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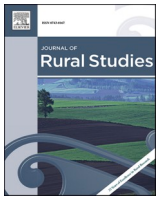

Drought, water management, and agricultural livelihoods: Understanding human-ecological system management and livelihood strategies of farmer's in rural California☆

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ABSTRACT

Mitigating impact between agricultural livelihoods and water conservation efforts in the face of significant drought requires a sophisticated understanding of policy efforts enacted to manage water supply and the logic of human livelihood decision-making. This case study extends literature on human-water decision-making in agricultural areas by using a political ecology framework to understand how and why farmers facing significant water shortages make livelihood decisions, and how such decisions are affected by broader socio-political contexts. Specifically, we focus on farmers' livelihood strategies in the Central San Joaquin Valley of California. Here, the effects of extreme and persistent drought have resulted in a resource management governance structure that forces farmer decision-making within the narrow bounds of the newly emerging California water policy. We argue that government public policy intervention has created a potential system of "big winners and big losers," leading to three divergent strategies farmers adopt: N*imbility, Abandonment, and Policy Engagement.* These findings raise questions about how policy interventions shape livelihood strategies of farmers in the Tulare Lake Basin and by extension other areas where public policy intervention is emerging to respond to decreased water supply resources.

1. Introduction

This article chronicles the livelihood strategies of farmers in Central California's Tulare Lake Basin in the wake of the implementation of California's landmark water management policy: The Sustainable Groundwater Management Act (SGMA). The Tulare Lake Basin is a region that has found itself at a critical time of transition under this new water governance structure. Here the long-term impact of drought, the challenges of climate change, and issues of water scarcity weigh heavily on residents. The basin is home to one of the most productive agricultural economies in the world and the primary crops of the area require irrigated farming, meaning that the Tulare Lake Basin's main economic driver and the main way water is used are among the most water intensive practices, placing increased stress on groundwater levels. Since 2013, 4307 wells have gone dry in the Tulare Lake Basin—a number of which accounts for over 77% of all wells gone dry in California (Dry Well Reporting System, 2023). In this environment farmers face tough choices regarding crop rotation, irrigation, and must continually assess if the benefits of farming in the region outweigh the risks of farming under adverse conditions.

Broadly speaking the human water dynamics in the Tulare Lake Basin are representative of the tensions that exist between farmers, water use, and natural resource governance in California and rural and peri-rural regions of the US generally. Groundwater is one of California's greatest natural resources, making up a significant portion of the state's water supply and offers a buffer against drought and climate change for agricultural actors and the residents of the region. Groundwater also serves as a major source of the state's total drinking water supply, and helps replenish streams, creeks, rivers, and wetlands that support wildlife. It is also the key resource used to irrigate crops and produce food in agricultural areas of California Sustainable Groundwater Management Act (SGMA). Since 2000, California has been plagued by

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significant periods of ongoing extreme drought and an overreliance on groundwater in the Tulare Lake Basin has made the area one of California's most critically over drafted groundwater basins (NIDIS 2024). In 2014 SGMA was enacted by the California state government to stop the overdraft of groundwater basins statewide and bring these regions into balanced levels of pumping and recharge. Citing climate change and the threat of prolonged drought to the state, SGMA established a new framework for how groundwater would be managed locally and required existing local governmental agencies to form Groundwater Sustainability Agencies (GSAs) in over drafted basins. GSAs were charged with designing and implementing Groundwater Sustainability Plans that would achieve long-term sustainable management of groundwater basins by balancing water outflows and inflows, determining "water budgets" and water allocation in groundwater Basins, and protecting or restoring groundwater quality and quantity throughout the state Sustainable Groundwater Management Act (SGMA).

Over the last decade research has begun to track the implications this new water governance system presents for farmers and agricultural areas in California and more broadly, studies have addressed water management schemes in California and across other drought-stricken areas of the US (Glieck, 2003; Escobedo Garcia and Ulibarri, 2023; Lund et al., 1992). Yet, there is a narrower—and far less developed—area of literature focused on the perspectives of farmers and the livelihood strategies employed by those who live in drought impacted agricultural areas—particularly in the United States. The aim of this article is to address this lacuna in the literature by moving beyond current drought-community dynamics to include farmer voices and identify broader systems that influence farmer's livelihood choices when facing resource scarcity.

Our analysis demonstrates that, in the case of the Tulare Lake Basin, the effects of extreme drought on the existing water supply have resulted in the enactment of new governance structures that place farmer decision-making within the narrow bounds of SGMA. We argue that government regulation of water resources in response to severe drought conditions has created a potential system of "big winners and big losers'' as one of our participants described—wherein water scarcity, land abandonment, and the deconstruction of the social fabric in the region have led to three divergent livelihood strategies for farmers. For some farmers, becoming involved in local water politics has become a way to make their voices heard and advocate for specific courses of action, resulting in a strategy of *Policy Engagement*. Other farmers choose to continue farming within the new guidelines of policy albeit with different crops, a strategy made more viable by incentives and subsidies. We term this strategy the *Crop Nimbility Strategy*. Lastly, some farmers choose to abandon farming, selling off their farms and some moving out of California altogether. We refer to this as the *Abandonment Strategy*. Our findings raise questions about the unintended consequences of public policy within complex social-ecological systems that shape livelihoods and the decisions made by farmers in areas where policy intervention is an emergent response to decreased natural resources in the face of climate change.

The article is structured as follows. We begin with a review of the literature surrounding human water dynamics and the impact of climate change on water systems and livelihood strategies of farmers and place this within the context of California and the Tulare Lake Basin. This constructs an analytical framework for our analysis and offers a synthesis of the context of the larger conditions that require understanding to make sense of the local dynamics surrounding farmers in the Tulare Lake Basin. We then discuss our research strategy and study design before reporting findings gathered over the course of a five-year study of the region. The article closes by reflecting on the findings of our study and provides a discussion within the context of future policy development.

1.1. Literature review

Agricultural economies are part of complex social-ecological systems that consist of value systems, various actors, and community ties. Literature suggests that social-ecological systems (SES) are organized by interacting sets of ecological processes (natural systems) and social institutions (human systems) (Shelton and Eakin, 2022). Recent scholarship has specifically employed SES frameworks to understand the intersections of institutional, social, and ecological drivers of rural economic change (Cumming and Peterson, 2017). These studies highlight the importance of how interactions and interdependencies between institutions, cultural mores, political systems, and the environment shape the ways in which rural economic change occurs amid environment crises, and how regions adaptively respond to climate change to transition to create new ways of living. In this view, policy processes and government actions are particularly important in shaping and constructing an SES—particularly during times of environmental challenges such as drought.

Policy processes engage a diverse set of actors who become involved in various stages of the policy-making process and who have differential access to power and influence within these policy processes. For particularly complex policy issues—like climate change, environmental disasters, and natural resource management—these diverse sets of actors are often characterized by divergent perspectives and competing interests which can make policy discussions rife with political conflict. Moreover, even within specific groups of policy actors and stakeholders, the impacts of policy preferences and outcomes are varied which can lead to contentious policy debates and uneven impacts.

The Tulare Lake Basin is one example of a place where drought alleviation policies have had varied impacts among stakeholders - particularly agricultural workers and farmers, who have been directly affected by such policies. The basin is one of the most productive agricultural regions in the world, with over 20,000 km2 of irrigated farmland which yielded a total value in agricultural products of over $113 billion in 2022 alone (California Agricultural Statistics Review 2022, 2023). Throughout the region and in the face of diminishing water supplies due to drought periods, groundwater overdraft—a practice of pumping water out of the ground beyond its replenishment rate has been a reality for most farmers in the area (Hanak et al., 2020). Groundwater overdraft has led to long-term declines in groundwater levels and has impacted the water table of the region resulting in the drying out of irrigation wells. In turn, increasing amounts of energy are required to pump water as more wells are drilled, searching ever deeper for groundwater in the wake of diminished supply. In 2021, about 640 new wells were drilled in the region, marking a 14% increase from the previous year (Kasler, 2021).

Since the early 2000s, water supply challenges facing the Tulare Lake Basin have drawn attention from state policymakers and were taken into context with broader concerns of the state, resulting in SGMA's enactment in 2014. The act required localities across the state to put plans into place that would bring groundwater use to sustainable levels. Due to the Tulare Lake Basin's outsized use of groundwater for agricultural irrigation, research has long argued that SGMA will have a significant impact on the basin (Singh et al., 2021). As a resource management policy, SGMA requires local governments and water agencies who have high and medium-priority basins in their jurisdiction to stop groundwater overdraft practices and bring groundwater basins into balanced levels of recharge and pumping by 2040 (San Joaquin County Flood Control and, nd). The Tulare Lake Basin is flagged as a high and

medium-priority basin, and under SGMA the local government was required to develop groundwater sustainability agencies (GSAs), who were responsible for drafting, developing, and implementing, groundwater sustainability plans (GSPs) to manage long term solutions for groundwater sustainability.[1] As of current, the Tulare Basin consists of seven groundwater sub-basins: Kings, Kaweah, Tulare Lake, Pleasant Valley, Westside, Tule, and Kern. Each of these sub-basins has 1 to 11 different GSAs (Groundwater Sustainability Plan, 2020a; Groundwater Sustainability Plan, 2020b; Groundwater Sustainability Plan for the Pleasant Valley Basin, 2019; Kings Subbasin Coordination Agreement, 2019; Sustainable Groundwater Management Act Groundwater Sustainability Plan, 2019; Tulare Lake Subbasin Groundwater Sustainability Plan, 2020; Westside Subbasin Groundwater Sustainability Plan, 2020).[2]

As designed the water governance structure across the Tulare Lake Basin is complex and quite diverse in structure, and regulations vary with each GSA. For example, one GSA using their regulatory power to allocate each parcel of land a base supply of water which landowners can pump out in a given year. The base supply is variable, depending on yearly water conditions. If a landowner pumps above the baseline (11-acre inches to 1.8-acre feet per acre) they will be charged $75 per acre-foot. Anything above this will be charged $125 and any water pumped beyond 2.8 acres feet enters a penalty tier and will be charged $500 per acre foot. Users who choose to fallow land can carry over their base supply of allotted water through the first five years. Other GSAs have been unable to create distinct types of plans that still meet the state standards. These variations in plans presents implications for the future viability of farmland in these regions and presents a myriad of decision matrixes that farmers must anticipate and make decisions within.

As a policy framework, research suggests that SGMA holds several significant implications to farmers in the Tulare Lake Basin. For example, SGMA mandates that farmers must cut groundwater use by 40%. But, to do so, research suggests productive farmland would likely need to be fallowed to reduce pumping, that water intensive crops (such as almonds) would need to be rotated with less water intensive crops to meet sustainable measures, and that farmers who grow feed crops such as hay, may have to discard that crop altogether as the cost to irrigate it generally outweighs its market value (Lauten-Scrivner, 2022). Agricultural lobby groups have further argued that these regulations will lead to hundreds of thousands of acres of nut tree fields being fallowed over the next decade which constitutes a significant farm revenue loss for the region (Allen, 2022). Together this body of literature suggests that SGMA may not result in positive economic change for the region in the long term and will alter long-standing agricultural practices in the area. Yet, little systematic and grounded research has been done to understand the impact of SGMA on agricultural practices in the region.

Moreover, the enactment of SGMA has further exposed tensions between farmers who have the monetary and social capital to adhere to the new associated rules and regulations and farmers or other agricultural actors who may not have the resources to make infrastructure changes necessary to adhere to the new policy. Such tensions are not surprising given scholarship has demonstrated that the impacts of resource management policy—particularly surrounding drought alleviation and water supply—are uneven given that they are shaped by socio-political structures (Bakker, 2007). Research on water policy and agricultural practices argues that policymakers are able to adapt water and resource management policies concerning climate change risks at a macro level. Yet, it is the local needs and resources that impact the overall desire for and efficacy of resource management policies due to the large number of stakeholders clamoring for their respective needs to be met. This suggests that adaptations focused on the macro-level may not be sufficient for accounting for localized realities that are responsible for constructing a complex social-ecological system like watersheds in agricultural areas (Leiserowitz, 2006). This point was illustrated by Iglesias and Garrote (2015) who considered water use adaptation strategies across Europe and found that the two main consequences for changes in agricultural water use through public policy were: 1) an increase in demand and 2) reduced water supply. They argued that there is a critical need to understand how stakeholders perceive the role of climate change in influencing water supply as such perspectives influence policy efficacy on the ground. Savelli et al. (2020) further extended this to suggest a need to understand how social power influences socio-hydrological processes and the success of public policy interventions related to water scarcity.

Specific to California, studies find similar findings regarding a trend in the over-drafting of groundwater and asymmetrical allocation of water supply to the benefit of users with considerable social and economic capital (Stewart et al., 2020). Research around the Tuolumne Watershed found that water supply in the watershed remains reserved for economically well-off users in urban areas, often unaffected by drought conditions. In contrast, rural users in the Central Valley of California—the largest agricultural producing region in the nation—had water flow reduced by 30% during drought periods (Stewart et al., 2020). Moreover, agricultural water management practices in the context of California agriculture place significant emphasis on farmers' ability to adapt to reduced water supply, not as a temporary condition but as a permanent state. However, these practices fail to understand the consequences of these types of adaptation conditions. Berbel and Esteban (2019) found that while policy responses have shifted slightly away from a crisis reactionary response to a proactive approach of resource management based on risk calculations, advances in irrigation technology and practices have not offset the overuse of agricultural water supply – which is the root issue such technology is meant to address. This suggests agricultural water users have had to adapt to drought as a constant crisis reactionary condition, despite advances in hydrological technology—which could indicate the inability for technology to effectively aid this area of climate change mitigation. This has the capacity to significantly influence water use and decision-making strategies implemented by farmers in California for the foreseeable future and holds implications for livelihoods strategies enacted in the face of climate change and persistent drought.

A large multidisciplinary body of work surrounds livelihood strategies in regions that are impacted by climate change and drought. This research highlights how adjusting to new ways of making a living in these regions entails costs for all residents but tends to substantially benefit those who have more access to various capitals (financial, social, natural) (Roncoli et al., 2001; Seif-Ennasr et al., 2016; Zobeidi et al., 2022). Research undertaken within the sustainable livelihood framework shows crop diversification is a key tool used to buffer crop production uncertainty caused by droughts (Adato and Suseela Meinzen-Dick, 2002; Sajjad and Nasreen, 2016). Williams and Carrico (2017) conducted household surveys in Sri Lanka to identify factors that influence how farmers adapt to water scarcity, finding that farmers use hybrid seeds to adapt to climate change and that those seeds positively correlate with farmers' rice yields, suggesting a net positive in terms of crop production. Other studies have examined farmers' decisions about land use and resource allocation, specifically choices regarding agricultural water use as part of adaptation methods (Barron et al., 2009; Varela-Ortega et al., 2011). Such studies highlight the need to better understand human-water dynamics in addressing water scarcity in agriculture.

Research surrounding the relationship between social ecological

[1] The California Department of Water Resources determines a basin's priority category based on a ranking system where points are assigned primarily through eight categories: population, population growth, number of public supply wells, total wells, irrigated acreage, reliance on groundwater, impacts on groundwater, and other relevant information.

[2] GSPs were submitted by each of the sub-basins in December 2019 or January 2020. All have since been approved or are in the processes of amending based on state recommendations.

systems and drought has also shown that public policy enacted to address water scarcity tends to be overly focused on the making and enforcing of rules and regulations about water use rather than the integration of adaptive strategies and new livelihoods for those impacted by these regulations. For example, Seif-Ennasr et al. (2016) analyzed 38 climate change adaptation measures in the Chtouka Ait Baha region in north-western Africa. They found that large agribusinesses in the region continued to overdraft groundwater, which underscored the development of policies by regional administration to address water deficits (i.e., groundwater contracts) and led to significant variations in response to such regulations by agribusinesses. Yet, the role farmers play in shaping public policy related to water supply regulation and allocation in the literature has remained focused on the actions of a few powerful actors with strong social ties, strong levels of policy influence, and even stronger financial capital. Thus, there exists a lacuna in the literature in relation to how local agricultural actors influence policy from the ground up. We contribute to the literature by examining the livelihood strategies of farmers in a region of high-water scarcity to empirically explore the hypothesized potential of public policy to shape social-ecological systems in equitable and sustainable manners. Such an examination holds implications for research and policy and makes this an imperative area of study to which this article now turns.

1.2. Research methods and study design

The analysis presented here developed from a large study funded by the *National Science Foundation* (NSF) focused on the impact of water conservation policy, strategies, and technologies of the coupled human and natural water system in the Tulare Lake Basin of California. The 5-year multidisciplinary study sought to understand the complexity of water policy implementation in California at the height of the state's historic drought. The research team was also interested in articulating the impact that water resource policy decisions had on multiple stakeholder groups in this highly water stressed region to inform policy learning. How did farmers perceive the relationship between groundwater overdraft and drought resilience or the tradeoff between current and future productivity? How did farmers in the region perceive the utility of alternative water management strategies and how did this impact the livelihoods of various groups of stakeholders? What strategies were available to agricultural stakeholders and community residents to further their resilience or vulnerability to external drivers and changes as it related to issues of water supply? These questions guided a 5-year multi-disciplinary study undertaken across the 4 counties in the Tulare Lake Basin of California.

Our research team wanted an approach that could explain and explore additional aspects of various stakeholder groups and their experiences including how stakeholders more generally ensured subsistence and well-being in the face of diminishing water supply. The idea of livelihood strategies emerged as a methodology given how previous research undertaken in the global south and European contexts had utilized this approach to understand stakeholder actions and decision-making in the face of limited natural resources highlighting the importance of familial resources, crop selection, and social cohesion in facilitating adaptive responses for farmers. As a methodology, livelihood strategies, refers to the understanding of the range of and combinations of activities and choices people make in order to achieve their livelihood goals based on their own goals, resource bases, and their understandings of the options available to them. Such a method entails understanding how strategies account for short term considerations such as ways of earning a living or conducting business, coping with shocks, and managing risks within the context of the local institutions and processes directly and indirectly influence livelihood strategies (Malleson et al., 2008).

Data for this article was collected during 36 months of ethnographic fieldwork conducted between 2018 and 2022 in the Tulare Lake Basin of California. For the purposes of this article, we focus on data collected from ethnographic field research activities during the period with 48 farmers across the Tulare Lake Basin who participated in our study. Of the 48 farmers included in this analysis, all but 3 were male—almost 80% identified as white while 15% identified as Latino, and 5% identified as some other race or chose not to identify with an ethnic/racial group. This profile was representative of the demographic profile of farmers in the region. Data was also collected through ethnographic fieldwork in the region more informally including participation in policy meetings, community engagements and activities, and farm visits.

Formal interviews were recorded and transcribed. Interview texts were analyzed by the authors using NVivo qualitative data analysis software. Additional informal interviews and ongoing participant observations were undertaken throughout the 36 months of fieldwork. Participant observations and interviews were conducted by a four-person research team that consisted of two of the authors and two research assistants. Two members of the research team are familiar with the area, having lived or worked in the Central San Joaquin Valley for a combined total of 26 years. However, no members of the research team had previously engaged in agricultural business or water policy discussions in the region. Given the research team's ties to the region, we were positioned as "insiders" to the regional context, but "outsiders" to the situations under study. Throughout our fieldwork, team members wrote reflexivity memos to consider social positions and relationships with individuals and settings which they interacted with and observed situations.

To capture dimensions of how farmers-built livelihood strategies in the face of changing policy and environment conditions, as well as to understand how farmers were adapting to changing environmental conditions, we deployed a comparative multi-case analysis approach treating each farmer as an individual "case." Data underwent three stages of analysis, moving progressively from descriptions to themes to assertions (Creswell, 1998). Open and closed coding techniques were utilized to identify themes that emerged across all interviews alongside fieldwork observations. Data was triangulated with the primary goal of capturing plural and contested perspectives from multiple data sources, and a secondary goal of identifying convergence and minimizing bias across cases. Such a process is appropriate for understanding complex social phenomena across scales and contexts—particularly when aspects of the subject of interest are not well understood (Mathison, 1988; Yin, 2004). In seeking to delineate respondents and their livelihood strategies, great care was taken to ensure they would not be personally identifiable. All names and places have been changed in this article to help preserve anonymity. From these efforts, three general types of livelihood strategies of farmers were illuminated.

In the next section, we present data that show how farmers in the Tulare Lake Basin have adopted at least three livelihood strategies in response to these changes including adapting crop rotation, the abandonment of farming, and engagement in water policy governance.

1.3. Agricultural livelihood strategies in the Tulare Basin

Most, if not all, basins in the San Joaquin Valley are identified as critically over drafted, including all the sub-basins of the Tulare Lake Basin. In total, the San Joaquin Valley in 2022 was over drafted by 8-million-acre feet (Philips, 2022), which translates into significant levels of competition for water resources. The question then arises: what are the livelihood strategies and land use decision-making strategies of local farmers and how have those farmers been impacted by the implementation of SGMA? How are farmers responding to living in areas where scarce water resources have generated policies that may create further restraints? In the case of farmers in the study area this competition, coupled with the impact of California's droughts, has forced them to consider different methods of adaptation. It is important to note that none of the livelihood strategies are exclusive and some overlap – meaning that farmers may undertake one or more of these strategies at a particular time dependent upon context.

1.3.1. Crop nimbility strategy: diversifying and switching crops to survive

Switching crops is a long-standing adaptation strategy in farming and is not a new strategy for farmers in the Tulare Basin or other areas impacted by climate change and drought. It is also a common strategy to keep agricultural lands productive. Yet, with recent SGMA regulations crop rotations, land use, as well as resource management decisions have become less about keeping land productive and more about reducing groundwater overdraft to comply with groundwater sustainability plans. Our findings show that in efforts to comply with sustainability plans, farmers have moved to three primary crop switching strategies: fallow fields, switching to less water intensive/lower revenue generating crops, and installing solar panels on previously productive lands.

1.3.1.1. Fallowing fields. During non-drought periods, fallowing is a farming technique where arable land is not planted for one or more planting cycles. This allows for land to recover from the stress of planting, allows for the recovery of moisture, and can reduce parasitic insects by removing the host crop. In the Tulare Basin, field fallowing allows farmers to reduce groundwater pumping in the region. However, this is not without a significant cost. While the implications of adapting to SGMA have yet to be fully seen, it has been suggested that up to 1 million acres of land will need to come out of production in the San Joaquin Valley by 2040 to reach the needed level of groundwater demand reduction (Hanak et al., 2020). This means millions of dollars in lost revenue for farmers, the communities in which they are located, and job losses in agriculture adjacent industries due to the loss of activity. Robert, an owner of a medium size dairy farm in the study region told us:

> ROBERT: So, I've decided to fallow at least one of my parcels each year perhaps one permanently at this point. It's a loss of revenue, but I've planted pistachios on another parcel so that will help to cover the cost. Maybe in a few years, I can switch the fallow land to solar panels. Some community groups are suggesting we could donate fallowed land to public land use like parks, but it's really hard to plan for the long term risks of fallowing the land in such a way like that. My priority is trying to lessen the spillover effects of these decisions on my workers and their families.

The risks associated with fallowing land that Robert highlights have led some communities in the Tulare Lake Basin to offer financial incentives to offset lost revenue. For example, one irrigation district has proposed to pay farmers to fallow acreage, about 1100 acres in total so it can then sell the resultant 4000-acre feet of water to buyers located outside of the county, which is estimated to result in about $1.6 million of revenue. The major downside of this is the selling of water to those outside of the community, which many of the farmers in our study indicated was not a preferable nor positive outcome. Another program sold 12,000 acre-feet of water allotted from fallowed land for $14 million to other farmers in that jurisdiction. The key difference between these two programs is that in the second example, the water stays local with the stipulation that the water must be used on farms located in the broader Tulare Basin. Farmers in our study noted that this was preferable as it kept water within the region and in their view by extension supported the local agricultural economy which was taking on the burden of this program.

1.3.1.2. Solar panels. Another crop nimbility strategy utilized by farmers has been to install solar panels on productive fields in place of agricultural crops. Ayres and Seymour (2022) estimate that solar panels could cover up to 500,000 acres of San Joaquin Valley that will need to be fallowed to comply with Groundwater Sustainability Plans; suggesting that this may be a viable way to repurpose fallowed farmland. Despite this, solar panel installations remain few and far between and farmers have not wholesale taken up the cause. While solar farming is increasing in the broader contexts of the Central San Joaquin Valley of California, it is still relatively small. As of 2022, there were 22 solar farms in Fresno County and 35 in Kern County, occupying in total about 28,000 acres (Current Solar Project Information, 2022; Master Kern Solar Projects List, 2022).[3] This is about 5% of 2022 crop acreage, which is substantially less than some of the key crops in the region including almonds (17%), pistachios (14%), and tomatoes (7%) (Crop Report 2022, 2022). A closer look into the types of farms who are adopting solar panels, indicates that those with large economic capital are the primary adopters while smaller and medium sized farm are less likely to adopt. Prosperity Orchard, a major Fresno based almond producer has built 160 acres of solar on their land. Prosperity Orchard's yearly revenue is around $15 million, making the farm one of the wealthiest landholders in the region. The assumption is, that with the ability to build on 160 acres of land, Prosperity must be able to make a profit off the rest of the productive acreage on the orchard. To put Prosperity's size in perspective, the average farm size in California is 348 acres (California Agricultural Statistics Review 2019-2020, 2020). As a representative of Prosperity Orchard told us:

> **MARK:** In many cases we were lucky, we have been able to turn this crop switching decision profitable. It's likely not going to be an answer for everyone—like other crops overproduction in one will lead to saturation in the market- as we saw in almonds. There are other reasons to be hopeful though that solar production may be profitable given future policy directives likely to emerge from the state regarding energy, but it's really hard to know. The risks in adopting any of these strategies is very real to those of us on the ground here, all of us who work these lands- whose livelihoods depend on it.

1.3.1.3. Crop switching: from almonds to pistachios. From corn to sorghum. Keeping land in production with minimal irrigation includes switching to less water intensive crops. In extreme examples, our participants described future farming practices in the Tulare Lake Basin could come to resemble those in arid regions, where crops such as winter wheat grow during the rainy season with less irrigation than a crop grown during the summer. All our respondents also described the enormous market pressures they were facing when making planting decisions. As one small scale farmer responded to our question 'how do you decide what to grow?':

> SAM: Let's be real, how much money you must invest in planting will guide what crop you can change to. For us it depends on the milk price. We grow Sorghum instead of corn because there's not as much water'. While market forces have always influenced which crop to plant, the pressures from this drought add additional monetary pressures. Then there's the risks of going to a crop that may lead you to financial ruin if say water allocation changes in the next year. We could always sell the water that we don't use of course, but I'm a farmer and I'd like to use that water to support the crops on my farm.

Taken together, the evidence suggests crop switching may be the most immediately pressing livelihood strategy for most farmers in the region. The primary factors pushing and pulling farmers to adopt a Crop Nimbility Strategy appear to be rooted in a "wait and see" strategy that can offer farmers the opportunity assess the impact of SGMA over the long term. It is important to note that the decision to switch crops comes with a series of costs and risks to growers and many farmers we interviewed indicated that the risks coupled with the unknowns of SGMA make it difficult to move to a decision such as fallowing land or changing to solar panels. Instead, most appeared to favor a switch to less water intensive crops to "buy time" to better understand the longer-term implications of SGMA and the natural changes to the watershed as California emerges from this historic drought. In this sense "crop switching"

[3] Determined by Fresno and Kings County solar projects records as of 2022, only inclusive of current approved solar farm projects in both counties.

could also be considered a maintenance of the "status quo" wherein farmers can stay in the game longer as the effects of SGMA become clearer.

1.3.1.4. ***Abandonment strategy:*** *selling off & moving out of California agriculture.* Some farmers who participated in the study noted that the implementation of SGMA has created a variety of new options for farming in the region including the option to sell land to developers, major investment companies, government entities, and nonprofits. For some, this has resulted in pursuing a strategy of leaving California agriculture altogether. Evidence from our ethnographic observations suggests the advent of water rights and water markets under SGMA may have induced larger farmers to buy up smaller farms either in land acreage or in water rights. The main buyers in this scenario have been major landowners previously established in the region—although there are new entrants into the market who were previously unestablished actors in the region as well.

All the farmers we interviewed—regardless of farm size or product—mentioned that large landowners have a significant advantage in new water markets given the skewed nature of who has money to buy water and who does not. For some, it is this imbalance that has fueled their decision to leave. As one farmer Jolene noted "It's really about an imbalance between supply and demand, and that's the root cause of the issue and while the supply of water in the area has decreased, the demand has stayed the same" (Personal Interview, 2021). This quote considers a few issues. First, while the supply of water has been decreasing, the planting of crops has stayed relatively the same and, in some areas, even increased throughout drought years in California. From our participants' perspective this was—at least in part—due to the difficulty in regulating groundwater, well drilling practices, and partly due to a reluctance of farmers to change to drought tolerant crops as these often command less revenue in the marketplace.

It is worthwhile to contextualize the California water market here to better understand the perspectives raised above. The California water market is a complex system through which cities and farms can purchase short or long-term leases of water during periods of drought. These sales are implemented by the California State Water Resources Control Board with the intent to curb the impacts of water scarcity across the state. Without the markets, water rights in California function on a seniority basis, wherein the permit holder who has held their water rights the longest, gets priority of future use - under the principle of "first in time, first in right." (The Water Rights Process, 2020) This becomes an issue during drought years when there is limited water access.

During periods of drought "first in time, first in right" ignores the actual value of land and functions based on tenure alone. Ideally, in this system, the scarce water supply would instead be allocated to agricultural land with the highest production value. The market system aims to alleviate this through the facilitation of the sale of water rights from senior but lower-value producers to junior higher-value producers (Schwabe et al., 2020). However, there are complicating factors related to this water market system. Liberalizing the water market relies on the willingness of senior lower-value producers to want to sell their water rights to higher-value producers. There are also considerations of accessibility relating to the cost of water rights, issues regarding the transportation of water purchased, and overall increased demand due to climate change (Arellano-Gonzalez et al., 2021). Such costs also underscore a power differential between large and established landowners and smaller farms with less capital resources.

Yet, the decision to sell agricultural productive land is not an easy one for farmers to make and has been fueled by human resource issues as well. Many of our participants discussed how personal ties and familial affinity to the land have kept them in place for years (many farms have been in families for generations). However, farmers also noted that, for many of them, there was no "heir-apparent" to continue the farm once they retired, as younger generations were opting to take jobs outside of agriculture, a trend which has been identified by studies of older youth in the region (Visser et al., 2021; Visser, 2018). Such a reality makes the prospect of selling land, eventually or in the near future, a timely choice for many small and large family based agricultural industries in the region. As Chris, one dairy farmer told us:

> **CHRIS:** I'm lucky, my daughter is interested in keeping the dairy going and has been part of the business for a few years learning so she can take over when I retire. Saul (the farmer next door), his kids are engineers. One moved to Oregon and one to New York City, there's no one to take over the family farm that has been in his family for at least 3 generations. That's why he sold his land to a major investment group and is getting ready to retire out to Arizona. (Personal Interview, 2021)

Evidence from public documents and recent reports from the region further suggests major investment groups have also helped drive land values upward making it a lucrative decision to sell arable land, water rights, and exit California agriculture. Pension funds and insurance companies have made entry into the region in pursuit of diversifying portfolios through land purchases—many of them in permanent plantings such as nuts. For instance, Prudential and Harvard University were notable purchasers of land in the Tulare Lake Basin from 2018 to 2021 (Gold, 2018; The San Joaquin Valley Sun, 2022; San Joaquin County 2021 Crop Report, 2022). With the implementation of SGMA, many of these land buyers sought out land with at least two sources of water on properties citing SGMA specifically as a concern that it would make some land more profitable than others. As Daniel, a farmer who had been experimenting with drought friendly crop watering strategies stated,

> **DANIEL:** "While these major investment groups are looking at SGMA as an opportunity, rather than a concern - it has created an interesting situation for farmers who hold land that only have access to groundwater. These farmers will have a harder time selling. Thus, while major buyers may help to give aging farmers and farm enterprises with no "heir-apparent" a pathway to exit, there are some who are going to simply have to transition crops - help invest in a second source of water - or just get out of farming entirely - regardless of the cost. Thus, what we are witnessing is the rise of a situation under SGMA that appears to be creating a universe in California agriculture of big winners and big losers.

Taken together, this evidence suggests the three primary factors pushing and pulling farmers to adopt the Abandonment Strategy. First, the introduction of major investment groups offers an opportunity for farmers with multiple sources of water supply and arable land the opportunity to lucratively leave the agricultural industry. Second, it may offer an option to farmers to transition to crops that allow for the introduction of a second source of water supply (such as drip irrigation) or to eventually exit agriculture if they cannot meet new infrastructure needs for a second water supply source. Third, for those farmers who only have groundwater as the option for their land, it may be the factor that "pushes" them to sell the land with whatever losses that may entail.

1.4. Policy engagement: impacting water governance

The enactment of SGMA was described by one of our participants as the overnight enactment of the "greatest policy experiment of the modern era—probably since the New Deal" (Robert, personal interview, 2021). Most significant was the creation of Groundwater Sustainability Agencies (GSAs), which are composed of 260 local governing bodies across 140 groundwater Basins in California. These GSAs work inside a policy domain that stretches across a myriad of other resource management governing agencies such as Irrigation Districts and Water Districts in the Tulare Lake Basin resulting in a significant growth and diversification of actors involved in water policy and water resources management in California.

The enactment of SGMA made the issue of water governance in California one of the most complex and challenging policy governance structures in the state. Similar to other "wicked policy problems" the question of water supply in California—particularly in an era of climate change and drought—is one addressed, steered, and governed at various levels of government. It also is a policy domain that interacts with various authority structures ranging from hyper-local governments (water and irrigation districts, cities, and counties) to natural resource boards at the state and national levels. As a result, policy decisions and processes are viewed as progressively crosscutting boundaries across policy domains and levels.

Research surrounding SGMA, as well as our interviews with farmers in this study, have highlighted a primary outcome of the creation of GSAs was the significant increase in the complexity of water policy governance in California. Yet, SGMA was also identified by our participants as having opened new opportunities for farmers to become engaged in policy discussions and arenas as well as in water governance structures themselves throughout the state. For many farmers who participated in our study, engaging in these policy arenas and governance structures were seen as a way to transform potentially constrained opportunity spaces. Farmers have a keen interest—as both producers and consumers of water—in engaging in these conversations and often serve as actors on the governing boards of irrigation districts and GSAs. Yet they also engage in community dialogues and partnerships by coming to the table with other stakeholders in the region at meetings and in informal settings—including residents and community-based organizations with the intent to work collaboratively to find winning solutions for multiple stakeholders in the region. By participating in these networks, many of the farmers we spoke to were able to better maximize resources and opportunities that have the potential to shape water allocation decisions in their local area.

Over 2⁄3 of the farmers in our study were active in policy discussions, debates, and governance boards surrounding water allocation in the Tulare Lake Basin in one form or another. For many, engagement was underscored by both a rational self-interest as well as a deep genuine concern for the water supply and quality of water in their local communities. These farmers regularly attended meetings of irrigation districts, water districts, and public hearings surrounding water issues at the local, county, and state levels. Given the complexity of, and the extent to which water governance spans various policy boundaries, farmers who participated in our study often viewed themselves as a type of "diplomat" or what the policy sciences literature might describe as a policy entrepreneur in these settings. Policy entrepreneurs are defined very broadly as public or private actors who undertake a set of strategies toward certain policy outcomes (Kingdon, 2003). Many of the farmers in our study said they participated in water policy to provide knowledge and input around particular issues that other decision-makers within the governance structure may not be intimately aware of, or to articulate the specifics of these issues as they relate to the unique social and ecological contexts of the Tulare Lake Basin. In this sense, farmers perceive themselves and are perceived by others in the governance system, as offering insights that can help to co-create environments in which cross-boundary policy challenges can be addressed.

Kelly's experience illustrates this. Kelly is the owner of a large family-owned agricultural livestock farm that has been in operation for over 40 years. Kelly was not active in water policy discussions until 2011 when issues of water quality and water supply became front and center in the local region. Kelly served on the Board of Directors for their local irrigation district and now is also on the board of the GSA in their area. Kelly has remained active in water supply policy discussions as a type of policy entrepreneur by helping to synthesize knowledge of a vast array of water governance. Such synthesis could create new understandings via their deep local knowledge and help in facilitating effective policy coordination. When we interviewed Kelly, they described how they became active in these arenas:

> **KELLY:** I had worked on my family's small farm growing up and took over the business after graduating with a B.S. about 23 years ago. I became involved with the local government [here] early on working with some of the local agencies. I got involved because I believed it was important to serve my community and my farm was at a point where I could devote more time to such activities and less to the day to day management. As discussions have grown to include more actors and issues over the last decade - particularly in relation to water quality and water recharge in the aftermath of the drought, and as I have watched some of these discussions turn hostile I have become particularly interested in trying to bridge multiple interests that were beginning to emerge and organize within our communities including: farmers, farm laborers, local residents, environmental groups, and community groups.

When asked to expand upon bridging multiple interests and addressing emergent concerns of multiple stakeholders, Kelly said they "saw no other option but to try to help to facilitate bringing diverse, multiple, and often antagonistic actors together to the policy table." They went on to describe that often these stakeholder groups had the same goal—just different perceptions on how to reach them. One specific area Kelly pointed to was a lack of knowledge surrounding water storage and groundwater recharge practices on farms; an early source of antagonism between community residents and agricultural producers in the region. A lack of knowledge surrounding water storage practices on farms often leads to debates and disagreements between community stakeholders and farmers about the cause of water contamination in local areas. As Kelly noted "being able to fill a void in knowledge often helps us to identify possible policy strategies to support." These included policies to support groundwater recharge areas on farms—which have been found to address shortages in water supply without negatively impacting the existing quality of drinking water in a local area.

To Kelly, their wealth of experience in agricultural water management enabled them to be a trusted messenger in policy discussions. This assisted Kelly in their efforts to garner support for ideas to address inadequate agricultural water supply. One example was the *Groundwater Recharge Pilot Program* which offers FID growers federal funding support to undertake groundwater recharge which can help to open up allocations of water supply elsewhere in the region. At the same time, offering this type of knowledge within very contentious policy forums can help promote dialogue and collaboration across stakeholders with disparate interests and preferences allowing them opportunities to work together towards common goals or find common ground. Such engagement is characteristic of policy entrepreneurship which is needed to catalyze change in particularly complex wicked policy systems (Kingdon, 2003).

Policy engagement is a strategy that may have the potential to transform the lived experiences and on ground impacts of water policy in the region. Scholarship has long suggested policy entrepreneurship, like the actions taken by Kelly, can strengthen policy support among diverse groups of stakeholders (May and Winter, 2009). Studies have also shown this is done specifically by forging linkages among different policy areas and actors and strengthening advocacy efforts to drive the diffusion of knowledge across horizontal and vertical boundaries (Jones and Jenkins-Smith, 2009). Such actions have implications that can steer policy processes, but these are embedded and constrained by contextual conditions that can influence outcomes (Oborn et al., 2011). This suggests a type of system of feedback in which change in one area can have a significant impact on the local ecosystems in which water policy is embedded. In sum, the natural system that influences water supply in the Tulare Lake Basin is affected by the human actors engaged within it, and in turn, the policy prerogatives of human actors are going to vary based upon how the natural system surrounding water supply influences water availability and variability—such as during a period of drought.

For the farmers in our study who undertook policy engagement as a strategy, adopting this strategy did not appear to be correlated with political affiliation, affinity, farm size, or water allocation issues. Rather,

two defining characteristics of farmers who undertook this strategy were evident: 1) residents who had lived longer in the region or who had been agricultural producers in the region for over 15 years; and 2) concern over the contentious nature of water policy in the region. Moreover, all expressed a high level of concern regarding how contentious water supply discourse had become in the last ten years not just between various groups of stakeholders in the region, but also amongst farmers themselves. Such a reality underscores that the environment surrounding water policy in California is one that at times can be highly contentious, antagonistic, and one wherein rational self-interests of economic actors may not be an adequate framework to understand motivations for policy engagement of farmers. Rather, our findings suggest that policy engagement as a strategy used by farmers in the Tulare Lake Basin occurs and develops within a complex social ecology and an opportunity space in which water management is embedded, and changes within this ecosystem can either influence support for—or equally excite opposition to—policy engagement and activity by farmers.

2. Conclusion

The analysis presented by this study has articulated the construction of livelihood strategies of farmers in the Tulare Lake Basin under increased water scarcity and new policy interventions. The situation facing farmers in the Tulare Lake Basin represents a case of actors engaged in a strained social and ecological system embedded in the context of a highly complex policy ecosystem. The nature of the human and water management dynamics surrounding water supply in the Tulare Lake Basin also illustrates how resource management policies enacted at a macro level may lead to variable and unexpected consequences like land abandonment and the erosion of the social fabric of rural communities, depending upon the broader political and sociocultural contexts that surround local ecosystems. Our analysis articulates how farmers have adapted and responded to new regulations and opportunities in the face of highly variable water supply and shows how the intersections of human and natural systems and resources influence—and by extension are influenced by—livelihood strategies adopted by farmers in the Tulare Lake Basin.

A political ecological analysis of the Tulare Lake Basin further highlights the cultural and ecological forces that underscore farmer livelihood decision-making in the wake of SGMA. In the Tulare Lake Basin, SGMA has created an environment in which farmer decision making is impacted by the scope and boundaries (real and envisioned) of water policy governance resulting in conflicting conditions for farmers. Farmers are now engaged in a system of "big winners" and "big losers" leaving them to navigate a specific opportunity space in various ways. In terms of policy implications for water conservation in California specifically, this analysis brings to the forefront the question of whether SGMA can ensure an equitable system of future resource management and economic development in the Tulare Lake Basin in the long term. Our findings underscore a need to better understand region-specific policies and strategies related to water supply management that are developed in response to macro-level policy decisions. More specifically, our findings highlight the need to identify specific local conditions that may help buffer or further hinder agricultural producers under SGMA.

In relation to California specifically, proposed state government policy directives during the transition to SGMA had hoped to support the creation of an equitable system of water allocation and economic development. California Assembly Bill 252, introduced in January of 2021, allocated $50 million to help farmers repurpose out-of-production farmland and created the Multibenefit Land Repurposing Incentive Program which would assign grants to agencies, counties, and entities to develop programs that support SGMA goals and land repurposing in the region. In theory, such a policy would have helped to support and bolster farmer nimbility by providing avenues for crop switching and may have reduced the number of farms that were abandoned and sold in the region. The bill never passed.

One promising policy directive is the Sustainable Agricultural Land Conservation Program established under a partnership with the Department of Food and Agriculture and the Department of Conservation. The program uses state proceeds from cap-and-trade to "protect critical agricultural lands that are at risk of conversion to more energy intensive uses by allocating grants focused on three areas." These include efforts to shift policy and economic strategies that target the development of agricultural land types as well as those that focus on acquiring and permanently protecting the land from development. Currently, the program has 168 acquisition projects (covering 194,000 acres in total) and has awarded over $373 million in funds looking at conserving agricultural land in the state of California (California Strategic Growth Council, 2023). While the impact of this program has yet to be evaluated, the potential to support sustainable crop switching and land fallowing suggests that this may be an avenue through which pressures underscoring the adoption of the abandonment strategy by farmers - particularly smaller farmers—may be assuaged. If the impact of such programs indeed a net positive, then clearly, state-led development policies matter and have the capacity to influence the construction of more sustainable and equitable livelihood strategies for farmers in areas where water supply is highly variable.

Yet, our study suggests that these policies impact communities in ways that are more determined by how farmers respond to these policies in conjunction with a suite of other pressing local conditions and realities—social, natural, economic, and political—rather than the macro-level goals of effectiveness such policies are often envisioned and designed through. Thus, while the effects of resource management policy on the livelihoods of farmers can be mediated, there is a need for a more nuanced understanding of how and why the relationship between resource management (particularly in times of scarcity) and human livelihoods varies across scale and geography.

As our study reveals, the nature of farmer's livelihood decisions within the context of narrow policy making like SGMA is variable and complex. As a result, the conditions of linked human and ecological systems is best understood through an examination of ways in which a constellation of various political, economic, and ecological forces unfold in relation to one another to influence the livelihood options available, shape how actors perceive these choices, and drive the livelihood strategies they then choose to employ. This leaves the question of how to reconcile the impact of water conservation policy with the livelihoods of farmers in highly strained localities unanswered, and the answer to this question will only be found through site-specific processes that begin with rigorous, critical, and multi-stranded analysis. However, such analyses must be able to articulate the reality that farmers (and other agricultural actors) construct their livelihood strategies and make their decisions in response to the specific opportunity spaces they confront in their everyday contexts, which highlights a need to return to grounded case study analyses and inductive approaches to advance the field's understanding of these issues.

CRediT authorship contribution statement

M. Anne Visser: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Grace Kumetat:** Writing – review & editing, Writing – original draft, Investigation. **Gwendolyn Scott:** Writing – review & editing, Resources, Investigation.

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