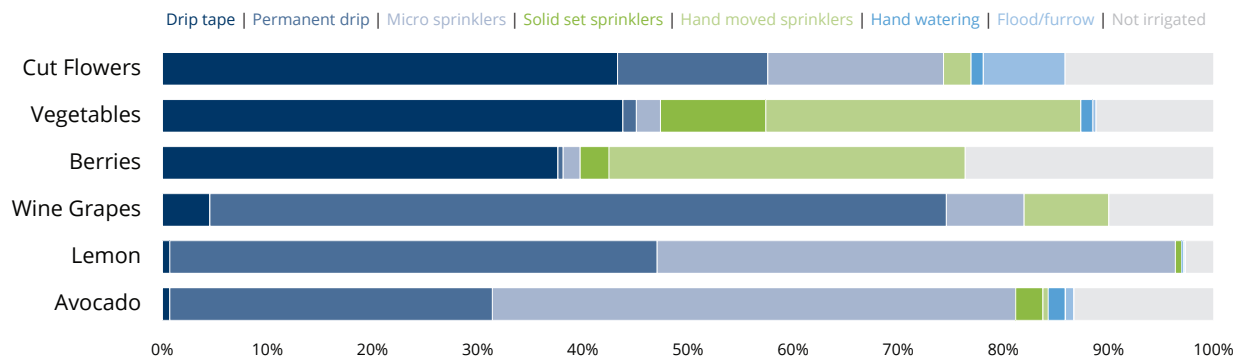


FIGURE E: PERCENT OF FARMLAND ACRES IRRIGATED BY DIFFERENT METHODS BY CROP TYPE



3.3 WATER LINE CONNECTION TO WATER DISTRICTS

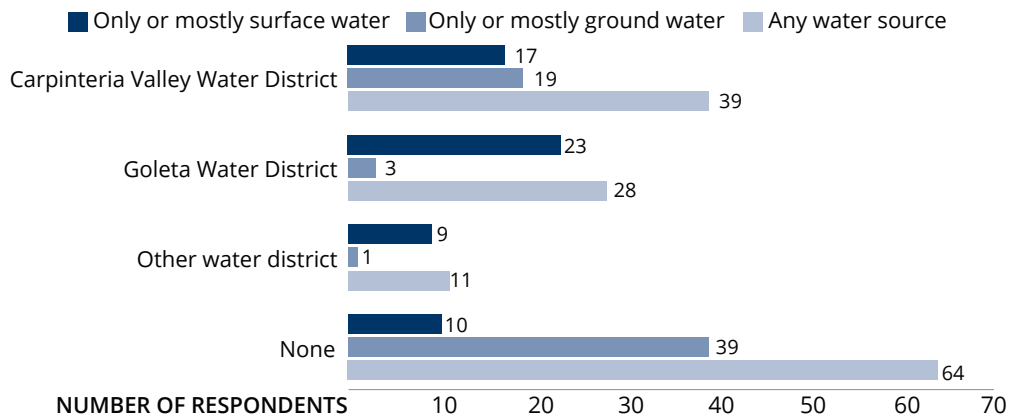
Of those respondents receiving agricultural water from the Carpinteria Valley Water District, 49% were reliant on only or mostly groundwater, amounting to 408 acres, 77% of which used micro sprinkler or drip systems. Of those respondents receiving agricultural water from the Goleta Water District, only 11% were reliant only or mostly on groundwater, amounting to 196 irrigated acres all using micro sprinkler or drip systems. The Carpinteria Valley Water District and Goleta Water District customers represented 86% of total respondents receiving agricultural water through a water line connection, whereas 45% of all respondents had no water line connection.

TABLE E: NUMBER OF RESPONDENTS WITH AGRICULTURAL WATER SERVICE PROVIDER

	Only or mostly surface water	Only or mostly groundwater	Any water source
Carpinteria Valley Water District	17	19	39
Goleta Water District	23	3	28
Other water district*	9	1	11
None	10	39	64
Total	59	62	142

* *City of Santa Barbara, City of Santa Maria, Golden State Water Company, La Cumbre Mutual Water Company, and Montecito Water District*

FIGURE F: NUMBER OF RESPONDENTS WITH AGRICULTURAL WATER SERVICE PROVIDER BY WATER SOURCE



3.4 OPPORTUNITIES TO CAPTURE MORE WATER FROM RAINFALL EVENTS

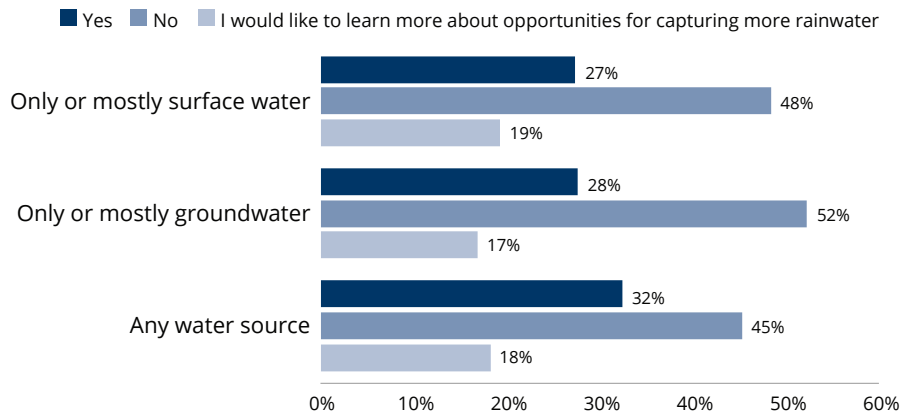
The source of irrigation water (surface vs. groundwater) has little influence on whether a grower perceives an opportunity to capture more water from rainfall events. About 27% of respondents irrigating primarily with surface water or primarily with groundwater believe there is an opportunity for more rainwater capture on the farm, while nearly half don't think an opportunity exists. As one third of all respondents see an opportunity for more rainwater capture, there is potential for water districts and agricultural support organizations to explore if improved methods for rainwater capture can be deployed on the region's farms as a means of reducing agricultural uses of surface and groundwater. In dry areas, rainwater capture on the farm can be enhanced by in situ water conservation practices (e.g., contour strips, conservation tillage, mulching, and otherwise improving soil water-holding capacity), or by installing storage for supplementary irrigation (e.g., tanks and ponds). At a larger scale, a water district or local government could consider targeted groundwater recharge by capturing runoff and diverting it to farm fields with suitable soil properties.

Avocado growers are the least optimistic about the opportunity to capture more water from rainfall events (24% believe an opportunity exists), while vegetable growers are the most optimistic (46%). About one third of growers producing lemons, wine grapes, and cut flowers see an opportunity. However, growers of vine and tree crops, including avocados, are generally more interested in learning about opportunities for capturing rainwater than growers of annual crops, so outreach on the subject should first focus on this group. Also, research has demonstrated that trees can improve soil hydraulic conductivity and reduce overland water flow,⁶ so focusing rainwater capture and groundwater recharge efforts in perennial crops could be a favorable strategy. The larger the size of the farm operation the more likely the grower is to believe that additional opportunities exist for capturing rainwater. Thus, managers of large farms (>100 acres) are over twice as likely than managers of small farms (0-15 acres) to believe that additional opportunities exist.



⁶ Ilstedt, U.; Bargaúes Tobella, A.; Bazié, H.R.; Bayala, J.; Verbeeten, E.; Nyberg, G.; Sanou, J.; Benegas, L.; Murdiyarsou, D.; Laudon, H.; Sheil, D.; & Malmer, A. (2016, 24 February). Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics. *Nature*. Retrieved from <https://www.nature.com/articles/srep21930>

FIGURE G: GROWER PERCEPTION OF OPPORTUNITIES TO CAPTURE MORE WATER FROM RAINFALL EVENTS BY SOURCE OF IRRIGATION WATER



Note: Percentages calculated for each independent variable. For instance, 27% of all respondents using only or mostly surface water answered "Yes."

FIGURE H: GROWER PERCEPTION OF OPPORTUNITIES TO CAPTURE MORE WATER FROM RAINFALL EVENTS BY CROP TYPE

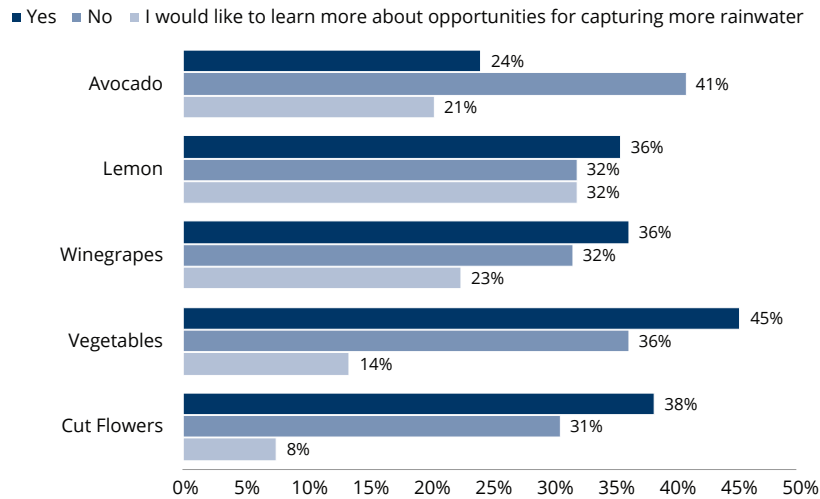
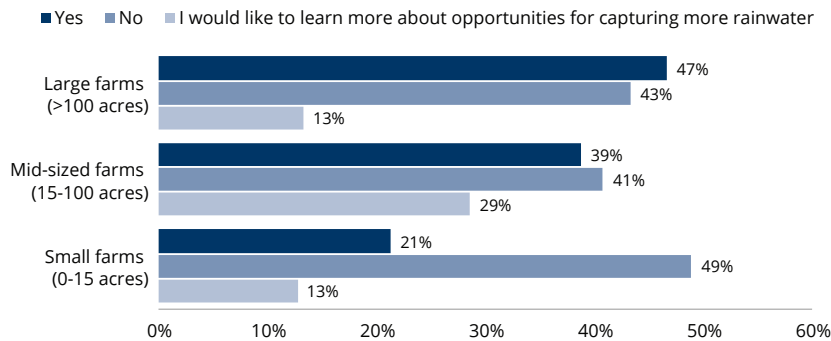


FIGURE I: GROWER PERCEPTION OF OPPORTUNITIES TO CAPTURE MORE WATER FROM RAINFALL EVENTS BY FARM SIZE



3.5 WATER MANAGEMENT TECHNOLOGIES AND PRACTICES FOR IRRIGATION SYSTEM DESIGN

FIGURE J: IRRIGATION SYSTEM DESIGN TECHNOLOGIES OR PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY ALL RESPONDENTS

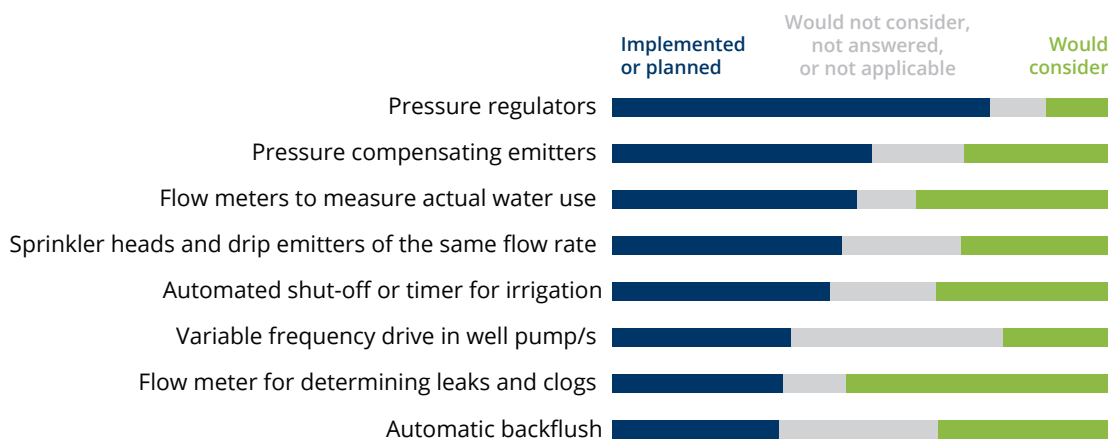


TABLE F: IRRIGATION SYSTEM DESIGN TECHNOLOGIES OR PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY CROP TYPE

	Avocado		Lemon		Wine grapes		Vegetables		Cut flowers	
	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider
Pressure regulators	* 82%	9%	* 95%	5%	* 84%	5%	* 62%	19%	* 83%	8%
Pressure compensating emitters	* 50%	30%	* 59%	* 36%	* 89%	11%	48%	29%	* 67%	25%
Use flow meters to measure actual water use	38%	* 45%	52%	* 43%	* 74%	26%	* 62%	29%	55%	27%
Sprinkler heads & drip emitters of the same flow rate	* 51%	33%	* 59%	* 36%	26%	26%	38%	29%	50%	* 33%
Automated shut-off or timer for irrigation	34%	34%	41%	23%	53%	* 32%	* 52%	* 48%	42%	* 42%
Variable frequency drive in well pump/s	27%	19%	29%	29%	58%	26%	43%	* 38%	* 60%	0%
Flow meter for determining leaks and clogs	33%	* 53%	48%	* 48%	53%	* 47%	43%	* 48%	55%	* 36%
Automatic backflush	27%	* 36%	55%	32%	53%	* 42%	38%	* 38%	42%	17%

Note: Percentages calculated within each crop type. Graded color scale going from the highest percentage of respondents (darkest) to the lowest (lightest). The Top 3 choices (4 if a tie) in each column are indicated by an asterisk.

3.6 WATER MANAGEMENT TECHNOLOGIES AND PRACTICES FOR IRRIGATION SYSTEM MAINTENANCE

FIGURE K: IRRIGATION SYSTEM MAINTENANCE PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY ALL RESPONDENTS

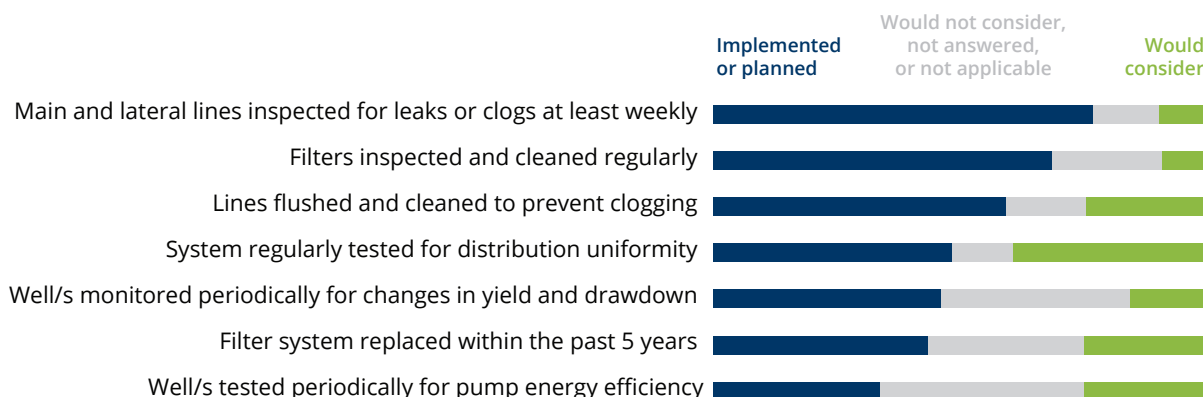


TABLE G: IRRIGATION SYSTEM MAINTENANCE PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY CROP TYPE

	Avocado		Lemon		Wine grapes		Vegetables		Cut flowers	
	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider
Main and lateral lines inspected for leaks or clogs at least weekly	* 84%	7%	* 86%	9%	58%	26%	* 71%	19%	* 75%	17%
Filters inspected and cleaned regularly	* 66%	10%	* 86%	0%	* 95%	5%	* 67%	10%	* 58%	17%
Lines flushed and cleaned to prevent clogging	* 56%	* 31%	* 77%	* 23%	* 79%	16%	43%	* 38%	50%	* 33%
System regularly tested for distribution uniformity	53%	* 39%	50%	* 41%	53%	* 47%	45%	* 45%	* 50%	* 30%
Well/s monitored periodically for changes in water yield and drawdown	35%	11%	41%	5%	* 78%	22%	* 62%	24%	40%	10%
Filter system replaced within the past 5 years	37%	* 25%	45%	18%	53%	* 32%	38%	* 38%	25%	* 25%
Well/s tested periodically for pump energy efficiency	26%	20%	23%	* 23%	58%	* 37%	38%	* 43%	36%	18%

Note: Percentages calculated within each crop type. Graded color scale going from the highest percentage of respondents (darkest) to the lowest (lightest). The Top 3 choices (4 if a tie) in each column are indicated by an asterisk.

TABLE H: IRRIGATION SYSTEM MAINTENANCE PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY FARM SIZE

	Small farms		Mid-sized farms		Large farms	
	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider
Main and lateral lines inspected for leaks, or clogs at least weekly	* 77%	13%	* 76%	8%	* 80%	10%
Filters inspected and cleaned regularly	* 59%	11%	* 76%	10%	* 77%	3%
Lines flushed and cleaned to prevent clogging	* 45%	* 34%	* 61%	27%	* 77%	10%
System regularly tested for distribution uniformity	43%	* 46%	46%	43%	67%	* 23%
Well/s monitored periodically for changes in water yield and drawdown	18%	13%	57%	19%	73%	17%
Filter system replaced within the past 5 years	35%	* 30%	51%	20%	50%	* 27%
Well/s tested periodically for pump energy efficiency	13%	15%	44%	33%	53%	* 27%

Note: Percentages calculated within each farm size. Graded color scale going from highest percentage of respondents (darkest) to lowest (lightest). Top 3 choices (4 if a tie) in each column are indicated by an asterisk.



3.7 WATER MANAGEMENT TECHNOLOGIES OR PRACTICES FOR CALCULATING IRRIGATION NEEDS

FIGURE L: PRACTICES FOR CALCULATING IRRIGATION NEEDS THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY ALL RESPONDENTS

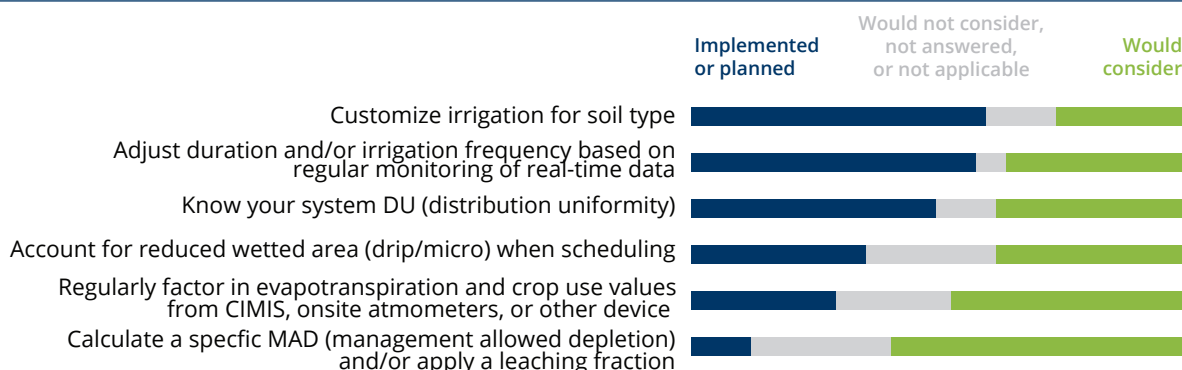


TABLE I: PRACTICES FOR CALCULATING IRRIGATION NEEDS THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY CROP TYPE

	Avocado		Lemon		Wine grapes		Vegetables		Cut flowers	
	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider
Customize irrigation for soil type	* 55%	28%	* 64%	32%	* 68%	32%	* 62%	29%	* 82%	18%
Adjust duration and/or irrigation frequency based on regular monitoring of real-time data	* 63%	34%	* 68%	32%	42%	* 53%	* 38%	* 52%	* 73%	27%
Know your system DU (distribution uniformity)	* 52%	* 42%	* 59%	36%	* 58%	37%	* 48%	33%	50%	* 50%
Account for reduced wetted area (drip/micro) when scheduling	40%	37%	32%	* 50%	26%	* 63%	19%	* 57%	* 60%	30%
Regularly factor in evapotranspiration and crop use values from CIMIS, onsite atmometers, or other device	28%	* 51%	27%	* 55%	* 6%	28%	35%	50%	18%	* 45%
Calculate a specific MAD (management allowed depletion) and/or apply a leaching fraction	11%	* 63%	9%	* 73%	21%	* 63%	14%	* 71%	0%	* 91%

Note: Percentages calculated within each crop type. Graded color scale going from highest percentage of respondents (darkest) to lowest (lightest). Top 3 choices (4 if a tie) in each column are indicated by an asterisk.

TABLE J: PRACTICES FOR CALCULATING IRRIGATION NEEDS THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY FARM SIZE

	Small farms		Mid-sized farms		Large farms	
	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider
Customize irrigation for soil type	* 47%	33%	* 3%	25%	* 77%	17%
Adjust duration and/or irrigation frequency based on regular monitoring of real-time data	* 51%	40%	* 58%	38%	* 70%	* 23%
Know your system DU (distribution uniformity)	42%	* 47%	50%	* 40%	60%	17%
Account for reduced wetted area (drip/micro) when scheduling	36%	38%	38%	33%	30%	* 43%
Regularly factor in evapotranspiration and crop use values from CIMIS, onsite atmometers, or other device	17%	* 61%	31%	* 42%	50%	* 23%
Calculate a specific MAD (management allowed depletion) and/or apply a leaching fraction	4%	* 71%	11%	* 57%	30%	* 43%

Note: Percentages calculated within each farm size. Graded color scale going from highest percentage of respondents (darkest) to lowest (lightest). Top 3 choices (4 if a tie) in each column are indicated by an asterisk.

3.8 MODIFICATION OF IRRIGATION DURATION AND/OR FREQUENCY

FIGURE M: HOW FARM SIZE INFLUENCES THE MODIFICATION OF IRRIGATION DURATION AND/OR FREQUENCY

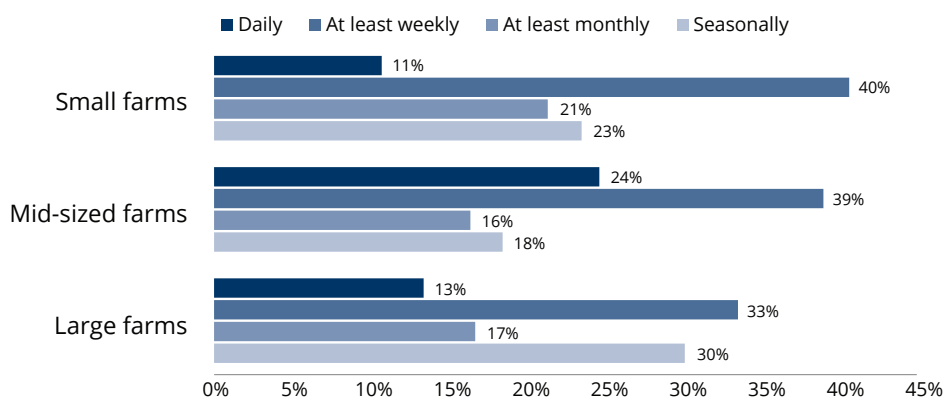
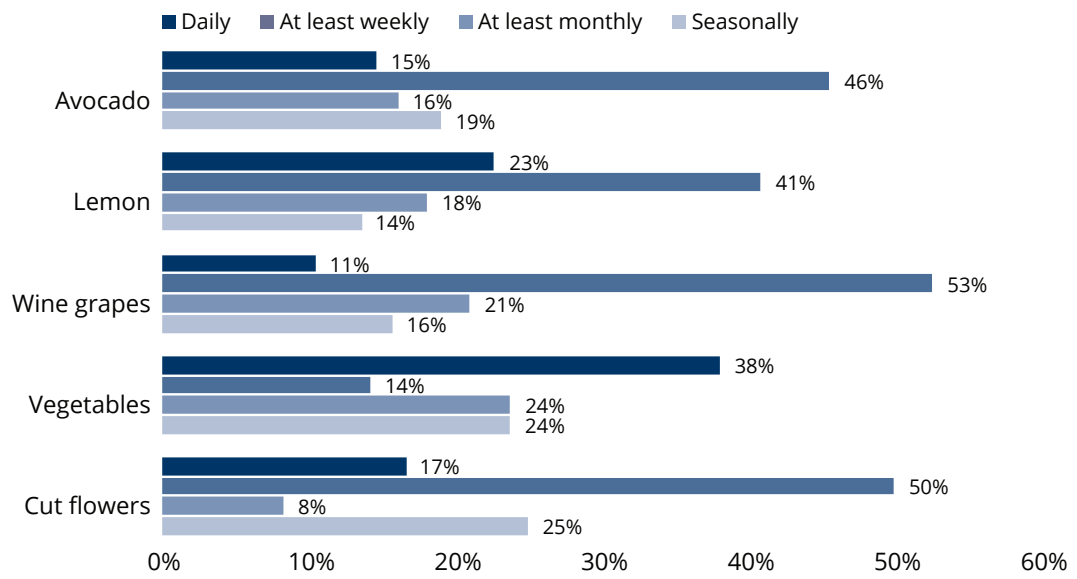


FIGURE N: HOW CROP TYPE INFLUENCES THE MODIFICATION OF IRRIGATION DURATION AND/OR FREQUENCY



3.9 WATER MANAGEMENT TECHNOLOGIES AND PRACTICES FOR MANAGING SOIL MOISTURE

FIGURE 0: SOIL MOISTURE MANAGEMENT PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY ALL RESPONDENTS

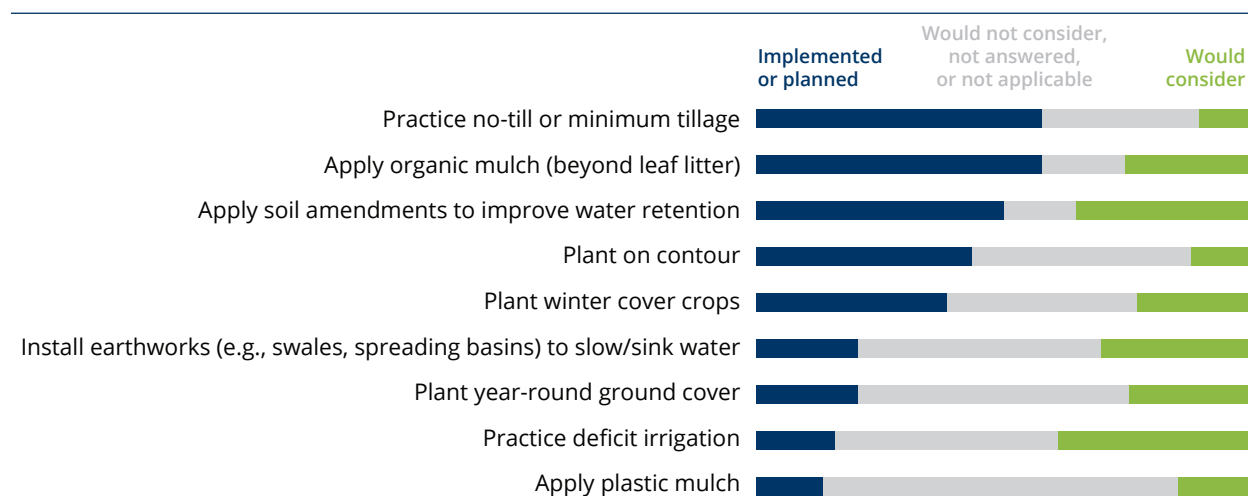


TABLE K: SOIL MOISTURE MANAGEMENT PRACTICES THAT HAVE BEEN IMPLEMENTED OR PLANNED, OR THAT WOULD BE CONSIDERED BY CROP TYPE

	Avocado		Lemon		Wine grapes		Vegetables		Cut flowers	
	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider	Implemented or Planned	Would Consider
Practice no-till or minimum tillage	* 66%	11%	* 71%	14%	* 50%	22%	* 57%	14%	* 58%	17%
Apply organic mulch (beyond leaf litter)	* 67%	23%	* 68%	32%	37%	* 53%	48%	*	* 64%	27%
Apply soil amendments to improve water retention	37%	* 48%	59%	* 41%	* 68%	21%	* 76%	19%	* 55%	* 36%
Plant on contour	* 52%	16%	* 68%	23%	21%	26%	* 57%	19%	36%	18%
Plant winter cover crops	22%	29%	45%	23%	* 79%	21%	* 62%	19%	33%	25%
Install earthworks (e.g., swales, spreading basins) to slow/sink water	14%	* 32%	18%	* 41%	16%	* 47%	43%	* 33%	40%	* 30%
Plant year-round ground cover	12%	* 32%	18%	* 41%	26%	26%	38%	* 29%	20%	* 30%
Practice deficit irrigation	12%	* 46%	10%	* 52%	42%	* 37%	19%	* 43%	18%	* 36%
Apply plastic mulch	3%	18%	5%	23%	5%	26%	52%	10%	0%	27%

Note: Percentages calculated within each crop type. Graded color scale going from highest percentage of respondents (darkest) to lowest (lightest). Top 3 choices (4 if a tie) in each column are indicated by an asterisk.

