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Technical Assistance Providers Identify Climate Change Adaptation Practices and Barriers to Adoption among California Agricultural Producers

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Abstract: Climate change will challenge California agriculture, requiring producers (i.e., farmers and ranchers) to adopt climate-adaptive management practices to sustain production. Agricultural technical assistance providers (TAPs) play a significant role in supporting producers' efforts to adopt climate-smart management practices. It is therefore important to understand current TAP perceptions of climate change, TAP recommendations for climate adaptation, and the barriers to adopting climate-smart practices. To understand these issues, we held four focus group discussions with small groups of TAPs from across the state and evaluated transcripts from the discussions to identify common themes and concepts. The TAPs that participated in the focus groups understood climate change and its impacts on California agriculture, with climate extremes and water-related issues being the most frequently cited climate-related challenges. Focus group discussions and subsequent evaluation revealed that while TAPs recommend science-backed practices for adapting California agriculture to climate change, producers may not be accepting of some recommendations. Critically, the TAP focus groups cited insufficient monetary support—both for themselves and for producers—and insufficient information and messaging around climate-adaptive practices as key barriers to practice adoption. This improved understanding of the intersection of TAPs' work on climate change and climate adaptation in California agriculture is useful for the development of information and resources that can bridge these identified barriers.

Keywords: agriculture; climate change; climate adaptation; focus groups

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1. Introduction

Favorable climate conditions are important for successful production of food, forage, and fiber. In California, a Mediterranean climate and extensive water conveyance infrastructure have supported the rise of a multibillion-dollar agricultural industry that produces more than 400 commodities over more than 3.8 million hectares of cropland and 5.7 million hectares of range and pasturelands [1,2]. California's agricultural sector supports hundreds of thousands of jobs [3], with hundreds of thousands more jobs (e.g., in food and beverage processing; [4]) reliant on farm and ranch production. Additionally, California is the leading agricultural state in the U.S. and a key global producer of commodities such as nuts and dairy products [5], making the state's agricultural production central to global food supply chains.

However, a changing climate stands to threaten livelihoods and food security. In recent years, California has experienced several climate-related stressors to agricultural production. The multi-year drought of the 2010s, 8–27% of which can be attributed to anthropogenic climate change [6], led to billions in direct revenue losses [7]. Likewise, heat stress in 2015 led to USD 180 million of insurance indemnity claims among pistachio growers (AgRisk Viewer; [8]) and extreme heat events in 2017 lowered avocado production, drastically reduced dairy output, and caused the deaths of thousands of cows [9]. Under climate change, these stressors and others are projected to become more frequent and/or severe, challenging California's agricultural sector [2] and requiring farmers and ranchers to incorporate climate adaptation practices in order to maintain production.

Technical assistance providers (TAPs) are trained professionals from university Cooperative Extension (CE), the USDA National Resources Conservation Service (NRCS), and state Resource Conservation Districts (RCD), along with certified crop advisors, pest control advisors, and agriculture-focused non-profits who collectively play a central role in assisting producers adapt to climate change. TAPs serve as resources for information and guidance on land and water management and agronomic practices and CE is an especially trusted source for climate change information [10,11]. The producer–TAP relationship thus provides an opportunity for the dissemination of climate change information and adaptation-centered guidance.

However, some surveys of TAPs suggest that they lack the ability or confidence to effectively serve as a climate adaptation resource for their clientele. For example, Wiener et al. [12] reported that while USDA field staff nationwide believe it is important for producers to adapt to climate change, they do not feel confident in their technical skill to help producers deal with climate threats. Likewise, Grantham et al. [13] reported that 88% of California CE professionals believe climate change is important to include in their programming but only 43% of CE professionals actually incorporate it into their work. These prior studies indicate that targeted resources are needed to support TAPs in developing climate change programming and advancing climate change adaptation in California agriculture. As a first step towards developing such resources, this study seeks to better understand TAP perceptions of climate change impacts to California agriculture, current TAP-recommended practices for climate adaptation, and the barriers TAPs face in supporting adaptation among California's agricultural producers.

2. Methods

Four focus group sessions, each consisting of $\leq$12 participants and lasting approximately 2 h, were held with agricultural technical assistance providers from across the state. The sessions were held over Zoom and were recorded for later analysis. A purposive sample of professionals from across multiple technical service provider organizations across the state were identified using existing professional networks and master directories of TAP organizations. Participation was solicited via email from individuals affiliated with NRCS, University of California CE, and California RCDs, as well as individuals from non-profit organizations; 29 individuals elected to participate (NRCS n = 6; RCD n = 11; UCCE n = 9; non-profit n = 3). Focus group participants were separated by the types of organizations they work in, so one focus group consisted entirely of NRCS staff, one consisted entirely of RCD staff, etc. Participants were asked open-ended questions in a semi-structured format to allow for open dialogue; each session's questions were subdivided into thematically related segments with accompanying prompts that addressed (1) climate stressors and their impacts, (2) recommended practices for adapting to climate change, and (3) barriers to adaptation (Appendix A). This protocol was determined Exempt by the University of California Davis IRB Administration. Participants granted their informed consent to participate and participant data are kept confidential; a COREQ checklist is provided in Appendix B.

Audio recordings from each focus group were transcribed by NVIVO transcription service and uploaded onto NVIVO 12 for analysis (NVIVO 12 Pro). Transcripts were then examined against the original audio for accuracy. Content analysis [14] was used to condense and summarize raw transcript text from the interviews. A blended approach was used to code the data, applying both deductive and inductive approaches (Table 1).

Deductive coding is a top-down approach in which researchers determine codes prior to data analysis and fit the data into those predefined codes; inductive coding is a bottom-up approach that allows for codes to be developed based on what the researchers uncover through analyzing the data. Here, we used the focus group thematic segments and the specific questions asked of participants during the focus group sessions (Appendix A) to develop high-level deductive codes. We then applied an inductive approach to develop a list of codes through exploration of the data within the deductive codes. For example, the deductive code "Perceived climate disturbances on agriculture" was predetermined and directly relates to a discussion question asked during the first thematic segment of the focus group sessions; the inductive code "Water-related stressors" emerged from our analysis of the data within the deductive "Perceived climate disturbances on agriculture" code. While the deductive codes were agreed upon prior to data analysis and did not change with analysis, the inductive codes were established following several rounds of consensus building among the research team [14,15]. Keywords were also identified from the text and analyzed for frequency, allowing for manifest content analysis and quantitative reporting [16]. Although we segregated focus group sessions by TAP organizational affiliation (e.g., ref. [17]), we considered the composite of responses in our analysis and reporting.

Table 1. The study's deductive codes, as developed from the focus group thematic segments, and inductive codes developed through consensus. Deductive codes are in bold typeface and their related inductive codes are *italic* typeface.

Focus Group Thematic Segment
Deductive Code
Inductive Codes
Thematic Segment 1: Climate stressors and their impacts
Perceived climate disturbances on agriculture
Water-related stressors
Increased occurrence of climate extremes
Shifts in expected climate patterns
Wildfire and smoke
Perceived outcome of climate disturbances of agriculture
Decreased productivity
Wildland fire and smoke damage
Compromised water resources
Increased crop stress
New pest and disease management
Thematic Segment 2: Recommended practices for adapting to climate change
Recommended adaptation practices
Water conservation
Enhancing soil health
Diversification or transition
Fire-related
Practices TAPs receive feedback on
Soil health practices
Agroecosystem practices

Table 1. *Cont.*

Thematic Segment 3: Barriers to adaptation
Barriers to adaptation faced by producers
Finances and funding
Cost or availability of suitable infrastructure
Regulations
Hesitancy around cover crops
Barriers faced by TAPs in supporting producers
Inadequate information and messaging
Insufficient funding
Growers do not prioritize climate change adaptation alone

3. Results

3.1. Climate Stressors and Impacts

Each focus group session opened with participants being asked which climate stressors affect California agriculture (Appendix A, RQ1). Participant responses were sorted into 98 distinct references that were categorized as water-related stressors, increased occurrence of climate extremes, shifts in expected climate patterns, and wildfire and smoke (Figure 1). Water-related stressors and climate extremes were the two most frequently cited stressor categories, accounting for 33% and 26% of all climate stressor references, respectively. Within these two categories, discussion focused on water quantity challenges (Figure 1, subcategory A) and the related stressors of drought and extreme heat (Figure 1, subcategories D,E).

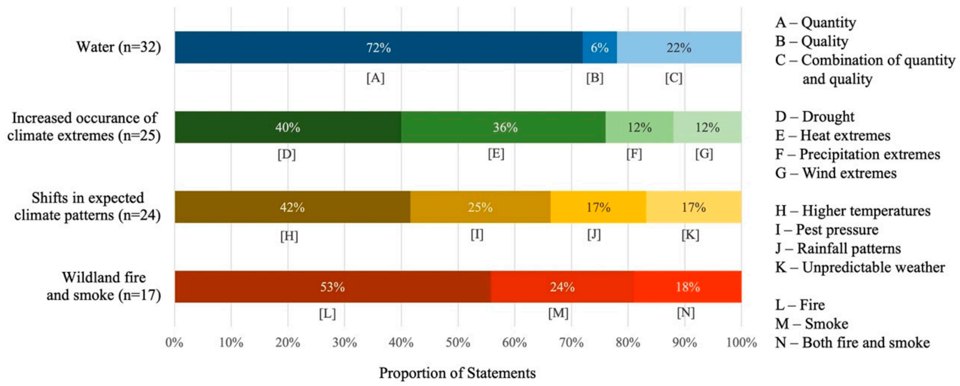

Figure 1. The 98 references to climate stressors were sorted into four categories: water, increased occurrence of climate extremes, shifts in climate patterns, and wildland fire and smoke. For each of these categories, the subcategories (A–N) denote the nature of the reference. The proportion of statements falling into each subcategory are provided as a percentage of the total statements within the category (e.g., 72% of all water statements were about water quantity).

TAPs reported that climate stressors had significant impacts on California agricultural production (Appendix A, RQ1.2), which were categorized as decreased productivity, wildfire and smoke damage, compromised water resources, increased crop stress, and a requirement for new pest and disease management practices (Figure 2). Decreased productivity was most cited (29% of impacts references), including decreased crop yield and/or quality (Figure 2, subcategory A), which TAPs linked to stressors including shifting seasonality and climate extremes. TAPs also referenced water-related stressors and impacts (20% of impacts references) to decreased productivity, noting that compromised water resources are a primary driver of "decreased fruit [and] nut production [and the] inability to grow certain tree crops in the future." Further highlighting the close connections between categories, compromised water resources were also linked to wildfire, with fire-driven reductions in water quality mentioned as an example of wildfire impacts to ecosystems (Figure 2, subcategory C).

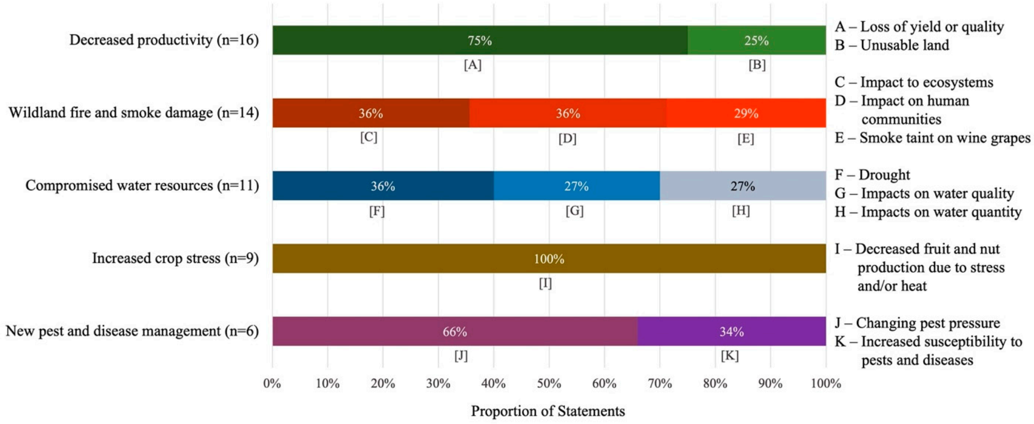

Figure 2. Impacts from climate stressors were sorted into five categories: decreased productivity, wildland fire and smoke damage, compromised water resources, increased crop stress, and new pest and disease management needs. For each of these categories, the subcategories (A–K) denote the nature of the categorical reference. The proportion of statements falling into each subcategory are provided as a percentage of the total statements within the category.

3.2. Recommended Adaptation Practices

Next, TAPs were asked about the practices recommended to producers to alleviate and adapt to climate change impacts (Appendix A, RQ2.1), and the response of producers to those recommendations (Appendix A, RQ2.2).

Recommended practices were categorized as water conservation, enhancing soil health, diversification or transition, and preparing for fire (Figure 3). The most frequently discussed water conservation practices were improvements in irrigation technology, which accounted for 53% of water conservation practices mentioned (Figure 3, subcategory A). Other water conservation practices mentioned included those related to agricultural managed aquifer recharge (AgMAR, 26%) and soil management for the purpose of water conservation (21%). In addition to discussing soil management in the context of water conservation, TAPs also discussed soil health practices where the primary goal of enacting the practice was not primarily water conservation (Figure 3, subcategories D,E). While the principal desired outcome(s) provided the context for how the practice references were categorized (i.e., whether categorized as a water conservation practice, a soil health practice, or both), TAPs acknowledged the dual benefits of water conservation and enhanced soil health for many soils-related practices. References to diversification and transition practices (Figure 3, subcategories F,G) and practices to reduce the impacts of wildfire (Figure 3, subcategories H–K) were also discussed, though to a lesser degree than water and soils related practices making up only 18% and 14% of practices referenced, respectively.

When recommending practices, TAPs only mentioned receiving feedback with respect to practices related to soil health and those that provide broader agroecosystem benefits (Figure 4). Despite soil health practices being frequently recommended (Figure 3, subcategories D,E), TAPs reported that the willingness of growers to adopt specific soil health practices is variable; 56% of references reported acceptance of soil health practices and 44% reported pushback (Figure 4, subcategories A,B). Accepted soil health practices included incorporating organic amendments, which most producers were reported as being enthusiastic about. One TAP referred to soil amendments as “one of the cheapest and easiest and most popular [practices] that we’re seeing.” Conversely, TAPs reported that producers are hesitant to use cover crops due to fears such as the practice creating a suitable habitat for rodents and the related concerns over food safety, and fears that cover crops could detract nutrients and/or water from crops. Practices providing larger scale agroecosystem benefits (e.g., building riparian buffers, supporting pollinator habitat, incorporating hedgerows, and enhancing landscape connectivity) were also met with a mixture of acceptance and pushback toward adoption among producers. For example, TAPs reported that supporting pollinator habitat was a well-received recommendation but incorporating hedgerows as a recommended practice was met with a grower focus on drawbacks. Throughout the discussion on recommended adaptation practices, TAPs continuously came back to the idea that growers will not adopt a practice unless the benefits outweigh the costs, with one TAP noting "... it's like soil health is a side advantage... they're farmers. You have to look at the financial aspects".

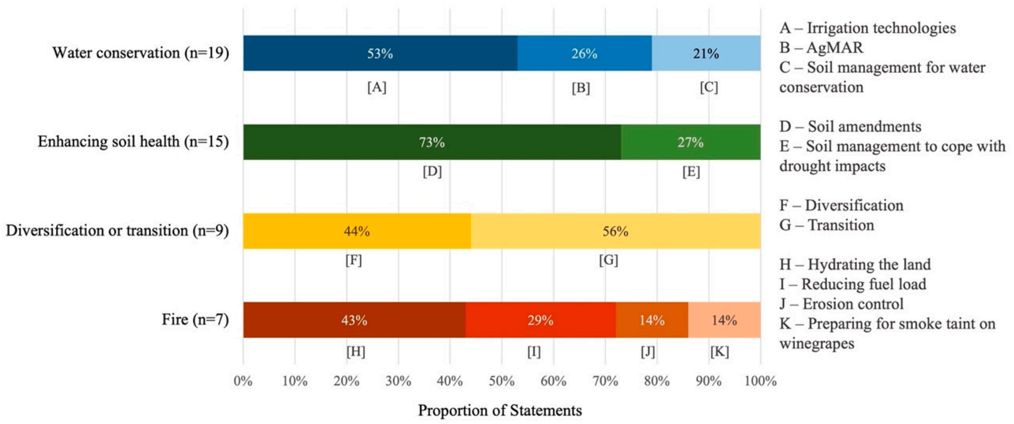

Figure 3. Recommended adaptation practices were categorized as those relating to water conservation, enhancing soil health, diversification or transition, and preparing for fire. Subcategories (A–K) denote the nature of the categorical reference. The proportion of statements falling into each subcategory are provided as a percentage of the total statements within the category.

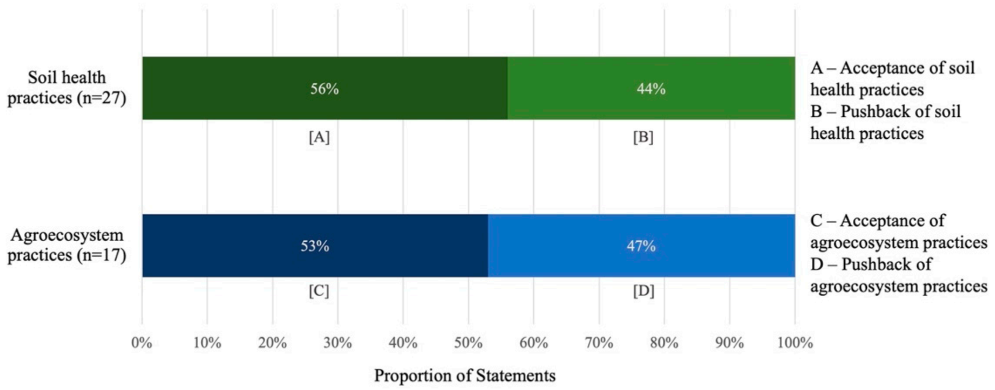

Figure 4. Practices that TAPs report receiving feedback on were categorized as those relating to soil health (subcategories A,B) and those relating to landscape scale agricultural practices (subcategories C,D). The proportion of statements falling into each subcategory are provided as a percentage of the total statements within the category.

3.3. Barriers to Adaptation

Finally, TAPs were asked two questions regarding barriers to adaptation: (1) what barriers do producers face in adopting climate adaptation practices, and (2) what barriers do they themselves face when trying to help producers respond to climate change (Appendix A, RQ3.1 and RQ3.2).

Barriers faced by producers were categorized as finances and funding, regulations, infrastructure limitations, and uncertainty around cover crops (Figure 5). The majority of finances and funding barriers related to the cost of implementing adaptation practices (Figure 5, subcategory A). One TAP captured this barrier by saying that most producers are "willing to try new things that are climate smart, they just don't have the money to do it." TAPs specifically called out infrastructure limitations, noting that producers may not have the ability to access or afford the infrastructure needed to adopt the preferred adaptation practices on their farm (Figure 5, subcategory D) and that infrastructure is "very individualized according to the farm, what they're growing, and their equipment" (i.e., there may be specialty infrastructure considerations for certain crops). Additionally, TAPs note that producers may be reluctant to invest in infrastructure in part because climate change is outpacing technology innovations (Figure 5, subcategory F). Beyond financial matters, TAPs report onerous regulations, and specifically fear of non-compliance with regulations, as a barrier for growers (Figure 5, subcategories G–I), and note that growers may be misinformed regarding regulations such as the Sustainable Groundwater Management Act (SGMA, Figure 5, subcategory I). For example, the notion that producers are hesitant to incorporate cover crops for fear of being non-compliant with groundwater regulations under SGMA was mentioned multiple times.

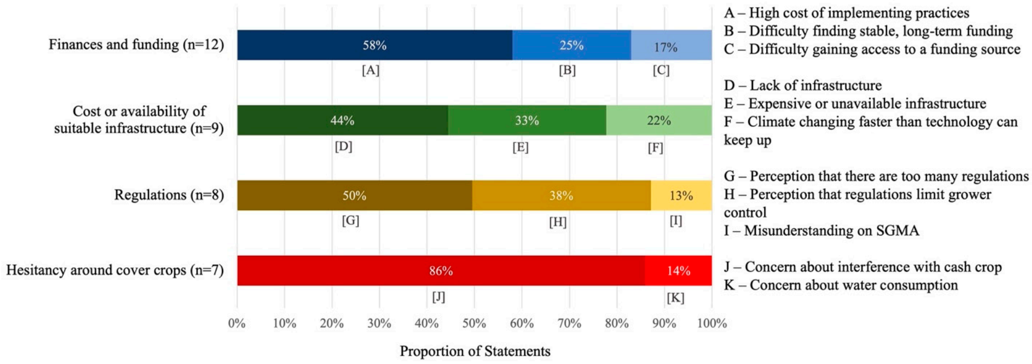

Figure 5. Barriers faced by producers were categorized as being related to finances and funding, cost or availability of suitable infrastructure, regulations, and hesitancy around cover crops. Subcategories (A–K) denote the nature of the categorical reference. The proportion of statements falling into each subcategory are provided as a percentage of the total statements within the category.

Barriers faced by TAPs when trying to help producers respond to climate change were categorized as inadequate messaging and information, inadequate funding, and TAPs' own perceptions that producers do not see value in climate adaptation (Figure 6). TAPs reported that they do not have adequate resources for understanding the breadth of climate adaptation practices available for agriculture and that when information is available the specificity is insufficient to aid adaptation for individual producers (i.e., the spatial scale is too coarse, or the information is not crop specific; Figure 6, subcategories A–C). TAPs also referenced a lack of a platform for messaging as well as lack of TAP capacity to disseminate information (Figure 6, subcategories B–D). That is, even if TAPs felt adequately educated on climate adaptation, there is no platform available for consistent and effective messaging.

Inadequate funding references were primarily about the inability of TAPs to secure funding to help producers implement climate adaptation practices and the lack of incentives to encourage producers to implement such practices (Figure 6, subcategories E,F). Additional funding references included mentions of TAPs being spread thin and the lack of funding for the additional time and work they may incur in helping producers adapt to climate change (Figure 5, subcategory G). TAPs also discussed the reluctance of producers to adopt practices for the sake of climate adaptation alone as hampering TAP efforts to increase adaptation among California producers (Figure 5, subcategories H–J).

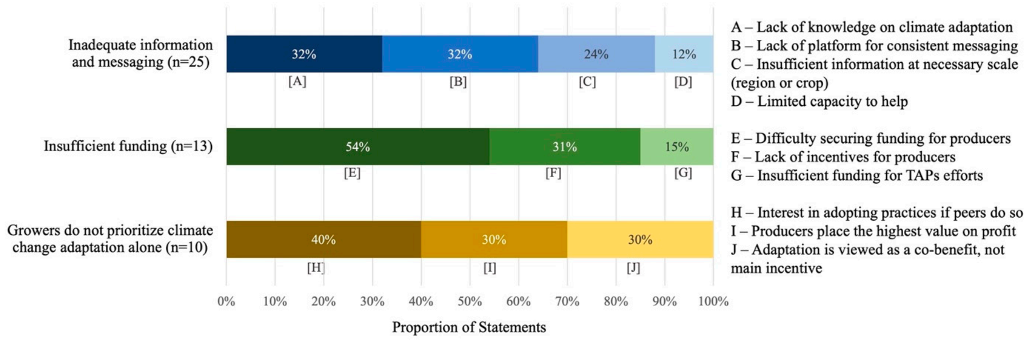

Figure 6. Barriers faced by TAPs in supporting adaptation among California producers were categorized as relating to inadequate messaging and information, insufficient funding for TAP support or producer engagement, and the perception that growers do not want to adapt for climate change reasons alone. Subcategories A–J show the nature of the references within each of these four categories. The proportion of statements falling into each subcategory are provided as a percentage of the total statements within the category.

4. Discussion

The breadth, and sometimes severity, of climatic changes affecting California's vast agricultural sector creates a need for useful and effective adaptation practices. With many producers looking to the technical assistance provider community for practical information on adaptive management, it is imperative we understand both how TAPs see climate change impacting producers and how TAPs see producers reacting to different recommended practices and the unique barriers both they and producers face in the adaptation process.

Our findings show that California's TAPs believe climate change is impacting producers throughout the state in diverse ways. Our focus group discussions may suggest that "seeing is believing" as we posit that recent events may have kept certain stressors at the forefront of the discussion. For example, the timing of the focus groups relative to the drought year of 2020, which followed closely on the heels of the exceptional 2012–2017 drought, may have put water-related topics in sharper focus; likewise, the emphasis placed on wildfire and smoke as a principal stressor may be outsized relative to its true impact as a function of the focus groups occurring mere months after the catastrophic 2020 wildfire season. Still, TAPs' perception that producers are increasingly facing climate-related challenges is echoed throughout the country (e.g., ref. [12]), and is validated by observations of warming temperatures and more frequent and intense heatwaves [2], shifting seasonality [18], increased annual wildfire-burned area [19], and more frequent drought conditions [20]. Likewise, research efforts corroborate that these climate stressors can have notable effects on water quantity [6] and quality [21], crop quality and yield [2], and pest pressure [2,22].

Second, we show that TAPs recommend a number of science-backed adaptive practices. Water conservation practices such as improvements in irrigation technology [23,24] are a widely accepted means for reducing water consumption. Similarly, managed aquifer recharge [25] is a relatively new, yet promising, approach for managing groundwater resources that can be integral to water conservation at a system level. Practices recommended by TAPs to improve water holding capacity have shown demonstrated success in perennial crop systems (e.g., ref. [26,27]), and TAP-recommended practices such as planting cover crops and using soil amendments have been shown to benefit soil health in semi-arid areas such as California [28]. However, TAPs report that these practices are not always consistently accepted recommendations from the producer perspective.

Third, our focus group analysis reveals that TAPs see a number of barriers to agricultural adaptation. Prior work has indicated that funding can be a significant barrier for producers in successfully adapting to climate change [29] and TAPs also report that insufficient funding for their efforts is a barrier. That is, without adequate funding, TAPs may not be equipped with the tools, trainings, and resources they need to educate growers on adaptation practices and the potential outcomes of practice adoption, and/or facilitate practice adoption. TAPs also see messaging challenges and information limitations to be major barriers to their capacity to engage with producers. Specifically, this work highlights information gaps that must be filled in order for TAPs to better help producers adapt to a changing climate. Efforts must be made to address the spatial scale of climate information (a barrier to adaptation also encountered by federal land managers [30]), and resources that allow TAPs and producers to develop 'place based' approaches to adaptation must be available [31].

Given that climate-related stressors are expected to affect California agricultural production more under future climate conditions, TAP efforts to help producers adapt will be a central part of more resilient agricultural industry. The improved understanding of the TAP-perspective on climate change and agricultural adaptation uncovered here provides valuable insight for researchers and boundary-spanning organizations to meet TAP community needs and fill these identified information gaps. For example, using the information from these focus groups, in concert with additional engagements with technical assistance providers and agriculture experts, the USDA California Climate Hub developed a menu of adaptation strategies, approaches, and practices for California specialty crop producers, offering information that can help in farm adaptation planning (in press). Likewise, the recently launched CalAgroClimate (calagroclimate.org), developed by researchers at UC-ANR, UC Merced, and the USDA California Climate Hub, is a web-based suite of climate data visualization tools and a repository for resources on climate and agriculture in California that helps meet the need for high resolution and crop-specific climate information. Using the insights gleaned from this work, researchers and boundary organizations can continue to develop and disseminate resources to support the resiliency of California agriculture to today's climate stressors and tomorrow's climate change.

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Institutional Review Board Statement: This study was deemed Exempt by the Institutional Review Board of the University of California Davis.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: Data from this study are not available due to privacy restrictions.

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Appendix A

RQ 1: What do TAPs perceive as being major climatic stressors and attendant impacts in California's agricultural operations?

Questions Asked:

1. What are some of the most challenging and concerning climate related stressors that producers you work with face on their operation?
2. What are the impacts of those stressors for the producers or the crop systems?

RQ 2: What are TAP recommendations for adaptation practices and how do those align with the practices farmers have adopted?

Questions Asked:

1. What is a particular climate-related stressor that you see as a big issue for the production systems you work on, and what are producers doing to try to either mitigate damages or adapt to this stressor?
2. What practices have you recommended for a particular stressor, and have any been particularly well-received or pushed back against?

RQ 3: From the TAP perspective, what are the barriers to adopting climate-adaptive management practices?

Questions Asked:

1. Going back to the adaptive actions that producers would like to undertake or actions that are recommended to them, what are some of the barriers that you see producers grappling with as they try to adopt those farm management practices?
2. What barriers or obstacles do YOU encounter in helping your clients to respond or adjust to climate change?

Appendix B

Consolidated criteria for reporting qualitative research (COREQ). This appendix provides responses to the COREQ. Note that not all of these details are provided in the body of the text.

Domain 1: Research team and reflexivity Personal Characteristics

1. ***Which author/s conducted the interview or focus group?*** All authors contributed to preparation of the focus group questions. Johnson, Parker and Ostoja conducted the focus groups, each in turn presenting focus group objectives and facilitating conversation.
2. ***What were the researcher's credentials?*** Author Johnson, M.S.; Authors Parker, Pathak, Crothers, Ostoja, Ph.D.
3. ***Occupation What was their occupation at the time of the study?*** Johnson, Assistant Specialist in Agriculture and Climate, UC Davis; Parker, Postdoctoral Fellow, UC Davis; Pathak, Extension Specialist in Agriculture and Climate, UC ANR; Crothers, Independent Researcher; Ostoja, Director of USDA California Climate Hub.
4. ***Was the researcher male or female?*** Authors Johnson, Parker, and Crothers are female. Authors Pathak and Ostoja are male.
5. ***What experience or training did the researcher have?*** Author Johnson has experience and coursework in qualitative research methods, surveys, and focus groups. Authors Parker, Pathak, Crothers, and Ostoja have experience in conducting surveys and focus groups for non-publication purposes.
6. ***Was a relationship established prior to study commencement?*** No.
7. ***What did the participants know about the researcher?*** The participants were aware that the focus groups were being done to guide the development of an agriculture adaptation workbook. The participants may have been aware of the researchers' prior work as available through public online search records.
8. ***What characteristics were reported about the interviewer/facilitator?*** The researchers were not introduced beyond their names and titles. No specific biases were discussed.

Domain 2: Study design, Theoretical framework

9. ***Methodological orientation and Theory What methodological orientation was stated to underpin the study? (e.g., grounded theory, discourse analysis, ethnography, phenomenology, content analysis)*** The discussion transcripts were analyzed using a thematic analysis where quotations were coded according to themes and subthemes. An inductive content analysis followed where codes were summarized. Quotes in the

manuscript provide qualitative context, while the content is primarily summarized quantitatively.

10. ***How were participants selected?*** Because the underlying purpose of conducting the focus groups was to garner feedback for the development of an adaptation decision support product for California farmers, the researchers recruited a purposive sample of professionals from across multiple technical service provider organizations across the state. The authors used existing professional networks to identify and recruit participants.
11. ***How were participants approached?*** Participants were invited via email by authors Parker and Johnson to take part in the focus groups.
12. ***How many participants were in the study?*** Twenty-nine.
13. ***How many people refused to participate or dropped out? Reasons?*** Participants were invited to a single focus group event, which reduced the rate of attrition during the data collection. Because solicitation was via email and researchers have no ability to know whether solicited participants received the email and refused response or they did not receive the solicitation at all, it is unknown the number of participants refused to participate.
14. ***Where was the data collected?*** The focus group was conducted on a Zoom call with participants calling in remotely from their individual office or home locations. This was due in part to COVID-19 health regulations at the time.
15. ***Was anyone else present besides the participants and researchers?*** No.
16. ***What are the important characteristics of the sample?*** For the purpose of this effort the key characteristic of the sample is the organization for which the participants work (e.g., NRCS, RCDs, UCCE, non-profit).
17. ***Were questions, prompts, guides provided by the authors? Was it pilot tested?*** Questions and facilitation were developed and provided by the researchers. The focus groups were noted pilot tested.
18. ***Were repeat interviews carried out? If yes, how many?*** No.
19. ***Did the research use audio or visual recording to collect the data?*** Yes. The focus groups were held over Zoom, with audio and video recorded. Only the audio was used in analysis. Consent was obtained from all participants and all recorded data are securely stored with researcher Parker.
20. ***Were field notes made during and/or after the interview or focus group?*** Some field notes were taken during the focus groups but only the focus group transcripts from recorded audio were used in analysis.
21. ***What was the duration of the interviews or focus group?*** The focus groups ranged in duration from 1.5 h to 2 h.
22. ***Was data saturation discussed?*** No.
23. ***Were transcripts returned to participants for comment and/or correction?*** No.

Domain 3: Analysis and findings, Data analysis

24. ***How many data coders coded the data?*** Authors Johnson, Parker, and Ostoja worked to develop codes via consensus. Author Johnson analyzed the data.
25. ***Did authors provide a description of the coding tree?*** No.
26. ***Were themes identified in advance or derived from the data?*** The main aspects of the data (e.g., impacts, adaptation practices, barriers, information sources) were identified before the focus groups and are built around the key research question areas. The underlying themes and subthemes were *not* identified in advance and were allowed to emerge from the data through a consensus building approach.
27. ***What software, if applicable, was used to manage the data?*** The audio and vidoe data were recorded on Zoom. NVivo was used to code and analyze the data.
28. ***Did participants provide feedback on the findings?*** No.
29. ***Were participant quotations presented to illustrate the themes/findings? Was each quotation identified?*** e.g., participant number The paper contains some anonymized quotations.

30. ***Was there consistency between the data presented and the findings?*** Yes. The quotations are provided as examples of the theme or subtheme being discussed within the body of the paper.
31. ***Were major themes clearly presented in the findings?*** Yes. Each paper results subsection presents a category of results and each related figure shows the major themes and subthemes within the category.
32. ***Is there a description of diverse cases or discussion of minor themes?*** Subthemes or minor themes are presented and discussed in part.

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