Broadening understandings of drought – The climate vulnerability of farmworkers and rural communities in California (USA)

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ABSTRACT

The vulnerability of food and agricultural systems to climate variability and change is extensively studied. However, the vulnerability of agricultural labor is largely ignored in climate vulnerability and adaptation studies, especially in the context of developed countries. This research examines the drought vulnerability of farmworkers both in the fields and in their communities by analyzing how changes in water resources and agricultural practices impact socioeconomic drought. A combination of surveys and semi-structured interviews with farmworkers, farmers, and social service providers in California’s San Joaquin Valley is used to identify the impacts of drought on agricultural labor, water security, food security, and health. Findings demonstrate that drought impacts and vulnerabilities are multi-scalar and uneven. Agricultural drought adaptations, including increase in groundwater pumping and changes in crops, reshapes the vulnerability of farmworkers and rural communities. There is a need for continued interdisciplinary research on the socioeconomic dimensions of drought as well as increased representation of needs and vulnerabilities of farmworkers and rural communities in drought and climate change adaptation planning.

1. Introduction

The climate vulnerability of food and agricultural systems is extensively studied, with much of the literature focusing on the impacts of climate on agricultural production, farmer decision-making, and subsistence agriculture in developing countries. However, agricultural and food systems are more complex, with a broad set of actors beyond farm owners. These include farmworkers, food processors and retailers, consumers, and institutions that govern natural capital and social welfare (see Ericksen, 2008 for description of the drivers and feedbacks in this system). Each actor can be vulnerable to climate impacts and individual climate adaptations has the potential for cross-scalar impacts across the system. However, the vulnerability of farmworkers and rural communities remains largely neglected in climate vulnerability studies (Turhan et al., 2015). Though waged farmworkers make up over 40% of the world’s agricultural workforce, they are not usually included in vulnerability assessments, adaptation plans, or global poverty alleviation programs (Hurst et al., 2007).

The case of the 2012–2016 California drought is an opportunity to identify socioeconomic impacts of extreme drought on farmworkers and rural communities, including agricultural employment and indicators of well-being such as food and water security. Agriculture and water access vary between the east and west side of the SJV, which lead to a varied landscape of drought vulnerability. Considering these differences, this research identifies the socioeconomic processes and feedbacks in the agricultural system that shape differential drought vulnerabilities of farmworkers and rural communities.

This paper is organized as follows. Section 2 connects the literature on socioeconomic drought in agricultural systems in developed countries with the scholarship on climate vulnerability. Section 3 describes the study area and the case study of the 2012–2016 drought. Section 4 summarizes the methods for data collection, including semi-structured interviews and a household survey. In Section 5, data results on the impact of the drought on agricultural employment and well-being are presented. Section 6 discusses these results in the context of socioeconomic drought and differential vulnerability. Finally, Section 7 concludes the paper with policy recommendations.
2. Literature review

2.1. Socioeconomic drought in agricultural systems

While droughts are coupled environmental and social events (Wilhite and Glantz, 1985; Redmond, 2002), socioeconomic impacts of drought remain a relatively neglected dimension of drought monitoring and planning, which traditionally emphasizes biophysical indicators of drought such as precipitation and soil moisture (Lackstrom et al., 2013; Bachmair et al., 2016). The lack of attention to socioeconomic drought impacts contributes to a disconnect between scientific monitoring of drought and how droughts are experienced locally (Bachmair et al., 2016). For example, Goldman et al. (2016) demonstrate the difference between the droughts identified and monitored by scientists and policymakers and the droughts identified by Maasai herders, with significant implications for drought relief depending on whose drought is deemed official.

The existing research on socioeconomic drought pays little attention to the processes that shape socioeconomic drought impacts, primarily focusing on identifying economic losses in the developed world (Kallis, 2008). In agricultural systems, this means that drought impacts on the farming community are not as well understood as drought impacts on crops (Head et al., 2011). The existing research on socioeconomic drought in agriculture focuses primarily on male farmers (Vins et al., 2015), and ignores many other groups involved in the larger food system. Notable exceptions to this include Furman et al.’s (2014) work on how historical legacies challenge drought risk management for African American farmers in the American Southeast, as well as Vásquez-León’s (2009) research on the drought vulnerability and marginalization of Hispanic farmers and farmworkers in the American Southwest due to lack of access to public resources. Villarejo’s research in California’s Central Valley highlights the impacts of reduced water supplies and land falling on employment of farmworkers and rural communities (Villarejo, 1996, 2004). In addition to identifying socioeconomic drought impacts, Vásquez-León and Villarejo’s work is notable for analyzing climate impacts on farmworkers, who face barriers in coping and adapting climate hazards (Burke et al., 2012; Orozco, 2010) and remain largely overlooked in studies of climate vulnerability.

The existing research on socioeconomic impacts of drought in agricultural systems highlights the need for social science and qualitative research methods that reveal local impacts and vulnerabilities that are not readily identified through census or economic data (Meadow et al., 2013; Tánago et al., 2016). Using qualitative approaches to identify local drought impacts in vulnerable communities is an important step in creating drought policies that respond to local impacts and needs (Ferguson et al., 2016).

2.2. Climate vulnerability

In addition to identifying socioeconomic impacts from extreme climate, it is also important to identify the environmental, social, and economic processes that make some groups more vulnerable than others to climate hazards. The concept of vulnerability emerges from multiple disciplinary traditions, including natural hazards, political ecology, and development studies (Adger, 2006; Eakin and Luers, 2006; O’Brien et al., 2007). This scholarship grew exponentially as the problem of climate change gained attention and vulnerability was identified as a major theme for the Intergovernmental Panel on Climate Change (IPCC). The IPCC defines vulnerability as the “propensity or predisposition to be adversely affected” by climate, which is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2014, p. 1775). There are multiple approaches to identifying vulnerability within this framework. The natural hazards approach focuses on identifying climate risks, impacts, and the geographic and temporal distribution of such hazards – therefore seeking to answer the what, where, and when of vulnerability (Eakin and Luers, 2006). Political ecology and political economy approaches to vulnerability focus on “why are people vulnerable or at risk,” and why certain groups of people experience climate differently (Ribot, 2011, p. 1160). Such research examines the political, social, and economic processes that explain why groups of people experience different impacts and capabilities to recover from climate threats.

A critical aspect of climate vulnerability of agricultural systems is understanding the socioeconomic and environmental drivers and feedbacks that lead to impacts at multiple scales across both time and space (Eriksen, 2008). One of the processes through which vulnerability changes over time occurs when adaptation actions to reduce vulnerability increases the vulnerability for those taking adaptation actions or for other social groups (Burton, 1997). Such adaptation actions, or maladaptations, can disproportionally burden the most vulnerable (Barnett and O’Neill, 2009). This redistribution of climate risk and vulnerability often accumulates among marginalized groups by increasing exposure and sensitivity or by decreasing adaptive capacity (Juhola et al., 2016; Warner and Kuzdas, 2016). Yet, climate risk redistribution continues to be overlooked in climate adaptation planning, highlighting the need for more empirical research on the redistribution of climate vulnerability onto vulnerable groups who are often excluded from climate adaptation planning (Atteridge and Remling, 2018).

The vulnerability literature is also paying greater attention to analyzing the impacts of climate at the individual and household scale, focusing on the non-economic dimensions of well-being (Adger et al., 2009; Graham et al., 2013; Tschakert et al., 2017). Feminist political ecology highlights the ways in which risk and vulnerability are experienced at the scale and materiality of the human body and in micropolitics of resource use and management (Elmhirst, 2011; Trueove, 2011). These experiences of vulnerability and well-being remain under-examined in drought literature and can inform new ways to identify and respond to drought impacts.

3. The case study: the 2012–2016 California drought

California’s SJV is a prolific agricultural region in the United States. Two counties in the valley, Fresno and Tulare, are the highest ranked in the country in agricultural sales (Fig. 1). This agricultural productivity is supported by a combination of surface and groundwater for irrigation. The surface water is primarily sourced from Sierra Nevada snowmelt through a complex series of state and federal canals.

While many SJV agriculture statistics are aggregated across the valley, there are significant differences between the “west side” and the “east side” of the valley. Surface water distribution for each side of the valley is managed by different irrigation districts, with the west primarily managed by the Westlands Water District and the east managed primarily by the Friant Water Authority. In the past, the east side has predominantly grown permanent crops such as citrus and fruit, while the west side has grown many annual crops such as tomatoes and field crops such as cotton. Over the last decade, there has been an increase in the production of fruit and nut crops across the valley.

Rural communities in the SJV are predominantly inhabited by farmworkers who work at crop harvesting and fruit packing plants. Approximately 68% of farmworkers in the region were born in Mexico, and circa 47% lack work authorization (Hernandez et al., 2016). These low-income communities have limited access to health and education (Lewis and Burd-Sharps, 2014). Additionally, these communities experience high food insecurity (Wirth et al., 2007) and water insecurity due to lack of investments in rural water infrastructure (Carillo, 2014; Gasteyer et al., 2016).

Beginning in 2012, California experienced the most severe drought in the last 1200 years (Griffin and Anchukaitis, 2014). The impacts of the drought across the state was highly uneven, leading Swain (2015) to call it a “tale of two California droughts,” where impacts were mild along the highly-populated coast and severe in rural agricultural areas (p. 9999). During the drought, surface water allocations were
drastically cut, with some irrigation districts receiving 0% of their water allocations.

The agricultural sector in the San Joaquin Valley adapted to the decrease in available surface water for irrigation in three ways: (1) fallowing land, (2) increasing groundwater pumping, and (3) switching to high-value crops (Howitt et al., 2014; Howitt et al., 2015; Cooley et al., 2015; Medellín-Azuara, 2016; Melton et al., 2015; Tortajada et al., 2017). Since the 1970s, groundwater has provided an average of 43% of the valley’s water supply (Faunt et al., 2016). During the drought, groundwater accounted for 70% of the water supply due to increase in groundwater pumping (Faunt et al., 2016).

Throughout the drought, farmers continued the trend of switching away from field and vegetable crops towards high-value permanent fruit and nut crops (Fig. 2). Between 2011 and 2016, Fresno increased the harvested acreage of fruit and nuts by 19% while Tulare county increased by 20% (Fresno County 2000–2016, Tulare County 2000–2016). This transition continued despite such crops requiring more water per acre than row crops. High market prices allowed for agricultural profits in both counties to increase (Fig. 2). The shift towards permanent fruit and nut crops was predominantly incentivized by high market prices, however many farmers also found the shift necessary to cover higher costs of water purchases and groundwater pumping during the drought. The financial impact of the drought on farmers was buffered by the global rise in prices for high-value commodities like almonds.

Meanwhile, economic studies estimate that the drought caused the loss of 17,100 agricultural jobs in 2014 (Howitt et al., 2014), 21,000 jobs in 2015 (Howitt et al., 2015), and 4700 jobs in 2016 (Medellín-Azuara et al., 2016) – inclusive of both direct seasonal farm jobs and indirect agricultural jobs. These economic studies provide a partial outline of drought impact on farmworker employment, but do not address other impacts such as food security, water security, and health.

4. Research methods

This research triangulates between semi-structured interviews, survey, and analysis of crop data, to assess the drought vulnerability of farmworkers and rural communities. Triangulation allows for cross-checking between data sets, producing a more comprehensive analysis (Nightingale, 2009). The research was conducted in two phases. The first phase comprised of 45 semi-structured interviews with a wide range of individuals, including farmworkers, farmers, non-profit staff, as well as government officials selected through snowball sampling (Appendix A). Interviews were conducted throughout 2015–2017 and ranged from 20 min to three hours in length. Questions focused on drought impacts on agricultural employment and well-being, comparison to past droughts, drought relief, and preparations for future droughts. Using both deductive, inductive, and abduction processes, codes were developed to identify different perspectives on drought impacts and vulnerability (Saldana et al., 2011). The software MAXQDA was used for analysis of coding of transcribed interviews.

The second phase of the research used themes emerging from the interviews to develop a survey that measured local perceptions of drought impacts in two farmworker communities on the east side (Porterville and East Porterville, Tulare County) and two communities on the west side (Mendota and Firebaugh, Fresno County) (Table 1). These communities were selected to account for differences between west and east SJV and based on availability of assistance from community organizations.

Given the lack of well-being indicators in the drought assessment literature, survey questions were informed by literature on measuring household food and water security (e.g. Jones et al., 2013; Jepson et al., 2017). Respondents were recruited at community markets and public events to provide sensitivity regarding potentially undocumented farmworkers. Surveys were conducted in person in Spanish and English.
A resident of each community identified by non-profits assisted with interviews. A total of 117 respondents answered the household survey, with 56 respondents in Fresno County and 61 respondents in Tulare County (Appendix A).

5. Findings

This section presents results from interviews and survey on perceptions of drought impacts experienced by farmworkers and rural community members. The impacts are grouped under agricultural employment and indicators of well-being, including water security, food security, and health.

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5. Findings

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5.1. Drought impacts on agricultural employment

One of the most critical drought impacts identified in interviews across all stakeholder groups was the decline in agricultural employment. Shorter harvest seasons, fewer hours, longer travel distances, and the closure of fruit packing plants were also reported. The survey revealed a great concern over the impact of the drought on declining employment opportunities and decreasing household income (see Fig. 3).

However, interviews revealed conflicting narratives on the loss of jobs in fields and fruit packing plants. One non-profit employee explained, “more information is getting fed back to us through our farmworker communities, impacts such as lower hours in the fields, work changing sporadically, actually getting threats from farmers saying if it doesn’t rain, they are going to lay off over 300 people.” (Interview 1, Non-profit staff, Fresno County). On the other hand, a Mendota farmworker explained “I have heard that there is less work because of the drought, but I haven’t experienced that. I think that less cantaloupe has been planted and that more pistachios are being planted, so the drought might affect work in the future. For last year and this year, the drought has not been a problem, but it might be a problem for next year” (Interview 11, Fresno County farmworker). These narratives demonstrate how perceptions of the impact of drought on employment in the region varied between and within communities.

In addition to land fallowing, the embedded labor demands of different crops also explain impacts of the drought on employment. Facing reduced surface water for irrigation, it is easier to fallow ground intended for row crops, than to stop irrigation for trees that represent years of investment. In Fig. 2, reported harvested acreage for Fresno County indicates a decrease in field and row crops such as vegetables during the drought. This decrease in row crops translates into a significant decrease in labor demand. For example, one acre of fresh tomatoes represents 153 jobs and one acre of melons represents 162 jobs (Medellin-Azuara et al., 2015). On the other hand, the harvest of almonds is highly mechanized and only represents 19 jobs per acre, while citrus typically represents 27 jobs per acre (Medellin-Azuara et al., 2015). As Tulare County produces small quantities of vegetables, there was no significant decrease in vegetable harvesting jobs during the drought. There was a decline in field crops during the drought in both counties, however these typically represent an even lower labor demand, ranging from 1 job per acre for irrigated pasture up to 19 jobs per acre for cotton (Medellin-Azuara et al., 2015). A comparison of perceptions of drought impacts between east and west SJV indicates a higher drought impact in western Fresno county. This is likely due to two factors: (1) the decrease in labor intensive vegetable crops during the drought, and (2) higher portion of survey respondents in Fresno county (55%) indicated household dependency on agricultural employment in comparison to Tulare county (67%).

5.2. Drought impacts on well-being

Impacts on rural communities affected not just income, but also additional dimensions of well-being such as food security, water security, and health. Many of these impacts are interconnected with a decrease in income, though results demonstrate additional pathways in which the drought impacted the well-being of farmworkers and rural communities. Interview and survey questions examined the perceptions of SJV rural residents on the perceptions of the link between the drought and food security, water security, and health (Fig. 4).

5.2.1. Water security

To examine the impacts of the drought on the water supply of rural communities, water security is defined as “the ability to access and benefit from affordable, adequate, reliable, and safe water for wellbeing and a healthy life” (Jepson et al., 2017, p3). This multi-dimensional definition expands drought impact on water security beyond just water availability.

Interview and survey respondents clearly connected the drought with the three dimensions of water insecurity: availability, prices, and quality. Many SJV rural households depend on household wells. As the drought intensified, and groundwater use intensified, many shallow household water wells dried up. Fresno County reported 230 well failures and Tulare County reported 2261 well failures (State of California, 2017). The household survey confirmed narratives from interviews that the problem of dried wells was more acute in Tulare County than Fresno County (Table 2). Most respondents in Fresno County were connected to municipal water lines, while many residents in Tulare County relied on domestic wells for water.

In interviews, it was stressed that many dried wells were not
officially reported, therefore the total numbers of well failures during the drought is expected to be higher. Underreporting occurred for several different reasons: renters fearing eviction, absentee landlords, or undocumented families fearing government authorities. Interview participants highlighted the extensive impact of the drought on everyday life while experiencing three to four years without running household water. A resident of Porterville explained:

For this drought, I had to humble myself. My husband had a stroke and it was very difficult for us to lift the water jugs. We could not use our laundry machine and had to go to a laundromat. I lost a lot of weight from the stress of this drought. I would flush the toilets with rain water. I read it is illegal to catch that rain water, but I would secretly do it… This drought has brought me to my knees (Interview 43, Porterville resident, Tulare County).

Non-profit employees and rural residents explained in interviews that coping with the lack of water was particularly difficult for elderly residents, those with health difficulties, and those without access to transportation to water distribution points. A combination of state and non-profit programs distributed bottled water and installed water tanks as part of drought relief. In East Porterville, temporary water showers were installed. Some of the government drought programs were contingent on the landlord requesting relief for a dry well, which left tenants with absentee landlords ineligible to receive water tanks.

The survey responses reinforce reports that the number of dry wells was more acute in eastern SJV, while interviews in western SJV exposed concerns over water prices. Several communities like Cantua Creek and Three Rocks do not have municipal access to groundwater and are dependent on surface water. With decreased surface water allocations from Central Valley Project, surface water prices increased dramatically. This price increase extended to household water bills. In a community water meeting in Cantua Creek, one resident expressed his frustration with water prices, “We have to decide now if we bathe with water or if we eat!”

In addition to decrease in availability of water, either due to dried wells or municipal water restrictions, interviews and surveys also indicated a perceived connection between the drought and a decrease in water quality.

5.2.2. Food security

Food security is defined as “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996). Food insecurity can be measured on several different dimensions – including availability, affordability, and nutrition. The impact of the drought on food security was frequently discussed in the interviews, especially for communities in Fresno County.

Drought relief providers linked rising food insecurity with drought-
related unemployment, and food aid was at the forefront of many drought relief programs. A community aid worker described changes in the increase demand for food assistance at food distribution points, “there are more men showing up for food distribution, which is uncommon. Usually you only see men show up in the winter, when there is no work. But now there are more men.” (Interview 8, NGO staff, Fresno County).

Interviews also highlighted other pathways by which the drought impacted food security. Food bank representatives reported a decrease in donated food from farmers, a practice that provides fruits and vegetables for the region’s food banks. Residents also reported that water rationing and dried wells affected their ability to grow food at home. When asked if there were any drought impacts not mentioned in the survey, seven respondents cited gardening and providing water for animals.

In addition to indicating a link between the drought and ability to afford food, survey respondents indicated a perceived link between the drought and food prices. A total of 62% of all respondents answered that food prices were higher during the drought. However, national data on food prices indicated that national average of inflation of food at home prices during the drought were below the historical average (USDA, n.d.).

5.2.3. Health

Health was discussed in interviews as a potential drought impact that was not actively monitored or reported. Health impacts reported in interviews and the survey included stress, asthma, decreased water quality, allergies, and lack of money to seek medical care.

While concerns over health were not as widely reported as other drought impacts, health was a significant challenge to coping with the impacts of the drought. Non-profit workers in East Porterville cited residents struggling with health challenges such as cancer and diabetes as the ones most impacted by the drought. As one woman explained, “It was harder on me because of what I was going through with breast cancer. The stress was very hard, especially when you have to take extra steps to be hygienic” (Interview 44, East Porterville resident). East Porterville residents also pointed to the challenge of keeping hygienic practices when relying on water tanks with non-potable water.

6. Discussion

6.1. Identifying socioeconomic drought

Drought and climate research in agricultural systems in the developed world primarily focuses on data that is easily accessible and numerated. The impacts of drought on farmworker communities is difficult to identify on two fronts – drought impacts are slow-moving and much of farmworker life is hidden from government data. Like these undetected and unreported drought impacts, much of farmworker life is lived unofficially. This intensifies the difficulty in drought monitoring and emphasizes the need for more qualitative drought research. Expanding drought assessments to include local perspectives and experiences allows for identification of multiple impacts of socioeconomic drought, especially in marginalized communities with limited coping capacity.

Drought impacts identified in this research reverberate through multiple dimensions of life in rural communities. Some of the impacts like water insecurity are easily identified and connected to drought, while others like unemployment and health are difficult to distinguish from changing economic and social conditions. While some of these drought impacts are not easily separated from existing marginal conditions in rural communities, drought is not experienced apart from them. The risk of impacts became a source of anxiety for many residents, as evident in the perceptions that the drought increased food prices.

Drought represents a slow erosion of the well-being of farmworker communities. It contributes to unemployment, water and food insecurity, and threatens the long-term economic stability of households. It is also an erosion that does not affect everyone equally. Vulnerability is differential and variegated, and some community and household members are impacted more than others. Conceptualizing drought as more than a biophysical process, but also as a place-based social and economic event, opens possibilities for drought monitoring that reflects local conditions as well as improving drought relief programs.

6.2. Vulnerability distribution in SJV

This research sought to identify socioeconomic drought impacts as well as understand the drivers and feedbacks that contribute to differential drought vulnerability. When Swain (2015) described the drought as a “tale of two California droughts,” he was referring to the differences in the experience of drought across the urban and rural divide in California. A “tale of two California droughts” can also describe the contrasting vulnerabilities within rural San Joaquin Valley, with drought experiences varying between farmer and farmworker, between the healthy and the chronically ill, and between east and west SJV.

A comparison of experiences of drought between east and west SJV reveals an uneven drought landscape. Interview and survey results indicate that perceptions of employment insecurity were higher in west SJV, while perceptions of water insecurity were higher in east SJV. This uneven drought landscape intensified over time, as adaptation choices within the agricultural sector deepened drought impacts among farmworkers and rural communities. Agricultural producers did experience impacts from the drought with decreased surface water allocations, but overall producers were able to adapt by increasing groundwater pumping and accessing high prices for fruit and nuts. On the other hand, research findings indicate that the drought impacted household income and well-being of farmworkers and rural residents.

This risk redistribution reflects a process of maladaptation whereby drought risk was redistributed onto farmworker communities. Both Christian-Smith et al.'s (2015) case study of California’s 2007–2009 drought and Tortajada et al.'s (2017) analysis of the 2012–2016 drought refer to the social impacts of the drought as maladaptation. The increase in fruit and nut production that preceded the drought left farmworkers more vulnerable to drought impacts on employment. The intensification of fruit and nut crops during the drought increased job insecurity and had cross-scalar impacts on water and food security of rural residents. Higher reliance on household wells in east SJV increased vulnerability to declining groundwater levels due to groundwater pumping. This research demonstrates in more depth the processes by which adaptation actions redistribute drought risk in agricultural systems and increase the vulnerability of other social groups.

The differential distribution of drought risk across the region is not only due to adaptation decisions made by agricultural producers, but also due to historical and social processes that shape access to resources for farmworkers and rural residents. Ascribing unemployment and water insecurity to drought and climate alone masks the inequities that produce vulnerability (Ribot, 2011; Eriksen et al., 2015). Historical patterns of settlement in the region are linked with differences in household access to municipal water and dependency on household wells, thus shaping water vulnerability. Many farmworkers live in unincorporated communities, where rents are cheaper and there is less government oversight. However, the trade-off is the dependency on risky wells. The precarity of seasonal farm labor, the lack of investment in water infrastructure, and the lack of access to social services are all important determinants of drought vulnerability in the region.

Not fully explored in this research are factors in addition to global prices that are shaping demand for farmworker labor in the region. A combination of strengthening of Mexican economy and stricter border policies has stemmed the flow of migrant farmworkers, thus contributing to a higher demand for labor. Agriculture is also becoming increasingly more technical, with great investment in mechanization and computerization, thus decreasing demand for seasonal farmworkers. As many of the rural communities already had high rates of unemployment prior to the drought, it is challenging to attribute unemployment in these communities solely to the drought. This research focuses on the perceptions and experiences of farmworkers and rural
resident and further research is needed to quantify the material impacts of drought in these communities.

7. Conclusion

While drought vulnerabilities in agricultural systems have been extensively studied, the continued focus on easily accessible, quantitative economic data obscures the impact of climate on farmworkers and rural communities. This research contributes to this existing gap by using social science research methods to identify multiple scales and dimensions of drought impacts as well as the economic and social processes that shape drought vulnerability for farmworkers and rural communities. Identifying these vulnerabilities is critical, for how we define and identify drought vulnerabilities shapes who gets what kind of drought relief. The climate vulnerability of farmworkers is different than that of agricultural producers, reflecting the need to expand our understanding of climate vulnerability of other groups beyond farmers in food and agriculture systems. More research is needed to document climate impacts and develop adaptation strategies that consider the multitude of actors in agricultural systems, such as farmworkers, drivers, and warehouse packers.

The drought experience of farmworkers and rural communities in California presents several lessons for future drought and climate change adaptation planning. First, planning for future droughts improves with the coordination and participation of diverse experts with knowledge of local communities and different dimensions and scales of well-being. The response to the human impact of the drought in California required the coordination and engagement of government officials, community leaders, farmworker activists, and non-profits involved in water security, food security, health, and employment training. Second, drought vulnerability is dynamic and changes with adaptation decisions made during a drought. Drought relief and planning needs continual assessments to consider the redistribution of drought risk given different adaptation decisions. Finally, greater inclusion and representation of vulnerable groups in drought and water resource planning and management is needed. Increased participation of vulnerable groups in drought and climate adaptation planning allows for inclusion of their needs and experiences.

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Appendix A

Table A1
Characteristics of Semi-Structured Interview Respondents.

<table>
<thead>
<tr>
<th>Interviewee Characteristics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Owner</td>
<td>3</td>
</tr>
<tr>
<td>Agriculture Industry</td>
<td>5</td>
</tr>
<tr>
<td>Farmworker</td>
<td>4</td>
</tr>
<tr>
<td>Rural Resident</td>
<td>4</td>
</tr>
<tr>
<td>Non-profit – Legal</td>
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</tr>
<tr>
<td>Non-profit – Environment</td>
<td>1</td>
</tr>
<tr>
<td>Non-profit and Community Based Organization – Economic Development</td>
<td>9</td>
</tr>
<tr>
<td>Non-profit and Community Based Organization – Water</td>
<td>7</td>
</tr>
<tr>
<td>Government (city, county, state, federal)</td>
<td>8</td>
</tr>
<tr>
<td>Academic Researcher</td>
<td>2</td>
</tr>
<tr>
<td>Total Interviewed Persons</td>
<td>45</td>
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Table A2
Characteristics of Survey Respondents.

<table>
<thead>
<tr>
<th></th>
<th>West Fresno County</th>
<th>East Tulare County</th>
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<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>54%</td>
<td>57%</td>
</tr>
<tr>
<td>Male</td>
<td>46%</td>
<td>43%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–29</td>
<td>43%</td>
<td>30%</td>
</tr>
<tr>
<td>30–29</td>
<td>25%</td>
<td>16%</td>
</tr>
<tr>
<td>40–49</td>
<td>25%</td>
<td>21%</td>
</tr>
<tr>
<td>50+</td>
<td>7%</td>
<td>33%</td>
</tr>
<tr>
<td>Does your household income depend on agriculture?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>88%</td>
<td>67%</td>
</tr>
<tr>
<td>No</td>
<td>12%</td>
<td>33%</td>
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