Climatic Change (2022) 173: 23
https://doi.org/10.1007/s10584-022-03417-9

Farmers adapt to climate change irrespective of stated belief in climate change: a California case study

Margiana Petersen-Rockney[1]

Received: 21 January 2022 / Accepted: 26 July 2022 / Published online: 13 August 2022

Abstract

Farmers are front-line workers managing climatic change. As in many parts of the world, climate change in northern California is threatening natural resource-dependent communities by exacerbating droughts, heatwaves, and wildfires. This article draws on ethnographic methods, including 108 interviews with crop and livestock farmers and key informants, to query climate change experience, belief, and response in rural northeastern California. I find that farmers recognize and describe climate changes that match the meteorologic evidence of anthropogenic climate change, but attribute these changes to weather cycles and harsh geographies. However, irrespective of their belief in anthropogenic climate change, farmers implement climate adaptations—many of these practices with mitigation co-benefits, bolstering growing evidence that climate change belief and action are not tightly coupled. To accelerate farmer adaptation, this work suggests that policy and programming focus on actions and outcomes, rather than reshaping belief.

Keywords Climate change belief · Agriculture · Farmers · Adaptation · Gender

Highlights

- Farmers recognize and describe changes in climate over time, as well as significant weather variability.
- Farmers discuss these changes in terms of their own lived experience, weather variability, ongoing cycles, and harsh geographies.
- Severe weather events did not shift belief in anthropogenic climate change, but did catalyze action.
- Farmers adopted a range of short- and long-term adaptations, irrespective of stated belief in anthropogenic climate change.

✉ Margiana Petersen-Rockney
margiana@berkeley.edu

[1] Berkeley Department of Environmental Science, Policy, and Management, University of California, 130 Mulford Hall #3114, Berkeley, CA 94720, USA

1 Introduction

Crop and livestock farmers have long managed environmental uncertainty (Brunson and Huntsinger 2008). They are now on the front lines of climate change-induced stressors (e.g., rising temperatures), shifts (e.g., earlier snowmelt), and shocks (e.g., more intense and frequent wildfires). Global greenhouse gas emissions continue to increase (IPCC 2022), and farmers are experiencing more extreme climatic events than they have historically (Pathak et al. 2018; Azadi et al. 2019). Physical climate impacts compound the portfolio of non-climate risks farmers already face, like economic precarity stemming from highly concentrated and unequal markets (Petersen-Rockney et al. 2021).

Farmers' responses to climate extremes are crucial to maintaining rural economies, food security, and biodiversity (Kremen and Merenlender 2018). Agriculture is a significant cause of climate change, especially in its release of methane and nitrous oxide from livestock and land use change (Shukla et al. 2019). Yet agricultural working landscapes have the potential to enhance adaptive capacity and mitigate emissions, especially when diversifying strategies are adopted (Kremen and Merenlender 2018). How farmers respond to climate change shapes current resilience and carbon sequestration, and structures future adaptive capacity (Petersen-Rockney et al. 2021).

Scholars have noted a gap between scientific understanding of climate change and farmers' adoption of adaptive management practices (Schewe and Stuart 2017). Belief in anthropogenic and long-term climate change remains low among US farmers, potentially limiting climate action (Arbuckle et al. 2013; Prokopy et al. 2015; Niles et al. 2015; Chatrchyan et al. 2017).

Yet the cultural and ecological context of climate change is rapidly changing. With increasing public climate discourse, and political polarization, as well as record-setting droughts, heatwaves, and wildfires, we are living in new and constantly changing times. It is crucial to better understand how farmers' experiences of climate are changing within this context. How farmers discuss and respond to climatic changes are not static. Instead, discourses, field-management practices, and livelihood strategies shift in relation to wider social and ecological changes. Through in-depth interviews and participant observation, this paper explores experiences, beliefs, and actions around climate change within shifting local and extralocal cultural contexts as climate extremes intensify.

California provides an ideal place to examine how farmers experience, perceive, and respond to climatic extremes like drought and wildfire. Severe weather events in the state, including record-setting heatwaves, droughts, and wildfires (Higuera and Abatzoglou 2020), are negatively impacting agriculture (Pathak et al. 2018; Woodmansee et al. 2021) and are projected to intensify (Karki et al. 2020; IPCC 2022). While climate change may create opportunities for farmers in some regions (e.g., Lane et al. 2018), the impacts of climate change on agriculture worldwide will likely be overwhelmingly negative (Karki et al. 2020). How farmers perceive and respond to climatic changes in California —one of the most agriculturally diverse and important regions of the world—may be a harbinger of other farming systems' potential to adapt in the future.

Northeastern California is especially well suited for analyzing the ways that farmers are experiencing and responding to climate change. Unlike much of the state's highly corporatized agriculture, most farms in northeastern California operate with primarily family labor, which may facilitate more decision-making agency (Price and Leviston 2014). Like many agriculturalists in the western US (Yung et al. 2015), most farmers in this region identify as politically conservative and hold anti-government sentiments, which are associated with

farmers' limited belief in anthropogenic climate change and reduced perceptions of climate risks (Safi et al. 2012). With fewer infrastructural and state resources to buffer climate extremes, farmers here are more vulnerable to droughts and wildfires than large-scale crop farmers in California's Central Valley.

To better understand the relationships between farmers' beliefs, experiences, and decision-making regarding climate change, I ask: How do farmers experience and describe climatic events like drought and wildfire? What are their beliefs and perceptions about these climatic extremes? And how are these extremes impacting farm management practices and livelihood strategies?

2 Theory and background

Climate change is broad and nebulous — both spatially and temporally — making pinpointing the experience of its cascading impacts difficult (Breakwell 2010). On the ground in a farmer's field, it can be difficult to distinguish the signal of global climate change from the noise of local weather variability (IPCC 2022). It is also difficult to determine the extent to which a particular climate event is influenced by warming due to anthropogenic greenhouse gas emissions. Teasing apart the climate signal from other anthropogenic impacts also poses a challenge. Wildfires, for example, are driven by anthropogenic fire suppression, water use, species change, and many other factors in addition to rising average temperatures (Hanan et al. 2021).

Yet measurable changes are occurring. For example, over the past four decades California's autumn precipitation has decreased by 30%, while temperatures have increased by about 1 **°C**, contributing to a 20% increase in aggregate fire weather indices each fall (Goss et al. 2020).

Farmers must adapt to climatic changes, which they often do before mitigating (Arbuckle et al. 2013). Adaptation is "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects" (IPCC 2022, p. 7). Decision-making around adaptation is more locally influenced than decision-making around mitigation (Haden et al. 2012), although many adaptation practices provide mitigation co-benefits (Gosnell et al. 2020). Adaptation actions range from coping with change, to incremental adjustments, to system transformation (Chhetri et al. 2019). Individual incremental adaptations can aggregate over time or through collective action, leading to transformational adaptation (Wilson et al. 2020).

The literature on individual farmer decision-making has primarily focused on the adoption of best management practices that improve conservation outcomes (Prokopy et al. 2019; Schewe and Stuart 2017). The theory of planned behavior (Ajzen 1991) has been used to predict farmer behavior based on characteristics of the farm (e.g., acreage or crop type) or farmer (e.g., experience or age), neither of which provide consistent explanatory power for farmer decision-making (Prokopy et al. 2019). Farmers often make economically irrational decisions, such as investing in conservation or keeping unprofitable land, based on factors like their socially constructed sense of identity, place, and culture (Lequin et al. 2019).

Cognitive factors like beliefs, attitudes, and perceived agency also shape farmer decision-making (Takahashi et al. 2019; Nguyen et al. 2019). Studies of farmers' decision-making regarding climate change have largely focused on farmers' beliefs (Chatrchyan et al. 2017; Findlater et al. 2018). Beliefs about climate change include the extent to which individuals believe in anthropogenic causes, and whether the climate is changing

at all (Hyland et al. 2016). Beliefs about climate change influence farmers' perception of the physical (Menapace et al. 2015), policy (Niles et al. 2013), and social risks (Petersen-Rockney 2022) of climate change. Belief in climate change's anthropogenic origins and its future impacts are often characterized as key motivators (Nguyen et al. 2016) and predictors of farmers' action on climate change, especially mitigation (Arbuckle et al. 2013; Roesch-McNally et al. 2017; Chatrchyan et al. 2017; Lane et al. 2018).

While the relationship between belief and action is most often observed in farmers' implementation of mitigation practices, many empirical studies with farmers and ranchers find a similar relationship between belief in anthropogenic climate change and adaptation (Chatrchyan et al. 2017). Adaptation is likely informed by beliefs, but belief in anthropogenic climate change is not *required* for farmers to adapt (Kuehne 2014; Chatrchyan et al. 2017; Lane et al. 2018). Experiences of bad weather and perceptions of the physical risks of climate change are also important motivators of adaptation action (Woodmansee et al. 2021).

Personal experiences of severe weather can help make climate change less abstract, and more proximate and believable (Azadi et al. 2019). Personal experiences with severe weather events positively influence farmers' beliefs in anthropogenic climate change and willingness to implement adaptation and mitigation practices (Niles and Mueller 2016; Schattman et al. 2016; Lane et al. 2018).

Belief or disbelief in anthropogenic climate change can also shape experiences of weather. For example, farmers in New Zealand who believed climate change was occurring perceived that they had experienced a greater increase in temperature than their peers who did not believe the climate was changing (Niles and Mueller 2016). Similarly, farmers and ranchers in Nevada who believed in anthropogenic causes of climate change perceived greater risks to their operation from future impacts than farmers who said that they did not believe in climate change's anthropogenic origins (Safi et al. 2012).

Despite considerable empirical research, the connection between farmers' experience, belief, and decision-making regarding climate change remains complex and difficult to generalize (Schattman et al. 2016; Findlater et al. 2019). Past experiences with unusually bad weather, especially in regions known for their harsh climate, can normalize potential future extremes, incentivizing farmers to hedge their bets each year and manage "well enough" instead of adopting proactive adaptation strategies (Takahashi et al. 2019). Unusually favorable weather can also reduce the salience of weather risks and adaptation action (Findlater et al. 2019).

Physical impacts, like droughts and heatwaves, are not the only effects of climate change that farmers experience. Individual experiences, and the cognitive factors that form and are formed by those experiences, shape farmers' frames of reference through their role in society, group interactions, and institutional engagement (Burke and Stets 2009). Cultural experiences of climate change, for example through media exposure (Findlater et al. 2019) and political affiliation (Dunlap et al. 2016), also influence climate change beliefs. In the US, climate change has been made into a politically divisive issue (Dunlap et al. 2016) associated with progressive political and environmental groups (Singh et al. 2020), groups that US farmers often distrust (Prokopy et al. 2015). Additionally, experiences not directly related to farming, like social interactions (Knapp and Fernandez-Gimenez 2009) and self-perceptions (Morton et al. 2017), shape farmers' beliefs about climate change and its origins (Singh et al. 2020), as well as perceptions of its impacts and appropriate responses (Karki et al. 2020). Understanding farmers' identity as co-constructed with situated ecological and cultural contexts creates new opportunities wherein researchers and policy makers can link individual and structural decision-making factors (Coughenour 2003).

In northeastern California, both the cultural and ecological contexts in which farmers are experiencing, perceiving, and responding to climate are changing. During the years of

this fieldwork, from 2017 to 2020, climate change became increasingly central to public life through media and political discourse. Climate science became front page news and political polarization around climate change rose to new extremes. Simultaneously, this period has been marked by the most severe drought in 1200 years (Williams et al. 2022) and extreme precipitation volatility (Swain et al. 2018), contributing to unprecedented mega-wildfires across the western US (Swain 2021).

The accelerating pace and scale of climate impacts, including novel droughts and wildfires, limits farmers' ability to rely on previous climate experiences (Takahashi et al. 2019). Farmers are, however, adopting new practices and strategies in response to climate impacts. In California's Central Valley, farmers who experienced water shortages adopted more efficient irrigation practices in response (Haden et al. 2012). Similarly, farmers in New York (Takahashi et al. 2016), ranchers in Montana (Yung et al. 2015), mixed crop and livestock farmers in New York and Pennsylvania (Lane et al. 2018), dairy farmers in Wisconsin, and oyster farmers in New England (De Master et al. 2019), have implemented adaptive management strategies in response to severe weather events, despite often limited willingness to attribute these impacts to anthropogenic climate change.

While adaptive action has long been recognized as less tied to belief in anthropogenic origins, mitigation action too is becoming less predicated on belief. Beef and grain farmers in Alberta, Canada adopted field-management practices with climate-mitigation benefits despite widespread climate skepticism (Davidson et al. 2019). As climatic events and trends become more extreme, and climate change more central to public life, the question is not whether farmers respond to climate change, but rather how they perceive those changes within their daily lived experience, how those perceptions are shaped by cognitive factors, and how those perceptions shape the practices and strategies they pursue.

3 Methods

3.1 Study site

This study of farmers' experiences, beliefs, and responses related to climate change was one component of a broader research project on rural livelihoods and agrarian and environmental change. After preliminary fieldwork in the fall of 2016, the field site and research questions were selected based on the region's climatic extremes and family-labor farm predominance. Over four years (2017–2020), I then conducted an extended case study (Burawoy 1998) in Siskiyou County, California (Fig. 1).

Ecologically, this region is an extension of the Great Basin and Range Province, marked by agricultural valleys surrounded by mountains. Historically, agricultural has primarily relied on mountain snowpack for surface water irrigation and rainfall for dry land crops and range forage. Siskiyou County's weather is subject to substantial variability, particularly fluctuations in temperature and relative dryness (Fig. 2). Commensurate with broader findings that heat wave intensity and frequency are increasing across Western North America (IPCC 2022),[1] maximum summer temperatures have risen over the past 70 years and mountain snowpack has decreased (Pathak et al. 2018).

[1] Scientific consensus is highest in the Western North American region, of anywhere in the world, that anthropogenic emissions are already contributing to observed climatic changes, especially droughts (IPCC, 2022).

Fig. 1 Map and characteristics of Siskiyou County, California

Siskiyou is home to a diverse mix of farms in terms of products, size, and structure. Compared to other California regions, farms in Siskiyou are more often mid-size and family-operated, with half of farm operators reporting farming as their primary occupation (USDA Census 2017). While cow-calf and forage crops remain culturally dominant, farmers raise a diversity of livestock and crop varieties. Like farmers in other US regions (Singh et al. 2020), many residents self-identify as politically conservative, economically marginalized, and describe climate change as a polarizing topic.

3.2 Research design

I employed an extended case study research design (Burawoy 1998) using ethnographic methods of in-depth interviews and participant observation to elucidate attitudes, beliefs, and conceptual understandings of climate change. Qualitative methods are especially well suited to investigating the nuances of politically polarized topics like climate change (Takahashi et al. 2016). Adhering to an extended case study design–wherein I made repeated trips to the region, built relationships with key informants, and iteratively adapted my lines of inquiry to allow for both deductive and inductive analysis—enabled me to take account of changing social and ecological dynamics (Findlater et al. 2018). Importantly, an extended case study research design facilitates a reflexive scientific process wherein intersubjectivity of the subject and scientist is explicitly understood (Burawoy 1998). Having grown up on a farm, and been a farmer myself, I was granted access to the farming communities I worked with and able to engage in "participant observation to locate everyday life in its extralocal and historical context" (Burawoy 1998 p. 1).

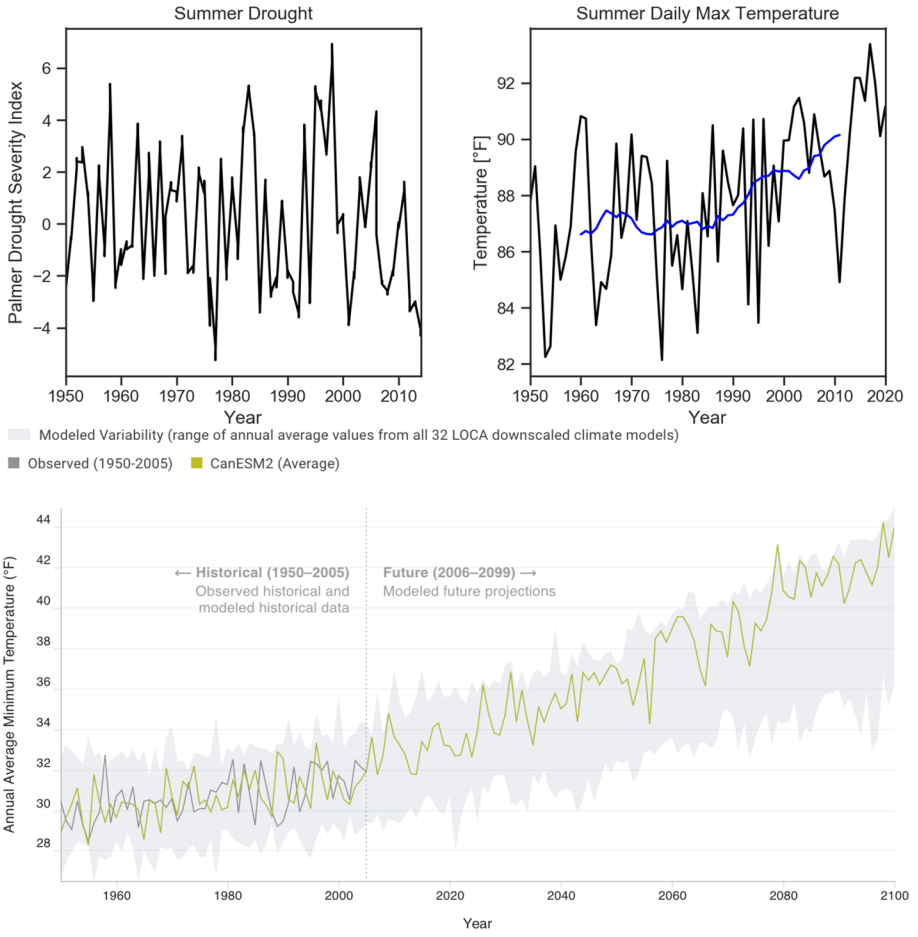

Fig. 2 Palmer drought severity index (left) for summers in Siskiyou County from 1950 to 201, note high degree of drought volatility. Summer daily maximum temperatures from 1950 to 2020 note the high degree of noise (black line) with subtle climate signals emerging (blue line, the 20-year rolling centered average). The drought index represents a regional average over a 2.5°×2.5° domain centered on (41.25, −121.25). The summer average of the daily max temperature data was taken from the Yreka weather station and was downloaded from the NOAA Climate Data center on August 30, 2021. Annual average minimum temperature in Siskiyou County (bottom), observed 1950–2020 (gray line) and modeled (green line) using an average simulation (CanESM2) in an optimistic scenario (RCP 4.5) in which emissions peak around 2040, then decline. Source: Cal-Adapt. Data: LOCA Downscaled Climate Projections (Scripps Institution of Oceanography), Gridded Historical Observed Meteorological Data (University of Colorado, Boulder). Thank you to Nathaniel Tarshish for assistance with these figures

A purposive sampling frame facilitated the inclusion of maximum variation in farm and farmer characteristics (Yung and Belsky 2007). Purposive sampling frame criteria were determined after a preliminary fieldwork trip in November 2016, during which I met with key informants (e.g., Cooperative Extension Advisors) and farmers to determine community-identified research needs and pilot potential interview themes. Farm characteristics of crop type, livestock species, farm size, and primary market (e.g., wholesale or direct market) emerged as locally important factors in those initial meetings. Similarly, I used

farmer characteristics[2] of gender, age, farming experience, and newcomer versus multigenerational status in the region as criteria for my purposive sampling frame. Notably, climate change belief was never mentioned as an important criterion and was not used as a sampling criterion, instead emerging from the data collected.

I recruited informants through snowball sampling (Parker et al. 2019) and I contacted some key informants directly based on their specific expertise (De Master et al. 2019). Interviews queried farmers' experiences with weather and climate, particularly water scarcity and wildfires, including memories and perceptions of those events, how they impacted the farm operation, how farmers understood their causes and consequence, actions taken or considered in response, and wider community interactions and interpretations. Additional interview topics included: ecological and economic crises and responses, political formations and control, social groups and belonging, information sources and trust, household dynamics, and farming goals and motivations.

To reduce risks to study participants some details associated with specific quotes, such as informant gender or farm product, have been changed in the text (Sherman 2021). This research received university IRB approval (Protocol #2018–04-11,036).

3.3 Data collection and analysis

I conducted 108 in-depth, semi-structured interviews with crop and livestock farmers ($n=76$) and key informants ($n=32$). Semi-structured interview questions queried respondents' experiences, responses, and beliefs related to temperature change, dryness, and other weather and climate impacts. Key informants, such as agricultural advisors, provided context and triangulation of farmer experiences, which was the focus of this study. Interviews were primarily conducted at informants' work sites, such as farm fields or public offices. Interviews typically lasted between one and four hours. Ninety interviews were audio-recorded; 18 informants preferred only detailed written notes be recorded. Farmer interviews included a baseline survey of demographic information and farm management practices, including farm practices employed at what spatial and temporal scale, and motivations for adoption.

I engaged in participant observation (Geertz 2005), including assisting farmers in everyday tasks and attending local events to understand broader community dynamics and experiences at the intersection of belief and action. In these direct observations, I took detailed notes, transcribing key quotes verbatim and recording observations of non-verbal interactions. Participating in farm tasks, like harvesting potatoes and fixing irrigation lines, facilitated more open and casual communication, allowed me to observe farm management practices, and to ask detailed follow up questions about motivations and perceptions around adoption. Participating in local events, like community cleanups or public meetings, helped me place farmers' experiences within their broader social and political context.

I transcribed qualitative interview data by hand and with Trint software. I then coded interview and participant observation data in MaxQDA using a grounded theory approach (Thornberg and Charmaz 2014). In an initial round of preliminary coding, I evaluated interview transcripts and observation notes for framings farmers themselves used in their understanding of weather and climate, as well as emergent themes. I then applied a mix

[2] Notably, neither race nor ethnicity were identified as key demographic criteria by key informants in this majority white county. I did, however, include these categories in my purposive sampling frame.

of semantic and latent codes both derived from the literature and emergent from the data (Schewe and Stuart 2017). To reduce bias, undergraduate research assistants independently coded a random selection of five percent of interview transcripts to check coding consistency.

I triangulated my qualitative data by drawing on secondary quantitative data (De Master et al. 2019) — including the USDA census, meteorological data, and regional climate models. While these data were not analyzed, they did facilitate ground truthing and comparison with farmers' experiences.

4 Results and discussion

4.1 Farmers experience, recognize, and describe climate signals amidst weather variability

Nearly every farmer I interviewed articulated their observations of the climate changing over time. Many distinguished climate signals rising above the noise of weather variability by noting, for example, warmer winter temperatures and snowpack reductions. Under projected climate change scenarios, these signals will emerge more strongly and increase the severity of extremes in Siskiyou County (Fig. 2). One row crop farmer in his 60s said, "The trend is it has been lighter and lighter winters. Now, we're lucky if we get six to eight inches that'll stick around for more than three or four days at a time… The winters have become much more mild."

Farmers also described a shift in the duration and intensity of droughts from temporally bounded shocks to constant stressors. Echoing a common recognition of this change, a cattle rancher said of droughts in decades past, "They just didn't seem to last very long. You'd have a [dry] summer. But it just didn't seem to go on and on and on and on. This is very different… we had a bad year and then the next year is worse, and we had a bad year, and then the next year is worse…I mean, that's bad… it's like, man, this is really discouraging." Observations like this are consistent with meteorological data that document California's record-setting drought from 2000 onward, with new extremes beginning in 2012 (Swain et al. 2018). Even drought reprieves, like the relatively wet 2016–2017 winter, led to more fuel growth, greater wildfire risk, and more drought-prone post-burn ecologies (Swain et al. 2018).

With warmer, drier conditions, catastrophic wildfires have increased across California. In every year since 2018, California megafires (defined as fires that burn more than 100,000 acres) have produced smoke that blanketed Siskiyou County for weeks. In addition to smoke that blows north and east to the region, Siskiyou has also seen an increase in wildfires. In 2021, the River Complex fire in Siskiyou County became one of the largest fires ever recorded in the state (CalFire 2021), and the Lava Fire burned down the slopes of Mt. Shasta, forcing farmers to evacuate (Whitcomb 2021

"We just got smoked in real bad," one farmer said while we were pregnancy checking cows, describing how "the grass just didn't grow like it usually does. Neither does the hay. It slowed things down… Much lighter gain and the cows didn't look as good going into the winter." A County Agricultural Commissioner summarized, "The situation is different, smoke and drought are out of control." Additionally, some farmers noted greater winds associated with warming. One vegetable farmer said, "We get so windy that there's so much more evaporation."

Many farmers from the region described a reduction in snowfall and snowpack over their lifetimes consistent with meteorological observations and climate models (Fig. 2). Farmers often described changes in temperature and precipitation by comparing current farming practices or landscape features to those of the past. Like many older farmers, a retired cattle and hay farmer compared today's conditions to those of his childhood in the 1950s and 1960s by saying, "You could grow usually a pretty good dry land crop, just off of snowmelt, just off the thunderstorms in the summer… now it's noticeably drier. We used to have two, three feet of snow on a pretty regular basis in the wintertime… When I was a kid this whole mountain range here in the springtime, the snow would melt and we'd have water running down sloughs or low spots out to the fields. There was a shallow lake, and it would freeze and we'd go there ice skating. I probably haven't seen water in there for 30 years now."

Farmers often described their memories of a different climate in relation to farm tasks that they used to perform, like regularly digging out snow to feed livestock and carrying feed by sled in winter. Farmers also observed changes in the broader ecology of their farm landscapes, particularly in wildlife migrations, abundance, and winter survival.

These results indicate that farmers in this region (a) acknowledge that the climate is different now than it was in the past, (b) describe similar trends that are observed and predicted by climate scientists, including distinguishing between short-term weather variability and long-term shifts in climate, and (c) describe those differences in terms of their lived experiences of weather.

These observations are consistent with other studies, which find that farmer perception of temperature changes consistently align with meteorological data and climate science literature (Karki et al. 2020; Foguesatto et al. 2020). Across different contexts, farmers' perceptions of precipitation changes tend to be more varied when compared to climate records. Sometimes farmers perceive *less* precipitation change than recorded due to the buffering effects of available irrigation water (Niles and Mueller 2016). Sometimes farmers perceive *more* variation in rainfall than recorded due to the significant negative psychological and economic impact drought events have on farmers, making these experiences and memories particularly sharp and salient (Foguesatto et al. 2020). Like farmers in other high-income country contexts, such as South Africa (Findlater et al. 2018), farmers in northeastern California observed changes and are sensitive to the physical risks of climate change, while still maintaining distinctions between their understanding of weather variability and broader climate change. Importantly, however, I found little evidence that farmers' experiences of physical climate change impacts increased their belief in its anthropogenic causes.

4.2 Farmers discuss changes in terms of weather, ongoing cycles, and harsh geography

Farmers primarily discussed the changes they observed in terms of weather, not climate. This allowed them to hold simultaneous mental models of both changing patterns and random weather events. A cattle and hay farmer said, "Weather pattern has changed. We have much milder winters. I don't know, I don't feel that the temperature fluctuation has been extreme. Some summers are warmer. Some are cooler. Just quite a bit less moisture." Another crop and cattle farmer described milder winters, adding, "Individual weather events, they're just pretty much random."

When asked about climate change, most farmers expressed disbelief in anthropogenic climate change. Many responded that weather is cyclical, offering comments like,

"Things are always changing in cycles" and "Droughts are always cyclical." Some farmers recounted specific cycles of dry or wet weather through multigenerational family histories. As we checked irrigation lines together, a diversified multigenerational farmer, for example, described family journals that detailed "the river going dry in the 1880s for an extended period of time where they drove wagons down the riverbed every day because there was no water." An alfalfa farmer in his 20s told me how his parent's generation described an oscillating pattern of wet and dry cycles back to their childhoods in the 1950's: "It just comes in waves… for guys that have been here for 40 years you see a lot of patterns."

When discussing climate cycles, farmers often acknowledged that weather patterns have changed profoundly during their lifetimes. One mixed vegetable farmer said, "Used to be you could pretty much count on the last freeze Memorial Day in the spring… We could plant in early May now." One cattle and forage farmer explained, "You're seeing drought cycles that are changing from what we were used to in the 70s, 80s, 90s. Now, when you get into 2000, it's been dry, you can see a whole cycle has changed."

Although many farmers remained unconvinced by climate science that documents contemporary anthropogenic changes, some farmers acknowledged paleoclimate science. A cattle rancher told me, "The climate has, is, changing. Just look at history, right? Climate changes over the eons of centuries. We go through cycles and I think we're in a drier cycle is what it boils down to… I know what the scientists say, global warming and the ice packs are melting and doomsday is ahead of us. But I don't necessarily buy into that so much. But I will admit that, yeah, the climate has changed. We are in a drier cycle right now."

Some farmers normalized the extreme changes they experienced in terms of agriculture's exceptional vulnerability to weather and the region's high degree of weather variability. Asked about changes in precipitation and temperature, a sheep farmer said, "Everything changes when you live on a farm. You get up in the morning and you don't know what's going to happen. You have no idea. You get to expect the unexpected." Most farmers noted the harshness of their geography (Fig. 2). While sorting seeds together, a mixed vegetable farmer told me, "So the climate change, I mean our area is so drastic all the time… it's extremely wet, extremely dry, extremely hot, extremely cold."

Farmers often shared specific examples of extreme or "bizarre weather events" they had experienced, like snow on the 4th of July and Memorial Day, as evidence of the general unpredictability of weather in the region. One farmer said, "It's all normal here," and another described the harsh climate as "a mother nature thing." Others noted the "pretty short growing window" that limits what crops they can grow "because it gets so cold" and "goes from cold and wet to hot and dry too quick."

While the majority of farmers said they did not believe in anthropogenic climate change, a small minority differed. A young orchardist said, "I believe in climate change, it's ok." A rancher who raised multiple species of livestock told me, "I think you would be silly to not admit it. I think you're watching one news channel too much… I mean, like it or not definitely our climate's different than the way it was 20 years ago." These private admissions were often accompanied by requests not to be identified within the wider community as deviating from a normative disbelief in anthropogenic climate change. This finding suggests the importance of social group affinity in shaping farmers' experiences of climate change. These farmers were adept at navigating differing social norms within distinct farming groups — sharing climate change belief with some and following social norms of discussing changes in terms of cycles and harsh geographies with others.

Findings that most farmers in this region attribute drought to natural cycles and express skepticism in anthropogenic climate change are consistent with previous studies of farmers and ranchers in the western US (Yung et al. 2015). A study of farmers experiencing

extreme drought in Australia concluded that belief in natural cycles reduced farmers' willingness to adapt and may have been, in part, a strategy to "avoid an obligation to make adaptation responses" (Kuehne 2014, p. 502). Ranchers in Montana who described droughts as part of natural cycles expressed a sense of reduced agency to act, as well as optimism that a cyclically changing climate would return to normal (Yung et al. 2015). While many farmers in this study described climate change as cyclical, they also asserted concerns that those cycles will get worse and that they need to change how they farm, diverging from the findings of previous studies.

4.3 Farmers respond to climate change impacts with a range of adaptations, irrespective of their stated belief in anthropogenic climate change

Every farmer in this study — irrespective of their climate change beliefs or perceptions — had changed how they farmed in response to the impacts of climate change, especially drought. Consistent with Woodmansee et al.'s (2021) finding that persistent drought conditions in California catalyzed ranchers to plan for droughts, farmers and ranchers in this study described droughts as "wake up calls" or "turning points" that spurred them to adapt. As one farmer who raised multiple species of livestock observed, "The drought has kind of shaken people up, saying 'OK this is not a guarantee'." In response to the impacts of climate change, farmers changed both their farm management practices and livelihood strategies.

4.3.1 Farm management practices

Nearly all farmers in this study had invested in new infrastructure and technology (Fig. 3). In response to increasing surface water precarity, farmers were reducing water use, increasing water storage capacity, and favoring groundwater sources. For example, many of the larger farms had replaced irrigation wheel lines with center pivots with Natural Resources Conservation Service funding assistance. A young alfalfa farmer said, "That's one thing I learned, it costs more money, but you've got to try to take mother nature out of the factor as much as you can, whether it's deepening your wells or having storage ponds or something."

About half the farmers I interviewed reported trying water monitoring technologies like soil moisture probes or crop monitoring software, with mixed results and enthusiasm. Several echoed the sentiment of one row crop farmer who said these technologies "didn't tell us anything we didn't already know."

Some studies have found that optimism in technologies can encourage farmers to delay adaptation and reduce their enthusiasm for adapting to climate change (Gardezi and Arbuckle 2020). Farmers I interviewed were not optimistic about technological "quick fixes," but they were realistic about the need to pursue a wide array of adaptations simultaneously, especially options that were easily available and publicly funded. Farmers often noted that input-based technological investments, like new irrigation systems, were encouraged and funded by institutional experts like Natural Resources Conservation Service staff.

Many farmers recognized that input-oriented infrastructure improvements – such as digging wells, or buying pivot irrigation and monitoring software – were helpful in the immediate term. Farmers often noted that these inputs were temporary coping tools that were not designed to fix the underlying trend of decreased precipitation. Some shared their observation that groundwater withdrawals in irrigation-intensive parts of the county corresponded with residential wells going dry. These farmers were articulating several common critiques

Fig. 3 Farmers reported diversifying strategies that improve soil moisture holding capacity and create new market opportunities (e.g., integrating pastured poultry with beef and hay production, left image). Farmers were also investing in irrigation infrastructure like deeper wells and pivots with LESA nozzles (right image). Many farmers described the region's harsh geography and cycles of drought — the bottom image captures the high desert landscape of much of the region, beef cattle grazing, and an irrigation pivot

of "maladaptive" practices that fail to address the drivers of vulnerability and can worsen the problem in the future or for other resource users (Schipper 2020).

In addition to infrastructure investments, most farmers had also changed land management practices (Fig. 3). Many expressed their intent to scale up or adopt field-management practices that would help reduce their reliance on inputs over the long-term. Adaptive field-management practices that increase soil organic matter, like crop rotation or pasture rotation, also offer mitigation co-benefits (Davidson et al. 2019; Gosnell et al. 2020; Petersen-Rockney et al. 2021). Farmers described how, in response to recent droughts, building soil organic matter became an important management goal. While walking through his verdant pastures to move electric fencing for rotational grazing, a young dairy farmer said, "The more organic matter you put in the dirt, the better it's going to hold its water." A vegetable farmer said simply, "Well maintained dirt will see you through a season."

While many farmers had always applied organic matter to their soil, some described recent water scarcity experiences as motivating additional efforts to increase soil organic

matter. Similarly, while most crop farmers had already been practicing some form of crop rotation and (with forage production) intercropping, most farmers cited drought experiences as a motivator for choosing certain crop rotations (e.g., incorporating grain crops into hay and alfalfa rotations) or specific forage species (e.g., planting alfalfa and orchard grass together to increase drought response diversity). Nearly every livestock farmer said that in response to drought they now manage pastures for higher residual dry matter to keep moisture in the soil. Most livestock producers said that they have also increased pasture rotation—some increasing rotation frequency and others implementing adaptive multi-paddock grazing plans. Many cattle producers had added additional livestock species, including sheep, hogs, chickens, and ducks, facilitating multi-species rotations that reduced input costs and spread risk.

With the expectation that current weather trends would persist and intensify, about half of all respondents had adopted new crops or livestock species. While farmers across farm and farmer characteristics were diversifying, women farmers and newer farmers especially emphasized this strategy. Farmers described adding new varieties as offering two primary benefits: spreading the physical risks of extreme weather and enabling them to access new market opportunities.

When making diversification decisions, some farmers explicitly sought farm enterprises that used less water. One young cattle and forage farmer said he added pastured pigs to his operation during the height of the drought in 2012–2014 because, "Pigs don't take a lot of water." A hay farmer added vegetable seed crops, citing a goal of maintaining his income with fewer irrigated acres of higher-value crops. In an interview, a vegetable farmer described her choice of drought-tolerant crops, like rosemary and dry beans, saying, "You know, they say drought places are getting a little drier. It's not like the water is disappearing right? We have a certain amount of water on planet Earth… So maybe I leave the crops that need a lot of water for places that have a lot of water."

Farmers also described downsizing their operations strategically to allocate the water they did have to the most productive land or their most lucrative enterprises. For example, an orchardist prioritized limited irrigation capacity to high-value fruit trees like cherries, allowing lower-value pear trees to die.

Many farmers said there was little they could do about smoke on their farms. Crop or species shifting was one of the only agricultural adaptation options farmers described adopting in response to smoke from wildfires. Some farmers, for example, reported shifting to faster maturing varieties and crops that could be harvested before late summer fire season blanketed the region in smoke so thick, "Grass can't photosynthesize properly," as one farmer phrased it.

Farmers in the region often expanded field-management practices they already employed, or adopted new practices grounded in familiar concepts like soil organic matter that increases water holding capacity. This finding is consistent with previous findings that farmers who already use conservation practices are more likely to increase the scale of those practices (Roesch-McNally et al. 2017) and that observing improvements is itself a significant motivator of adoption (McCann et al. 2015). Yet farmers also experimented with novel, even transformative, adaptation practices, such as early spring flooding to recharge groundwater or managing tree cover on pastureland (adding or removing trees) to provide shade or reduce water uptake, that did not have previous local analogues.

Farmers often implemented reactive coping strategies in response to climate shocks. During drought years, for example, cattle ranchers sold calves earlier and at lighter weights, changed where and when they grazed, prioritized irrigation water to their best pastures, bought hay they did not have enough water to grow, and reduced their herd size.

Farmers who implemented reactive coping strategies often expressed their intent to return to their prior practices when the weather changed, but this was often difficult or impossible. One cattle rancher said, "We have no choice. You can't afford to buy feed… We do herd reductions and then you rebuild, and you do herd reductions, and you rebuild… But it takes a decade or more to rebuild a cow herd, it takes three to four years to rebuild a flock of sheep." Additionally, she explained that returning to prior management is rarely possible because land leases have been irrevocably lost or the timing of calving or calf sales has shifted in an inflexible concentrated market. Adaptations may begin as temporary and reactive,[3] but returning to prior farm structures and practices may be impossible or undesirable (Saliman and Petersen-Rockney 2022). As coping strategies aggregate and continue, they can become proactive adaptations, even leading to transformation (Wilson et al. 2020) as climate crises (e.g., drought and smoke) and non-climate crises (e.g., markets and land access) persist.

4.3.2 Livelihood strategies

In addition to adopting new field-management practices in response to drought and smoke, some respondents also implemented broader livelihood adaptations like seeking long-term off-farm incomes or leaving agriculture altogether. Scholars have long identified flexibility in off-farm employment as an important coping strategy for family farm persistence (Mooney 1982). The majority of US farm households today are reliant on at least one off-farm income (USDA Census 2017). Yet for many farmers I interviewed, recent compounding crises, particularly water scarcity combined with low market prices for hay or cattle, precipitated a shift in how families approached off-farm employment.

Many farm families in Siskiyou described off-farm jobs as temporary in the past. Older farmers often recounted a gendered labor division of seasonal or temporary off-farm work during lean years, wherein men worked in the local logging industry and women in potato packing sheds. Multiple farmers described working as teachers or in construction for a few seasons while they were beginning to farm and paying for land, or starting their families and especially in need of health insurance.

Recent droughts and wildfire smoke have fueled a shift towards understanding off-farm work as a more permanent livelihood strategy. In one family that raised cattle, for example, the mother was taking night classes to become an accountant. As we stood in the barnyard, she described the goal of this common, and commonly gendered, concurrent on- and off-farm career strategy as an effort "To diversify [our] income so [we're] not completely dependent on the weather and the cattle market." Another farmer described, as we collected eggs and fed the laying hens, how she and her husband were both looking for permanent off-farm employment, resigning themselves to farming on nights and weekends. Voice shaking and tears welling, she attributed this shift from being two full-time farmers to needing two full-time off-farm incomes to the previous three years of reduced farm revenue due to low livestock weight gain, which she attributed to wildfire smoke.

The few farmers who shared their belief in anthropogenic climate change during interviews described how climate change directly impacted their farm planning, often shifting away from production and towards offering services like agritourism. For example, during an interview a young orchardist said that climate change was, "Something we thought

[3] Roche (2016) defines "proactive" strategies as those adopted to prepare for future climate impacts, versus "reactive" strategies adopted in response to climate impacts.

about when buying the farm… It is funny that we decided to buy a farm in a community like this… I don't regret buying a farm at all, but I don't know if we would have purchased a fruit orchard in a desert… We start taking out the older trees and not replacing them with younger trees, but replacing them with row crops that would take less water or leaving them open and just having event space." Another farm family had converted part of a hay field into a "u-pick" berry patch – planting strawberries, blueberries, and raspberries – with the hope that the public's willingness to pay for an agricultural experience would help offset lost alfalfa sales as they scaled down their irrigated acreage.

For many farmers, planning ahead meant focusing on concerns about how their children would be able to continue farming. When I asked about climate change beliefs during an interview, one multi-species livestock farmer said, "My poor kids. You know, that's why I love what I do is that we're trying to be carbon positive and using animals to do these things. I mean, we really take that into consideration." While this farmer was unique among those in my sample for his willingness to discuss his belief in climate change, his concerns for the future were widely shared. Nearly every farmer I interviewed expressed hope that the next generation would continue farming and worried that droughts and wildfires — among other challenges — would impede that goal.

But while many farming families hoped off-farm careers or farm-adjacent enterprises would allow them to continue farming, others adopted what Barnes et al. (2017) has called the "transformational" livelihood adaptation of leaving agriculture altogether.

Farmers (and key informants like agricultural advisors) noted spikes in land sales — both voluntary and forced — during intense drought periods. Like economic crises, drought crises create debt and dispossession for some, and accumulation for others (Dudley 2000). Multiple farmers interviewed had bought land as neighbors sold their farms during droughts, especially in the 2001 and 2011–2014 drought peaks. While foreclosures did occur, few farmers were willing to discuss these openly, preferring to emphasize farmers' agency in farm sales. One mixed livestock farmer reflected that, "You actually saw some people here selling off a lot of cattle and driving a brand-new pickup in the peak of the drought. You know, if you're going to cash in your chips… this is a good opportunity for us to walk away." Another cattle rancher observed that, for many farmers, recent droughts and wildfires had been, "Come to Jesus moments when people leave their bad relationship with farming."

Farmers in Siskiyou have adapted to climate impacts irrespective of how they described weather events and trends, or whether they believed in anthropogenic climate change. In addition to short-term adaptive measures in response to climate change impacts (Yung et al. 2015; Takahashi et al. 2019), I found that farmers in Siskiyou were also implementing a range of long-term adaptive management practices and livelihood strategies. Many expressed either the intent to continue these strategies into the future, or that it would be impossible to return to a previous state, even after the drought or smoke abated. As climate impacts increase in intensity and shocks persist, becoming chronic stressors, more farmers and ranchers are recognizing that the physical risks of impacts like drought will intensify in the future, irrespective of beliefs about their causes, and are proactively adopting practices in preparation for those changes (Findlater et al. 2018; Woodmansee et al. 2021).

While farmers elsewhere have identified economic factors, like reduced costs and increased efficiency, as the primary motivation for adopting conservation (Burke and Running 2019) and climate mitigation practices (Davidson et al. 2019), I also found a deeper set of core motivations. Farmers wanted to reduce their water costs, but doing so was not driven solely by a desire to save money (economic rationality) or save water (conservation motivation). Many farmers described a broader motivational orientation in response to confounding crises, predicated on structuring their farming operations

so that they could exert more control over their means of production (e.g., water) and make decisions more flexibly and independently (with less state and market intervention) so that the next generation might be able to continue farming.

5 Limitations and future research

Beliefs and actions are embedded within historical, ecological, cultural, political, social, and institutional contexts and particular places (Karki et al. 2020). Place-based empirical research is limited in its scope and direct applicability to other contexts, but can contribute to understandings of societal significance (Burawoy 1998). Situated in one region and farming context, the findings in this study may not be broadly generalizable to other cultural, political, or environmental contexts.

These findings suggest that the most relevant question may no longer be about farmers' beliefs in climate science or anthropogenic causes, but instead about their actions, especially in contexts where farmers remain skeptical of human contributions to climate change. Beliefs about the benefits and consequences — ecological, economic, social, and political — of implementing various adaptation and mitigation practices are central to developing effective policies and programs that increase the pace and scale of farmers' action on climate change.

The few farmers who stated their belief in anthropogenic climate change, and the many who stated disbelief, were planning for drier and more fire-prone futures while describing these climatic events as just one factor driving them to change their farming practices and livelihood strategies. It is possible that belief in anthropogenic climate change spurs some farmers to adapt more, earlier, or in different ways than their peers who deny climate change's anthropogenic origins, a comparison that would lend itself to further quantitative work. Yet it is important not to overstate the relationship between belief and action, given that intention to adapt and actual adaptation are poorly correlated (Niles and Mueller 2016).

Future research can broaden inquiries that take farmers' perceptions seriously (Karki et al. 2020; Soubry et al. 2020) by asking, for example, how multiple understandings of climate change affect the pace and scale of adaptation and mitigation. The results of this study suggest that new research questions about farmers' beliefs may be productive. For farmers considering adoption of new farm practices and livelihood strategies, belief in anthropogenic climate change may not be essential. Instead, beliefs about the ecological, economic, and social costs, benefits, and tradeoffs of adoption may be more central to individual farmers' decision-making. Additionally, future research could focus on the public institutional actors who operate in boundary spaces between farmers and researchers and policy makers. The ways agricultural advisors, for example, navigate differences between local beliefs and global climate science may be key to understanding how institutions can better support farmers' responses to climate.

6 Conclusion and implications

Crop and livestock farmers in Siskiyou County are implementing varied adaptation strategies in response to climatic extremes, while many simultaneously express skepticism of anthropogenic climate science. This study builds on recent research that begins to decouple

the relationship between belief in anthropogenic climate change and adoption of best management practices (e.g., Yung et al. 2015; Schattman et al. 2016; Davidson et al. 2019; Takahashi et al. 2019). This study highlights novel ways that farmers describe and distinguish weather variability and climate signals; discuss climate change in culturally acceptable terms of harsh local geographies and cycles; and employ both novel field-management practices and livelihood strategies in response to impacts like droughts and wildfires — all while the majority of farmers continue to express disbelief in anthropogenic climate change.

Madhuri (2020) conceptualize farmers' perceptions of climate change as falling into three dimensions: awareness, understanding, and experience. Farmers in Siskiyou County are aware that the climate is changing and experiencing its impacts. This study shows that farmers, even those who express climate science skepticism, both describe meteorologic changes and *distinguish* between weather variability and climate signals. But, like farmers elsewhere in the US, most farmers in this study did not relate those trends to anthropogenic climate change. Instead, farmers described the changes they experienced in terms of the region's harsh geography and ongoing weather cycles.

Attention to the ways that farmers describe climatic events can help policy makers and researchers more effectively support climate change action. Framing drought and other climatic changes in terms of harsh geography and weather may, in some farming contexts, help reduce social risks that farmers associate with climate change (Petersen-Rockney 2022). In the context of extreme politicization around climate change, some farmers may perceive that talking about climate change, or taking actions associated with climate change, can jeopardize access to social network and institutional benefits like reciprocal labor exchanges or porous property boundaries (Petersen-Rockney 2022). Engaging farmers and ranchers in climate change concerns on their own terms, and using locally accepted terminology, may reduce social risk perceptions and enable agricultural advisors and policy makers to work on these issues more effectively.

Results of this study suggest that multiple understandings of climate change do not, however, preclude climate action. Irrespective of belief in anthropogenic climate change, or how they described climatic events, farmers in northeastern California adopted a range of new field-management practices, many with mitigation co-benefits, and shifted livelihood strategies in response to new intensities and persistence of droughts and wildfires.

This study highlights that, as climatic events become more extreme, farmers' belief in anthropogenic climate change may be less important to adaptation action. California's droughts and wildfires foreshadow the future climate, and farmers will continue to adapt to maintain their livelihoods. My findings differ from those of previous empirical research conducted in less extreme climate contexts (e.g., Arbuckle et al. 2013; Nguyen et al. 2016), perhaps because catastrophic (and increasingly frequent) drought and wildfires are now simply impossible to ignore.

Additionally, I did not find that farm or farmer characteristics predicted farmers' beliefs or experiences of climate change. While cattle ranchers, fruit orchardists, and alfalfa farmers grapple with distinct impacts to their operations and experience water scarcity differently, I did not find evidence that enterprise type was a key factor in determining how farmers described changes in climate or were primed to act. Notable, however, were the ways that farmer responses to drought and smoke varied by gender and generation. Livelihood strategies like pursuing off-farm work are gendered, with women in the farm household more often working both on and off the farm. Women and newer farmers often led diversification efforts, by, for example, adding new varieties of crops and livestock. Gender and generation were not, however, key determinants of beliefs or perceptions of anthropogenic

climate change, or whether action was taken in response to its impacts. In this study — across farm and farmer characteristics — farmers' perceptions of themselves in their social context, including group understandings of climatic change and understandings of structural and material access to resources, were more powerful forces in shaping farmers' beliefs, experiences, and actions than how individual farmers identified or what they farmed.

Farmers hold diverse, dynamic, and socially situated identities and motivations (Hyland et al. 2016), as well as understandings of their experiences with weather and climate (Karki et al. 2020). Individual farmers can also hold simultaneous mental models — as many did in this study — of both changing weather cycles and naturally random events. Ambiguity allows divergent motivations to result in convergent action (Eisenberg 1984; Davenport and Leitch 2005): if farmers reduce their water use in the face of drought, does it matter if some did so to save money on electricity, some did so to keep more water in their soil, and some did so because they believe in climate change?

By centering farmers' experiences and perceptions (Soubry et al. 2020), I found that belief or disbelief in climate change's anthropogenic causes was not the main factor determining whether or how they responded to climate impacts. Farmers in this study recognized and expressed concern about droughts and wildfires, but these concerns were often overshadowed by more pressing market forces (Lane et al. 2018; Kuehne 2014). While there are certainly tradeoffs and maladaptive responses to some crises, many changes farmers implement in response to, for example, market disparity and economic precarity, also increase their capacity to adapt to climate change (Kuehne 2014; Chatrchyan et al. 2017). Several studies find that farmers are implementing field-management practices that increase adaptive capacity and offer mitigation potential not in response to climate change, but because these practices offer economic benefits (e.g., Lane et al. 2018; Davidson et al. 2019; De Master et al. 2019). Additionally, the structural barriers to adopting best management practices in response to crises, such as limited resource access and insecure land tenure, often overlap (Ranjan et al. 2019). As farmers navigate a complex landscape of interacting crises, programs can better support them by considering adaptations beyond the field scale. As this study illustrates, farmers are also changing their livelihood strategies in response to changing ecological and policy contexts around climate change.

Policies and programs that increase the pace and scale of adaptation and mitigation action are urgently needed (Findlater et al. 2018). Decoupling climate belief and action opens new possibilities in an era of increased climate change intensity. Leaving belief aside, diverse stakeholders can find common ground by focusing on impacts instead of causes, and solutions instead of blame. Instead of talking about climate change, farmers may respond positively to communication around normalcy (normal vs. abnormal conditions relative to historic climate), temporality (temporary vs. permanent changes), and co-benefits of climate action (Chatrchyan et al. 2017; Findlater et al. 2019; Davidson et al. 2019). Farmers in this study articulated co-benefits of adaptation strategies that motivated when, why, and how they changed their farms in response to climatic events, factors like saving time and money and reducing regulatory burdens (Lane et al. 2018; Davidson et al. 2019). Farmers also articulated meta-motivations that undergird these outcome-oriented goals. Supporting farmers in regaining control over their means of production and building capacity for the reproduction of cultural livelihoods offers a chance to address what matters most to farmers and build adaptive capacity at the same time.

Acknowledgements Thank you to the farmers and key informants who participated in this study, as well as reviewers who helped narrow and shape the manuscript. Thank you to Nathaniel Tarshish for assistance with figure 2 and advice on an earlier draft of this manuscript. Thank you to undergraduate research assistants Alexa Hernandez Benavente and Laura McFarland for help coding.

Author contribution The author collected and analyzed all primary data, drafted the manuscript, and approves this final version.

Funding This work was supported by a National Science Foundation Graduate Fellowship Program.

Data availability The primary data employed in this study is qualitative and protected by IRB Protocol #2018–04-11,036.

Declarations

Ethics approval This research received university IRB approval (Protocol #2018–04-11036). Study participants consented to their participation and the publishing of these data.

Competing interests The author declare no competing interests.

References

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50(2):179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Arbuckle JG, Prokopy LS, Haigh T et al (2013) Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. Clim Change 117:943–950. https://doi.org/10.1007/s10584-013-0707-6

Azadi Y, Yazdanpanah M, Mahmoudi H (2019) Understanding smallholder farmers' adaptation behaviors through climate change beliefs, risk perception, trust, and psychological distance: evidence from wheat growers in Iran. J Environ Manage 250:109456. https://doi.org/10.1016/j.jenvman.2019.109456

Barnes M, Bodin Ö, Guerrero A et al (2017) The social structural foundations of adaptation and transformation in social–ecological systems. Ecol Soc 22. https://doi.org/10.5751/ES-09769-220416

Breakwell GM (2010) Models of risk construction: some applications to climate change. WIREs Clim Change 1:857–870. https://doi.org/10.1002/wcc.74

Brunson MW, Huntsinger L (2008) Ranching as a conservation strategy: can old ranchers save the New West? Rangel Ecol Manage 61:137–147. https://doi.org/10.2111/07-063.1

Burawoy M (1998) The extended case method. Sociol Theory 16 (1):4–33. https://doi.org/10.1111/0735-2751.00040

Burke PJ, Stets JE (2009) Identity theory. Oxford University Press, New York

Burke J, Running K (2019) Role identities and pro-environmental behavior among farmers. HER 25:3–22. https://doi.org/10.22459/HER.25.01.2019.01

CalFire (2021) Top 20 largest California wildfires. CalFire table. https://www.fire.ca.gov/media/4jandlhh/top20_acres.pdf. Accessed 25 Aug 2022

Chatrchyan AM, Erlebacher RC, Chaopricha NT et al (2017) United States agricultural stakeholder views and decisions on climate change. Wires Clim Change 8:e469. https://doi.org/10.1002/wcc.469

Chhetri N, Stuhlmacher M, Ishtiaque A (2019) Nested pathways to adaptation. Environ Res Commun 1:015001. https://doi.org/10.1088/2515-7620/aaf9f9
Coughenour (2003) Innovating Conservation agriculture: the case of no-till cropping. Rural Sociol. https://doi.org/10.1111/j.1549-0831.2003.tb00138.x
Davenport S, Leitch S (2005) Circuits of power in practice: strategic ambiguity as delegation of authority. Organ Stud 26:1603–1623. https://doi.org/10.1177/0170840605054627
Davidson D, Rollins C, Lefsrud L et al (2019) Just don't call it climate change: climate-skeptic farmer adoption of climate-mitigative practices. Environ Res Lett 14:034015. https://doi.org/10.1088/1748-9326/aafa30
De Master KT, LaChance J, Bowen S, MacNell L (2019) Terroir in transition: environmental change in the Wisconsin Artisanal Cheese and New England Oyster Sectors. Sustainability 11:2969. https://doi.org/10.3390/su11102969
Dudley KM (2000) Debt and dispossession: farm loss in America's Heartland. University of Chicago Press
Dunlap RE, McCright AM, Yarosh JH (2016) The political divide on climate change: partisan polarization widens in the U.S. Environ Sci Policy Sustain Dev 58:4–23. https://doi.org/10.1080/00139157.2016.1208995
Eisenberg EM (1984) Ambiguity as strategy in organizational communication. Commun Monogr 51:227–242. https://doi.org/10.1080/03637758409390197
Findlater KM, Satterfield T, Kandlikar M, Donner SD (2018) Six languages for a risky climate: how farmers react to weather and climate change. Clim Change 148:451–465. https://doi.org/10.1007/s10584-018-2217-z
Findlater KM, Kandlikar M, Satterfield T, Donner SD (2019) Weather and climate variability may be poor proxies for climate change in farmer risk perceptions. Wea Climate Soc 11:697–711. https://doi.org/10.1175/WCAS-D-19-0040.1
Foguesatto CR, Artuzo FD, Talamini E, Machado JAD (2020) Understanding the divergences between farmer's perception and meteorological records regarding climate change: a review. Environ Dev Sustain 22:1–16. https://doi.org/10.1007/s10668-018-0193-0
Gardezi M, Arbuckle JG (2020) Techno-Optimism and farmers' attitudes toward climate change adaptation. Environ Behav 52:82–105. https://doi.org/10.1177/0013916518793482
Geertz C (2005) Deep play: notes on the Balinese cockfight. Daedalus 134:56–86. https://doi.org/10.1162/0011526057744315 63
Gosnell H, Charnley S, Stanley P (2020) Climate change mitigation as a co-benefit of regenerative ranching: insights from Australia and the United States. Interface Focus 10:20200027. https://doi.org/10.1098/rsfs.2020.0027
Goss M, Swain DL, Abatzoglou JT et al (2020) Climate change is increasing the likelihood of extreme autumn wildfire conditions across California. Environ Res Lett 15:094016. https://doi.org/10.1088/1748-9326/ab83a7
Haden VR, Niles MT, Lubell M et al (2012) Global and local concerns: what attitudes and beliefs motivate farmers to mitigate and adapt to climate change? PLoS ONE 7:e52882. https://doi.org/10.1371/journal.pone.0052882
Hanan EJ, Ren J, Tague CL et al (2021) How climate change and fire exclusion drive wildfire regimes at actionable scales. Environ Res Lett 16:024051. https://doi.org/10.1088/1748-9326/abd78e
Higuera PE, Abatzoglou JT (2020) Record-setting climate enabled the extraordinary 2020 fire season in the western United States. Glob Change Biol. https://doi.org/10.1111/gcb.15388
Hyland JJ, Jones DL, Parkhill KA et al (2016) Farmers' perceptions of climate change: identifying types. Agric Hum Values 33:323–339. https://doi.org/10.1007/s10460-015-9608-9
IPCC (2022) Summary for policymakers. In: Pörtner H-O, Roberts DC, Poloczanska ES, Mintenbeck K, Tignor M, Alegría A, Craig M, Langsdorf S, Löschke S, Möller V, Okem A (eds) Climate Change 2022: impacts, adaptation, and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press
Karki S, Burton P, Mackey B (2020) The experiences and perceptions of farmers about the impacts of climate change and variability on crop production: a review. Climate Dev 12:80–95. https://doi.org/10.1080/17565529.2019.1603096
Knapp CN, Fernandez-Gimenez ME (2009) Knowledge in Practice: Documenting Rancher Local Knowledge in Northwest Colorado. Rangel Ecol Manage 62:500–509. https://doi.org/10.2111/08-175.1
Kremen C, Merenlender AM (2018) Landscapes that work for biodiversity and people. Science 362:6020. https://doi.org/10.1126/science.aau6020
Kuehne G (2014) How do farmers' climate change beliefs affect adaptation to climate change? Soc Nat Resour 27:492–506. https://doi.org/10.1080/08941920.2013.861565

Lane D, Chatrchyan A, Tobin D et al (2018) Climate change and agriculture in New York and Pennsylvania: risk perceptions, vulnerability and adaptation among farmers. Renewable Agric Food Syst 33:197–205. https://doi.org/10.1017/S1742170517000710

Lequin S, Grolleau G, Mzoughi N (2019) Harnessing the power of identity to encourage farmers to protect the environment. Environ Sci Policy 93:112–117. https://doi.org/10.1016/j.envsci.2018.12.022

Madhuri SU (2020) How do farmers perceive climate change? A systematic review. Clim Change 162:991–1010. https://doi.org/10.1007/s10584-020-02814-2

McCann L, Gedikoglu H, Broz B et al (2015) Effects of observability and complexity on farmers' adoption of environmental practices. J Environ Planning Manage 58:1346–1362. https://doi.org/10.1080/09640568.2014.924911

Menapace L, Colson G, Raffaelli R (2015) Climate change beliefs and perceptions of agricultural risks: an application of the exchangeability method. Glob Environ Chang 35:70–81. https://doi.org/10.1016/j.gloenvcha.2015.07.005

Mooney PH (1982) labor time, production time and capitalist development in agriculture; a reconsideration of the MANN-DICKINSON THESIS*. Sociol Rural 22:279–292. https://doi.org/10.1111/j.1467-9523.1982.tb01063.x

Morton LW, McGuire JM, Cast AD (2017) A good farmer pays attention to the weather. Clim Risk Manag 15:18–31. https://doi.org/10.1016/j.crm.2016.09.002

Nguyen TPL, Seddaiu G, Virdis SGP et al (2016) Perceiving to learn or learning to perceive? Understanding farmers' perceptions and adaptation to climate uncertainties. Agric Syst 143:205–216. https://doi.org/10.1016/j.agsy.2016.01.001

Nguyen TPL, Seddaiu G, Roggero PP (2019) Declarative or procedural knowledge? Knowledge for enhancing farmers' mitigation and adaptation behaviour to climate change. J Rural Stud 67:46–56. https://doi.org/10.1016/j.jrurstud.2019.02.005

Niles MT, Mueller ND (2016) Farmer perceptions of climate change: associations with observed temperature and precipitation trends, irrigation, and climate beliefs. Glob Environ Chang 39:133–142. https://doi.org/10.1016/j.gloenvcha.2016.05.002

Niles M, Lubell M, Haden V (2013) Perceptions and responses to climate policy risks among California farmers. Glob Environ Chang 23:1752–1760. https://doi.org/10.1016/j.gloenvcha.2013.08.005

Niles M, Lubell M, Brown M (2015) How limiting factors drive agricultural adaptation to climate change. Coll Agric Life Sci Fac Publ 200:178–185. https://doi.org/10.1016/j.agee.2014.11.010

Parker C, Scott S, Geddes A (2019) Snowball Sampling. SAGE Research Methods

Pathak TB, Maskey ML, Dahlberg JA et al (2018) Climate change trends and impacts on California agriculture: a detailed review. Agronomy 8:25. https://doi.org/10.3390/agronomy8030025

Petersen-Rockney M (2022) Social risk perceptions of climate change: a case study of farmers and agricultural advisors in northern California. Glob Environ Chang 75:102557. https://doi.org/10.1016/j.gloenvcha.2022.102557

Petersen-Rockney M, Baur P, Guzman A, Bender FS, Castillo F, LaChance J, Mooshammer M, Ory J, Price MJ, Stanley P, Iles A, Bowles T (2021) Narrow and brittle or broad and nimble? Comparing adaptive capacity in simplifying and diversifying farming systems. Front Sustain Food Syst 5. https://doi.org/10.3389/fsufs.2021.564900

Price J, Leviston Z (2014) Predicting pro-environmental agricultural practices: the social, psychological and contextual influences on land management. J Rural Stud 34:65–78. https://doi.org/10.1016/j.jrurstud.2013.10.001

Prokopy LS, Arbuckle JG, Barnes AP et al (2015) Farmers and climate change: a cross-national comparison of beliefs and risk perceptions in high-income countries. Environ Manage 56:492–504. https://doi.org/10.1007/s00267-015-0504-2

Prokopy LS, Floress K, Arbuckle JG et al (2019) Adoption of agricultural conservation practices in the United States: evidence from 35 years of quantitative literature. J Soil Water Conserv 74:520–534. https://doi.org/10.2489/jswc.74.5.520

Ranjan P, Church SP, Floress K, Prokopy LS (2019) Synthesizing conservation motivations and barriers: what have we learned from qualitative studies of farmers' behaviors in the United States? Soc Nat Resour 32:1171–1199. https://doi.org/10.1080/08941920.2019.1648710

Roche LM (2016) Adaptive rangeland decision-making and coping with drought. Sustainability 8(12):1334. https://doi.org/10.3390/su8121334

Roesch-McNally GE, Gordon Arbuckle J, Tyndall JC (2017) What would farmers do? Adaptation intentions under a Corn Belt climate change scenario. Agric Hum Values 34:333–346. https://doi.org/10.1007/s10460-016-9719-y

Safi SA, Smith JW, Liu Z (2012) Rural Nevada and climate change: vulnerability, beliefs, and risk perception: vulnerability and climate change. Risk Anal 32:1041–1059. https://doi.org/10.1111/j.1539-6924.2012.01836.x

Saliman A, Petersen-Rockney M (2022) Rancher experiences and perceptions of climate change in the Western United States. Rangel Ecol Manag 84:75–85. https://doi.org/10.1016/j.rama.2022.06.001
Schattman RE, Mendez VE, Merrill SC, Zia A (2017) Mixed methods approach to understanding farmer and agricultural advisor perceptions of climate change and adaptation in Vermont, United States. Agroecol Sustain Food Syst 42(2):121–148. https://doi.org/10.1080/21683565.2017.1357667
Schewe RL, Stuart D (2017) Why don't they just change? Contract farming, informational influence, and barriers to agricultural climate change mitigation. Rural Sociol 82:226–262. https://doi.org/10.1111/ruso.12122
Schipper ELF (2020) Maladaptation: when adaptation to climate change goes very wrong. One Earth 3:409–414. https://doi.org/10.1016/j.oneear.2020.09.014
Sherman J (2021) Dividing paradise: rural inequality and the diminishing American dream. University of California Press, Oakland
Shukla et al (2019) IPCC, 2019: Climate change and land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/. Accessed 9 Nov 2020
Singh AS, Eanes F, Prokopy LS (2020) Climate change uncertainty among American farmers: an examination of multi-dimensional uncertainty and attitudes towards agricultural adaptation to climate change. Clim Change 162:1047–1064. https://doi.org/10.1007/s10584-020-02860-w
Soubry B, Sherren K, Thornton TF (2020) Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007–2018. J Rural Stud 74:210–222. https://doi.org/10.1016/j.jrurstud.2019.09.005
Swain DL (2021) A shorter, sharper rainy season amplifies California wildfire risk. Geophys Res Lett 48:e2021GL092843. https://doi.org/10.1029/2021GL092843
Swain DL, Langenbrunner B, Neelin JD, Hall A (2018) Increasing precipitation volatility in twenty-first-century California. Nature Clim Change 8:427–433. https://doi.org/10.1038/s41558-018-0140-y
Swain DL, Singh D, Touma D, Diffenbaugh NS (2020) Attributing extreme events to climate change: a new frontier in a warming world. One Earth 2:522–527. https://doi.org/10.1016/j.oneear.2020.05.011
Takahashi B, Burnham M, Terracina-Hartman C et al (2016) Climate change perceptions of NY state farmers: the role of risk perceptions and adaptive capacity. Environ Manage 58:946–957. https://doi.org/10.1007/s00267-016-0742-y
Takahashi K, Mano Y, Otsuka K (2019) Learning from experts and peer farmers about rice production: experimental evidence from Cote d'Ivoire. World Dev 122:157–169. https://doi.org/10.1016/j.worlddev.2019.05.004
Thornberg R, Charmaz K (2014) The SAGE handbook of qualitative data analysis. SAGE Publications Ltd. USDA NASS Census of Agriculture. 2017. United State Summary and State Data. Volume 1. Geographic Area Series. Part 51. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf. Accessed 8.31.21
USDA Census (2017) USDA Census Full Report. https://www.nass.usda.gov/Publications/AgCensus/2017/index.php#full_report. Accessed 20 May 2020
Whitcomb T (2021) "A California county spars over water, marijuana law and race." High Country News. Sept. 7, 2021: https://www.hcn.org/articles/water-a-california-county-spars-over-water-scarcity-illicity-marijuana-and-racism
Williams AP, Cook BI, Smerdon JE (2022) Rapid intensification of the emerging southwestern North American megadrought in 2020–2021. Nat Clim Chang 12:232–234. https://doi.org/10.1038/s41558-022-01290-z
Wilson RS, Herziger A, Hamilton M, Brooks JS (2020) From incremental to transformative adaptation in individual responses to climate-exacerbated hazards. Nat Clim Chang 10:200–208. https://doi.org/10.1038/s41558-020-0691-6
Woodmansee G, Macon D, Schohr T, Roche LM (2021) On-ranch adaptation to California's historic 2012–2016 drought. Rangelands 43:222–230. https://doi.org/10.1016/j.rala.2021.10.003
Yung L, Belsky JM (2007) Private property rights and community goods: negotiating landowner cooperation amid changing ownership on the Rocky Mountain front. Soc Nat Resour 20:689–703. https://doi.org/10.1080/08941920701216586
Yung L, Phear N, DuPont A et al (2015) Drought adaptation and climate change beliefs among working ranchers in Montana. Weather Clim Soc 7:281–293. https://doi.org/10.1175/WCAS-D-14-00039.1