Small Farms and the Future of AgTech

Needs Assessment on Tools & Technology for Small Farms in the San Joaquin Valley of California

November 2025

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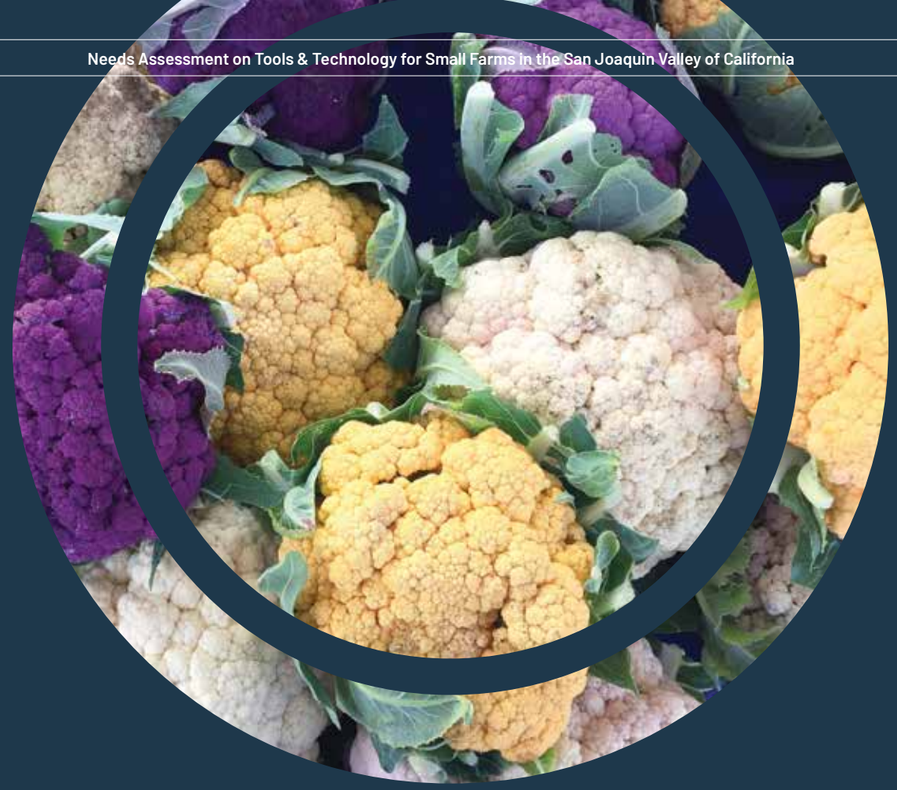

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Executive Summary

Small farms in the San Joaquin Valley are a cornerstone of California's agricultural landscape and local communities. They produce diverse crops, sustain regional food security, and embody the ingenuity and adaptability that have long defined California agriculture. Increasingly, small farms are exploring and adopting new tools - both digital and mechanical - to improve sustainability and efficiency, manage water and labor constraints, access new markets, and build long-term resilience.

While agricultural technology has often been developed for large-scale operations, the central goal for small farms is not simply gaining access to innovation—it is **maintaining economic viability** amid increasing climate, market, and policy pressures. **Technology can support this goal** by improving efficiency, reducing costs, conserving water, and managing risk, but adoption is only one part of the equation. Across the San Joaquin Valley, small farms are testing practical, right-sized tools that fit their operations. The challenge now is to ensure that policy, funding, and technical assistance are aligned with the on-the-ground realities of small farms.

A central finding of this assessment is that **successful technology adoption depends as much on the surrounding ecosystem—training, financing, infrastructure, supply chains, research support, and trust—as on the tools themselves.** When these supports are missing, even promising technologies often go unused or abandoned. **Technology must ultimately serve as a tool for resilience,** helping small farms adapt to market shifts, climate stress, and evolving policy environments.

Purpose of the Assessment

This report explores:

- The specific **technology needs** of small-scale farmers in the San Joaquin Valley.
- **Barriers** that prevent or slow technology adoption where appropriate tools exist, and challenges that limit the development of tools suited for small farms.
- **Opportunities** to strengthen support systems and ensure equitable access.

Drawing from farmer surveys, focus groups, interviews, and consultations with technical assistance providers and experts, the assessment offers practical guidance for policymakers, funders, and technology developers.

Key Findings

- **High demand** for affordable, locally adapted technologies—both equipment and digital tools—that fit the scale and diversity of small farms.
- **Major barriers** include high upfront costs, limited training and technical assistance, language and cultural barriers, and inadequate digital and physical infrastructure.
- **Promising innovations** and pilot programs exist, but expanding their reach and scaling them to small farms requires coordination, long-term funding, and farmer-led design, testing, and feedback.
- **Resilience depends** on the surrounding ecosystem—knowledge, financing, infrastructure, and trust—as much as on the technologies themselves.
- **Technologies** that have a significant impact on efficiency and increase production, marketing opportunities, or save costs, such as solar cold storage and inexpensive smart irrigation systems, add the most resilience to small farms.

Priority Solutions

To close the technology gap and strengthen small farm viability, the report recommends:

Priority Solutions	Examples Initiatives
1. Expand equipment-sharing and mobile technology hubs to reduce costs and increase access	New Hampshire Association of Conservation Districts (U.S.) Equipment Rentals
2. Invest in bilingual, hands-on-training and peer-to-peer learning to build local capacity and confidence in new tools	The HoneyBee Network (India); CAPÉ (Canada); TECLA (Latin America)
3. Establish a farmer-led innovation consortium to guide development and scaling of appropriate technologies	Prolinnova (Global); L'Atelier Paysan (France)

By centering **farmer-identified needs** and building on their proven capacity to innovate, stakeholders can accelerate technology adoption that enhances both economic viability and environmental resilience. Small farms are not simply recipients of innovation - they are **active co-creators** of a more sustainable and equitable agricultural future for California.

Photo credit: Hahn Farm at Jujube harvest

Introduction

The Importance of Small Farms

Small farms in the San Joaquin Valley play an essential role in California's agricultural landscape and the vitality of local communities. They produce a remarkable diversity of crops, strengthen regional food security, and contribute to the resilience of farming systems in a region facing mounting challenges. At a global scale, small farms are the backbone of food security, biodiversity, and rural livelihoods.[1]

Small farms are vital because they anchor local food systems that are diverse, culturally relevant, and less vulnerable to disruptions in national or global supply chains. They support local economies by employing local labor and keeping spending within the community. On a per-acre basis, small farms often produce high yields and less waste while maintaining more diverse habitats, seed varieties, and cultural farming practices. Many use polycropping and integrated systems that naturally guard against pests and diseases, promoting both ecological and economic resilience.

Beyond their environmental and economic benefits, small farm businesses connect directly with consumers, offering choice, connection, and personalized experiences that foster community and trust. They also contribute to the growing agritourism sector across California, drawing people to experience the state's agricultural heritage firsthand. In the Central Valley - where roughly a quarter of the nation's food is grown, including 40% of its fruits and nuts and 30% of its vegetables [2] - small farms play a critical role in sustaining community wellbeing.

Despite their importance, small-scale farmers are often overlooked in public and private investment. Development funding tends to prioritize larger farms, where returns to scale are faster and more visible. As a result, small farmers frequently lack access to the capital, technology, and infrastructure needed to remain viable. Rising input costs, labor shortages, water scarcity, climate uncertainty, and uneven access to resources all shape their capacity to innovate and adapt. [3]

Farming is often the economic and cultural foundation of rural communities in the San Joaquin Valley. Livelihoods in these areas are closely tied to groundwater access, meaning policy decisions under the Sustainable Groundwater Management Act (SGMA) - without small production-focused safeguards - can destabilize entire communities. As groundwater restrictions tighten, small-scale farmers face heightened risks of economic displacement. Land fallowing and declining production ripple through local economies, affecting farmworkers, equipment suppliers, processors, and service providers.

In this context, understanding and addressing the specific technology needs of small-scale farmers is essential. Tools that improve efficiency, water management, and resilience can help small farms remain viable under SGMA and future climate and economic pressures.

[1] Sarah K. Lowder et al., "Which Farms Feed the World and Has Farmland Become More Concentrated?," World Development 142 (June 2021): 105455, https://doi.org/10.1016/j.worlddev.2021.105455.

[2] Valley Farm Water, "15 Staggering Statistics About California's Agricultural Powerhouse," Valley Farm Water, December 30, 2024, https://www.valleyfarmwater.org/post/15-staggering-statistics-about-california-s-agricultural-powerhouse.

[3] California Climate Adaptation Strategy, "Summary of Projected Climate Change Impacts on California," accessed October 24, 2025, https://climateresilience.ca.gov/overview/impacts.html.

"Nos trae mucha felicidad llevar nuestro producto a la mesa de la comunidad americana e hispana y otras culturas"

- Small farmer from Sanger, Fresno County.

Translation:
"Bringing our product to the tables of the American and Hispanic communities and other cultures brings us great joy."

Purpose and Scope of This Report

While agricultural technology has advanced rapidly, innovation has largely centered on large-scale, capital-intensive operations. Small farms - despite their outsized contribution to local economies, biodiversity, and food security - are often excluded from these advances. The gap between the tools available and those that are practical, affordable, and relevant for small-scale operations remains wide.

This report aims to fill that gap by identifying the specific technology needs of small-scale farmers in California's San Joaquin Valley, examining barriers that limit or slow adoption, and offering actionable recommendations for policymakers, funders, technical assistance providers, and technology developers.

REPORT OBJECTIVES

1. **Identify the top technology needs and priorities of small farms in the San Joaquin Valley.**
2. **Examine structural and practical barriers to technology development, access and adoption.**
3. **Highlight opportunities for investment, collaboration, and innovation that strengthen small farm resilience and sustainability.**
4. **Provide recommendations to ensure agricultural technologies are appropriately scaled, accessible, and equitable.**

Approach

Findings in this report draw from surveys, interviews, focus groups, and consultations with farmers, technical assistance providers, and subject-matter experts across the San Joaquin Valley. (A full description of methods follows in the next chapter).

This report focuses on small farms - typically under 80 acres - that operate outside of mainstream wholesale commodity markets. These include diversified fruit, vegetable, and specialty crop farms, as well as monoculture operations producing niche or high-value crops, often for direct markets or specialty wholesale markets. Many are operated by older adults, women, and immigrant farmers who face overlapping economic, infrastructural, and regulatory challenges.

While centered on the San Joaquin Valley, the findings and recommendations have broader relevance for small-scale agriculture across California and the western United States. The report is intended for farmer support organizations, policymakers, funders, and technology developers. By grounding recommendations in farmer experience, it aims to guide practical, equitable strategies for expanding access to agricultural technology.

Overview of Small Farms in the San Joaquin Valley

Small farms in the San Joaquin Valley are highly diverse in size, crops, income, and marketing strategies, ranging from monoculture (usually small orchards) to highly diversified vegetable operations.[4] This report centers on five counties - Fresno, Kings, Tulare, Merced, and Madera - which together form the core of California's small-scale farming landscape in the central San Joaquin Valley. These counties have some of the highest concentrations of small farms in the state, and reflect a mix of agricultural contexts, from intensive orchard and vineyard production to highly diversified vegetable operations, making it a representative geography for understanding the needs, challenges, and opportunities of small-scale farmers in the region.

The USDA's 2022 Census of Agriculture illustrates the distribution of farm sizes across the focus region (see Table 1).[5] While the average farm size is relatively large, the median farm size is far smaller - showing that the majority of farms are small and the mean is skewed upward by a small number of very large farms.

Table 1: County Summary Highlights (USDA Census of Agriculture, 2022)

County	# of Farms	Average (Mean) Acres	Median Acres
Fresno	4,427	375	45
Kings	862	688	61
Madera	1,255	553	80
Merced	2,047	426	45
Tulare	3,713	353	40

[4] University of California Agriculture and Natural Resources and University of California Cooperative Extension, "Small Farms Definitions: Defining Small Farms in California," accessed October 24, 2025, https://ucanr.edu/site/small-farms-and-specialty-crops-fresno-and-madera-counties/small-farms-definitions.

[5] National Agriculture Statistics Service, United States Department of Agriculture (USDA), "2022 Census of Agriculture, County Data," 2022.

Small farms across these counties grow a wide variety of crops, including orchard and vineyard products (almonds, citrus, stone fruit, grapes), mixed vegetables (leafy greens, tomatoes, squash), berries, and niche specialty crops such as lemongrass and jujubes. Many also manage livestock operations, including honey bees, goats, poultry, and cattle.

Because small farms often operate outside of commodity markets - either due to crop diversity or low wholesale prices - they rely heavily on direct-to-consumer and niche wholesale markets to sustain their businesses. Many face persistent challenges related to infrastructure, including limited access to cold storage, postharvest handling facilities, and access to electrical infrastructure. Without adequate cold storage, farmers are often forced to sell quickly at harvest, sometimes at a loss, to intermediaries who can hold and resell their produce later at higher prices.

Most small farms in the region are family-run operations, often led by older adults, women, and immigrant farmers. They face ongoing challenges related to access to working capital, land tenure, and stable markets, which in turn constrain their ability to invest in infrastructure, equipment, or technology. These resource constraints, coupled with tightening water supplies under SGMA combined with periodic droughts and other climate related events, heighten their vulnerability but also underscore the importance of targeted support and appropriate innovation.

Agricultural Tools and Technology

Agricultural technology has advanced rapidly in recent decades, offering powerful tools to improve productivity, reduce costs, and manage natural resources. Yet, most new technologies are designed for large-scale, capital-intensive operations. This creates a persistent mismatch between what is technologically possible and what is practical and affordable for small farms, leaving small-scale farmers without access to equipment and systems that could help them remain competitive in a changing agricultural landscape.[6]

While many technologies exist that could increase efficiency, profitability, and sustainability, few are designed for the realities of small or diversified farms. The gap between what is available and what is practical for small farms creates a critical challenge for farmers, technical assistance providers, and policymakers alike. For small-scale farmers, the value of any technology depends on whether it is accessible, affordable, appropriately scaled, and relevant to their operations.

Unlike large-scale commodity producers who often benefit from economies of scale, small farms face unique constraints, including limited capital, diverse cropping systems, irregular plot sizes, and reliance on family or seasonal labor. Tools designed for industrial agriculture are often too large, costly, or inflexible to meet their needs.

Small farms often operate with thin margins and cannot risk investing in equipment that does not quickly generate returns. As a result, technology adoption in this sector depends not only on engineering solutions but also on factors such as training, peer-to-peer learning, reliable infrastructure, and supportive policy.

Understanding these dynamics is essential for identifying which technologies can truly strengthen small farm viability in regions like the San Joaquin Valley.

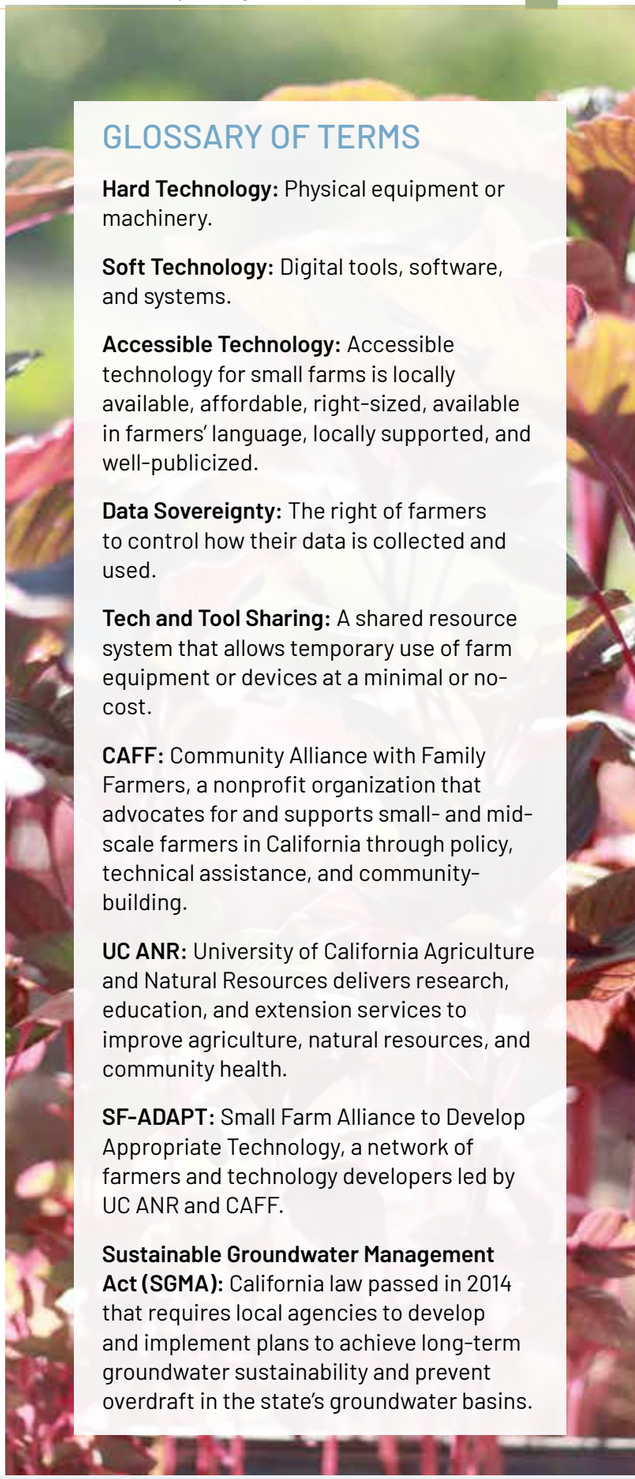
[6] Sarah K. Lowder et al., "The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide," World Development 87 (November 2016): 16–29, https://doi.org/10.1016/j.worlddev.2015.10.041.

Guiding Principles for Appropriate Technology Adoption

The following Principles of Appropriate Technology, developed by UC ANR's Small Farms Team in Fresno, are designed to help policymakers and technology developers ensure that new initiatives support the viability and sustainability of small farms.[7] These principles emphasize making technology accessible, relevant, and equitable by centering small farmers in the design process and using guiding questions throughout development. The goal is to create tools that reflect the diversity of small farming operations, overcome barriers related to cost, scale, and access, and strengthen the resilience of farmers, their communities, and local food systems. The Principles for Appropriate Technology are:

1. **Human-Centered:** Design technologies around small-scale farmers' real needs and ensure authentic engagement, feedback, and fair compensation.
2. **Appropriately-Scaled:** Match tools to the size, diversity, and economic realities of small farms.
3. **Cost-Effective:** Keep technologies affordable to purchase, maintain, and repair, with a favorable cost-benefit ratio.
4. **User-Friendly:** Make tools intuitive, easy to learn, easy to repair, and straightforward to integrate with existing operations.
5. **De-Risked Experimentation:** Create low-risk opportunities for farmers to test technologies before full adoption.
6. **Protection of Privacy:** Safeguard farmer data with transparency and clear opt-out options.
7. **Strengthening Local Economies:** Design tools that connect farmers and consumers to local markets, services, and inputs.

By grounding technology development in these principles, we can strengthen small farms' resilience, expand their economic viability, and increase food security within our communities.



GLOSSARY OF TERMS

Hard Technology: Physical equipment or machinery.

Soft Technology: Digital tools, software, and systems.

Accessible Technology: Accessible technology for small farms is locally available, affordable, right-sized, available in farmers' language, locally supported, and well-publicized.

Data Sovereignty: The right of farmers to control how their data is collected and used.

Tech and Tool Sharing: A shared resource system that allows temporary use of farm equipment or devices at a minimal or no-cost.

CAFF: Community Alliance with Family Farmers, a nonprofit organization that advocates for and supports small- and mid-scale farmers in California through policy, technical assistance, and community-building.

UC ANR: University of California Agriculture and Natural Resources delivers research, education, and extension services to improve agriculture, natural resources, and community health.

SF-ADAPT: Small Farm Alliance to Develop Appropriate Technology, a network of farmers and technology developers led by UC ANR and CAFF.

Sustainable Groundwater Management Act (SGMA): California law passed in 2014 that requires local agencies to develop and implement plans to achieve long-term groundwater sustainability and prevent overdraft in the state's groundwater basins.

[7] University of California Agriculture and Natural Resources, Small Farms Network, "Development of Appropriate Technology for Small Farms: Principles and Guiding Questions," Forthcoming.

Summary of Approach

Objectives

This assessment aimed to understand what technologies small farmers in the San Joaquin Valley currently use, how well they work, and what improvements or new tools could increase productivity, support sustainability, and enhance quality of life. A central focus was identifying what makes technology practical and accessible for small farms. Ultimately, the report explores how agricultural tools, technology, and equipment can strengthen farms, support local economies, and build a more resilient food system.

Approach

The assessment combined surveys, interviews, focus groups, and consultations with farmers, technical assistance providers, and technology experts. Published reports, market studies, and peer-reviewed research provided additional context. Together, these sources created a comprehensive picture of technology use, barriers, and opportunities for small farms in the region. Farmers were engaged with support from CAFF and UC ANR, with intentional outreach to Hmong, Latinx, and Punjabi growers. Engagement took place at farm tours, tradeshows, and community events. Participants represented a wide range of experience, gender, acreage, crop types, with many operating diversified fruit and vegetable farms. Appendix G provides a timeline of engagement and a detailed list of participants.

Farmer and Stakeholder Input

The core insights of this assessment came from extensive engagement with farmers, technical assistance providers, service organizations, technology developers, and vendors. Table 2 shows a summary of farmer and stakeholder input.

11 events | Over 200 small farmers | 24 companies

Table 2: Farmer and Stakeholder Input

Stakeholder Group	Method	Participants / Examples
Farmers	Surveys	102 farmers
Farmers	Focus Groups; Listening Sessions with Farmers	Conducted in: Punjabi (~30), Spanish (~40), Hmong/Iu Mien (~30), English (~10)
Farmers	Case Studies	3 family farms (2–6 owners each)
Technical Assistance Providers	Interviews; Observation	UC ANR Fresno Small Farms Team, CAFF Tech Hub, California Farmlink, Pan Valley Institute
Industry & Cross-Sector	Convenings; Field Observations; Survey	SF-ADAPT (40 participants), World Ag Expo (24 exhibitors)

Together, these sources provide a rich mix of quantitative and qualitative data: survey results illustrate demographic and operational patterns, while listening sessions, interviews, and case studies capture the nuanced decision-making, barriers, and lived experiences of small-scale farmers.

APPENDIX G

Here is an example of one source for stakeholder input as listed in Appendix G.

The 2nd Small Farm Tech Expo was held on November 8, 2023 at UC Kearney Agricultural Research and Extension Center. This event brought together more than 200 attendees with information and interpretation in four different languages - English, Punjabi, Hmong and Spanish. Over 20 technologies featured, curated specifically for small farm operations.

Data collected was from Surveys, interviews and facilitated feedback discussions in four languages for farmers only.

Demographics of farmers who provided feedback:

52 years of age

13 years of experience

37% chance of being female

28 acres farm size

Growing vegetables, prunes, or berries

Top 3 reasons farmers acquire technology:

1. Reduce labor demand
2. Increase productivity
3. Make heavier tasks easier

Top 3 factors farmers consider before buying new technology:

1. Price
2. Operation costs
3. Functionalities/features

Top 3 main task farmers want equipment for:

1. Planting/seeding
2. Weeding
3. Irrigation

Most useful equipment from Expo:

1. Two-wheeled tractor from BCS
2. Soil moistures sensors
3. Transplanter from Sutton Ag

Part I: Key Findings in Technology Adoption

Small farms in the San Joaquin Valley operate in a complex and resource-constrained environment, where economic pressures, ecological challenges, and regulatory requirements shape daily decisions. While a wide range of agricultural technologies exist globally and domestically, adoption among small farms remains limited - partly because suitable tools are not always available locally and partly because most are designed for large-scale operations rather than small, diversified systems.

Two landscape reviews - one regional, one international - identified more than sixty relevant technologies across irrigation, cold storage, field preparation, post-harvest handling, digital management, and security. Many have proven effective on small farms elsewhere, demonstrating that right-sized innovation can improve water efficiency, product quality, and market access. However, adoption in the San Joaquin Valley remains low due to barriers such as availability and knowledge of technologies, cost, training gaps, language access, connectivity, and limited support for adaptation to local conditions. A synthesis of these landscape reviews is available in appendix L and on CAFF's website.[8]

Globally, smallholder farmers are using affordable tools such as sensor-based irrigation, solar-powered cold storage, and mobile farm-management platforms to reduce costs and risks. Locally, similar technologies exist - ranging from soil moisture sensors and automated irrigation controls to digital recordkeeping tools like LiteFarm and CropManage - but their uptake is slowed by financial constraints, steep learning curves, and lack of technical support. Across both contexts, success depends on coupling technology access with education, peer networks, and financing mechanisms tailored to farm scale and capacity.

The findings that follow build on these reviews and direct farmer feedback. They underscore that technology adoption depends as much on the surrounding ecosystem - training, financing, and trusted technical assistance - as on the tools themselves. Farmers need culturally relevant, bilingual, and locally available support systems that help them identify practical technologies, evaluate cost-effectiveness, and sustain adoption over time.

Evaluating and Prioritizing Technologies

Key Findings:

- Farmers prioritize tools that support efficiency, crop quality, and ecological outcomes, including seeders, harvest carts, and soil sensors.
- Evaluation criteria for technologies include affordability, usability, repairability, and ecological benefit.
- Equipment-sharing programs are particularly valuable for seasonal or specialized tools that are expensive or infrequently used.

[8] Rebekka Siemens et al., "Landscape Review Part 1 (Domestic/Regional)," California Alliance with Family Farms, 2025, http://www.caff.org/tech-assessment.

Evaluation Criteria

In listening sessions, surveys, and case studies, farmers consistently emphasized that the value of any tool or technology depends on how well it meets their practical realities. To identify priority needs, farmers and technical assistance providers highlighted a set of evaluation criteria:

1. Affordability – Is the cost realistic for a small farm's budget?
2. Usability – Can the tool be operated easily across varying skill levels and languages?
3. Repairability – Are parts available, and is local expertise accessible for maintenance?
4. Ecological Benefit – Does the tool support sustainability practices such as soil health or water efficiency?

These criteria guided the identification of technologies most needed by small farms in the region. The Principles of Appropriate Technology (see Appendix E) can also be referenced by technology developers to evaluate the effectiveness of their products.

Priority Tools and Equipment Sharing

Using the above criteria, farmers highlighted a cluster of tools that consistently rose to the top as unmet needs. For individual ownership, farmers emphasized irrigation technology (soil sensors), harvest carts, and seeders/planters - tools that directly influence efficiency and crop quality but are often too costly or specialized for immediate purchase. For equipment-sharing programs, priority tools included planters and seeders, weeding tools (especially mechanized or automated), sprayers, mulchers, and compost spreaders. These were selected not only for their frequency of use and cost but also for their potential to improve labor efficiency and ecological outcomes. Equipment such as compost spreaders, mulchers, and electric carts also build soil health, enhance resilience, and reduce dependence on external inputs like plastic mulch, pesticides, or fossil fuels.

The suitability of tools for sharing was another important consideration. Farmers and advisors noted that some equipment, such as irrigation infrastructure, is difficult to share due to near-constant use, while seasonal or task-specific tools (e.g., chippers or mulchers) lend themselves well to cooperative ownership or lending libraries. Scheduling challenges can arise since farms in the same region often need the same equipment at the same time, but these can be mitigated by careful coordination or acquiring multiple units. In addition to cost savings, equipment-sharing programs play a valuable role in letting farmers test tools before purchase and gain access to equipment that provides long-term ecological benefit but may not deliver short-term financial returns.

Photo credit: GT Florists spreading compost

F3 EQUIPMENT LENDING LIBRARY

The Lending Library offers short-term access to specialized farm tools and equipment, helping small-scale farmers in California's Central Valley reduce upfront costs and experiment with new technologies before committing to purchase. Housed at the Kearney Agricultural Research & Extension Center (KARE) in Parlier (Fresno County), the Lending Library is designed to support the adoption of climate-smart, labor-saving, and scale-appropriate innovations that can increase productivity and sustainability on smaller farms. For more examples of existing equipment sharing programs, see Appendix F.

Farmer Needs, Barriers, and Enablers

Key Findings:

- Diversified farms and specialized farms have distinct technology needs.
- The most persistent barriers to technology adoption on small farms are finding tools that are appropriately scaled, financially viable, and known or accessible to farmers.
- Adoption is a process that depends on awareness, trust, affordability, and ongoing support.
- Peer-to-peer learning, local availability, and trusted technical assistance are among the strongest enablers for adoption.

Distinct Needs: Diversified versus Monocrop Farms

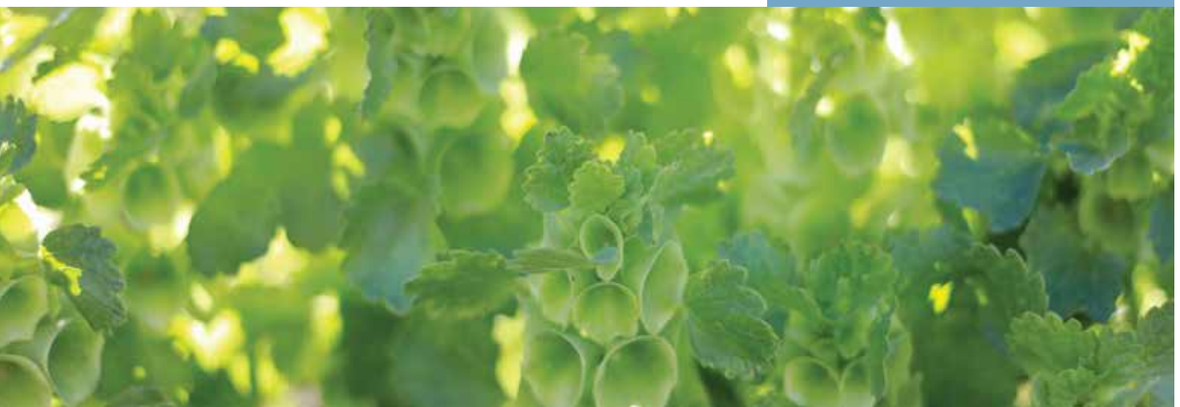
Small farms in the San Joaquin Valley vary widely in size and production systems, but a key distinction lies between diversified and monocrop operations, which strongly shapes their technology needs.

Diversified farms grow many crops in smaller, irregular plots and require frequent bed turnover and adaptable, small-scale tools to work efficiently in tight spaces. Monocrop farms, such as citrus or almond operations, often rely on standard commercial equipment or hire custom operators for specialized tasks, though smaller growers are often deprioritized by service providers who favor larger clients.

Across all farm types, the core challenge remains the same: finding tools that are both appropriately scaled and financially viable. This mismatch between farm needs, tool design, and access continues to limit technology adoption, particularly for farmers working with niche or emerging specialty crops that lack established equipment solutions.

"Smaller farms have always been a challenge to service based on the minimum economics quantity of certain programs. However, we have equipment and logistics solutions that will work for any farm, so long as the grower is interested in participating. Sometimes help from a co-op or extension can make all the difference there."

– Irrigation solution provider with operations in the Central Valley.



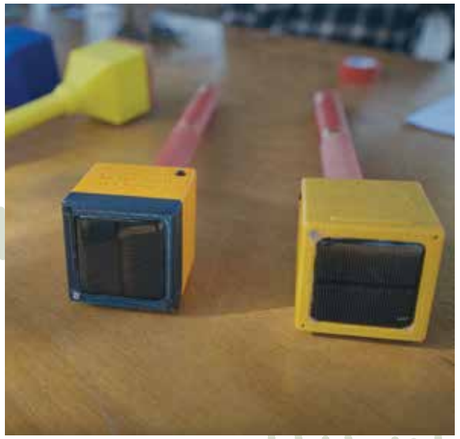
"Hard" and "Soft" Technologies

Farmers identified needs for both "hard" (equipment, implements, irrigation infrastructure) and "soft" (software, training, data, and marketing tools) technologies. When used together, these can create "smart" systems - such as an irrigation network that combines pumps and emitters with sensors and remote monitoring software.

Successful adoption depends on iterative user feedback, training, and local support over time. Table 3 summarizes examples of tools farmers expressed interest in testing or adopting. For more detail, Appendix D provides a comprehensive list of the technologies identified as high priority, and those they would be interested in trialing.

Table 3: Sample List of "Hard" and "Soft" Tools

"Hard" Tools and Technologies	"Soft" Tools and Technologies
Sprayers	Apps and tools for farm management
Electric tractor or robotic tractor	Crop planning, agronomics, reporting
Soil moisture sensors	Automated irrigation monitoring and control systems
Mower	Marketing platforms
Weeder	Bee pollination monitoring tech
Bed former and mulch layer in-one	Weather forecasting app
Shade cloth	Accounting software



Adoption as a Process

Before a farmer can adopt or integrate new technology, they first have to know it exists. Many small-scale producers lack exposure to available tools due to limited outreach, retail presence, or peer networks. Awareness is just the first step - adoption also requires confidence that a tool will deliver real benefits, be supported long-term, and integrate effectively into farm operations.

Technology adoption, where it makes sense, unfolds in stages: selection, purchase, implementation, maintenance, and adaptation. Each stage requires support. In practice, many small farms receive minimal training or follow-up when new tools are introduced, leaving them to troubleshoot or repair equipment on their own. Peer-to-peer learning often fills this gap, with farmers teaching one another through shared experience.

Accessibility determines whether a farmer can meaningfully use and sustain a technology. Beyond affordability, accessibility depends on usability, appropriate scale, and the presence of local support. Farmers are more likely to adopt tools that are available nearby, easy to maintain, and demonstrated by trusted peers or advisors. When tools are stocked locally - not just sold online - farmers can see and test them, repairs are faster, and confidence grows through shared experience.

Without these conditions - ongoing training, local support, and access to affordable, well-matched tools - even promising tools often go unused or are abandoned, a costly process known as disadoption.

Summary of Farmer Needs and Barriers to Adoption

Technology adoption on small farms is shaped by the fit, cost, and scale of available tools, as well as access to training and local support. Addressing high costs, limited technical support, and tools designed for larger farms - while investing in both hard and soft technologies - is critical to maintaining small farm viability. These barriers are not unique to the San Joaquin Valley and have been identified globally as key points to address in fostering resilient food supply systems.[9]

Table 4: Summary of Farmer Needs and Barriers to Technology Development and Adoption

Farmer Needs	Barriers to Adoption (identified by farmers, TA providers)
Affordable, reliable irrigation infrastructure	High infrastructure costs and insecure land tenure
Knowledge and training on tools and technology	No allocated budget/program and/or uneven outreach; limited peer-to-peer learning opportunities
Assurance of cost-effectiveness and benefit	Uncertainty of return on investment; risk of financial losses; steep learning curve
Appropriately scaled and priced implements	Tools sized for industrial farms; high purchase price; limited local suppliers
Post-harvest storage and cooling solutions	High upfront and ongoing costs; energy needs; limited technical support for maintenance
Expanded market outlets and better prices	Market concentration; low bargaining power; limited access to digital marketing tools
Regulatory compliance support	Complexity of regulations; language barriers; limited trusted assistance
Permanent infrastructure, such as cold storage & greenhouses	Lack of affordable land; insecure leases limiting long-term investment in technology or infrastructure.

[9] Kenneth Iversen et al., "Frontier Technologies for Smallholder Farmers: Addressing Information Asymmetries and Deficiencies," United Nations, Department of Economic and Social Affairs, n.d.

In conclusion, technology adoption among small farms in the San Joaquin Valley is less a question of willingness than of access, fit, and sustained support. The right tools must be designed and delivered within a supportive ecosystem - one that values scale-appropriate technology, affordable financing, and locally available training and repair networks. Addressing these interconnected needs will require coordinated action among farmers, researchers, technical assistance providers, and equipment developers to bridge the persistent gap between available technologies and on-the-ground realities. When small farms have access to well-matched tools, trusted guidance, and community-based learning networks, technology becomes not just a tool for efficiency, but a pathway to long-term resilience and viability.

Sustainable Production and Economic Viability

Key Findings:

- Technology should reduce labor and improve efficiency without fully replacing human work.
- Both simple and complex tools enhance productivity, conserve resources, and improve economic viability.
- Smart irrigation and automation can save water, reduce labor, increase yields, and support regulatory compliance.

Effective, Low-Tech Approaches

Over time, agricultural tools and technology have become more complex, especially with the advent of AI and the promise of "smart" digital tools. However, simpler tools are highly effective and often easier to implement. For example, basic technology such as shade cloth or mulch to reduce water needs and hardware upgrades to irrigation systems, such as pressure regulators, can save money, time, and effort for farmers with relatively little investment and risk. On the Cruz Martinez Farm (see Case Study 1), the use of shade cloth over peppers reduced irrigation pumping costs by approximately $700 per month between summer 2024 (without shade cloth) and summer 2025 (with shade cloth), while also improving crop quality and soil moisture retention. The farm works as a system so a complementary practice can also lessen the need for a quick fix by an external input, e.g., building water holding capacity of the soil over the years through compost amendments, cover crops, laying mulch, etc. will also save on irrigation costs.

Smart Irrigation

Irrigation automation and smart irrigation with integrated sensors and data analytics has the potential to save costs on water, save labor, increase efficiency by delivering water when and where it is needed, thereby increasing yields. The cost and time savings and increase in yields can make a farm business more economically viable, as well as conserving water, which is a sustainability issue for the agricultural industry in this arid region. In addition to the economic and environmental benefits, the Sustainable Groundwater Management Act (SGMA) will require monitoring and reporting of water use, which can be very burdensome for small farming operations, and the use of smart irrigation systems has the potential to streamline reporting and help mitigate the undesirable impacts of SGMA. Table 5 below shows current wifi options for farms looking to add this layer of technology.

Table 5: Wi-Fi as a Prerequisite to Adopting Smart Irrigation

Option	Price per Month	Notes
AT&T, Comcast, Cal.net, etc.	$30+/month	Limited availability to rural farm sites
Starlink	$60+/month	Expensive extra cost that farm needs to justify
Install cell phone as hot spot	$20+/month	Takes creativity and knowledge on how to set-up this system, power the phone, etc.

Data and Technology Sovereignty

Key Findings:

- Farmers want transparency, opt-in data use, and local control over their farm data.
- Bilingual data literacy training and farmer-led governance are critical for adoption of digital technologies.
- Proprietary equipment and opaque digital tools limit autonomy and hinder adoption.

Concerns Around Data Use

Digital technology has the potential to streamline many aspects of farm work, including irrigation scheduling, crop and workflow planning, and record-keeping and reporting.[10] However, there is widespread concern among small-scale farmers about how digital data is being used, who owns it, controls it, and makes money from it, and the privacy of business and personal information.[11] Many apps rely on farm data but include opaque terms, raising fears that information could be sold, leaked, or misused. Sensitive information related to regulations and certifications is particularly concerning, as errors could result in penalties, lost sales, or failed compliance.

Data sovereignty - the ability to control how data is stored, accessed, and shared - is a core priority. Farmers emphasize that data sharing should be opt-in rather than opt-out and that software should offer transparent, ethical practices. Projects like OpenTEAM provide examples of solutions that prioritize equity and transparency, helping farmers feel confident in adopting digital tools.[12]

Equipment Autonomy

Farmers value the right to repair. Proprietary restrictions on equipment repairs reduce autonomy and make ownership a liability. Many farmers prefer older machinery they can fix themselves rather than depend on costly dealer maintenance.

Training and Support

There is a need for bilingual data literacy training and technical support around the use of farming software for technologies from automated irrigation systems and farm management software, to robotic tractors. Technology developers and technical assistance providers should engage farmers in shaping data policies and include ongoing training and maintenance funding in program budgets.

Enabling Environments: Policy, Funding, and Partnerships

Key Findings:

- Small farms lack dedicated funds for technology validation and culturally relevant training.
- Existing programs (SWEEP, EQIP, SJVAPCD) provide support but are uneven or paused. A training budget is also lacking with most government sponsored grants.
- There is a clear need for technology-focused incentives tailored to the needs and capacities of small farms.
- High potential for partnerships between local, farmer-serving organizations.
- SF-ADAPT is currently in a pilot stage, with working groups being formed to engage farmers directly.

[10] Iversen et al., "Frontier Technologies for Smallholder Farmers: Addressing Information Asymmetries and Deficiencies."

[11] Francesco Ajena et al., Agroecology & Digitalisation: Traps and Opportunities to Transform the Food System (IFOAM Organics Europe, 2020), https://www.researchgate.net/publication/361376159_agroecology_digitalisation_traps_and_opportunities_to_transform_the_food_system_commissioned_and_published_by_IFOAM_Organics_Europe_Main_Sponsor_Co-financed_by.

[12] OpenTEAM, "Agricultural Data Use Documents," accessed October 24, 2025, https://openteam-agreements.community/.

Technology Adoption Programs

Several state and federal programs have played an important role in supporting technology adoption among small farms in the San Joaquin Valley. While these programs can provide critical cost-share funding, farmer experiences show that access, design, and delivery often limit their impact. For more details on the challenges of each program, see Appendix M.

State Water Efficiency and Enhancement Program (SWEEP): Administered by the California Department of Food and Agriculture, SWEEP offers grants for on-farm water efficiency upgrades like pumps and sensors but faces irregular funding rounds, short timelines, and competitive scoring that disadvantages small farms.

Water Efficiency Technical Assistance (WETA): A California Department of Food and Agriculture (CDFA) program that funds organizations to provide water and nutrient management support, however, it depends on intermittent state funding and has limited availability.

Environmental Quality Incentives Program (EQIP): Operated by the USDA Natural Resources Conservation Service (NRCS), EQIP offers cost-share funding for conservation and infrastructure improvements, but small farms often struggle with complex applications, long timelines and reimbursement periods, and limited multilingual outreach.

San Joaquin Valley Air Pollution Control District (SJVAPCD) Agricultural Equipment Replacement Program: The SJVAPCD incentive program helps farmers replace older diesel equipment with cleaner models, yet high demand has paused new applications, and long waits have delayed farmer benefits.[13]

Proposition 4: Equipment Sharing Funding: The 2024 Climate Bond will fund regional equipment-sharing libraries managed by CDFA which would increase the accessibility of tools and equipment to small farmers.[14] Program design and implementation are still in early stages.

Photo credit: GT Florists

Pilot Programs in the San Joaquin Valley: Across the San Joaquin Valley, pilot programs are showing how targeted technology investments can transform small farm operations. A key focus is solar-powered infrastructure, which reduces costs and emissions while strengthening resilience to rising energy prices and unreliable grid access. The Solar Fresco cold storage pilot by California Farmlink powers portable cooling units with solar energy, helping small farms improve efficiency, preserve crop quality, and expand markets.[15] Similarly, the LEAP Institute in Fresno and Huron is developing solar-powered tools like the MegaIntelliTrailer 4.0, a towable solar battery that supports on-farm energy needs and farmer training. With stronger policy support - such as grants and streamlined permitting - these programs could scale to benefit more small producers across the region.

Emerging opportunities, such as the Proposition 4 equipment sharing funding and pilot programs like Solar Fresco, demonstrate how targeted policy and funding can increase accessibility, reduce costs, and improve both sustainability and economic viability for small-scale farms in the San Joaquin Valley.

[13] San Joaquin Valley Air Pollution Control District, "Tractor Replacement Program | Valley Air District," t, https://www.valleyair.orghttps://www.valleyair.org/grants/tractor-replacement-program/.

[14] Gokce Sencan and Spencer Cole, "How Prop 4 Will Impact California's Climate and Natural Resources Investments," Public Policy Institute of California, accessed October 24, 2025, https://www.ppic.org/blog/how-prop-4-will-impact-californias-climate-and-natural-resources-investments/.

[15] California Farmlink, Solar Fresco Program, 2025, https://www.californiafarmlink.org//blog/announcing-solarfresco.

Attendees of the Small Farm Tech receive a demo of the BCS tractor. Presentation had live interpretation in three different languages.

Strengthening Partnerships and Networks

Survey and focus group feedback underscored farmers' need for greater access to training, financing, and guidance on technology—along with frustration that funding often benefits larger entities rather than small producers. Clearer outreach and direct farmer participation in shaping programs are essential.

Strengthening partnerships among farmer-serving groups can expand culturally relevant outreach and hands-on support. Launched in 2024, the Small Farm Alliance to Develop Appropriate Technology (SF-ADAPT) models this approach by engaging farmers directly in technology development and decision-making. Similar collaborations, such as UC ANR's work with South Asian growers to develop tools like a lemongrass harvester and jujube pitter, demonstrate how co-designed technology can increase productivity and resilience on small farms. A non-exhaustive list of organizations supporting small-scale farmers in the San Joaquin Valley is available in Appendix K.

In conclusion, technology adoption among small farms in the San Joaquin Valley depends less on innovation itself than on access and alignment - between tool design, farm realities, and the systems that support their use. Farmers are eager to adopt technologies that improve efficiency and profitability, but most tools remain sized or priced for industrial operations. When small farms gain access to well-matched technologies - such as solar-powered cold storage or precision irrigation - the benefits are clear: lower costs, higher yields, and greater resilience.

Sustained progress will require coordinated investment across public agencies, research institutions, and community organizations. Programs should focus not just on distributing equipment, but on building the ecosystem that enables lasting adoption—through peer learning, equipment sharing, local repair and training networks, and policies that value small-scale innovation. With dedicated support, small farms can continue to anchor a more resilient and sustainable agricultural economy for California.

Part II:
Farmer Innovation Case Studies

Technology adoption on small farms is rarely a straightforward process. Each decision to adopt, adapt, or reject a tool reflects a balance of risk, cost, trust, and lived experience. For many farmers in the San Joaquin Valley, innovation is not defined by the newest and most advanced technology, but by finding practical, affordable solutions that work within the realities of their operation. The three case studies presented here - from Cruz Martinez Farm, Hahn Farm, and GT Florists - exemplify how small-scale producers navigate the opportunities and barriers to technology adoption. Whether through grant-supported irrigation upgrades, low-cost on-farm innovations, or cautious experimentation with digital tools, each farm demonstrates a distinct approach to sustaining productivity, meeting regulatory requirements, and supporting family livelihoods.

These stories also underscore the role of family knowledge, cultural traditions, and community networks in shaping technology decisions. Innovation often emerges through modifying equipment, adapting traditional tools, or drawing on shared expertise rather than simply purchasing products off the shelf. Together, these case studies illustrate that appropriate technologies for small farms must be accessible, adaptable, and responsive to farmers' lived realities.

We thank the farms for generously sharing their histories and experiences, and for being willing to share their story with a broader audience. We hope these stories help illuminate how future investments in agricultural technology, informed policy, and community support can strengthen and sustain a future with thriving small family farms. Their full case studies can be read in Appendix H, I and J.

Case Study 1: **Cruz Martinez Farm (Madera County, CA)**

"Connecting with our local community has given us the opportunity to share our practices and give them hands-on experience in farming"

- Javier Cruz,
Cruz Martinez Farm.

On a hot summer morning in Madera County, rows of peppers grow beneath shade cloth supported by wooden stakes. Nearby, a seasonal creek (now irrigation ditch) runs diagonally across the otherwise perfectly flat property. Cruz Martinez Farm, a 28-acre certified organic vegetable and fruit operation, demonstrates how small farms in the San Joaquin Valley evaluate, adopt, and adapt tools and technologies to strengthen their operations. Established in 2012 by Teodora and Melecio and now managed with their son, Javier, and his wife, Olga, the farm highlights both the potential and limitations of technology in supporting small farm sustainability. What began as a small leased plot has grown into a thriving operation rooted in family collaboration - with Javier managing deliveries and partnerships and Olga bringing new rigor to recordkeeping and compliance systems. To read the full case study, see Appendix H.

Tools and Technologies Adopted:

- Transplanter: A two-row transplanter increased production speed, efficiency, and plant health, reducing labor costs and improving yields.
- Solar Cold Storage: Installed through a CA FarmLink pilot project, the solar-powered cooler doubled harvest and delivery capacity, cut costs, opened new market opportunities (i.e., school district sales), and provided surplus energy for other tools like welding equipment and digital recordkeeping. Javier knows the issues of cold storage for farmers in his region and wants to share how much it has helped him so that the community can grow together.

Shade Cloth: A low-cost, low-tech innovation reduced irrigation needs, prevented sunburn damage, and lowered energy costs for pumping.

- Recordkeeping Systems: Adoption of QuickBooks and a full time dedicated bookkeeper improved compliance and financial planning. While reporting requirements for organic certification and FSMA remain burdensome, the data that has resulted from careful record keeping has helped the family to come to agreement about which crops and varieties to grow and which infrastructure projects to work on first.

Technology Needs and Gaps:

- Digital Recordkeeping and Compliance Tools: Affordable, user-friendly software to streamline reporting for food safety, organic certification, payroll, and input tracking.
- Irrigation Infrastructure: Planned upgrades, such as variable frequency drive (VFD) controls, automated systems, and soil moisture sensors are expensive at approximately $100,000, but they have seen a significant reduction in irrigation water needed this year by installing simple shade cloth covers over some of their fields.
- Harvest and Packing Aids: An electric mobile cart with shelves and tables could reduce worker strain, improve food safety compliance, and increase packing efficiency.
- Accessible, Repairable Equipment: Farmers expressed hesitancy toward high-cost technologies requiring specialized maintenance (e.g., certain tractors), preferring tools that can be repaired on-farm.

Lessons for Small Farm Technology Adoption:

- Return on Investment Matters: Technology must deliver clear benefits in efficiency, cost savings, or new market access to justify adoption.
- Low-Tech Can Be High Impact: Simple solutions like shade cloth provide significant operational and ecological benefits at a fraction of the cost of advanced systems.
- Infrastructure Unlocks Opportunity: Cold storage and land ownership enabled access to new markets and funding, illustrating how foundational investments make other technologies viable.
- Support Networks Are Critical: Pilot programs, nonprofits, and peer networks helped the farm access and implement tools that would otherwise be out of reach.

Key Takeaways

The story of Cruz Martinez Farm shows that appropriate tools for small farms must be accessible, affordable, and adaptable. For Javier and his family, innovation isn't about chasing the latest technology but, rather, about finding practical solutions that fit their operation, budget, and values. While advanced systems can deliver big gains, many small farms like theirs rely on steady, low-cost improvements and strong community support to stay resilient. Even modest upgrades, such as record keeping software, right-sized planters, or shade cloth, can make a meaningful difference in daily operations and profitability. Javier's belief in "good, sustainable technology" - tools that serve both the land and the business - has led to real progress through the adoption of the Solar Fresco cooler and upcoming irrigation upgrades. For Cruz Martinez Farm, innovation means balance: the right tools, thoughtful decisions, and the strength of working side by side.

Case Study 2: **Hahn Farm (Fresno County, CA)**

An open irrigation ditch runs across the middle of the property in a wavy line, separating young jujube trees in neat rows from a fallowed area being prepared for planting. Hahn Farm, established in 2012 by Nick and Manyla Hahn, is a 40-acre jujube orchard near Fowler, CA. Located in Fresno County's Central San Joaquin Valley, the farm reflects both traditional and innovative approaches to orchard management. While Nick handles most of the field operations, Manyla manages the business and digital aspects, drawing on her background in business and information systems. Their story highlights both the promise and challenges of adopting tools and technologies that fit small farms. To read the full case study, see Appendix I.

Tools and Technologies Adopted:

- EV UTV Ranger for multiple orchard tasks, from hauling to spraying.
- Off-grid propane-powered engine for well pumping where electricity was unavailable.
- Mechanization of heavy or repetitive tasks (e.g., contracted Flory Track Shredder for branch shredding).
- Cell phone used for farm task tracking, receipts, and communication.
- Custom-built furrow-making tool bar adapted to tree spacing.

Technology Needs and Gaps:

- Irrigation automation to reduce labor and improve efficiency.
- Affordable, reliable theft-prevention technology suited to a rural farm site.
- Cold storage capacity to extend sales windows and improve market flexibility.
- More efficient weed control (e.g., correctly sized flail mower, side-arm mower, alternatives to weed whacking).
- Digital software to support tracking cost of goods sold, profit margins, marketing, and online sales platforms for direct-to-consumer channels.
- Streamlined access to publicly funded programs (e.g., equipment trade-ins, conservation programs).
- Pest management tools tailored to gophers and birds.

Lessons for Small Farm Technology Adoption:

- Off-grid and improvised solutions (like the propane well pump or custom tool bar) show how farmers adapt when affordable options aren't available.
- Mechanization that reduces physical strain has immediate value for farm sustainability.
- Digital technologies must balance function with farmers' preferences; tools that add administrative burden or require constant troubleshooting are unlikely to be sustained. Many small-scale farmers, including Nick, do not enjoy computer or desk work, preferring to be outside on the land - a key preference that technology developers should keep in mind.
- Program design and delivery (timeliness, accessibility) can be as important as the technologies themselves in enabling adoption.

Key Takeaways

Hahn Farm highlights the importance of tailoring tools and technologies to reduce labor strain, improve water efficiency, and increase market flexibility for small farms. Irrigation automation, effective theft prevention systems, and affordable cold storage emerged as top priorities. The case also illustrates how cumbersome program access and reporting requirements can limit farmers' ability to adopt new technologies. Finally, the Hahns' situation underscores a broader need for small farm–appropriate mechanization and digital tools that provide real value without adding administrative or technological burdens.

Case Study 3: **GT Florists (Fresno County, CA)**

"Farming is not easy, but our family takes great pride in our produce. We have found it a great privilege to be a part of so many families' tables over the years and want to continue feeding our community."

- Lilian Thaoxaochay, GT Florists.

GT Florists is a 20-acre, multigenerational, family-run farm located just south of Fresno. Established in the 1990s, the farm cultivates mixed vegetables alongside semi-permanent crops such as guava, jujube, and dragonfruit. Managed by the Thaoxaochay family, the farm illustrates how small-scale, multigenerational operations in the San Joaquin Valley selectively adopt new tools while relying heavily on family labor, ingenuity, and low-cost innovations to sustain production and market access. To read the full case study, see Appendix J.

Tools and Technologies Adopted:

- Irrigation Upgrades: A variable frequency drive (VFD) pump and flow meter installed through a 2021 SWEEP grant reduced water use, though full optimization remains a challenge due to learning curves and risk tolerance.
- Cold Storage: A small conventional cooler extends the shelf life of leafy greens and heat-sensitive crops, though frequent condenser breakdowns add costs.
- Manual and Custom Tools: Precision planting and harvesting are largely done by hand, supported by push seeders and specialized Southeast Asian hoes for weeding. Farmer-built equipment, such as a 36-inch bed leveler/compost spreader and custom scaffolding for hoop house construction, exemplifies low-cost, adaptable innovation.
- Digital Payments: Adoption of Venmo and Zelle during COVID-19 expanded payment flexibility for community-based markets.

Technology Needs and Gaps:

- Value-Added Equipment: A jujube pitter would enable expansion into processed products; UC Extension is currently researching options.
- Desired Implements: Bed shaper, drip tape mulcher, and improved small-scale seeders.
- Energy Systems: Solar power for both the agricultural pump and residential storage container is planned within two years.
- Security: Theft (particularly copper from irrigation pumps) has forced costly enclosures, or inconvenient cable plugs, creating financial and operational stress.
- Digital Tools: Soil moisture sensors and recordkeeping software have been frustrating due to inflexible design and lack of crop-specific data, leaving the family reluctant to adopt more digital technologies.

Lessons for Small Farm Technology Adoption:

- Risk and Learning Curves Matter: Even technically skilled farmers face challenges with new systems like VFD pumps—limited production windows mean technology failures can be too costly to risk.
- Innovation Is Farmer-Led: On-farm ingenuity and repair skills, rather than expensive commercial tools, remain central to sustaining operations.
- Regulatory Burden Shapes Adoption: The cumulative weight of water, food safety, and labor compliance creates paperwork fatigue and discourages interest in adopting additional digital tracking systems.
- Market Access Comes First: Strong community relationships and high demand for specialty crops like jujubes ensure profitability, reducing pressure to adopt unfamiliar or unnecessary digital marketing platforms.

Key Takeaways

The GT Florists experience underscores how multigenerational small farms balance selective adoption of new technologies with reliance on family labor, applied knowledge, and adaptable low-cost tools. While incremental upgrades like VFD pumps, cold storage, and digital payments support efficiency, advanced mechanization, sensors, and digital recordkeeping remain out of reach—or undesirable—due to cost, complexity, or lack of relevance. The farm's innovations highlight how farmer-built solutions and community trust can be just as critical as cutting-edge technologies in sustaining resilience and viability in the San Joaquin Valley.

Collectively, these case studies illustrate how small farms navigate the intersection of technological opportunity and structural constraint. Their experiences underscore the importance of designing technologies that prioritize accessibility, adaptability, and are relevant to farmers' lived experience. By aligning technology development with the practical realities of small-scale production, stakeholders can help ensure that innovation strengthens the resilience and long-term viability of small family farms in the San Joaquin Valley.

Part III: Priority Needs and Opportunities

This section identifies the most pressing technology needs and opportunities for small-scale farms in California's San Joaquin Valley. These priorities were derived through triangulation of three evidence streams: (1) Local and international landscape reviews of available technologies, (2) a gap analysis comparing those technologies to the needs and constraints of local small-scale farmers, and (3) stakeholder input from farmers, technical assistance providers, and community organizations. Technologies were ranked for **impact** (e.g., yield gains, labor savings, risk reduction, improved farmer wellbeing) and **feasibility** (e.g., affordability, training access, language accessibility, and trust/privacy considerations).

A central finding emerged: **the success of any agricultural technology depends as much on the systems that support farmers in accessing and using it as on the technology itself.** Farmers consistently emphasized the need for accessible financing, trusted and bilingual technical support, reliable infrastructure, and transparent data practices. These cross-cutting enablers form the foundation of any effective investment or policy strategy. To make technology adoption feasible and sustainable, the following enabling systems must be strengthened:

- Financing and Ownership Models: Expand microloans, cost-share, and revolving funds for small-acreage producers; streamline relief funding and support cooperative ownership and equipment-sharing programs.
- Technical Assistance and Training: Provide bilingual, hands-on training through trusted farmer-serving organizations, covering all stages of adoption and maintenance.
- Infrastructure and Connectivity: Improve broadband access and expand options to power for irrigation, cold storage, and digital tools via solar programs and capital for electrical infrastructure improvements.
- Trust and Data Privacy: Require transparent vendor data policies and third-party vetting or certification to build farmer confidence in new technologies.

Addressing these foundational supports alongside specific technologies will strengthen small farm resilience and ensure equitable access to innovation. Within this framework, five key priority areas emerged for targeted action and investment:

1. Irrigation and water management tools
2. Cold storage and post-harvest handling
3. Business decision making tools and support
4. Farm management and compliance tools
5. Theft prevention and security

Priority Solutions by Key Area

1: Irrigation and Water Management Tools

Need: Farmers consistently identified access to water for irrigation, efficient water use, and cost reduction (both through reducing pumping costs and through using less surface water) as top priorities, particularly under drought, weather variability, and decreasing groundwater allocations under SGMA. Many small farms still rely on manual or timer-based irrigation systems with limited data to guide scheduling. The options for automating irrigation have multiplied, creating opportunities for customization and a range of price points and levels of service. Trusted farmer mentors, technical assistance providers, and research-based data on water use requirements are critical in helping to sort the options and assess fit.

Opportunity: Water use monitoring, sensor-based irrigation systems, soil moisture and plant stress monitoring, and automated scheduling can help optimize water use. These systems are common on large farms but less accessible to small-scale growers due to high costs, steep learning curves, and limited bilingual support. These systems remain out of reach for many small farms due to cost, complexity, lack of irrigation scheduling recommendations for niche crops, and limited bilingual support. Integrating them into SGMA outreach and training could expand access.

Enabling Conditions

- Subsidized or low-interest financing programs to reduce financial barriers.
- Bilingual training and technical assistance delivered through trusted farmer-serving organizations such as community partners and extension programs.
- Partnerships with irrigation districts and water conservation agencies to support adoption.
- Incentives or cost-share programs targeted to small-acreage producers.

Priority Opportunity: Targeted irrigation technology pilots for small farms, paired with financing and technical support, could produce immediate water savings and build local proof of concept.

"I'd like to see increased funding for sustainable and renewable energy including cold storage for farms, as weather is so variable. Extreme heat makes it impossible to keep produce food safe and marketable during peak grower season."

- Lilian Thaoxaochay, GT Florists.

Attendees learn about the battery powered Amiga tractor cart.

2: Cold Storage and Post-Harvest Handling

Need: Perishable crops like berries, greens, and stone fruit lose value without adequate cooling and storage. Many small farms lack affordable cold storage, limiting market access and forcing same-day sales.

Opportunity: Solar-powered or mobile cold storage units, shared facilities, and cooperative models—such as California FarmLink's *Solar Fresco* pilot[16]—can extend shelf life, reduce waste, and enable higher-value markets for small farms. Efficiency gains from cold storage can "trickle down" and create other opportunities including fewer delivery trips, the ability to harvest more produce at once (scaling up), cooperative relationships with other small farms, and potential of sales to local businesses or institutions (such as restaurants or schools) that do not have their own cold storage for volume purchases.

Enabling Conditions

- Shared ownership or rental models to reduce initial and individual capital burden.
- Accessible financing or grant support to offset installation costs.
- Solar panels with battery packages to reduce operating costs in off-grid or low-reliability areas.
- Smooth permitting and installation process with local governments.
- Technical support for cold storage maintenance and post-harvest best practices with ongoing training available.
- Pathways to land ownership, enabling farmers to invest in permanent infrastructure such as cold storage.

Priority Opportunity: Supports for on-farm cold storage solutions, including training, financing and permitting assistance.

3. Business Decision Making Tools & Support

Need: Farmers often lack guidance on evaluating return on investment or integrating new technology into business operations. Without these supports, technology can add complexity rather than value.

Opportunity: Business planning, financial analysis tools, and peer mentorship can help farmers make informed decisions and sustain technologies long-term. Programs should include training, planning for Wi-Fi or maintenance costs, and post-adoption support to ensure continuity.

Enabling Conditions

- Additional business support and training opportunities to support farmers with sustaining technology adoption after initial input costs are covered.
- Access to educational resources with clear value-proposition so that farmers understand how the coursework will benefit their business. These could be courses offered through farmer-serving organizations in collaboration with state agency and university partners.
- Increased access to financial advisors, mentors or organizations providing support in business decision making such as Kitchen Table Advisors, FarmLink, and beginning farmer training programs.
- Increase and encourage peer-to-peer learning opportunities between beginning farmers and experienced farmers. Having the opportunity to learn from other farmers is a pathway to understanding how the return on investment works for other farms.

Priority Opportunity: Increase, add, or allow for a wider range of expenses, and at a longer timeline in publicly funded technology adoption programs to better meet a farmer's needs, e.g., ongoing training, paying for wifi service, maintenance expenses, hired expertise, etc. This will also support technology adoption to continue past multiple phases of development.

[16] California Farmlink, Solar Fresco Program.

4: Farm Management and Compliance Tools

Need: Compliance with food safety, labor, and sustainability reporting creates major administrative burdens for small farms still relying on paper records. Digital tools could save time and improve accuracy, but adoption is limited by cost, usability, and data privacy concerns.

Opportunity: Mobile, multilingual management platforms (e.g., LiteFarm, Tend, CropManage) can streamline recordkeeping and analysis. With training in digital literacy and data governance, these tools can enhance compliance and decision-making. Table 6 illustrates some options for crop management and accounting software. Note that some software handles mostly production data while others handle data related to production and accounting.

Table 6: Examples of Crop Management and Accounting Software

Tool	About
FarmRaise	A digital platform that provides financial management tools (payroll, inventory, taxes, etc) and connects farmers with funding opportunities.
Good Agriculture	A digital platform to improve efficiency and productivity by centralizing data and offering actionable insights for bookkeeping, marketing, and identifying grants.
LiteFarm	LiteFarm is a free and open source farm management software created by British Columbia University.
Tend	Tend is a for-profit farm management software designed for small-scale, diversified farms. It streamlines operations by centralizing planning, tracking, and sales into one platform, helping farmers manage tasks, inventory, sales, and compliance from planting to harvest
TigerJill	Tiger&PocketJill supports agriculture management and compliance. Management variables include Caretaking, Budgets, Expenses, Inventory, Purchasing, Yield, Personnel, Equipment, Maintenance, Chemical & Fertilizer Applications, Weather Data, Recommendation, Reporting, Work Order, Billing, Receiving, Commission, Safety, Food Safety, Regulatory Compliance and Connectivity.
Purdue: Digital Farm Records Templates	Free Airtable templates provided by Purdue's Vegetable Crops Hotline for creating digital field records, FMSA records, and crop activity records.
UC ANR: Crop Manage	CropManage is a free crop management web application developed by UC ANR which helps farmers manage irrigation and fertilization scheduling.

Enabling Conditions

- Training and understanding of recordkeeping principles. Coaching on digital literacy and system use, delivered in English and underserved languages such as Spanish, Punjabi and Hmong.
- Subsidized or group-purchase licenses to lower ongoing costs.
- Clear and transparent data privacy agreements from vendors.
- Technical support networks tailored to small farms.

Priority Opportunity: Pilot a low-cost, bilingual farm management software with technical assistance and develop a community-based data stewardship framework to build trust.

5: Theft Prevention and Security

Need: Farmers report increasing losses from crop and equipment theft, which can be devastating for small operations operating on thin margins. Commonly stolen equipment includes irrigation technology, power tools, and tractors. Crop theft is also common with one farm reporting half their harvest being stolen at 40 acres worth of crops (stone fruit, citrus, and grapes). Remote farm sites, limited electrical and internet connectivity, and limited law enforcement response contribute to vulnerability. See the footnote for news articles that go into more detail on the nature and scale of the problem.[17]

Opportunity: Low-cost security technologies such as solar-powered motion-detection cameras, GPS trackers for equipment, and smart locks can deter theft and enable recovery. Community-based approaches such as shared patrol services or coordinated reporting networks can further reduce risk.

Enabling Conditions

- Vendor partnerships to lower equipment costs through group purchasing.
- Training on technology setup and data management.
- Development of community-based security networks or cooperative patrol models.
- Policy support for liability protections and insurance incentives.

Priority Opportunity: Launch a community security pilot program integrating low-cost technology with insurance support.

Photo credit: Hahn Farm

[17] Ruben Vives, "California Authorities Say They Broke up Farm Equipment Theft Ring," Los Angeles Times, October 30, 2024, https://www.latimes.com/california/story/2024-10-29/california-authorities-say-they-broke-up-farm-equipment-theft-ring.

Recommendations and Roadmap for Action

Farmer Resilience and the Role of Technology

Farmer resilience—the ability to anticipate, adapt, and recover from disruption—is the throughline across all recommendations. Resilience grows not just from new technologies, but from **knowledge, networks, and secure foundations:** access to water and land, trusted training, affordable financing, and digital inclusion. When small farms have these supports, technology becomes a tool for stability, not risk.

As artificial intelligence and other emerging tools enter agriculture, centering farmer agency and ethical design will ensure that innovation strengthens—not replaces—local knowledge and community resilience. Building this foundation of trust, skills, and access is essential to sustain small farms as anchors of a thriving, adaptive food system.

This section outlines strategic recommendations and a roadmap for action to address the priority needs and systemic barriers identified in this Small Farms Technology Needs Assessment. Together, these actions aim to expand access to water, land, and digital tools while building the financial, educational, and infrastructural capacities that underpin farmer resilience. Strengthening these systems will enable small farms to adapt to market, climate, and policy change while sustaining their businesses over time.

1. Supporting Small Farms' Groundwater and Water Management Practices Under SGMA

Rationale: As implementation of the Sustainable Groundwater Management Act (SGMA) advances, small farms face rising uncertainty about water access. Declining groundwater levels and unreliable surface water threaten farm viability, while many farmers remain unaware of SGMA's local implications. For decades, large corporate farms have benefited from cheap groundwater access while local small farms' wells, which are typically more shallow, are going dry. Increasing access to surface water will not be enough, as surface water sometimes is not available frequently enough to irrigate annual crops, and microbial or chemical contamination issues may need to be addressed before a small farm can utilize that water, especially where food safety or organic certification are at stake.

Goal: Explore how small farms maintain reliable access to groundwater under SGMA, and what role can technology, policy, or collaborative strategies play in supporting this access.

Key Actions:

- Support the awareness and development of technology and monitoring tools that might help farmers optimize irrigation, conserve groundwater, monitor groundwater levels, plan for water scarcity, and access surface water for irrigation, storage, and groundwater recharge while protecting groundwater quality and avoiding microbial contamination.
- Raise awareness among small farms of how SGMA may impact their farm and how technology can assist them through farmer-led peer groups, bilingual and culturally relevant training, partnerships with agencies, extension support, and technical assistance.

2. Expand Farmer Peer-to-Peer Learning and Evaluation of Appropriate Technologies, Especially Ones That Address Climate Resilience

Rationale: Peer learning is one of the most effective ways for small farmers to evaluate and adopt new tools. Exposure to proven, affordable technologies—combined with ongoing training—builds confidence and long-term use.

Goal: Create pathways for farmers to discover, test, and share effective small-scale technologies.

Key Actions:

- Invest in iterative testing by end users of new technology under the human-centered design model to right-size and fit technology to user needs.
- Ensure that both public and private sector technology sales and adoption programs include built-in, long-term access to training, technical assistance, and user support to enable sustainable and effective adoption.
- Invest in regional demonstration and sharing programs, such as mobile technology demonstration hubs, tool sharing libraries and multilingual training centers across the region.
- Support the awareness and development of technology and monitoring tools that support climate resilience priorities for the region.

3. Align External Funding Sources with Principles of Appropriate Technology

Rationale: Funding programs often favor large-scale, high-tech innovations that overlook the realities of small farms. Farmers expressed concern about aggressive marketing and vendor pressure to adopt technologies that may not fit their farm scale or needs. This highlights the importance of funding frameworks that prioritize farmer agency and ensure that technology adoption is guided by on-the-ground needs, not by vendor influence.

Goal: Ensure that the technology industry, government, and philanthropic agricultural innovation programs prioritize farmer-centered technology development by aligning investments with the principles of appropriate technology and the needs of small, diversified farms.

Key Actions:

- Incentivize technology companies in adopting the principles of appropriate technology.
- Require farmer co-design, evaluation, and compensation in all state-funded agricultural technology development programs (CDFA, UC ANR Innovate, F3 Innovate, etc.).
- Fund regional pilot programs and living labs that test and refine technologies in small, diversified farm contexts.
- Establish ethical data collection, consent, and transparency requirements for all technology grantees and vendors.
- Create dedicated small-farm innovation funding tracks within CDFA and UC ANR.

Photo credit: GT Florists

4. Address Land Access and Pathways to Ownership

Rationale: Land access and security of land tenure remain major barriers to the sustainability and growth of small farms, and specifically to the proactive adoption of technology. Farms have more capacity to invest in technology and tools, soil health, and other practices that increase the viability of their businesses when they have the assurance through secure land tenure that they will be able to benefit from these investments.

Goal: Create supportive policy frameworks that prioritize small farm businesses, land tenure, and their workforce.

Key Actions:

- Update local general plans and zoning codes to enable small farm operations and business activities (farm stands, signage, agritourism, on-site sales) as well as use of technology and equipment.
- Develop or expand land-link programs and lease-to-own models that help beginning farmers transition to ownership.

5. Strengthen Digital Access, Technology Adoption, and Security for Small Farms

Rationale: The digital divide continues to limit technology use and competitiveness for small farms. Reliable broadband, digital literacy, and cybersecurity are essential for effective use and trust. Theft of farm equipment further undermines confidence and financial resilience.

Goal: Ensure that small farms have reliable digital access, confidence in data protection, digital literacy, and security measures to maintain and benefit from technology investments.

Key Actions: Digital Access

- Expand broadband investment in rural zones and pilot low-cost connectivity programs.
- Integrate digital literacy and cybersecurity into farm training programs as appropriate.
- Include connectivity and digital access as eligible activities in farm funding programs.

Key Actions: Technology Security

- Support group purchasing of security tools (solar cameras, GPS trackers, smart locks).
- Provide support with installing security tools and managing subscriptions and tracking.

Roadmap and Timeline for Implementation

Implementing these recommendations will mean bringing together many agencies, community organizations, non-profit organizations, university programs, agricultural technology companies, and both small and large farms to coordinate their efforts. By prioritizing small farms' needs around irrigation, infrastructure investment, land tenure, security, and training there is an opportunity to strengthen the region's agricultural economy, food security, and resilience to rapidly changing circumstances.

Near-term (in the next 2 years):	Medium-term (2–5 years):	Long-term (5 years and beyond):
• Build advocacy coalitions for SGMA small farm protections and broadband access. • Expand UC ANR Fresno Equipment Lending Library. • Pilot mobile tech hubs and regional broadband test sites. • Build on UC ANR's existing bilingual programs by expanding training center partnerships with farmer-serving organizations to strengthen and extend bilingual education and support.	• Prioritize Principles of Appropriate Technology in CDFA and UC ANR ag-tech innovation funding. • Create regional lease-to-own programs for small-scale farm equipment. • Establish the agricultural theft prevention taskforce and reporting system.	• Institutionalize data and privacy standards for agricultural technology vendors. • Scale validated small farm technology pilots across the San Joaquin Valley. • Create land access programs that meet the needs of producers from the region.

Conclusion

Small farms in the San Joaquin Valley remain a cornerstone of California's agricultural and community landscape. They produce diverse crops, sustain local food security, and embody the ingenuity and adaptability that have long defined the state's agricultural identity. Increasingly, these farms are exploring and adopting new tools—both digital and mechanical—to improve sustainability, manage water and labor constraints, and build long-term resilience. Yet their central challenge is not access to innovation alone, but maintaining economic viability amid rising climate, market, and policy pressures.

This assessment confirms that the success of agricultural technology depends as much on the surrounding ecosystem—training, financing, infrastructure, supply chains, and trust—as on the tools themselves. When these supports are missing, even promising technologies go unused or abandoned. Farmers are eager to adopt right-sized, affordable solutions that improve efficiency, conserve water, and reduce costs, but adoption will only succeed when policy, funding, and technical assistance are aligned with the on-the-ground realities of small farms.

To close the technology gap and strengthen small farm viability, public and private partners must expand equipment-sharing programs, invest in bilingual, hands-on training, and ensure long-term access to technical assistance. Scaling successful pilots will require coordination, sustained funding, and farmer-led design, testing, and feedback. Technology must ultimately serve as a tool for resilience - helping farmers strengthen their operations, reduce vulnerability, and sustain their livelihoods for the long term. Supporting appropriate, accessible technologies is therefore more than an efficiency strategy - it is an investment in the vitality of rural communities, the resilience of the food system, and the stewardship of the land that sustains us all.

Photo credit Hahn Farm

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Appendices

Appendix A: Survey Instruments

Facilitation Questions used for Nov 8, 2023 Farmer Feedback Sessions

(Groups were facilitated by one or more speakers of the group language–Punjabi, Spanish, Hmong/Iu Mien, and English–and a volunteer notetaker was assigned to each group.)

Questions: *(Please prioritize first two questions)*

1. What technologies from the Tech Expo would you like to test on your farm? Please share why?
   a. What technology from the demo sites?
      i.
   b. What technology from the exhibition hall?
      i.
2. What should ANR prioritize in a public sponsored lending library?
   a. Context for lending library: This library would be available for small farms within Fresno County and adjacent counties to meet equipment needs.
3. What type of equipment or technology was missing from this event that you would like to see at a future event?
4. Deeper questions on technology (if time):
   a. How could the existing technology be better adapted to your needs?
   b. What challenges do you think you will have in adapting to this technology?
   c. What production challenges are you interested in regarding tools, equipment to help address.

Digital technologies survey

This is an anonymous survey. Your assessment is key to improving our future work. Please take a few minutes to complete this survey.

What are you using now to track your farm tasks? (check all that apply)

- Nothing
- Pad & pencil
- Excel or g-sheets
- Paid subscription or open-source software
- Other: _____

What are the main reasons you adopted / would adopt digital technologies? (check all that apply)

- Reduce labor demand
- Make admin tasks easier
- Increase production
- Improve crop quality
- Efficient use of resources
- Better decision making
- Implement sustainable practices
- Other:_____

What are the factors that hinder you from using digital technology? (check all that apply)

- Lack of knowledge
- Lack of tools to use them (smartphone, laptop, wifi, etc)
- Price
- Operation cost
- Functionality/features
- Compatibility with other technology
- Other (please specify) _____

Would you be interested in testing any digital technologies on your farm?

- Yes
- No
- Maybe

If yes, which one:_____

Do you have any feedback you would like to share?

_____

_____

_____

_____

Appendix B: Case Study Interview Guide

CAFF Survey Questions for Farmers on adopting (digital or not) tools and technology

Farmer questions:

1. What is your age?

2. What is your gender?

3. How long have you been farming?

4. What is your role on the farm? (Owner, manager, crew, all of the above, or other?)

Farm questions:

Tell us about your farming operation and practices.

5. What is the size of your farming operation? Do you own or lease your farmland? What crops do you grow?

6. How do you plant? Harvest? Irrigate? Do weed management? Pest management?

   What tools do you use to do your farming?

   What is the most useful tool you have?

   What tool doesn't work very well? Why?

7. How do you market your produce? Where do you sell and who are your customers?

8. What are the bottlenecks on your farm? (Those things that make you less successful than you could be)

9. This question applies to anything happening with your farm operation. What do you want to do? If you didn't have to do X (something you don't like doing), you could finally do Y. What is your Y?

Digital technology:

10. What are you using now to track your farm tasks? (e.g., paper and pencil, excel or google sheets, paid or open-source software, nothing/your brain

11. What comes to mind when you think about digital technology, computers, the internet? What are your feelings about digital tools on farms?

12. Which digital tools do you use? What kinds of tasks do you, or would you, like to try using digital farm tools for?

   What are the reasons you're interested in digital technology for farming?

   What are the factors that hinder you from adopting digital technologies?

13. Tell us about the main reasons you have used/want to try out digital technologies on your farm. Anything else you're hoping to achieve from trying these out?

14. What are the main concerns or reasons you haven't tried digital technologies? i.e. Lack of knowledge, lack of tools, price, operation cost, functionality/features, compatibility with other technologies, something else?

Is privacy or data protection a concern?

Are there other risks you perceive or have experienced with digital technology

on the farm?

15. Do you have any other thoughts about how digital tools can help or hinder your small farm?

Which tools, if any, would you like to try?

How can automation help your farm or farms similar to yours?

Closing question:

16. What equipment or technology (old or new) do you wish was available at the right size and price for your farm?

Appendix C: Technology Evaluation Criteria Table Example

This matrix is designed to help farmers, technical assistance providers, or technology developers evaluate tools and technologies. The example row below shows how to fill it out.

Tool / Tech	Category	Cost Estimate	Availability	Requirements	Benefits	Challenges	Applicability	Cost (1–5)	Ease of Use (1–5)	Suitability (1–5)	Scalability (1–5)	Local Support (1–5)	Water Efficiency (1–5)	Overall Score	Contact / Vendor
Cool Bot	Cold Storage	~$400 controller; ~$4,600 for full walk-in cooler	Nationwide (Store It Cold ships to CA)	Insulated space + AC unit; electricity required	Cheaper than refrigerated trucks; simple setup	Right AC required; not for rapid cooling	Works with all crops	5	4	4	5	5	5	28	661-000-0000

Appendix D: Full List of Tools Identified by Farmer Respondents

High priority	Interest in trialing
Basic instructions for tools in Spanish	Marketing and sales platforms
Seeders/drills (cover crop, row crop)	Soil moisture sensors that include other metrics of soil health
Transplanter (two row)	Small robotic weeder for orchards
Weeders	Bee pollination monitoring technology
Irrigation sensors and automation	Robotic harvest cart that follows worker, does simple routines
Tractors	Farm Hand tractor
Cool or cold storage solutions	Farm management, compliance tools
Sprayers (for organic fertilizer, for tree crops and for field crops)	Farmer created basic innovations appropriate for beginning farmers
Tiller	Steamers and propane weeders
Bed former	Mobile cold storage
Mulcher (sheet mulcher + roller)	Drone beneficial insect release (co-op)
Spreaders (for orchards, for beds)	Transplanter into plastic
Furrow maker	Wind machine
Shredder	Orchard mower with side swing arm
Flail mower (orchard and vineyard)	Jang seeder
Flail shredder	CropManage (with small farm relevant info)
Cultivator (like Tilmor)	
BCS tractor	
Roller blade flail mower- BCS attachment	
Plastic mulch layer- BCS attachment	
Bed shaper- BCS attachment	
Pressure washer- BCS attachment	
Front loader	

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Appendix E: Principles of Appropriate Technology

Development of Appropriate Technology for Small Farms: Principles and Guiding Questions

University of California, Agriculture and Natural Resources Small Farms Network

Small farms in California include a large diversity of crops, types of farming operations, and markets. Most have developed alternative marketing strategies to reduce competition with large, industrial-scale farming businesses that produce large volumes of crops and compete for prices in wholesale markets. Many small farms are diversified, sell directly to consumers through local markets, and/or produce unique small-acreage crops and products for specialty markets, both direct and wholesale. Small farms produce a variety of niche, emerging, and mainstream crops, livestock, and animal products, as well as value-added products and some of California's major commodities grown on a smaller scale. Small farms also represent diverse demographics, including immigrant and refugee farmers, beginning farmers, veteran farmers, and farmers with limited access to resources and capital. Many produce culturally important crops that contribute to food security and access to healthy produce for their communities.

Technology developed for small farms has potential to benefit the viability and sustainability of these operations, for example through improved ergonomics, reduced labor costs, and alternatives to chemical inputs. However, technology developed without meaningful feedback and inclusion of stakeholder priorities and experiences may not be beneficial for small-scale farmers. Below, we discuss several guiding principles with questions for reflection and discussion on how they might be applied to the development of new technology, tools, and equipment with these types of farmers and their operations in mind.

1. Human-Centered

Development of technology for small farms must be driven by the priorities of the end users. The principles of human-centered design (Norman, 2023) provide a useful framework: 1) understand and address core problems, beginning with real-world observations of actual practice; 2) start with the needs and abilities of people, then design technology around their interests; 3) focus on an entire activity with a systems approach, rather than only isolated components; and 4) employ multiple, rapid iterations of prototyping and testing with participation and feedback from end users. Without an approach that centers the end user, technology developed for small farms with the best intentions may fail to address the key challenges and priorities of small-scale farmers.

Collaboration with small-scale farmers as active, continuous end users during the development of new technologies will help to ensure that technologies address on-the-ground priorities and are relevant to the unique contexts of small farm production practices and business operations. The process of collaboration should emphasize authentic engagement with farmers to solicit their input as well as meaningful participation in testing and improvement of new technology. Farmers often give generously of their time and resources to public and private projects, and many innovate on their own and may already have their own prototypes that can be developed and improved for wider use. Farmer contributions to development of new technology should be compensated appropriately, recognized, and protected as intellectual property when appropriate.

Guiding Questions: Human-Centered

a. How are farmers being engaged to provide feedback during the process of technology development?

b. How does the technology address the interests, challenges, and priorities determined by small-scale farmers through meaningful community engagement and observations of actual practice?

c. How are farmers being compensated for their time and contributions?

d. Are farmers contributing intellectual property, and is it recognized and protected?

e. How can frequent iterations of beta testing be built in, with improvements based on direct feedback, before the technology is released?

f. How does the technology fit into a whole small-scale farming operation, and can it be integrated with other tools and systems in use?

g. Have safety standards and trainings been developed to avoid safety risks?

2. Appropriately Scaled

Technology developed for small farms must be on an appropriate scale to match the farming operations, budget, and cropping patterns of a small-scale farming operation. Often, innovations in agricultural technology target farming operations with larger operational scales and large monoculture acreages of high-value commodities. These operations differ substantially from small farms in characteristics such as field sizes, row spacing, acreage, diversity of crops, production methods, and marketing strategies. Technologies developed for large-scale monocultures likely are not applicable or accessible for small farmers because they are physically too large for their production contexts, have a cost-benefit ratio that only is profitable across large acreages, would be utilized over a scale that is too small to justify a large purchase, and/or are not adaptable to smaller-scale diversified cropping patterns. For example, although precision agriculture technologies involving automation and remote sensing can be beneficial and cost-effective for reducing inputs on large-scale monoculture farms, they are less appropriate for small farms where patterns in crop health, nutrition, etc. can be observed locally and purchase of precision agriculture technology may not be cost-effective.

Appropriately scaled technologies should take into account the unique operational contexts of small-scale farms as a central aspect of the development of new technologies that will be relevant and accessible to small farmers. At the same time, technology that is too small-scale or too labor intensive can also be inappropriately scaled. Small farms can include a range of operations, from urban farms on less than an acre, to commercial production of niche specialty crops on a few more acres, to family-operated livestock operations larger than these but still considered small farms by comparison with industrial and corporate farms. Hand tools or walk-behind tractors may be appropriate for very small-acreage farms, while larger small farms may need tractor implements and mechanized equipment with enough capacity for larger volumes of inputs and/or sufficient horsepower to cultivate soil or transport heavier loads. While robotics and larger mechanized equipment can be incompatible with cropping system design or too expensive for a small-scale farm, technology can also be limited by elements that are too small, such as insufficient horsepower, battery life, volume, or other specifications needed for production. The goal should be to match the technology to the scale of the farming operation with the farmer's interests, production practices, and economic context in mind.

Guiding Questions: Appropriately Scaled

a. What scale of operation on the spectrum of small farms is the technology targeting?

b. What labor, economic, and production constraints are important to address at this scale of operation?

c. Will the technology be cost-effective for the scale of farm being considered?

d. Will the technology have enough power, capacity, volume, etc. for the farm size it targets?

3. Cost-Effective

The cost of technology for small farms should be within the range that a small farming operation can either directly purchase or access through other means, such as shared equipment programs. This applies to costs of purchase or access as well as to costs of ongoing use and maintenance. The purchase, use, and long-term maintenance of technology must have a favorable cost-benefit ratio for the scale of the farming operation, considering the size of the area that it will be used on, labor required, maintenance costs, and any other associated costs. For example, the installation of soil moisture sensors should result in economic benefits such as reduced pumping costs that exceed the costs of purchasing, installing, and maintaining the sensors. Analysis of costs and benefits should also account for opportunity costs of purchasing the technology instead of some other use of available funds, as well as time spent learning to use it.

Cost-benefit ratios can also help determine whether new technology includes multiple implements and functions to maximize the benefits of a more expensive purchase, or whether it is more effective to develop one function that is very effective at addressing a specific priority. Development of a multi-function technology may be successful if a farmer is likely to use all or most of the functions, and if all the functions and parts are cost-effective within the business plan of the farming operation. However, more affordable technology performing a single function very effectively may be easier to learn, use, and maintain, less risky to purchase, and easier to target for continued testing and improvement.

Companies developing technology for small farms may benefit from a business plan based on high volume of low-cost units sold, rather than higher pricing for fewer units. Technology that succeeds in benefiting small farms could be purchased by a large number of small-scale farmers both domestically and internationally. One example of this is the CoolBot, which currently costs under $500 per unit and is purchased by many small-scale farmers across the US. Avoiding potentially burdensome required subscriptions and proprietary controls, keeping technology open-source, and ensuring that farmers can repair technology on their own when possible, also helps keep technology affordable.

Guiding Questions: Cost-Effective

a. Does a cost-benefit analysis show the technology to be profitable based on reduced costs and/or increased profit, including the costs of purchase/access, operation, additional inputs needed, maintenance, and repair?

b. Is the up-front cost to purchase, rent, or subscribe to the technology feasible for the scale of small farm being considered?

c. Is a multi-function or single-function technology more cost-effective to address the priorities identified by farmers?

d. How many units would a company need to produce and sell to be profitable on the basis of volume?

e. How can the technology be designed to be profitable for the developers without required subscriptions or proprietary controls?

4. User-Friendly

Technology, tools, and equipment appropriate for small farms should be easy to use, maintain, and integrate into ongoing farming operations. Firstly, innovations should consider the ability of small-scale farmers to access digital infrastructure. If technologies and equipment require Wi-Fi connection, cell phone modems, broadband, and/or computers for successful use, this may present accessibility and usability challenges for small-scale farmers with limited resources or technological literacy.

Technologies are more accessible if they use easily attainable knowledge to operate rather than advanced technical knowledge. For example, digital technologies that require coding by the operator limit use to a subset of technologically literate farmers who have this skill. New technology can be more accessible when accompanied by opportunities for technical training and peer-to-peer knowledge sharing, with the goal of knowledge being further shared among communities of end users. Training and knowledge sharing can be facilitated by business owners, extension organizations, technical assistance providers, and/or end users. Emphasis should be placed on ensuring these education opportunities are culturally relevant for diverse stakeholders of the small-scale farming community.

Technologies should be streamlined and intuitive to accomplish tasks appropriate to small farm operations and provide information at the decision-making level. While needs and preferences for the level of interpretation made by the user may vary, technologies that require less interpretation are generally easier to use. For example, a decision support technology for irrigation or pest management could produce simplified, practical recommendations based on accurate scientific research to minimize the need for interpretation by the end user, presenting a user-friendly version of the information needed to decide whether to irrigate or manage pests rather than the raw data.

Finally, maintenance and repair of technology should be easy to access, affordable, and simple, and small-scale farmers should be empowered to be as self-sufficient as possible. End users should be able to repair and maintain their own tools and equipment when needed, purchase parts, and be informed of recommended maintenance practices. Whenever possible, small-scale farmers should not be obligated to outside entities or subscription services for essential maintenance and repairs.

Guiding Questions: User-Friendly

a. Have you identified the potential end users of the technology, and do you have a way to request feedback from them?

b. Does the level of technical knowledge and education required to effectively use the new technology match the majority of the target end users?

c. Can farmers either maintain and repair the technology on their own, or easily get it serviced affordably and locally?

d. Are the parts and components needed for repair and maintenance available and accessible, either locally, domestically, or through an easy-to-use service?

e. Does the level of complexity match the time, labor, size, and current practices of the farming operations that the technology is being developed for?

f. Can farmers access information on how to use or improve upon the innovation so that it can better address their interests and challenges?

g. How much interpretation is required for the user to make a decision supported by the technology?

h. Does the technology allow easy adjustments to adapt to different field configurations and cropping systems?

5. De-Risked Experimentation

Small farms are small businesses often operating on tight margins, which can make experimenting with new management strategies, technologies, and practices riskier. This is especially true when large capital investments in equipment are required, and/or when innovations are still in an experimental phase. Small-scale farming operations may not have the financial flexibility to experiment with or integrate new technologies, especially those that are costly to purchase and maintain.

Further, adoption of new technologies requires experimentation and may not always be successful immediately, which is highly risky for small-scale operations because their profit margins are less flexible. To ensure that the inherent risks of farming are addressed, the introduction of new technologies should include accessible opportunities to experiment on-farm as well as demonstrate their uses. Efforts to facilitate low-risk technology testing could include tool and equipment sharing or lending programs, cost-share programs, demonstration farms, grants to support technology experimentation, and regional events to exhibit relevant appropriate technologies.

While technologies that involve comprehensive use through different phases of farm operations can also benefit small farms, they are more difficult to de-risk for testing and feedback. Technologies that require use from start to finish on a farm rather than being brought in to do a particular task, or that require ideal conditions for use, are more difficult to try out on a one-time basis. For example, a robotic weeder that requires prior setup with the row spacing, bed height, and plant spacing of a farm is difficult to try out on a farm that has already been planted. Tools that function well under ideal circumstances may be difficult to use in more varied and difficult environments, such as uneven terrain, dense vegetation, or dry or wet soils. Small-scale farms are often more diverse and less homogenous than larger-scale industrial farming operations. The more adaptable to different environments without requiring extensive prior setup and adjustment, the easier a technology is to test and evaluate with user feedback and generate interest in adoption. Technologies that can be easily substituted for an existing method are easier to try out instead of the usual method with low risk.

Guiding Questions: De-Risked Experimentation

a. How will farmers learn about and experiment with the technology?

b. What opportunities are there for on-farm demonstrations, cost-share programs, equipment lending or sharing programs, or events that facilitate farmers trying out new technologies?

c. How can de-risking experimentation with technology be built into funding and business models, such as options for compensating farmers if trialing new technology results in an economic loss?

d. Have you evaluated how your technology might fall short or fail during use? What problems might arise during use, and how might they be resolved?

e. How long do you expect your technology to last? 5 years or longer?

f. How can you build in evaluation of both continuous user and new users?

g. Does the technology require comprehensive use throughout the farming system from start to finish, or is it possible to trial for one-time uses?

h. Does the technology require certain conditions to function well? How well can it adapt to variable on-farm environments?

6. Protective of Privacy

Processes for collecting and using data from sensors, online platforms, internet of things (IoT), geographic information systems (GIS) and other technologies must be transparently outlined for users and safeguarded as confidential. Farmers are required to report a wide range of information to regulatory programs and can face substantial risks if they are out of compliance. This is especially true for small-scale underserved farmers because there are often resource, language, and capacity barriers to successful regulatory compliance. In addition, the widespread presence of ambiguous data use terms has caused concern from users across many technology applications. Given these contexts, there is understandable skepticism among farmers of all scales to engage with technologies that have obscure data use or sharing policies. Appropriate technologies should be protective of data privacy to enable more farmer engagement and ensure that technology use is respectful and safe for all farmers. Further, as data continues to become a central commodity in itself, data use and sharing policies should be both fully transparent and easily understood, as well as having an option for users to opt out of data sharing.

Guiding Questions: Protective of Privacy

a. Does the technology collect data from farmers?

b. If so, how is the privacy and confidentiality of the data protected?

c. If data is collected, will the farmer be compensated for their data at an appropriate rate?

d. Is data shared with third parties, and if so, what is it used for?

e. Are end users fully informed of how data is used and shared?

f. Is there a clear process for end users to opt out of data collection and use?

g. Is there a process with accountability for data to be deleted after a certain period of time?

7. Strengthening Local Economies

New technologies should maximize opportunities to connect and strengthen local and regional food and agriculture economies by improving transparency, assuring reliability, and facilitating new connections across the local agriculture and food system. Decentralizing the purchase of both crops and agricultural inputs can contribute to increasing regional economic activity through improved interactions between farm operators, ancillary services, and consumers in the community. Technologies focused on logistics management can also create more connection points among multiple entities in the food and agriculture sector.

Some examples of technologies that improve networking and connectivity include those developed to promote e-commerce and online sales. These technologies help to connect small farms and local businesses to promote shorter food supply chains, higher circulation of local capital, and closer connections between production and consumption. Other examples include technologies that could improve a small-scale farmer's access to locally produced agricultural inputs and services, such as facilitating the distribution of appropriately sized and locally available loads of compost for small acreages, collection of drip tape and other agricultural plastics for recycling, or purchasing appropriate volumes of alternative pest management supplies (e.g. pheromone lures, traps, or biological control organisms).

Guiding Questions: Strengthening Local Economies

a. What gaps currently exist in access to markets, inputs, or services that the technology could help address?

b. How could the technology address gaps in connection among farmers and sellers of inputs and service?

c. How will the new technology increase sales, access to market channels, capabilities for farm business management, and/or access to desired inputs?

d. How will the new technology strengthen the local food system and economy?

References:

Norman, Donald A. Design for a Better World: Meaningful, Sustainable, Humanity Centered. Cambridge, MA, MA: The MIT Press, 2023.

Appendix F: Tool Sharing and Lending Resources

- Rogue Farm Corps webinar and resources with models and international examples

  https://www.roguefarmcorps.org/equipment-sharing
- A resource guide for equipment sharing from NE SARE

  https://projects.sare.org/media/pdf/S/h/a/Sharing-Guide-2018-_-Web.pdf
- Fact sheet with example of Intervale Center in Vermont

  https://nesfp.nutrition.tufts.edu/sites/default/files/resources/ifec_fact_sheet_to_share.pdf
- Example of clearing-house style sharing using an airtable

  https://futureharvest.org/resources/resources-for-farmers/tools-sharing-rental/
- Decision making tool for equipment joint ownership from Iowa State

  https://www.extension.iastate.edu/agdm/crops/html/a3-34.html
- News article on informal agreements

  https://www.farmprogress.com/farm-operations/simple-equipment-share-agreement-anchored-by-trust

EXAMPLES:

- https://www.nhacd.net/equipment-rentals
- https://www.straffordccd.org/equipment-rentals/
- https://calclimateag.org/breaking-barriers-ground-how-equipment-sharing-empowers-small-scale-farmers-in-california/

  https://www.plowsharealliance.org/
- https://ucanr.edu/blog/supporting-small-farms/article/evaluation-fresno-small-farms-equipment-sharing-pilot-program

Selecting and caring for tools: Here's a link to the resources created by Georgia Organics in this project funded by SARE (Tractor, Small Engine, and Hand Tool Selection, Use, Maintenance, and Repair for Small to Mid-Scale Sustainable Farms).

Appendix G: Sources for Stakeholder Input

Date	Event/Item	Notes on Stakeholders	Type (survey, interview, etc)
Nov 8 2023	Tech Expo at KARE	Four group discussions took place at the Expo organized by language groups; Punjabi, Spanish, Hmong/Lu Mien, English. Group size varied from 10 to 40 producers.	Listening sessions with detailed notes taken.
Nov 8 2023	Tech Expo at KARE	56 respondents. Demographics of farmers who provided feedback: 52 years of age 13 years of experience 37% chance of being female 28 acres farm size Growing vegetables, stone fruit, berries, among others	Hard copy surveys collected at the event.
Spring and summer 2025	Case Studies	3 farms (family farms each including 2-6 farmer/owners)	In-depth interviews lasting multiple hours on-site, with follow up for clarification or more depth
February 2025	World Ag Expo	24 exhibitors were recorded.	Targeted survey of vendors and service providers. In-person visit to booth with assessment completed by CAFF staff.
March 2025	SF ADAPT First meeting	An in-person meeting held at KARE with 40 stakeholders interested in shaping small farm tech. Responded to farmer feedback from CAFF, UC ANR surveys to identify immediate priority actions.	Focus group
2025	Observing technical support cases offered by CAFF	TA session with a farmer setting up farm management software. The researcher observed 1 session lasting 2 hours.	Observation of in-person technical support provided by CAFF Tech Hub staff to a small farm.
2024	Roundtable on wheels	Pan Valley Institute hosted a tour and conversations with 4 farms in Merced and Madera counties to educate community organizers	Tour, question and answer sessions lead by staff of community organizations and expert farmers
2024	Interviews of UC ANR Small Farms Team	Experienced Technical Assistance providers to small farms in the Fresno region	Video interviews with 8 members of UC ANR Fresno Small Farms Team
March 2024	In-person surveying at Small Farm Tech Expo	Event involved approximately 100 attendees with 21 producers actively participating in the surveying.	In-person surveying through multiple methods including paper survey, notecards, and post-its to collect farmer responses followed by discussion.
Spring 2023	Rise and Restore event	Bilingual listening session: List of issues and concerns raised by Central Valley Farmers	Listening Session
August 2025	Solar Fresco Program	CA Farmlink solar cold storage pilot program staff, Fernando Garcia.	Video interview program goals, progress, challenges

Appendix H: Cruz Martinez Farm (Case Study 1)

The following case study is based on two visits and one in-depth interview with members of the Cruz Martinez Farm.

Farm: Cruz Martinez Farm

Year Established: 2012

Location: Madera, CA (Madera County)

Type: certified organic vegetables and fruits

Size: 28 acres

Favored Technology:

A two row transplanter, purchased a couple of years ago, has increased production capacity.

The solar cooler installed as part of a pilot project* has doubled the amount of product they can harvest and deliver to the distributor in a single trip–creating efficiencies in harvest, packing, and delivery which not only saves money but also creates time to do projects that would otherwise be deprioritized. Beyond this, the excess power and infrastructure that come with the solar cooler provide opportunities for other operational improvements including welding capabilities and remote office space.

Communication channels that have connected them to local buyers, access to grants, land purchasing. For example, the non-profit Kitchen Table Advisors has supported with financial readiness for loan and grant applications.

Farm Innovations:

Installing shade cloth covers over some of their fields. Not only do the plants in the shade need less water, they also have less crop loss due to sunburn.

Identifying multi-functional spaces that serve multiple purposes such as a hedgerow planting that protects the integrity of the surface water ditch, provides pollinating habitat to a partner farm, prevents cross contamination of overspray from a neighboring lot, and a wind break for plantings.

Technology Needs and Gaps:

Software that would ease reporting burdens for FSMA, organic certification, and tracking of specific business activities/purchases to make future decisions and purchases (i.e., fertilizer productivity, paying nursery to grow seedlings, etc)

Adopting variable frequency drive (VFD) controls to control the pump motor's speed and efficiently match the system's variable flow and pressure demands.

An electric, slow-moving cart with shelves that improves packing speeds, reduces touch points for food safety, and helps alleviate body strain from lifting pack boxes multiple times. Equipment such as the Amiga tractor by Farm-ng was identified. The mobile cart would be outfitted with stainless steel tables and move along the end of rows at the speed of the workers for more efficient, safe, and accurate packing.

Introduction:

On a hot summer morning in July, I met with Olga and Javier at their farm outside of Madera, CA. It is a beautiful spot in the central San Joaquin Valley, with a seasonal creek (now irrigation ditch) running diagonally across the otherwise perfectly flat property. Along the creek, there are many trees and shrubs, including majestic Valley Oaks that create deep, welcoming shade on the banks. As I follow Javier in his truck toward the shady area, I notice the soil under my tires is very fine and sandy; even at speeds below 10mph we are creating dust clouds.

Under the trees, we set up for our interview at a shade trailer normally used by farmworkers for their breaks. Between where we sit and the main road is a large field divided into two or three plots. The majority of the area has just been disced, incorporating the residue of the squash crop that was recently harvested. The remainder is planted in a few varieties of peppers, some of which are growing under shade cloth that is supported with tall wooden stakes.

On the opposite side of the creek, the main headquarters of the farm operations is situated around an old farmhouse, set far back from the road. An agricultural well services that house the farm irrigation needs, and a second house on the property. Around the well are growing several shade trees which provide a break area for workers. Nearby, there is a packing area and storage container and a new off-grid solar cold storage room.

Farmers:

Cruz Martinez Farm was started by Teodora and Melecio in 2012 after many years working as farmworkers on other people's farms. Although they were good at growing produce, they faced many challenges around regulations and paperwork. Both the language barrier between Spanish and English as well as a lack of bureaucratic literacy were hurdles to farming, beyond the many logistical and technical challenges of growing and marketing produce. Javier helped his parents with paperwork in his spare time, but starting in 2016 he took on more responsibility for the business side of the farm, helping with records, compliance, and finding support and resources for the farm. Since then, Javier has become the "face" of the farm, doing deliveries, interacting with customers, public agencies, farmer support organizations, and helping with all aspects of the farm, while Teodora focuses on distribution, sales, and packing produce. Melecio is responsible for the cultural tasks of farming, equipment maintenance, and farm management, and Olga joined the farm about a year ago to focus on the farm books: record keeping, farm management, budgets, planning, reporting and compliance. In addition to the family members working on the farm, the farm is committed to nine employees year-round. Since starting in 2012, the family has tripled their production acreage and seen tremendous growth in their business acumen and success.

Themes:

Key themes arose from the interviews with the Cruz Martinez family including 1) Record keeping especially for meeting reporting requirements for food safety (FSMA) and organic certification 2) increasing infrastructure has been extremely helpful; a transplanter has increased production capacity, a solar cooler has doubled the amount of product they can harvest, pack, and deliver, improving irrigation infrastructure remains a challenge 3) irrigation efficiency and associated costs.

The Farm:

Purchasing the 28 acres that they farm is a relatively recent achievement for Cruz Martinez Farm; they leased farmland when they began farming and for many years. Javier noted how being land owners, even though they still have to make the mortgage payments, has immediate benefits for technology and infrastructure investments. Not only does it make longer-term investments in all kinds of infrastructure more sustainable, it also helps them to qualify for grants and pilot programs which stipulate ownership as a condition of participation.

The Cruz Martinez family grows a variety of vegetables and some fruits on their certified organic land. They sell most of their produce to a distributor near the central coast, and have recently formed a partnership with a local high school to grow produce that the school needs for their nutrition program. The farmers plan what to grow primarily by matching their crops to customers' needs. While the older generation had originally intended to sell at local farmers' markets, this hasn't worked out well for them so far, but it is something they still have an interest in: feeding their local community.

The current crops in mid-summer were varieties of peppers, corn, melons, squash, and fava beans. They also grow cucumbers, lettuce, herbs, and dandelion greens. This year they planted 10 citrus trees through a cooperative grant with the school district, and expect to plant blueberries this winter with similar support.

Irrigation:

A pain point is irrigation cost and infrastructure. While planned infrastructural improvements are expensive at approximately $100,000, they have seen a significant reduction in irrigation water needed this year by installing simple shade cloth covers over some of their fields. Additional improvements would be adopting variable frequency drive (VFD) controls to control the pump motor's speed and efficiently match the system's variable flow and pressure demands. VFD controls will also reduce the mechanical and electrical stress on the pump, leading to additional energy savings, longer equipment life, and optimal water delivery. Booster pumps, controllers, and pressure regulators would also be included in these improvements. Currently, water is pumped directly from the well to the field and drip lines, leading to blow outs, overworked equipment, and limited efficiency. Ideally, the future irrigation system is also fully automated and interacts with weather data and soil moisture sensors.

Weather and heat are two major bottlenecks for this operation, as they are for many small farms experiencing extreme climate events. Heat waves are appearing more rapidly and unexpectedly, which leads to less preparation time to irrigate, shelter, or harvest the crops before they are lost to heat. Heavy rainfall also happens unexpectedly, without proper soil moisture content which increases flooding risk and erosion. Improving infrastructure is a high priority for the farm because it helps them to be more resilient to disasters. Irrigation infrastructural improvements are slated for 2026.

Surface Water

Cruz Martinez Family Farm relies exclusively on their well water and does not use surface water from the ditch that runs along their property, even though it is readily available and provided by Madera Irrigation Water District. The surface water may include contaminants which would impact food safety and become a major challenge to mitigate, especially with an open ditch and their farm being downstream from many other operations. If they used it, they would have to increase their water testing every quarter and report to the Water District (another report to manage with additional oversight) and if a test comes back showing any contaminants from upstream farms, they run the huge risk of abandoning entire plantings and losing sales from those harvests. They also want to ensure their crops remain organic with no residual pesticides or other chemicals infiltrating the system. Their well water is more reliable with less testing required.

Maintaining their surface water ditch remains their responsibility (not the irrigation district) and their operation has lots of incentive to keep the ditch well maintained. They clear fallen trees and debris regularly from the ditch to prevent future flooding and damage to their property due to overflow. During the 2022-23 storms, neighbors lost crops and structures while their operation experienced no damage. However, the farm is able to use this marginal ditch space as an opportunity since it is difficult to grow row crops in the space. They have partnered with the honey farm, Queen Madera, and they worked collaboratively to plant a pollinator hedgerow along the farm that benefits the farm in several ways; it provides a useful space for honey production, prevents overspray drift from neighboring farms protecting their organic practices, and provides a wind break for their field crops. The honey farm, Madera Queen Honey, has their headquarters on-site for now a year. Having Madera Queen Honey has been very beneficial to the farm by having pollinators year-round for peppers and other crops for better yields. In addition, some of the Madera Queen bees have access to flowering plants year round. This hedgerow provides a perfect example of a multi-function investment that provides numerous benefits to the farm and local community; an easy choice for any farm to make.

Infrastructure:

The solar cooler that they had installed as part of the Solar Fresco pilot project facilitated by CA FarmLink has doubled the amount of product they can harvest and deliver to a wholesale buyer in a single trip- creating efficiencies in harvest, packing, and delivery which not only saves money but also opens up time to do projects that would otherwise be deprioritized. Beyond this, the excess power and infrastructure that come with the solar cooler provide opportunities for other operational improvements including; powering electric equipment, welding, a small office, ipads for workers to enter data, etc. Moreover, the improvement to quality of life for the delivery person (usually Javier) and increased safety due to driving while rested instead of tired are very significant, especially in the ongoing, week after week, year after year context of a small farm.

Before cold storage was installed on the property they would only be able to utilize half a truck load for deliveries. A typical harvest would last for four hours producing three to four pallets of produce, and then they would drive 2.5 hours to get to the packing house before closing. With their increased cold-storage, they are now able to harvest longer, load six to eight pallets of produce and make the delivery the next day and utilize an entire truck load and transport costs. Long-term, the results of this increased capacity may support increasing the farm's credit potential for further expansion.

During the winter months, soon after the unit had been installed, Cruz Martinez realized he was able to extend the season on some of his root crops, since in prior years he had nowhere to store them and the winter moisture and temperature fluctuation lead to the product quickly going bad. Thus, the farm would leave more viable product in the field once the rainy season began. This last winter they were able to store this product for about two weeks in refrigeration and mentioned planning to plant more this year since they know the harvest will last a few more weeks in storage. The additional cold storage has allowed them to increase their wholesale buyers overall. For example, being able to provide produce on a consistent basis was a challenge of working with local school districts, who often lack storage capacity themselves. The farm is now able to provide produce consistently to Chowchilla Union High School District, which increased sales for the farm and increased access to organic, fresh produce for the school lunch program with 81.8% of students on the free, reduced, priced meal school lunch program.

Labor:

While labor remains a broad challenge for agriculture across all scales and operations, the issue is more nuanced for a small family farm and business with year round employees. Cruz Martinez Farm employs nine full-time employees throughout the year. The business has a commitment to pay the employees year-round, which means investing in new technology that removes hand labor for this workforce does not necessarily make sense for the farm. The farm cannot simply spend more money on technology and less on payroll as they also cannot afford to lose their skilled workers if they were unable to provide constant employment.

Technology improvements can work alongside skilled labor, as demonstrated by the automated mobile cart which could improve hand harvesting. Hand harvesting is often necessary due to fragile crops, so investing in specialized equipment is not often prioritized. However, the automated mobile harvest cart was identified as a way to make the harvest better: easier on the body, more efficient in handling the produce, facilitating regulatory compliance. In this way, technology doesn't replace the workers, but makes their job safer and more efficient, allowing the farm to capture more produce for each employee. In another example, they cultivate between rows with a tractor pulled weeder when the timing is right, but in some cases, it is just faster, easier, and has better results to send in the crew with hoes, especially if work is limited during that time, and the farm would need to find other tasks for the employees anyway.

Equipment:

A transplanter, purchased a couple of years ago, has increased production capacity in numerous ways. They now have increased speed and efficiency for transplanting thousands of seedlings, reduced labor costs, implemented timely planting for maximizing yields, and plants are planted with more consistency, and less transplant shock, which leads to healthy plants and higher yields. They now buy their own seeds, but outsource most of the starts to a nursery to keep up with their increased production capacity.

An automated mobile cart was identified as a way to save time and plant quality by supporting the harvesting process at human speed. Currently they move down the row and pack bundles or other items as they go into the boxes. By the end of the row, they no longer have an accurate count of how many bundles are in the box. Eventually, the whole box is recounted and repacked. With an automated harvest cart that straddled the crops, with shade, and followed the speed of the human packers, a worker can drop the item (after bundling) onto the cart and it can be counted and packed at the end of each row. This method would save time, human backs, and make food safety compliance easier.

Maintenance is a consideration for Cruz Martinez before adopting certain technology and equipment. For example, the John Deere tractor requires specialized maintenance and repairs, and does not allow a user to fix it themselves. There are many skilled individuals on farm operations and not being able to utilize your own mechanic skills to repair your own equipment is reason enough to not adopt technology.

Affordable low-tech solutions:

While the farm waits for increased capacity and cash flow to invest in irrigation infrastructure, simple low-tech solutions have made a big difference. The farm installed shade cloths with vine stakes and string to lessen evaporation loss and prevent sunburn on their plants. They have noticed a big difference with shade cloths versus none and are still identifying the proper shade percentage to utilize on the farm. Twenty percent coverage was low so they are now experimenting with 30%. There are also farms who swap out their coverage during the growing season to match the change in temperature. Irrigation expenses have now decreased about $700/month due to less irrigation required for these rows and less electricity usage for pumping. The shade material also lasts five seasons or more, a great investment when compared to other farm supplies that are constantly under the hot Central Valley sun.

Record Keeping & Reporting Requirements:

With the unpredictable nature of farming, record keeping and managerial accounting practices can support decision-making, performance evaluation, and strategic planning. The farm recently adopted Quickbooks and hired a dedicated employee, Olga, to keep more detailed records and manage cash flow. Cruz Martinez Farm has a list of activities and expenses that they would like to further track in order to create more accurate predictions and inform future purchases and investments, such as tracking data to evaluate the effectiveness of particular fertilizers, outsourcing seedlings to a nursery vs. keeping in house, productivity differences with planting different sized seedlings, etc. They have already seen improvements in choosing varieties and crops based on both yield and sales numbers, and found that record keeping helps the team come to agreement based on the real costs and profits, and not just based on intuition or emotions.

The burden of reporting for food safety (FSMA) and organic certification is a major pain point for the farm but has gotten much better since Olga came onto the team to work on record keeping. They are interested in software that would ease reporting burdens. With nine employees plus family members and over 14 plots across 28 acres, it is difficult to track not only basic business records such as sales and employment records, but they also need to maintain records required by their third party certifiers for organic and food safety.

"Connecting with our local community has been giving us the opportunity to share our practices and give them that hands-on experience in farming."

- Javier Cruz

Digital Technology

There is a general hesitancy toward adopting digital technology with monthly subscription costs, especially because of limited internet service making it impractical to use these services from the field. Turning data digital also turns over a certain amount of oversight to the system and places a lot of trust in the digital system and who has, or will have access to the information.

Ideally, they would also use iPads and digital record keeping for employee payroll and tasks but the internet would need to be reliable and there are also concerns with data privacy, employee safety, and creating digital records in general.

Cruz Martinez Farm will make investments if they know it will work and be reliable. Currently they drive back and forth on the farm to use the internet and the addition of the solar cooler is making them reconsider internet use and access on the property. If the internet signal was fast and reliable, and data privacy concerns were minimized, they would love to use digital tools for mapping, crop rotation planning across fields, and tracking crop productivity.

Conclusion

Javier's business acumen is obvious as he successfully grows his family farm into the second generation. His positive view of "good, sustainable technology" has led to promising results of business gains that are also good for the environment with the adoption of new technology such as the Solar Fresco cooler and the planned improvements to irrigation infrastructure. Cruz has identified that a new investment needs to deliver higher returns. Through support of non-profits such as Kitchen Table Advisors, Cruz received helpful business advice, sales strategy (determining that farmers markets and farm stands wouldn't be as profitable for the time being due to labor) and advice on operating loans to take his business to the next level. Cruz also demonstrates the value of giving back and showcasing a collaborative spirit. He shares a quarter acre with an employee for them to grow their own food in their free time, which provides for their family and provides extra income from sales. He seeks to uplift other farmers so he can give back what has been offered to them. He knows the issues of cold storage for farmers in his region and wants to share how much it has helped him so that the community can grow together.

Case Study

Hahn Farm

Appendix I: Hahn Farm (Case Study 2)

Farm: Hahn Farm

Year Established: 2012

Location: Hanford, CA (Fresno County)

Type: Jujube orchard

Size: 40 acres

The listed tools below are not an exhaustive list but a highlighted list to help highlight what technology is currently available, working well and where there are gaps. All farms, including the Hahn Farm, rely on dozens of different tools and hired out services for their annual production needs.

Favored Technology:

EV UTV Ranger for pulling vineyard trailers, checking irrigation, pulling the spray tank trailer for weed control, and carrying pruning equipment through the rows, among other jobs. It lasts for an entire day on a single charge.

Mechanization of laborious tasks that are hard on the body such as hiring company with a Flory Track Shredder, weed control with their bush hog and weed whacker

Cell phone for recording tasks, receipts, voice memos.

Farm Innovations:

Off grid well pump. There was no electricity available near the new well site, so Nick Hahn built a propane-powered engine to run the pump “off-grid.”

For preparing the irrigation furrows, Nick built a specialized tool bar with a shovel at each end to make furrows at the correct spacing on either side of the trees.

Technology Needs and Gaps:

Irrigation automation to save time and money (physical time managing current irrigation system, SGMA reporting, water & electricity use)

Theft prevention technology that meets the needs of their particular site

Replace bush hog type mower with flail mower of correct width once drip is installed. Currently uses weed whacker for inside of furrows, along berms, around the base of trees but it is hard on the back.

Having capacity to install cold storage and increase duration for sales (confirm with Nick)

Adopting digital software to better track cost of goods sold, profit margins, marketing, and online sales for direct-to-consumer to increase profit margin

Quicker access & turnaround time for publicly funded programs, i.e., tractor program from the CA Air Resources Board & how their program is managed

Technology that supports better deterrence or management of pest pressure.

Most damaging pest are gophers and they use a company to gas them. For birds- they are considering a cannon but trying to find something the neighbors won't mind

Access to quality inputs, i.e., root stock

Introduction:

We met Manyla and Nick Hahn on a blustery spring morning at their jujube orchard in Fresno county. It looks like many other small and medium sized farms in California's Central San Joaquin Valley: flat and dusty, surrounded by almond orchards and vineyards, and with a small farmyard packed with equipment and tools spanning the past seven decades. A shop and a pole barn house some smaller tools on one side of the farmyard, and on the other is an older farmhouse near the corner of the property. The remainder of the property is split between young jujube trees in neat rows, and a fallow area being prepared for planting. An open irrigation ditch runs across the middle of the property in a wavy line, separating the planted orchard from the fallow field.

Just as we are getting started with a tour and some interview questions about tools and technology on their farm, Manyla gets a call. Manyla and Nick exchange disappointed glances as she tells us she'll have to miss the interview to pick up their youngest child from school. The family lives in Hanford, about 35 minutes away from the farm, a fact that impacts the functioning of the farm, particularly when it comes time to irrigate and regarding theft.

Throughout our conversation Nick points out areas of their farming business that are Manyla's expertise and where she would be better able to answer our questions. Manyla came to the United States as a young child from a refugee camp in Thailand, where she was born after her family escaped the Khmer Rouge genocide in Cambodia. Manyla holds a bachelor's degree in business management and information systems and an MBA from Fresno State, so the business and digital technology aspects are primarily managed by her. Nick previously worked in government, but left the stress and bureaucracy of that position to start farming in 2012. Since then, he has avoided computer work as much as possible.

Themes:

Themes from the Hahn Farm interview, that have also come up in other farmer input, include 1) the burden of reporting and paperwork related to SGMA and grants or government assistance programs; 2) the financial, emotional, and physical work related to recovering from theft and preventing theft on the farm; 3) the difficulty of living off-farm and commuting especially in regards to irrigation (which goes around the clock), and theft; 4) farming is a chosen profession partially for the possibility of not having to use digital technology or computers most of the time.

The farm:

The farmland is 40 acres of flat sandy loam soils that tend to be very sandy and powdery. When Nick started farming it in 2012, it was planted in Thompson Seedless grapes for raisins, a crop that was typical of the area through the early 2000's, and many nearby properties are still in vineyards. However, Nick and Manyla decided to move away from raisins because the price has plateaued since the 1990's while the drought reduced productivity, increased pest pressure, and the cost of labor has more than doubled from $8/hr to $16/hr and their proportion of budget.

Since then, they have been gradually planting the jujube orchard, with blocks planted in 2022, 2023, and 2024, covering about a third of the 40 acres, all on the south side of the irrigation ditch. They plan to plant the remainder in jujubes this coming winter, but that will require irrigation infrastructure since there is currently no way to get water to crops on the north side of the ditch.

Irrigation:

Hahn Farm's jujube orchard is in Consolidated Irrigation District and has access to water via the ditch. There are also two agricultural wells on the property, one newly drilled, and an older one that had to be recently abandoned when a piece of the pumping mechanism broke off and became lodged across the bottom of the casing, preventing repair. For the new well, there was no electricity available near the well site, so Nick built a propane powered engine to run the pump "off-grid." The propane engine produces 30 hp and 10 gallons/hour but they are now installing electrical service for the pump. The new well is 380 feet deep and cost about $35,000 to drill.

The current irrigation system uses furrows on either side of trees to flood-irrigate approximately every two weeks during the growing season. Nick creates the furrows with an equipment bar with two plow shanks attached that he made to fit the tree spacing. He pulls this with a John Deere 509SM tractor, which is dedicated just to furrowing. Water from standpipe to furrows: the well discharges into a standpipe that is about 7-8' tall. From the standpipe the field is connected to a network of concrete pipelines with some sections of the line being 40+ years old to about 70 years old. The concrete line is constantly generating leaks requiring repairs. The concrete line is laid out so that the line is right under the edge of tree rows and a concrete riser and valve feeds water at the end of each row (only one end of each row not both). Water from the ditch feeds into the same concrete line that is connected to the standpipe. Water enters the concrete line at the edge of the ditch from a gate (sometimes called head gate-big metal valve capping the concrete line at the ditch inlet). The ditch water flows into their concrete irrigation line and feeds though gravity feed, with no pumping siphoning etc.

However, for the trees that will be planted on the other side of the irrigation ditch, and in order to reduce the labor time required to make sure water gets to the end of each furrow, Nick and Manyla plan to install a drip irrigation system with automation. The time savings and remote operation potential are important to them because they live an hour round trip commute from the farm, making checking irrigation a very cumbersome task that interferes with sleep, family time, and the like. Based on past experience with irrigating grapes, Nick believes that drip irrigation will save 75 percent of the time spent on irrigation. He estimates that the cost will be $40,000 for an irrigation automation system with drip, sensors, filters, booster pump, remote controls, and data tracking for SGMA reporting.

Jujubes:

Jujube trees are grafted on wild jujube rootstock planted at 18 foot center to center spacing. They require pruning for shaping, keeping open structure, and topping. Cutting off rootstock suckers and taking off last year's fruit shoots if they don't fall off on their own (like they are supposed to) is necessary. The primary pests affecting the orchard are gophers which damage the tree root systems and cause irrigation leaks and problems with the furrows. Nick said the biggest problem with jujubes has been getting bad stock from a nursery, so he will be going with a different nursery this next planting. The GA866 variety seems to have a skin prone to damage much easier than the Li variety which is the other main commercially grown cultivar. The GA866 needs gas to brown much more than the Li to reach the sugar level of maturity. Outside of cold storage this variety doesn't have a very long shelf life before losing firmness and freshness.

Jujube fruit has a relatively thick skin which means they are not extremely fragile, but are still susceptible to spoilage. Nick and his family harvest themselves and usually bring in a couple of temporary workers for part of the harvest season. Harvesting is done by hand with a picking bucket, and culling is done in the field when transferring to boxes. The filled boxes are put onto vineyard trailers, weighed and sold to wholesalers. The flowering period is long (~2 months) so the harvest and ripening period is also long. Jujubes are harvested in intervals to pick when ripe, but some loss is inevitable. By the end of the harvest season, Nick often lets a packing-house bring in their own labor and take all the rest of the fruit for a fixed price. They sell a very small amount of their crop direct to consumers, but would like to have online sales set up for the future in order to capture more profit. The trees are currently small and producing a smaller crop, but production will be increasing over the next few years as the trees reach maturity, so both the labor for harvesting and the benefit of direct sales will be increasing.

Equipment:

Like many farms, the impression upon arriving at the farmyard is of a lot of equipment and tools! Some of this equipment came with the property, some Nick already had, some has been purchased, and some belongs to friends who were having theft problems so stored it at Hahn Farms while away to minimize risk. In addition, the shop building and the pole barn structure were burglarized and around 30k in tools were taken, with insurance not covering most of the loss. As a result of the burglary and efforts to secure tools and equipment, the area in the shop and pole barn are now in disarray, much to Nick's dismay. However, making time to organize those areas is a priority because they would like to install a cold storage unit in the pole barn area to allow them to have more flexibility with jujube harvest and sales, and it is also a real challenge since Nick and Manyla are behind on other time-sensitive farm tasks.

The equipment used on the farm varies from basic hand tools, to tractors, to digital technology. Beginning with winter pruning, Nick uses pruning shears to shape the young trees and keep the canopy open and easy to harvest. He hires a company to shred branches with a Flory track shredder. This saves the need to haul branches or arrange them for pushing or shredding, it also causes less soil compaction than other methods of brush removal because of the tracks instead of wheels, and it produces better mulch size and distribution. The company he uses for shredding requires a $1000 minimum price for the job, which Nick feels is worthwhile for the time and savings to his bad back. The next orchard maintenance task is keeping the weeds down in the rows, in the irrigation furrows, and between the trees. For this Nick uses a weed wacker and a bush hog mower. The brush hog mower is pulled by a dedicated orchard tractor. Once drip irrigation has been installed, he will purchase a flail mower of the correct width for his rows, which will save time and extra passes with the brush hog mower which is not the ideal implement for the job. He has also done some work to his mechanical weed tiller and put it into action helping with berm weed management.

For preparing the irrigation furrows, Nick built a specialized tool bar with a shovel at each end to make furrows at the correct spacing on either side of the trees. He pulls this with a different dedicated tractor. Other irrigation equipment used is the propane pump which he built himself to operate his off-grid well. There are long boards for propping branches as the fruit weighs down the branches before harvest, and for harvest, there are the picking baskets, boxes, vineyard trailers, and scale. The UTV Ranger EV side-by-side is the most useful piece of equipment and is used for pulling vineyard trailers, checking irrigation, pulling the spray tank trailer for weed control, and carrying pruning equipment through the rows, among other jobs. It lasts for all day use or more on a single full charge.

Equipment wishlist:

Nick would like to trade in one of his older not very comfortable or clean tractors for a good orchard tractor with a factory installed cab, but the California Air Resources Board Program takes too long, with perhaps a two year or more backlog and high staff turnover making it difficult to get his application through the program. As of September 2025, Nick got the tractor replacement grant approved and is looking to purchase a tractor in the coming weeks.

A picker platform would be helpful.

The ability to borrow/lease a side-arm mower with string trimmer for mowing on berms around trees, and cutting suckers; would use 1/mo during growing season. This would be especially useful for organic orchards.

Once more time and capacity is acquired, they plan to install an affordable cold storage unit. They just need to make space for it and set up power infrastructure.

Looking to the future, perhaps a robot could be trained to prune trees.

Digital technology:

There is no internet on the farm but the cell signal is good. Nick uses his phone to track a majority of their farm tasks; texting to self, tracking farm tasks via a calendar app, taking photos of bills/receipts and adding to an album app. Occasionally a paper receipt book is used for invoicing but deposits paid and balances carried become difficult to track.

They see digital technology as being useful for automating irrigation, tracking and reporting, and monitoring for theft. They have experimented with security cameras to deter theft but ultimately found that the system didn't work well enough to justify the subscription costs. They found a product that relied on a cellular network, solar charged, and motion triggered. But it didn't film for long enough, didn't sufficiently charge, and changing out or recharging the batteries was difficult to do since they were mounted and hard to access (to prevent tampering).

Automating irrigation will save time, likely decrease water and electricity usage, and support the tracking and reporting requirements of the Sustainable Groundwater Management Act (SGMA) that their regional water district has agreed to. But it is an investment to shift from their furrow system to one of microirrigation with sensors, remote values, and data tracking.

Nick would like to know what is available to better track his sales and profit margins. He shared that it would be nice to text with buyers (wholesale and retail) invoices or receipt for order including number of boxes sold etc. and track the costs associated with each sale. Currently he keeps a note in their phone on how much they paid pickers for the order, expense of boxes, etc. Sometimes the picking labor gets paid directly from the wholesaler, sometimes Nick negotiates and provides their own boxes for fruit. It would be helpful to have the ability to track the amount received per box or per pound to better analyze profit margin, and to track cycles in price paid throughout harvest season since it varies greatly.

Eventually, they would like to look into digital sales platforms to increase their profit margins by connecting with customers directly. Nick would prefer to be out in the field vs behind a computer desk but this is an activity that Manyla may be able to pursue.

Case Study
GT Florists

Appendix J: GT Florists (Case Study 3)

The Thaoxaochay family is a multi-generational family with farming roots that go back generations. Having farmed in the Central Valley for over forty years, their story mirrors that of many immigrant families who came to California in the 20th century in search of opportunity. The following description of the family's farm is based on a series of conversations with Lilian, one of the "younger generation" of the family, who also has off-farm employment.

Year Established: 1990s (land purchase)

Location: South of Fresno, CA (Fresno County)

Type: Mixed vegetables, semi-permanent crops (guava, jujube, dragonfruit)

Size: 20 acres (18 farmed, 2 residential)

Favored Technology:

Irrigation:

Lilian's family has adopted a variable frequency drive (VFD) pump system and a flow meter through a SWEEP grant (2021), which reduced water and material use. They use both flood (50%) and drip irrigation (50%) with fertigation. Crop diversity and learning curve has constrained full VFD optimization, due to low risk tolerance.

Manual tools and labor:

Most planting and harvesting are done by hand.

Planting is done mostly by hand due to higher precision, along with push seeders and seeder implements. Specialized triangular Southeast Asian digging tools remain essential for weed management.

Harvesting of jujubes is especially labor-intensive due to staggered ripening and fragility of fruit, making mechanization impractical.

Cold storage:

A small-scale conventional refrigeration room - converted and insulated shipping container - has been vital for leafy greens and sensitive crops in the heat of Fresno summers. However its condenser needs to be repaired every so often due to failures. It also requires constant energy in summer months to keep operating.

Farm Innovations:

Experimenting with biosolarization for weed control, reducing tillage, and trying out different pruning methods on young jujube trees.

Her father was a general contractor, has a background in engineering and mechanics and manages their farm equipment including adapting existing tools. Examples include building specialized scaffolding to self-install hoop houses that are funded by the EQUIP grant. Other farms have contracted him out to install their houses and offering that service to the community has helped the farm financially.

Her father's ingenuity in modifying farm equipment and leveraging CARB tractor exchange programs (Agricultural Tractor Replacement Program) illustrates the family's reliance on adaptable, low-cost innovation. Some examples of modified farm equipment include a multi-functional tractor attachment which is a 36 inch bed leveler, with an added frame and compost level to raise level instead of using front loader for ½ ton of compost. It also serves as a compost spreader to plant cover crop seed.

Technology Needs and Gaps:

Jujube pitter would be helpful for adding value-added production and is currently being researched by UC extension.

Desired future tech:

- Bed shaper, drip tape mulcher, and small-scale seeders.
- Solar power for both the agricultural pump and residential storage container (within 2 years).
- Automation for value-added potential or labor saving tasks (i.e., mechanical jujube pitting to expand into processed products).

Theft issues led to costly pump enclosures. Lack of fencing and theft, particularly copper wire from irrigation pumps, has created financial and operational stress. Dealing with insurance and the sheriffs is too troublesome, so theft issues are underreported. Reported cases have not resulted in return or restitution of lost items - including crops stolen from the farm.

Frustration with digital sensors like the Watermark soil moisture sensors on jujube orchards due to lack of crop-specific reference data, data is hard to extract and interpret, "obscure" software is overall inflexible and difficult to use.

Background

Lilian Thaoxaochay is a seventh generation farmer. Her family has been living in the valley since the 1980s. They have been actively farming since this migration. During European colonization of Southeast Asia, her grandfather, being the oldest son, was expected to stay home to take care of the family homestead and make sure the family had enough food versus participate in the French colonial school system as his siblings did. He made sure to send all of his children to school. When the family was displaced and came to the United States, they did not expect to stay in farming. Once refugee benefits expired, the family had to assess what skills they could offer the economy and decided to get back into farming. Hmong women always cultivated herbs and medicinal plants to support postpartum health. Some of these herbs are included in everyday food dishes–and that part of their culture remained active even if the family was living in more urban landscapes, including in apartments with little land. Hmong farmers saw farming opportunities in California and many moved over in the 1980's with the dream to make a living off of their farming knowledge and skill sets. Her parents started farming strawberries because that is what everyone else was doing, then they branched out to daikon radishes, peppers, and experimented with other crops. Their pioneering spirit and ingenuity led them to grow wholesale habaneros at a time when no one was familiar with the commodity and didn't see any feasibility with the crop because of its high cost of labor. They were always community pioneers and were a part of a Hmong co-op in the 1990s. The farm remains a "a very full family operation" which is unusual because most succeeding generations aren't interested in taking over such a difficult task once they find full-time, off-farm work. All of her siblings have bachelors degrees, with three of the children having received advanced degrees beyond college.

GT Florists is a family-operated 20-acre farm located just south of Fresno city limits. Strong community and marketing acumen built since the 1990s is critical to the business.

The farm cultivates semi-permanent specialty crops (guava, jujube, dragonfruit) alongside mixed vegetables and smaller selection of herbs and cut flowers. Over the decades, the surrounding agricultural landscape has shifted from alfalfa to diversified row and specialty crops, reflecting broader changes in Fresno County agriculture.

Walking across the property, every few feet (1-10 rows) are planted with different vegetables, making tool reuse difficult as each crop may require a different planting, management, and/or harvesting method.

The farm sits just one or two blocks outside internet and cable access, relying on satellite internet and strong Verizon cellular service.

Farmers

Multigenerational, fully family-run operation: Lilian co-manages planning, decisions, grants. Her parents—who own the land—bring decades of experience and handle daily farming tasks with a preference for hands-on, manual labor. Her father is especially skilled at grafting, having expanded the jujube orchard from a handful of experimental trees into over five acres of production.

Primarily family labor. No standing outside crew; occasional piecemeal hires for prep/cleanup or when timing/travel requires it. Family collaboration spreads tasks (equipment, records, compliance), but that also disperses critical information across people.

The family has learned to question practices done on other farms before adopting and to lean on the expertise of UC Extension researchers. Their family is fortunate in that the uncle made an early relationship with their staff and Lilian was able to join the UC team as an employee and helped connect the farm to additional resources.

Themes

1. Digital Hesitancy: Parents' resistance to formal digital recordkeeping means that planning and data tracking happen informally and reactively. During the COVID-19 pandemic, due to concerns around handling money, there was a successful transition to digital payments on top of taking cash payments.
2. Low-cost Innovation: Creativity and adaptation (jerryrigged equipment, tractor exchange, manual tools) sustain the farm. Parents rely on applied knowledge, while younger co-managers seek tools tied to grants or direct efficiency gains. At the same time, limited internet, outdated storage, and theft issues highlight vulnerabilities to adopt technology.
3. Market Access: The farm was established three decades ago and consolidated in the community, and therefore there hasn't been a shortage of buyers in the past years. They sell 60% of produce at Fresno farmers markets and 40% wholesale, while jujubes are split evenly between wholesale and direct farm sales. Community customers often purchase 4–5 cases directly from the farm. The demand for jujubes is more than what the farm can produce. Bitter melon and other Asian vegetables remain consistently marketable and price-stable.
4. Climate Pressure: More intense summer heat is undermining summer crop viability, pushing reliance on jujubes and other resilient crops or focusing on more high-value crops. Shifting crop choices and declining summer crop performance highlight the urgency for adaptive tools and practices.
5. Adoption is generational: Generally, the older generation is more hesitant to adopting new tools than the younger generation. "Mechanical planters don't do it the right way, not firm enough, not straight enough."

Irrigation, weed management and fertilization

They are in the process of fully adopting a variable frequency drive (VFD) pump system and a flow meter through a SWEEP grant (2021), which reduced water and material use. Flood irrigation covers half the fields, while drip lines with risers and a VFD-supported pump cover the rest. Fertigation is done with liquid UAN32. The family still needs to run trials to identify what is the best setting of the VFD system to operate at for their production needs. The family has the skill-set to figure it out (with numerous family members having engineering degrees and mechanical skills) but it is a puzzle to identify when to do this when you have one shot at your production window. Also, with so many different crops being grown - full automation of irrigation may not truly save time.

While efficient, weed management remains labor-intensive, relying primarily on manual hoeing, with occasional pre-emergent backpack spraying. Experiments with biosolarization are underway.

Light fertilizer spreadings in spring and fall. Composting was adopted through a Healthy Soils Program project (2020–2022) funded by the CDFA.

Infrastructure

Includes a small hoop house, an aging but functioning cold storage unit, multiple tractors through a tractor exchange program, and ATVs. The family employs tractors for field prep but prefers precision by hand.

- **Cold Storage:** A small converted half-container refrigeration unit extends shelf life but requires expensive condenser repairs.
- **Solar Plans:** Pending installation for the pump and residential storage container.
- **Connectivity:** Satellite internet and good cellular service support basic digital tasks but limit advanced software use.
- **Equipment:** The farm runs six tractors (three large, three small), ATVs (including one UTV via an Air Pollution District replacement program), and modified tools. Some tractor implements include a seeder, chipper and shredder.
- **Hoop house:** The 20 ft clearance restricts use of bigger equipment and its equipment storage capacity. Only 3 of the 6 tractors fit in it.
- **Security:** Copper theft at the pump drove enclosure investment; underreporting due to insurance/law-enforcement friction.

Farmer Innovation

- Triangular long-handle hoe (imported): replaceable shovel-style handle; durable steel; holds an edge; ~3" working face doubles as a consistent spacing/measurement tool; agile corners for weeding/planting. Is very sturdy and durable and needs less sharpening.

- 36" bed leveler fabricated in-house.
- Frame-mounted compost level "raiser" to meter ~½-ton applications without front-loader cycling.
- Compost/cover-crop spreader adapted for multi-use seeding.
- Custom scaffolding + hydraulic-lift rig for hoop-house builds (evolved from ladder-on-van to safer tractor-mounted platform); occasionally installs houses for EQIP recipients.
- The family is able to repair and adjust their discs

Specialty Crop: Jujubes

Jujube cultivation has become a reliable cash crop, it is GA866 variety and its sales cover the down season of the farm. Three acres of jujubes that are 8 years old today, and 2.5 acres that are one-year old. Dad is very skilled at grafting trees.

Experimenting on a farm is a constant practice. Pruning research is non-existent for jujubes so they continue to run trials to identify what works.

Harvesting remains labor-intensive and hand-based due to the fruit's delicate nature, but returns justify the cost. Post-harvest sorting is done manually by size, color, and quality. Pruning strategies remain experimental as orchards mature, with both mechanical topping and hand-pruning employed.

Record Keeping & Reporting Requirements:

Farmers have historically used UC Cooperative Extension for new and/or unfamiliar paperwork; now mostly self-served after routines are established. Registered as a Certified Producer with the county; not organic-certified due to yield tradeoffs and compliance burden. Enrolled in the Irrigated Lands Regulatory Program (ILRP); periodic participation in NRCS EQIP and FSA programs. Similar to other farms in the region, the family does not use surface water although they still retain water rights and are aware of the linking infrastructure.

The farm keeps files for NRCS and FSA programs, and Irrigated Lands Regulatory Program enrollment. The cumulative nature of regulations—water quality reporting, worker safety, well registrations—feels heavier than any single program on its own. Cooperative Extension remains an important resource to interpret notices and deadlines, but what the family wants most is clarity and for regulatory paperwork burden to stop compounding; it's not one single entity, it's all of them combined, and some have different standards (i.e., a family member doesn't need to be listed as an employee with one agency but it does with another).

Parents' resistance to formal digital recordkeeping means that planning and data tracking happen late or informally. Sales and income are tracked through Excel, but operational data—like rotations, inputs, or soil salinity responses—remain undocumented.

Lilian expressed frustration at her parents' refusal to map the farm despite salinity pressures requiring rotations. The only metrics tracked are jujube yields and sales.

Regulatory paperwork has compounded over the last five to six years with the Sustainable Groundwater Management Act, food safety, worker compliance, etc. Climate uncertainty is also an increased concern at the same time. Accurate yields and planning would be critical for some federal safety net programs (i.e. crop insurance). Keeping paperwork in-check and communicated across key stakeholders has led to frustration for the family. These developments are also not encouraging for new farmers and family members to take over the family farm - an office job seems much more reliable and less variable.

Digital Technology

Software has been rarely adopted due to the lack of information on their crops; tools without reference data (i.e., for jujubes) are perceived as useless by everyone at the farm. Experiential knowledge has been the driving force behind the farm.

Digital marketing adoption is limited but marketing hasn't been an issue for the farm since they have really strong business relationships in the community and can't produce enough to meet demand. There is some social media marketing handled by younger family members. Venmo and Zelle payments were adopted during Covid.

Concerns around digital tools include cost, inflexibility, lack of exposure, and data privacy. They prefer practical tools that ease decision-making, not systems that create new administrative burdens.

They have learned about a few e-commerce options but the crop variety at the farm makes the adoption of these platforms too complex.

Conclusion

GT Florists illustrates the balance many small-scale, multigenerational farms in the San Joaquin Valley must strike: adapting just enough technology to stay efficient and competitive, while holding firmly to practices that are familiar, low-cost, low-risk, and proven reliable.

The family has integrated selective upgrades like a VFD pump, cold storage, and digital payments, but continues to rely on hand tools, ingenuity, and family labor to keep operations viable. Digital recordkeeping, advanced sensors, and scalable mechanization remain out of reach—either due to cost of purchase and maintenance, lack of trust, or cultural preference.

Their story highlights key themes central to the broader needs assessment: the limits of digital tools when they lack flexibility or crop-specific relevance; the weight of cumulative regulatory requirements on family-run operations; and the critical role of farmer-built innovations in bridging resource gaps. Jujubes, once an experiment, now anchor the farm's resilience.

Lilian's vision for the future includes solar adoption, better seeders, and adaptable tools—but always within the scale and philosophy of a family farm that values flexibility, resilience, and community trust.

The family plans to adopt solar within the next 2 years, but is otherwise unlikely to introduce new technologies within the next five years.

With the family farm's level of education, seven generations of farming knowledge, and specialized skills, they demonstrate how difficult it can still be to adopt new technology. Adopting new technologies always comes with some level of risk. Each farm has unique needs with many variables layered into their farming operation. Even with a full understanding of mechanical concepts, understanding the mechanics of your operation, and clear directions on how to use your new equipment - adding a new piece of equipment still comes with a learning curve, takes time and production space, and likely will need some customization. The production season happens once and it needs to happen right. The technology that can support the most is often the technology that holds the most risk, such as making a change to your irrigation system or farming schedule. While that change isn't necessarily a bad thing, it takes time to assimilate and adapt, and the risk may fuel hesitancy.

"You only get one shot at the season, and you can't afford to have it be a total failure."

- Lilian Thaoxaochay, GT Florists.

Appendix K: Organizations Supporting Small-Scale Farmers in the San Joaquin Valley

Organizations supporting Small-scale Farmers in the San Joaquin Valley (non-exhaustive list with focus on regional and statewide groups)

Organization / Network	Focus Area	Type of support	Regions served
Community Alliance with Family Farmers (CAFF)	Technology access, direct marketing	Technical assistance, policy advocacy, farmer education	Statewide
UC ANR Small Farms Network	Food safety, soil health, irrigation,production efficiency	Research, extension, bilingual training, and resource development	Central Valley, Central Coast, Southern California
Resource Conservation Districts (RCDs)	Climate resilience, agroecology	Technical assistance and resource development	Statewide, with active districts in most counties
CA FarmLink	Business planning, capital access	Financial education, loans and land access programs	Statewide but most active in Central Coast, San Joaquin Valley
Kitchen Table Advisors	Business planning and business management	Business education	Central Coast, San Joaquin Valley
Allensworth Progressive Association	Business development	Social impact	Allensworth
Community Colleges	Access to higher education	Education	Statewide
Punjabi Farmers / Farmer Coalitions	Farm viability	Community building, peer-to-peer learning	San Joaquin Valley
Office of Kat Taylor	Agricultural Platform Collective	Market access, technical support, financial support	Statewide
Fresno BIPOC produce	Farm viability	Access to aggregated sales	San Joaquin Valley
SBA offices	Business development	Workshops, mentorship, resources	Statewide offices
Farm Bureau Offices	Advocacy, general support	Regional issues and resources.	Statewide offices
USDA offices	Federal programs	FSA paperwork, loan programs, etc	Statewide offices
Ag Commissioner	Regulations	Inspections for pesticide use, certified farmers markets, etc.	Statewide offices
NCAT	Appropriate agriculture technology	Technical support, resources, hotline, etc.	Statewide offices
Certified farmers market managers	Market access	Connect farmers to additional resources	Statewide
PAN Valley Institute	Cultural Institute	Provides community and resources to immigrants and refugees, many of whom are farmers	Fresno

Appendix L: Summary of Landscape Review Part I and Part II

Summary of Key Findings of the CAFF Landscape Review Part I and Part II (also available on the CAFF blog).[18]

- Landscape Review Part 1 (Domestic/Regional): Survey of tools currently available or in use among small-scale farms in the San Joaquin Valley.
- Landscape Review Part 2 (International): Survey of innovative tools and technologies used by small farms internationally that could be useful in the context of small farms in the San Joaquin Valley.

Together, these reviews catalogued more than 60 technologies including irrigation, cold storage, field preparation, planting, weeding, pest management, post-harvest handling, farm management, security, and supporting digital infrastructure. The reviews examined technology features, costs, training requirements, accessibility (language, connectivity, technical support), and evidence of impact. This synthesis highlights the most relevant patterns and lessons for small-scale farms in the San Joaquin Valley.

Key Findings:

1. Irrigation and Water Management Tools

International context: In water-scarce regions such as Israel, India, and parts of Sub-Saharan Africa, sensor-based irrigation and remote monitoring systems are used on small farms to optimize water use. Low-cost soil moisture sensors and solar-powered drip systems have shown significant water savings and yield gains when paired with farmer training.

Local context: In California, commercial systems such as WiseConn, Jain Logic, Netafim GrowSphere, and IrriWatch are used on larger operations. These systems integrate soil moisture sensors, weather data, and automated valve control. While highly effective, they are rarely adopted by small farms due to high upfront costs, subscription fees, and steep learning curves. Farms who do adopt, often juggle multiple standalone systems for managing daily operations, and the cognitive load becomes overwhelming with so many disconnected tools and apps.

2. Cold Storage and Post-Harvest Handling

International context: In regions such as East Africa, India, and Southeast Asia, solar-powered cold rooms, mobile refrigerated trailers, and evaporative cooling chambers are used to reduce post-harvest losses among small-scale farmers. Cooperative ownership and rental models are common to reduce costs. Decentralizing these tools in the production chain leads to greater autonomy for small farmers, allowing them more control over sales outlets and pricing.

Local context: California has piloted mobile cooling trailers and shared cold storage hubs (i.e., through nonprofit-led aggregation centers), but most small farms still lack reliable access to affordable cooling. Energy costs and permitting challenges have proven to be barriers. Solar or mobile cold storage can significantly extend shelf life and increase market access for small farms, but cost, ownership models, and maintenance support need to be addressed. It is worth pointing out that insecure land tenure, specifically not owning the land, is a barrier here because it is impractical to make expensive infrastructure investments without assurance of reaping the benefits for years to come. Additionally, the available pilot programs, grants, and loans for cold storage often stipulate ownership as a criterion of participation, for the same reasons.

3. Farm Management and Compliance Tools

International context: Small farm-focused digital platforms (i.e., Farmforce, AgroStar) support crop planning, recordkeeping, and compliance tracking via mobile apps. These often include local language support and embedded advisory services.

[18] Siemens et al., "Landscape Review Part 1 (Domestic/Regional)."

Local context: Platforms such as LiteFarm, Tend, Farmbrite, Good Agriculture, and Croptracker are available in the U.S. and are used by some diversified farms. They can support compliance documentation (food safety, organic certification) and planning, but require reliable internet access and digital literacy, plus an initial investment of time for set-up that can be very daunting for a small operation that has limited human resources. Many are only available in English and carry subscription costs. Digital farm management tools have great potential to reduce administrative burdens, but language access, affordability, and data privacy concerns must be addressed for broad adoption by small farms.

4. Training Resources, Community Building, and the Digital Gap

International context: Small acreage farmers aboard have access to town centers and markets keeping them engaged with their local community on a regular basis.

Local Context: Research institutions, Extension offices, government entities and non-profits provide helpful guidance and research related to small farm production but accessing this information looks different in many communities. Some communities access digital records, while others lean on peer-to-peer networks, radio coverage, publications, etc. Overall, farms are accessing information but it is difficult to track which technical support advisors are providing what resources at what time when dozens of different groups and technology companies are working with farmers on similar issues.

5. Theft Prevention and Security Tools

International context: Small-scale farmers in parts of Africa and Latin America have adopted low-cost security technologies such as solar motion cameras, GPS trackers, and smart locks to protect equipment and crops, often supported by cooperative patrol networks.

Local context: Agricultural theft in the San Joaquin Valley is increasing[19], and was evidenced in the farm case studies and farmer feedback for this report. Limited broadband on many small farms impedes the adoption of security tools that require internet access, and offline security tools tend to be more burdensome and less effective. Use of security technology on California small farms is still limited, though interest is rising. Some farmers have adopted solar trail cameras and GPS trackers informally. Limited secure and permanent storage facilities, connexes, and private driveways on small farms make basic security measures a challenge. However, affordable security tools exist and could reduce losses, but awareness, coordination and technical support for these tools are requisite to farmer adoption.

In conclusion, the landscape reviews show that a wide range of effective agricultural technologies are available globally and domestically, and many have demonstrated success on small farms. However, adoption among small farms in the San Joaquin Valley remains low due to structural barriers. These insights informed the gap analysis and the prioritization of needs and opportunities presented in the following sections of this report.

Farmer Needs and Barriers

Key Findings:

- The most persistent barrier to technology adoption on small farms is finding tools that are both appropriate in scale and financially viable.
- Diversified farms and specialized farms have distinct technology needs, shaped by crop diversity, field layouts, and frequency of tool use.
- Farmers need both “hard” (i.e., equipment, implements, irrigation infrastructure) and “soft” technologies (i.e., software, training, market platforms).

[19] Vives, “California Authorities Say They Broke up Farm Equipment Theft Ring”; Isaiah Garrison, “Economic Fallout of Farm Theft Reaches Far Beyond the Field,” Valley Ag Voice, June 30, 2025, https://www.valleyagvoice.com/economic-fallout-of-farm-theft-reaches-far-beyond-the-field/.

This section explores the range of needs farmers have for tools and technologies, as well as the barriers that prevent or slow their adoption. Most of these needs and barriers were articulated by farmers through focus groups, surveys, and interviews. Others were identified by subject matter experts, including technical assistance providers from CAFF’s Tech Hub and the UC Small Farms and Specialty Crops extension program in Fresno and Madera Counties.

Diversified versus Monocrop Farms

Across all farm types, farmers emphasized the importance of appropriate scale and cost-effectiveness: tools must match their production system and be used often enough to justify the investment. This challenge - finding tools that are both suitable and financially viable - is one of the most persistent barriers to technology adoption on small farms. Small farms in the San Joaquin Valley vary widely in scale and production systems, but an important distinction is whether they operate as diversified farms or monocrop farms. This difference strongly shapes their technology needs.

Small monocrop farms, such as citrus or almond operations, can often rely on the same large-scale equipment as bigger farms by contracting custom operators for occasional tasks like harvest or chipping. However, due to their size they may struggle with access and be scheduled last or completely pre-empted due to companies prioritizing larger clients. They may still invest in frequently used machinery such as tractors or mowers, but their uniform crops and field layouts allow them to leverage existing commercial equipment and services. In contrast, diversified farms grow many crops in smaller, irregular plots and often require frequent bed turnover and succession planting. These systems need a wider variety of tools - often smaller, adaptable, or hand-operated - to work efficiently in tighter spaces. Many small farms also produce niche or emerging speciality crops, either as monocrops or within diversified operations. With fewer established practices supported by commercial equipment for these crops, farmers face additional complexity when seeking appropriate tools.

"Smaller farms have always been a challenge to service based on the minimum economics quantity of certain programs. However, we have equipment and logistics solutions that will work for any farm, so long as the grower is interested in participating. Sometimes help from a co-op or extension can make all the difference there."

- Irrigation solution provider with operations in the Central Valley.

"Hard" and "Soft" Technology Needs

Farmers identified needs for both "hard" and "soft" technology.

- Hard technologies include physical equipment and implements such as planters, weeders, tractors, irrigation pumps, sprayers, bed formers, shading methods, and post-harvest cooling units.
- Soft technologies include digital tools and support systems such as farm management software, crop planning tools, bilingual tech guides, ongoing training, online marketing platforms, and irrigation automation programs.

These two kinds of technology can often be used together to create a "smart" system, such as an irrigation system that uses hardware - pumps, filters, lines and emitters - and also uses digital sensors plus software to allow remote operation and monitoring of the irrigation system.

Constant iteration with user feedback, and user training taking place over an extended period of time is required to ensure technology remains useful. Both training and maintenance are key variables for the successful adoption of any type of technology and including this in development budgets is important to make sure farms have continued support with adoption

A sample list of "hard" and "soft" tools that farmers were interested in using or trialing:

"Soft" Tools and Technologies may include:

- Bi-(or multi-)lingual tech guides/interfaces
- Apps and tools for farm management
- Crop planning, agronomics, reporting
- Automated irrigation monitoring and control systems
- Marketing platforms
- Bee pollination monitoring tech
- Weather forecasting app
- Accounting software

"Hard" Tools and Technologies may include:

- sprayers, electric tractor or robotic tractor
- Soil moisture sensors
- Mower
- Weeder
- Bed former and mulch layer in-one
- Shade cloth

Table 1 (below) summarizes key tech infrastructure needs and barriers to adoption. For more detail on farmer identified technologies, Appendix D provides a comprehensive list of the tools that farmers identified as high priority, and those they would be interested in trialing.

Adoption of technology on small farms is shaped by the fit, cost, and scale of available tools, as well as the training, support, and local knowledge needed to use them effectively. Addressing barriers - such as high costs, limited technical support, and tools designed for larger farms - alongside the development of appropriate hard and soft technologies, is critical to meeting farmers' needs and enabling more widespread, effective adoption of technology that can support small farms to remain viable and successfully address production, marketing, and regulatory challenges.

Table 1: Summary of Farmer Needs and Barriers to Technology Adoption

Farmer Needs	Barriers to Adoption
Affordable, reliable water and irrigation infrastructure, such as smart irrigation systems with integrated soil moisture sensors, and variable frequency drive pumps	High infrastructure costs; water scarcity; complexity of water rights and access (especially regulations such as SGMA and ILRP). Not owning the land.
Knowledge and training on tools and technology	No allocated budget/program and/or uneven outreach; limited peer-to-peer learning opportunities; absence of culturally relevant training
Assurance of cost-effectiveness and benefit	Uncertainty of return on investment; risk of financial losses; steep learning curve
Appropriately scaled and priced implements	Tools sized for industrial farms; high purchase price; limited local suppliers
Post-harvest storage and cooling solutions	High upfront costs; energy requirements; limited technical support for maintenance
Expanded market outlets and better prices	Market concentration; low bargaining power; limited access to digital marketing tools
Regulatory compliance support	Complexity of regulations; language barriers; limited trusted assistance
Permanent infrastructure, such as cold storage & greenhouses	Land access and secure tenure. Lack of affordable land; insecure leases limiting long-term investment in technology or infrastructure.

Appendix M: Technology Adoption Programs

Technology Adoption Programs

Several state and federal programs have played an important role in supporting technology adoption among small farms in the San Joaquin Valley. While these programs can provide critical cost-share funding, farmer experiences show that access, design, and delivery often determine whether the support actually results in successful technology uptake.

State Water Efficiency and Enhancement Program (SWEEP)

Administered by the California Department of Food and Agriculture, SWEEP provides grants for on-farm water efficiency improvements such as pump upgrades, soil moisture sensors, and variable frequency drives (VFDs). These technologies not only reduce water use but also support compliance with the Sustainable Groundwater Management Act (SGMA). While SWEEP enables adoption of advanced irrigation technologies, ongoing technical support and bilingual training are essential for farmers to realize their full benefits. Additionally, the program has an irregular timeline, short application period when it opens, and has become more competitive in their last rounds, with many local farmers claiming the program has become more difficult to participate in because the program scoring criteria gives more points to applications that demonstrate a bigger impact overall instead of impact per acre.

Water Efficiency Technical Assistance (WETA) is a program by the California Department of Food and Agriculture (CDFA) that provides grants to eligible organizations for technical assistance to farmers on water and nutrient management. The program, funded by the 2021 state budget, is designed to help organizations provide on-farm evaluations, pump efficiency testing, and training to improve agricultural water efficiency. The most recent grant solicitation was in 2023, and it is currently closed, but future opportunities will be announced on the CDFA website.

Environmental Quality Incentives Program (EQIP)

Operated by the USDA Natural Resources Conservation Service (NRCS), EQIP offers cost-share funding for conservation practices that include irrigation modernization, infrastructure upgrades, and more. Farmers in the region have used EQIP to access equipment or make system upgrades that would otherwise be unaffordable. However, as noted by several technical assistance providers, EQIP can be difficult for small farmers to navigate because of complex paperwork, lengthy timelines, long reimbursement periods, and limited outreach in languages other than English.

San Joaquin Valley Air Pollution Control District (SJVAPCD) Agricultural Equipment Replacement Program

The SJVAPCD incentive program provides funding to replace older diesel-powered tractors and specialty equipment with cleaner models, including electric or hybrid options. On July 31, 2025, SJVAPCD temporarily suspended the acceptance of new applications for the program due to the significant volume of existing applications currently in the District's funding queue, which far exceeds projected available funding for the foreseeable future.[20] Farmers reported that they have already been waiting years for their applications to be processed, with no estimated date of approval.

Proposition 4: Equipment Sharing Funding

A recent policy change that could benefit small farmers in the San Joaquin Valley region is the provision for equipment sharing in Proposition 4. In November 2024, California voters passed Proposition 4, also known as the Climate Bond, a general obligation bond that will yield $10 billion to fund a variety of programs, including regional equipment sharing libraries.[21] This initiative will be run by CDFA, and it will increase the accessibility of tools and equipment to farmers. It will provide funding for the establishment of regional equipment sharing libraries and make tools available more widely that farmers would otherwise not have access to. Tools that can be easily shared include items that are used only a few times or less each year, and those things that can be used together, such as cold storage, processing equipment, and transportation, to name a few. These programs can build farm resilience by showcasing tools that farmers are not currently using, but which have been utilized by other farmers who can demonstrate their long-term benefits.

Pilot Programs in the San Joaquin Valley

Across the San Joaquin Valley, pilot programs are showing how targeted technology investments can transform small farm operations. One promising area is solar-powered infrastructure, which not only reduces costs and emissions but also strengthens farm resilience against rising energy prices and unreliable grid access.

The Solar Fresco cold storage pilot program, run by California Farmlink, illustrates this potential.[22] By using solar energy to power portable cold storage units, the program has helped small farms increase efficiency, preserve crop quality, and expand their market opportunities.[23] The LEAP Institute, based out of Fresno and Huron, has also been developing solar powered technology and training farmers on its use, including their MegaIntelliTrailer 4.0 which is a solar powered battery that can easily be towed around a farm property. With stronger policy support, such as grants and streamlined permitting for on-farm solar systems, these innovations could scale to benefit many more producers and provide multiple benefits:

- Efficiency gains for labor used in harvest, packing, and delivery
- Improved quality produce leading to higher price point to farm and increased sales
- Surplus off-grid power to use for other farm purposes, such as charging electric battery powered tools, electric vehicles, welders, processing machinery, phones, tablets
- Partnerships with or support of neighboring farms to share cold storage space
- New potential customers such as through a farmstand or to small local businesses that don't have much cold storage space of their own.

[20] San Joaquin Valley Air Pollution Control District, "Tractor Replacement Program | Valley Air District."
[21] Sencan and Cole, "How Prop 4 Will Impact California's Climate and Natural Resources Investments."
[22] California Farmlink, Solar Fresco Program.
[23] California Farmlink, "California Farmlink 2024 Annual Report," 2024.

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