



Investigating environmental migration and other rural drought adaptation strategies in Baja California Sur, Mexico

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Abstract

This paper explores the relationship between specific household traits (region of residence, head of household occupation, financial diversity, female level of education, land and animal ownership, social capital, and climate perception) and choice of specific adaptation strategies used by households in two sites in Baja California Sur, Mexico, during a severe drought from 2006 to 2012 using survey data and key informant interviews. We analyzed the co-occurrence of household traits adopting different drought adaptation strategies, then applied Qualitative Comparative Analysis (QCA) to examine the relationship between traits and strategies and integrated interview data to understand how rancheros perceive associations. We found evidence of diversity among households within the larger cultural group, both in the types of resources they have available and in the adaptation strategies they select. However, the most robust finding across the analyses appeared to be urban access; that is, the more a household was able to access urban services including piped water, the less likely they were to have used one of the drought adaptation strategies under study. These findings suggest that social structure and public investments are stronger predictors of smallholder adaptation rather than individual household traits. We also found that rancheros seem to rely less on traditional environmental migration to adapt to drought and rather settle in key watershed zones. We call for targeted policies to address inequities to access fresh water, including urban water, during drought times for the benefit of overall watershed health and the sustainability of rural rancharo livelihoods as they evolve to respond to climatological and economic change.

Keywords Drought · Adaptation · Environmental migration · Livelihoods · Climate change · QCA · Multiple methods

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Introduction

The increase in drought risk due to a progressively drier climate in the subtropical latitudes over parts of North America (Cook et al. 2010) translates to a growing need to understand how households will adapt to drought changes, and why households respond in certain ways. Furthermore, novel approaches are increasingly necessary to better understand complexity in household responses to these environmental changes (Kok et al. 2016; Okpara et al. 2016). This paper analyzes the relationship between specific household characteristics and their decisions to adopt drought adaptation strategies. It does so by combining multiple methods: analyzing the co-occurrence of household characteristics with adoption (or not) of drought adaptation strategy, and complementing this information with qualitative comparative analysis and the thematic analysis of qualitative interview data.

Vulnerability research has highlighted specific household traits that enable the ability to adopt drought adaptation

strategies, including financial diversity (de Janvry and Sadoulet 2001), the amount and type of land and livestock owned (Massey et al. 2010), membership in social organizations (a mechanism to draw on social capital and social networks for help) (Narayan and Pritchett 1999), female education (Blankespoor et al. 2010), and access to fresh water sources (Gray 2009). Previous research has also identified the main coping and adapting strategies that smallholder rural households take during drought: changing farm practices, finding off-farm work, and migrating. Changing farm practices and finding off-farm work have been shown to be important survival mechanisms among smallholder farmers (for example, Laube et al. 2012; Mardero et al. 2015). Others move the entire household or single household members away from the environmental threat (for example, Afifi et al. 2013; Alscher 2010; Gray and Mueller 2012; Leighton 2011; McLeman and Ploeger 2012), here defined as environmental migration.¹ Persistent environmental degradation might also undermine watershed health, reducing the economic benefit of staying for households who depend on immediate ecosystem services whether or not these households attribute their decision to the changing environmental conditions (IOM 2007).

Climate model scenarios for Baja California Sur Mexico, predict that precipitation will decrease by as much as 30% by 2050 (Cavazos and Arriaga-Ramírez 2012). How households, and specifically rural households in this area, are likely to respond to extended droughts has not been well studied to date. Anecdotal evidence suggests that the rural households of Baja California Sur, known as *rancheros sudcalifornianos*, were more mobile in the past—they were able to move from one grazing area to another or switch to fishing on the coast to wait out the drought. The question of whether or not *rancheros* can maintain ranching as their main economic source and their lifestyles within a changing environmental and social context remains to be answered.

In this paper, we assess whether and how specific household characteristics (traits) in Baja California Sur influence household adoption of four specific drought adaptation strategies: (1) environmental migration (direct), (2) household member migration (indirect), (3) changing farm practices, and (4) finding off-farm work. We assess these relationships by analyzing the co-occurrence of specific traits in cases of adoption versus not adoption of a drought adaptation strategy by analyzing how different trait configurations lead to adoption/not adoption of specific adaptation strategies, and

by comparing these with an analysis of trait and adaptation strategy themes embedded in the in-depth interviews.

Methods

Study area

The northern Mexican states registered significant drops in precipitation starting in 2006 and peaking in 2011–2012—the worst drought in Mexico in the previous 70 years (CONAGUA 2013). Baja California Sur recorded the most serious decrease in rainfall, by 70% (*ibid*). Mexico declared a federal drought emergency in three municipalities in Baja California Sur in 2011 where rural *rancheros* live (*ibid*)—two of which are studied here (Figure 1 Site Map, Online Resources). The rural area adjacent to the state capital of La Paz runs along the corridors of the Novillo and Trincheras mountain ranges, which receive the most rain per year in this region and is considered the main recharge zone for the city's only aquifer. Through discussions with local practitioners, it was estimated that the total population in 2010 in the Sierra catchments was approximately 750 persons in a 1417-km² area (Niparajá 2014). The other rural area, San Javier, is adjacent to the municipal capital of Loreto with 131 inhabitants according to the 2010 Census (INEGI 2010). San Javier is the location of an historic Spanish Jesuit mission site and attracts some international tourism in addition to a small-scale agriculture economy (e.g., cattle, palms, onions, sugarcane, honey, etc.).

Ranchero survey

A household survey targeted rural households exposed to a severe, federally declared drought from 2006 to 2012 (see [Online Resources](#) for the full survey in English and Spanish). Sample sizes for each location were calculated to achieve a 95% confidence level with a +/- 5% margin of error. Because *rancheros* did not have internet access or addresses for mailing, participants were contacted in their homes using a door-to-door dispersed sampling method. *Rancheros* were selected based on the following criteria: were at home and available at the time of survey, consented, and were located within the boundaries of either the Sierra (La Paz) or San Javier (Loreto) watersheds. At the time, there was not an updated map (online or otherwise) showing current homes nor were either areas designed on a grid, making it impossible to know the true household locations for random sampling. However, in high dense areas, every third household was approached and extreme efforts were made to reach the most isolated areas including homes without road access. A trained team of 12 local students conducted the surveys in Spanish who read the

¹ We define environmental migration in accordance with the International Organization for Migration (IOM) (2007) “Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad.” We define “migration” as crossing a specified boundary to establish residence for any period of time, in this case, across a watershed boundary.

question and answer choices aloud and marked the participants' answer.

Survey development took into account previous research assessing the relationship between specific household characteristics and adoption of drought adaptation strategies. In order to systematically review previous work, we searched Web of Science, Science Direct, JSTOR, and EBSCOHost using the following keywords: “adaptive capacity index,” “adaptive capacity assessment,” “drought adaptation,” and “environmental migration.” A total of 13 peer-reviewed journal articles were used to select indicators for the household survey, summarized in Table 1. The six household traits we elicited, together with location of household, whether the head of household ranches as their primary occupation, and whether the household perceived changes in weather patterns, were considered to influence the ability and the household decision-making with respect to drought strategy.

To ensure cultural sensitivity, experts from a local university and two local non-profit organizations² reviewed the survey to assess the cultural appropriateness and wording of the survey questions. Once accepted, we piloted the survey with two *ranchero* households within the two municipalities of choice. Table 1 reports the symbol, meaning, and descriptions of the variables used in this study.

Ranchero interviews

In addition to the surveys, 11 *ranchero* groups (some individual, some groups of neighbors) were selected for in-depth interviews on their drought experiences in Baja California Sur. Interviewees were selected according to the following criteria: spread of geographic location including proximity to urban centers, broad age range to capture differing drought memories and adaptation choices related to stage in the life cycle, and a mix of males and females to capture potential gender-specific roles in drought response. A total of 18 *rancheros* participated in the conversations, six groups in the La Paz region and five groups in the Loreto region consisting of five women and 13 men ranging in age from 29 to 96 years. Two locals were hired to conduct the interviews in the Spanish dialect specific to rural Baja California Sur in the presence of the first author. One interviewer was an employee of a water conservation non-governmental organization (NGO) in the area, and the other worked informally with a local sustainable ranching NGO. Some respondents spoke to us alone while others were more comfortable speaking to us with a spouse or neighbors, dynamically taking their cues from each other. The interviews were semi-structured in that questions were

not asked verbatim to each respondent. Interviewers were trained to guide the open-ended conversation towards drought experience, drought response, and available resources for responding to the drought. Interviewers were also trained to prompt for place, age, and gender details (e.g., urban access, drought memory, gender roles such as carrying water, etc.). Interviews typically lasted from 30 min to an hour. The interviews were audio-recorded with permission and two bilingual speakers transcribed the recordings in both English and Spanish. English versions were thematically coded using the household traits (region, female education, head of household occupation, access to surface water for human consumption, climate perception, social capital, financial diversity, land ownership, and livestock ownership) and four adaptation strategies (environmental migration, household migration, changing farm practices, and acquiring off-farm work) using NVIVO Pro 11.4.1 for Mac (see Online Resources Table 2 for summary). Illustrative remarks are included to provide deeper meaning to the results.

Analysis

The relationships between household traits and strategies are assessed via the following methods: (1) visualization of trait co-occurrence in relation to the adoption of specific strategies using household survey data, (2) assessing configurations of traits that lead to specific strategies via qualitative comparative analysis (QCA) using household survey data, and (3) thematic coding of traits and strategies of purposively sampled interviews. While co-occurrence can give insights on what type of traits are more frequently associated with adoption and non-adoption of adaptation strategies, the use of QCA allows us to assess which traits are the most “important” ones in shaping household decisions to adopt or not a specific drought strategy. We complement these methods with insight from the in-depth interviews to allow for a deeper understanding of the phenomenon we are analyzing.

For both co-occurrence analysis and QCA, we assess presence and absence of a specific trait in relation to the adoption or non-adoption of a specific adaptation strategy (see Table 4, Online Resources). Co-occurrence analysis highlights the traits which are more likely to co-occur in the presence (or absence) of a specific adaptation strategy. Following a similar approach, Baggio et al. (2016b) analyzed the co-occurrence of institutional design principles and their relationship to successful common pool resource regimes, while Rocha et al. (2015) analyzed co-occurrence of drivers in marine regime shifts. This type of analysis is purely visual and can be thought of as a first step in identifying the relationship between trait configurations and strategies. To gain a deeper knowledge of the trait configuration—drought response relationship—we complement the co-occurrence analysis with

² Experts were contacted at the local non-profit organizations Niparajá (<http://niparaja.org/>), headquartered in the La Paz area and Raices Vivas (<https://livingrootsbaja.wordpress.com/>) in the San Javier area, and professors at the Universidad Autónoma de Baja California Sur.

Table 1 Household traits and drought coping/adaptation strategies

Household traits	
Symbol	Description
reg	The household lived in the Loreto (0) or La Paz (1) municipality
edu	Any female in the household reporting any secondary or higher schooling
rch	Head of household reported "rancher" as their occupation
wat	The household reported accessing surface water for human consumption
clm	The respondent responded positively to the question "Have you perceived that the weather has been unpredictable in the last ten years?"
soc	The respondent responded positively to the question "Are you a member of a community organization?"
fin	The household reported more than one source of income including business income, remittances, government aid, or pensions
tit	Household held a title to their land
lvs	Household-owned farm animals (chickens, cows, mules, horses, or goats)
Adaptation strategies	
Symbol	Description
Adoption of any drought strategy	In response to the question "During the last drought, did you take any of the following actions to mitigate the negative effects?," respondent marked one or more options from the list or wrote in an answer
Environmental migration	In response to the question "During the last drought, did you take any of the following actions to mitigate the negative effects?," respondent marked the option "migrate" (<i>migrar</i>)
Any household member migration	For each household member, respondent was asked if they had migrated, and if so, the years. Household members

Theoretical, empirical, and cultural (site-specific) justification
The level of urban access differs between the two sites due to road conditions. La Paz has more urban access than Loreto
Education, and specifically female education, has been found to positively contribute to the greater capacity of the household to respond to drought and other extreme events (Blankespoor et al. 2010)
The ability of rancheros to sustain a traditional ranching lifestyle under environmental and social conditions was undetermined at the time of study
A household's ability to directly access fresh water for human consumption gives a family agency in managing their water storage, consumption, and conservation in times of scarcity (Gray 2009)
Ranchero awareness of climatic change was undetermined at the time of study

Social networks are often found as a key predictor in relation to how households make migration decisions (Narayan and Pritchett 1999; Vincent and Cull 2010) and influence a community's ability to withstand both social and ecological changes (Baggio et al. 2016a)
Maintaining multiple income streams (financial diversity) helps households manage water resource-related fluctuations like farm production shocks (Eakin 2005; Ellis 2000; Nelson et al. 2005; Vilel and Dabbert 2007).
Land is required to raise livestock, and tenure has long been considered an important aspect of vulnerability under various ownership options and land reform in Mexico (Liverman 1999)
Livestock can be used as assets to sell or trade in drought times (Massey et al. 2010; Nelson et al. 2005)

Adaptation has been defined in the literature as "a process of deliberate change in anticipation of or in reaction to external stimuli and stress" (Nelson et al. 2007). This study focuses on the external stressor of extreme drought
Migration is one known adaptation strategy to drought (Afifi et al. 2013; Gray and Mueller 2012; Leighton 2011; Afifi et al. 2013; McLeman and Ploeger 2012; Saldaña-Zorrilla 2008). To what extent rancheros sustained traditional migration from one fixed home to another during times of drought was undetermined at the time of study

While adaptation is generally defined as a *deliberate* process (Nelson et al. 2007), one motivation of this study was to

Table 1 (continued)

Household traits	
Presence/absence of any household member migration during drought years 2006–2012	who migrated during the drought years (2006–2012) were considered in this group
Change in farm practices	<p>In response to the question “During the last drought, did you take any of the following actions to mitigate the negative effects?,” respondent marked corralled animals, traded cows for goats, and/or planted fodder</p> <p>determine if household members were migrating without attributing their decision to the drought, but could have been due to indirect causes of the drought (e.g., economic depression)</p> <p>Changing farm practices have been shown to be important survival mechanisms among smallholder farmers in southeastern Mexico, for example (Mardero et al. 2015). Site-specific outcome options were solicited from local experts and non-profit organizations</p>
Acquired off-farm work	<p>In response to the question “During the last drought, did you take any of the following actions to mitigate the negative effects?,” respondent marked obtained temporary work and/or obtained outside work</p> <p>Changing farm practices or finding off-farm work have been shown to be important survival mechanisms among smallholder farmers in southeastern Mexico, for example (Mardero et al. 2015). Site-specific outcome options were solicited from local experts and non-profit organizations</p>

QCA (as in Baggio et al. 2016b). The output of QCA is a list of all possible combinations of relevant conditions within the parameters of this study that lead to the designated outcome. Here, we assess whether household traits are necessary or sufficient for the adoption or non-adoption of a specific strategy (Ragin 1987; Ragin 2014). A trait, or a trait configuration, is necessary if it must be present for a certain outcome to occur. A trait, or a trait configuration, is sufficient if, by itself, it can produce a certain outcome (Ragin 1987). A trait or a trait configuration is both necessary and sufficient if it is the only cause of the outcome (see [Online Resources](#) for more information). QCA also allows us to assess the consistency, or the degree to which a relation of necessity or sufficiency is met in a given dataset, and coverage that provides a “degree” of relevance of the sufficiency and necessity conditions for an outcome to occur. Both metrics vary between 0 and 1: 0 indicates no consistency or coverage, and 1 indicates complete consistency/coverage.

QCA allows us to identify the multiple, different, and non-exclusive trait configurations of rural households that lead to the adoption or non-adoption of different strategies. We focus on specific household traits relating to the drought strategies identified for study (if any), and not on the linear relation between variables. We also pay close attention to the sensitivity of QCA to missing information. Following Baggio et al. (2016b), QCA is complemented by a reliability metric based on missing value imputation. The metric proposed in Baggio et al. (2016b) allows us to build a range of reliability for the information presented.

Finally, we complement the results with in-depth interviews to broaden our analysis beyond the binary variables that were necessary to establish co-occurrence and QCA. The integration of co-occurrence and QCA with in-depth interviews and knowledge of the system allows researchers to increase our understanding of system under study (Baggio et al. 2016b; Barnett et al. 2016).

Results

Household survey results

We attained a high response rate (90%) with the household survey, representing a total of 163 ranchero households and 657 individual family members. Of the 163 rancheros surveyed, the majority (87%) reported that they responded to the 2006–2012 drought in some way while 13% reported that they did nothing (see Table 1, [Online Resources](#)). Among the strategies analyzed, changing farming practices and acquiring off-farm work were much more prevalent than either type of migration (> 50 vs. < 30%, respectively).

Trait Co-occurrence

We start our analysis of trait combinations by identifying co-occurrence of household traits under different coping/adaptation strategies. Here, we present only results for complete cases (see [Online Resources](#) for co-occurrence patterns using missing value imputation).

First, we analyzed differences between households who did not respond to the drought versus those who did, independent of the specific type of strategy. Figure 1 shows households who did not employ the strategy under consideration (left side) and households who did (right side) with stronger co-occurrence represented in redder and weaker co-occurrence represented in bluer colors. Overall, we see that those who had strong co-occurrence of household traits (redder squares) were more likely to have adopted a drought adaptation strategy, and this was true for each individual strategy except for acquiring off-farm work (Fig. 1). Households that responded to the drought shown in Fig. 1b are characterized by the co-occurrence of financial diversity and land title as represented by red squares, and these co-occurred more strongly with livestock ownership and climate perception. Households in La Paz who had social capital and also perceived changes in the climate were slightly less likely to have responded to the drought (Fig. 1a, b).

Environmental migration

Fifteen percent of our sample self-reported migration as a direct drought strategy. Households who reported environmental migration were characterized by the co-occurrence of the following traits: female education, climate perception, and livestock ownership, and a stronger co-occurrence between climate perception and land title (Fig. 1d). Meanwhile, households in the La Paz area who were aware of climate changes were less likely to have environmentally migrated (Fig. 1c).

Household member migration

Twenty-nine percent of households surveyed had a member who migrated during the drought years 2006–2012, whether or not they attributed this movement directly to the drought. These families were more likely to have the combination of perceived climatic changes in the last 10 years, females with higher education, and livestock ownership (Fig. 1f). Also, these households were more likely to have the combination of social organization membership (social capital) and livestock ownership (Fig. 1f). On the other hand, households who perceived a change in climate patterns in the last

10 years and owned livestock, but also lived in the La Paz municipality, were less likely to have had any migration during the 2006–2012 drought.

Changing farming practices

More than half of the households (56%) reported changing farming practices as a drought strategy. Households who changed their farming practices were more likely to have the combination of the following traits: financial diversity, owning a title to the land, and owning livestock, or the co-occurrence of female education and livestock ownership as shown by the comparison of Fig. 1g, h. Living in the La Paz municipality and holding a land title co-occurred in households that did *not* change their farm practices as shown in Fig. 1g.

Acquiring off-farm work

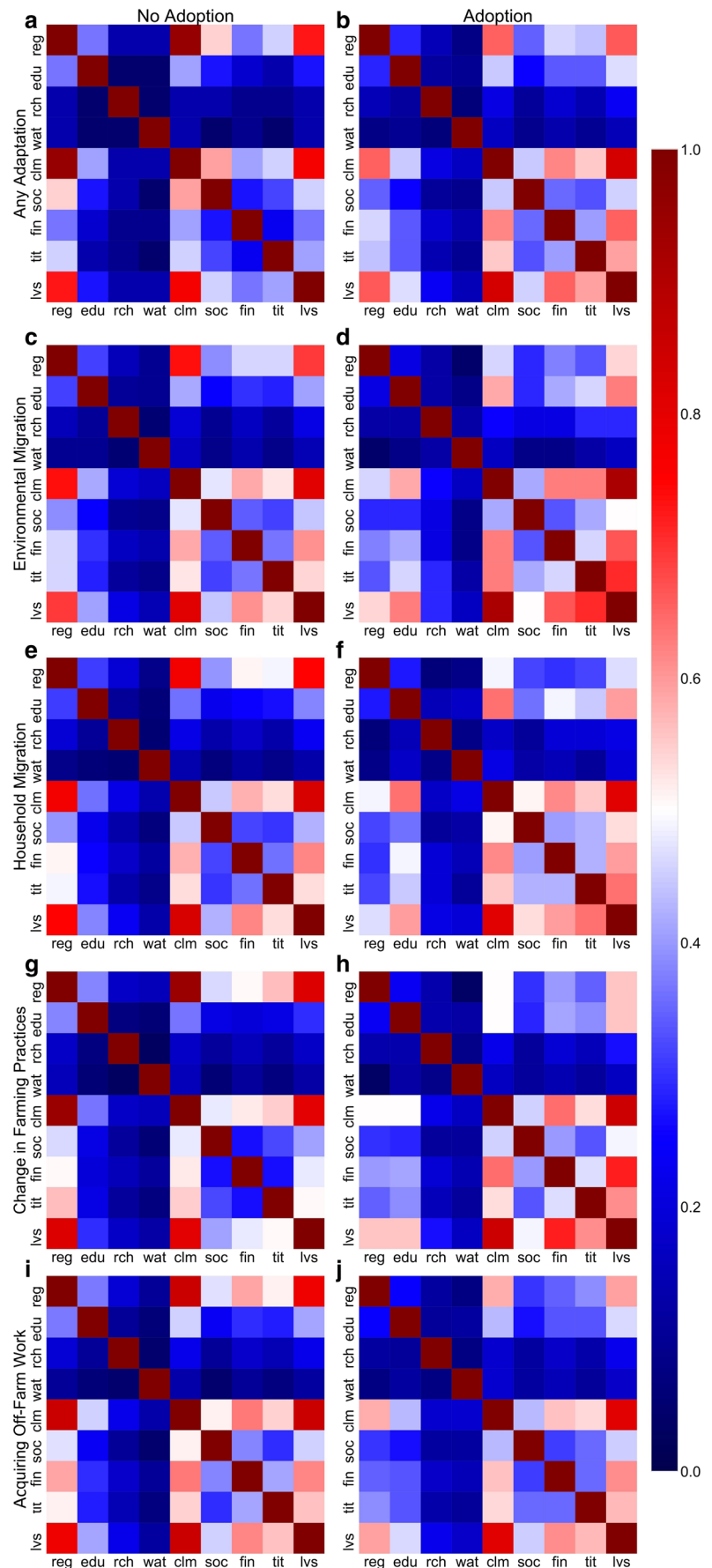
Acquiring off-farm work was the most adopted strategy, although marginally (57 vs. 56% that adopted changing farming practices). Co-occurrence analysis indicates that the strongest distinction was that households living in La Paz with financial diversity were less likely to acquire off-farm work.

Qualitative comparative analysis

Figure 2 reports results of the relative trait importance in determining household decisions to adopt specific drought adaptation strategies. Trait position is given by the frequency in qualitative comparative analysis (QCA) solution sets relating to adoption and non-adoption of specific drought adaptation strategies (see [Online Resources Tables 4 and 5](#)). We report solution sets in which the configurations occur in over 50% of cases (consistency > 0.5). Trait position in Fig. 2 identifies discriminatory factors in the adoption of drought adaptation strategies. Traits placed in the upper left quadrant are positively associated with strategy adoption, while traits placed in the bottom right quadrant are negatively associated with strategy adoption. Traits placed in the other quadrants are neither positively or negatively associated with strategy adoption.

Figure 2 shows that owning a land title is positively related to the adoption of environmental migration even when accounting for missing cases. This means that owning land was often present in trait configurations that led to the adoption of the environmental migration strategy, and was, at the same time, absent when environmental migration was not chosen (top left quadrant). Ranching was also positively related to the adoption of environmental migration, albeit to a lesser extent and with lower reliability. Female education was positively correlated to having any member of the household migrate during the drought years. Living in the La Paz

Fig. 1 Frequency of household traits of co-occurrence by type of strategy. Strong associations between two traits are closer to 1 (1 indicating that two traits always co-occur) and are represented by darker red colors. Weak associations between two traits are closer to 0 (0 indicating that two traits never co-occur) and are represented by darker blue colors. For example, observing Fig. 1a, one can infer that households that lived in La Paz (*reg* = 1) and stated that they perceived changes in the climate (*clim* = 1) were less likely to adopt one of the drought adaptation strategies under study (darker red color where the row meets the column). On the other hand, the two traits co-occurred less frequently in case of households that adopted one of the adaptation strategies inferred by the darker blue color where the row meets the column (Fig. 1b). The middle diagonal boxes represent the intersection where a trait on the x-axis is the same as the y-axis (essentially showing that it “co-occurs” with itself 100% of the time. Refer to Table 1 for abbreviations



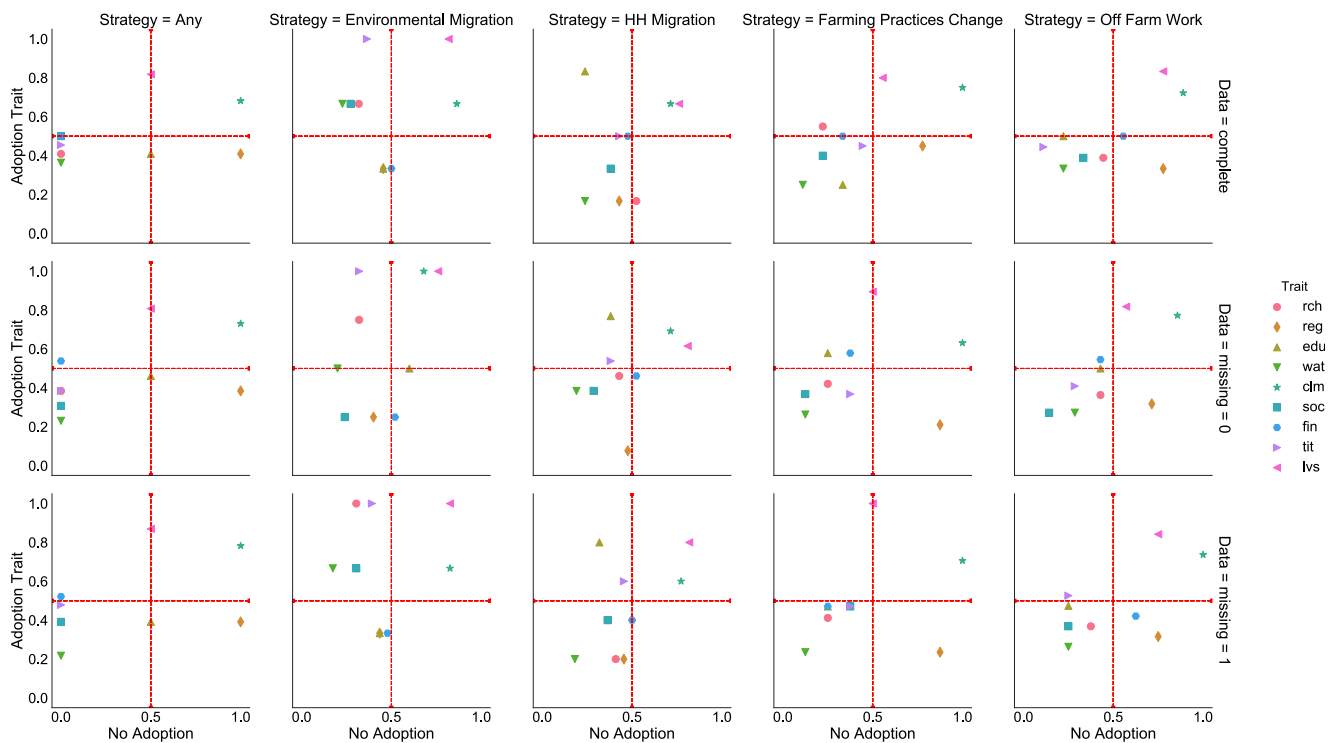


Fig. 2 Positive association (top left quadrants) and negative association (bottom right quadrants) of household traits with each drought strategy. The top row shows complete cases, the middle row shows data when

missing values are assumed 0 (absence of trait), and the bottom row shows data when missing values are assumed 1 (presence of trait). HH refers to “household”

area was negatively associated with changing farming practices and acquiring off-farm work. No traits were positively associated with the adoption of drought adaptation strategies in general, while living in La Paz was negatively associated with adopting drought adaptation strategies in general.

Interview data

All respondents we approached agreed to an interview and agreed to be recorded, resulting in a 100% response rate. The interviews revealed that the cultural identification with rancheros was separate from the practice of ranching; in other words, they considered themselves to be rancheros even if they did not ranch. Several rancheros told us that they considered ranching to be too difficult to maintain, for example, as one ranchero said: “I am struggling. We struggle and suffer. There are two or three goats left to support me out of thirty or forty. And you can see that in most ranches, you can see the lack of animals, there are no animals, there is nothing (San Javier).” Table 2 in the Online Resources summarizes the topics that rancheros explored when discussing drought in the area, categorized by the assets we analyzed in the co-occurrence analysis and the QCA. Notably, no rancheros mentioned female education in any way, including, leaving the ranch to attend school, learning about drought strategies in school, or gender inequities in

school attendance (Table 2 Online Resources, female education). Across the interviews, drought severity was mostly assessed by detriment to livestock (Table 2 Online Resources, livestock ownership).

Climate perception and livelihoods

In line with the descriptive statistics showing that 90% of the respondents were aware of the weather becoming more unpredictable in the last 10 years, the interviews also demonstrated that rancheros were very aware of how environmental conditions affects their livelihoods and ability to respond to drought. Some noted that the rains they expected in June did not fall until September and when they did fall, they were thunderstorms. Another rancher perceived more frequent hurricanes in the area (supported by other rancheros in the household survey open-ended questions). Further, some respondents told us that they chose land based on local knowledge, specifically in relation to weather patterns. For example, one respondent commented that rain was an important factor in their decision to migrate, in addition to social capital: “Because we had some relatives in the *ejido* (a system of cooperative land tenure) and it rains more here, there was more grass and water. There’s more life here, so to speak (La Paz region).”

Table 2 Summary of trait influence on the adoption of specific drought adaptation strategy for each analysis

Method	Drought strategies	Environmental migration	Household migration	Changing farm practices	Off-farm work
Co-occurrence	Any	Positive: female education and climate perception Negative: La Paz area and climate perception	Positive: female education and climate perception Negative: La Paz area, climate perception, and livestock	Positive: financial diversity, land title, and livestock Negative: La Paz area and land title	Positive: no distinction Negative: La Paz area and financial diversity
Qualitative comparative analysis (QCA)	Positive: none Negative: La Paz area	Negative: La Paz area and climate perception Positive: land title and ranching as a primary livelihood Negative: no distinction	Negative: La Paz area, climate perception, and livestock Positive: female education Negative: no distinction	Positive: no distinction Negative: La Paz area	Positive: no distinction Negative: La Paz area
Interviews	Negative: urban access	Negative: declining opportunity overall due to rising costs, no association between strategies and female education	Positive: individuals who migrated used the phrase “come and go”	Negative: farming and ranching seems to be becoming more difficult to maintain	Positive: alternative employment opportunities are unstable

Changes in water availability and water distribution over time

Many respondents also observed declines in both surface and groundwater sources (Table 2, Online Resources) coinciding with climatological changes and urban extraction pressures on aquifers (Haefner et al. 2016).³ The interviews further revealed a perceived opposition between the efficiency values of the government and sufficiency ideals of rancheros in both regions, with respondents observing more government relief in the most recent drought than in previous years but not at sustainable rates. Those who were alive during the 1950 and 1970 droughts indicated that they did not receive any sort of government drought relief.⁴ Specifically, older respondents remembered “none,” “none,” and “not much” drought relief from the government for the dry periods associated with 1953, before Hurricane Liza (pre-1976), and 1983, respectively, but all respondents recalled receiving some government assistance in 2011. Despite acknowledging this increase in assistance, one group in the La Paz region discussed this situation with one explaining that the government supplied 12 l of water per person per day in the last drought with one respondent retorting “I could barely shower!” and another lamenting “Barely enough to drink, even.”

La Paz region residents talked about urban access to government water delivery and car transport of water from cities (Region row, Table 2 Online Resources) whereas Loreto region residents talked about local water infrastructure and neighbor sharing (Access to surface water row, Table 2 Online Resources). For example, a respondent told us: “When they brought water from La Paz, we had to transport it in a car (La Paz region).” Another ranchero in the La Paz region told us that even though he owned a truck, he could not afford the gas to go to town to get water. Houses in the La Paz region were also more likely to have indoor plumbing and water provided by a utility company. When conducting the survey in the La Paz municipality, we observed that the houses near the main highway were able to access the relatively more reliable urban pipe system (a *tandeo* system in which water is available every other day), and 21 of these households regularly used urban water for their animals.

Migration outcomes

From the interviews, we can further infer that *seasonal* migration was an important part of the ranchero adaptation portfolio. This might be why we saw a higher percentage of households who had a household member who migrated during the

³ No respondents mentioned water quality issues such as saltwater intrusion, only quantity issues.

⁴ Baja California Sur became a state of Mexico in 1974, which may have prevented previous aid distribution to the territory.

drought years but did not relate it directly to the drought. Tellingly, a popular response in the household survey to how long household members left the household was “*va y viene*,” (used in more than 66 write-in responses corresponding to 10% of all individuals considered) translated to “come and go.” This response was common whether the respondent moved between rural areas or to urban areas. When our interviewees did talk about migrating due to water scarcity, they talked about it in tandem with other driving factors, such as finding economic alternatives. According to one respondent, migration may be due to drought, even if not directly related to it: “They have left because there are no jobs here, no jobs at all. Because there are not any jobs here that pay very much. It used to rain a lot; there was water (La Paz region).” Another *ranchero* told us that while he used to migrate more readily in the past, costs were becoming too expensive to do so now: “There have been many droughts, I went to Puerto Escondido [a harbor town], because there was nothing here... The thing is, things weren’t as expensive as they are now, and now you can’t go anywhere... (San Javier).”

Discussion

Mixed methods: Integrating co-occurrence analysis, qualitative comparison analysis, and in-depth interviews

Comparing the knowledge gained via in-depth interviews with co-occurrence analysis and QCA allowed us to better identify the key existing relationships between household trait and drought adaptation strategy adoption as well as *why* traits may influence such adoption. QCA provided the means to compare household trait make-up and drought responses while adding an important dimension to studying the variety of ways that rural households adapt to changing climatic conditions. QCA, however, required that complex factors to be collapsed to create binary variables. For example, owning livestock could have different effects depending on the type and number of livestock owned; land title could have different effects depending on the amount of area owned. Hence, by using QCA, we do lose some detailed information collected through the survey. The use of in-depth interviews reduces the limitations of QCA as they allow for complex factors to be better explained. Such interviews revealed the seriousness of drought consequences as well as knowledge gained about social capital, migration, and the importance of living closer to urban areas for water access, as all are critical traits that were identified in the in-depth interviews.

According to our co-occurrence analysis, financial diversity and female education, together with owning livestock and land title, were more prevalent in households who responded to the drought. However, according to the QCA, the most

important traits seemed to be land ownership and female education together with regional characteristics. Female education and owning land positively affected the decision to migrate: households that owned land titles with at least one female going to secondary school were more likely to choose to migrate. On the other hand, our interviews did not elicit any association between female education and drought adaptation. Furthermore, living in the La Paz municipality was negatively associated with household choices to change farming practices or finding off-farm work. Table 2 summarizes our findings for each of the methods used in this study.

Positive and negative definitions denote relationship, not normative assumptions. “Positive” means that the household trait is associated with the adoption of the drought adaptation strategy; “Negative” means that the household trait is associated with the non-adoption of the drought adaptation strategy.

On the one hand, the co-occurrence and QCA results show that living in the La Paz area was negatively associated with decreased adoption of drought adaptation strategies. On the other hand, the interviews highlighted a situation where some La Paz area households were able to access urban water supplies, which seemed to increase their robustness to droughts. The importance of accessing urban water supply is highlighted by the fact that 21 households in the surveys, all in the La Paz region, told us that they regularly bring water from the city or use potable water from pipes for animal consumption. While our results are able to capture the relationship between rural households and drought adaptation strategies in Baja California Sur, the role of hard human-made infrastructure (i.e., canals, dams, piping of water, etc.) warrants further investigation. Increased reliance on such hard infrastructure may increase robustness in the short-term at the expense of reduced adaptive capacity in the future by changing (and possibly reducing) options available to the *rancheros* (Haeffner et al. 2016). Dependency may erode *ranchero* ability to adapt to more intense and frequent droughts, especially if urban water supplies should diminish or increase in cost, or regulatory barriers put in place that prevents rural access to urban water. This could especially become true given the current concerns of the *ranchero* community about rising costs and declining opportunities, unstable job market, and ultimately, the increased difficulty in maintaining farms and livestock. Finally, we found that while obtaining off-farm work was a popular choice for *rancheros*, environmental migration was not. A review of the open-ended and write-in answers to the survey questions revealed that the most popular head of household occupation was day-laborer. This type of low security employment is a short-term strategy to cope with changing social and environmental conditions but may add to overall vulnerability since those types of jobs depend on external factors like real estate markets (for new construction investments), the global tourism industry (for road building projects), federal funding (for

disaster recovery), and the like. Given that the respondents in this study continue to identify as *rancheros* despite choosing alternative livelihoods to respond to drought, our findings suggest that, as Vadjunec et al. (2016) have proposed, smallholder identity may be as much of a state of mind as it is a certain number of hectares or livestock owned.

Financial diversity was key for a household's ability to create a buffer against drought according to the co-occurrence results, as well as enabling mechanisms that increased the ability of households to adopt other drought adaptation strategies such as migrating, or changing farm practices. The key role of financial diversity is not new, as its prominence is known within the literature on adaptive capacity (e.g., de Janvry and Sadoulet 2001; Liverman 1999; Massey et al. 2010). Owning livestock in this context can be thought to increase financial diversity if owners sell their animals as an income source. Although no one explicitly stated it in the interviews, it is likely that owning livestock allowed for households to "invest" in female education especially in the region of study, where secondary education is only available in urban centers (a high cost for households). Female education, whose benefits include increased social capital as girls are exposed to networks outside of the home, is considered key in increasing households' overall adaptive capacity to respond to crisis (Eakin 2005; Gray 2009; Laczko and Aghazarm 2009; Massey et al. 2010). Specifically, research has shown that the number of educated girls and women in a household is associated with reduced flood and drought risk (Blankespoor et al. 2010).

Social capital, and specifically social networks, has been shown to be an important factor for both migration decisions (Narayan and Pritchett 1999; Nelson et al. 2005) and community robustness (Baggio et al. 2016a). The relationship between social capital and female education in this specific region could underlie the relation between female education and the decision to adopt migration strategies to adapt to drought, although this connection was not elicited in the interviews. Further, contrary to the robust literature on the role that social capital plays in adaptation in general (Narayan and Pritchett, 1999), our survey findings did not find strong associations between social capital and other household traits in relation to drought outcomes (but did find an association with household member migration for any reason). We used "membership in a formal organization" as a measure of social capital in the survey, a common indicator in the extant research literature (see for example, Narayan and Pritchett 1999; Vincent and Cull 2010). Perhaps this indicates a need to increase social capital among rural Baja California Sur households. On the other hand, this could suggest that the way that social capital is measured by

researchers does not capture the types of social bonds in these communities, and future research could focus on culturally appropriate social capital measures designed by *rancheros* (for an example of social water management on mainland Mexico, see Navarro-Navarro et al. 2017).

Possible justification for discordant results

As we looked at *ranchero* drought adaptation from multiple angles, we found that some associations were emphasized using one lens while other associations were lost in the noise when looking at the data through a different lens. Indeed, our three-pronged data analysis process was designed to avoid confirmation bias of theoretical associations while exposing associations between traits and adaptation strategies that might not be immediately obvious at the household scale. Consider the fact that female education was related to household member migration strategies (a theoretical association) in both the co-occurrence and QCA analyses, but was not prominent in respondents' telling of their drought experiences even when prompted. If we had only conducted interviews, we may have missed this important association and may have concluded that drought experience in Baja was gender neutral. While some might point to the inconsistency across analyses as a threat to validity and reliability, we believe that the information provides clues for further research, especially in the subjective observations of drought experience on the one hand and what we might be capturing when we think we are measuring female education on the other. Looking at the data through all three lenses also exposes the complexity of urban access shown by the La Paz region—we cannot conclude whether urban access alleviates or prevents households in the La Paz region to adopt drought strategies, only that there are strong relationships. This warrants further investigation as to the spatiality of inequity in access to urban water.

Implications for water managers

There is an opportunity here to re-imagine the narrative of *rancheros* as simply water end users or drought aid recipients to a partnership that recognizes *ranchero* settlement in key aquifer recharge zones. Drought insurance schemes are also scarce in this region but could provide needed economic recovery after drought disasters. A budget specifically earmarked for droughts could allow utilities to repair infrastructure in a timely manner to reduce lapses in urban water access, which we found to be important for many La Paz region households. And, while we acknowledge the climatic challenges of encouraging driving, short-term incentives such as a gas credits for car-pooling to transport water would allow *rancheros* more equitable access until long-term solutions are put into place. Indeed, potable water is already trucked to *ranchero* villages at the discretion of municipal utilities or

commercial vendors in the La Paz region, but only household near major roads tend to have access to this urban water. It might be useful for municipal public utilities to work with city officials to review any restrictions, taxes, or laws preventing rural access to urban water, including exchange and sharing, especially in times of drought.

Identifying where *ranchero* needs lie can help government policy makers address sufficiency gaps. Knowing this, government agencies could concentrate on options for households to be more flexible and secure in choosing drought adaptation strategies “in place,” such as supporting sustainable agriculture projects in the region, increasing transportation options to access city centers, providing access to insurance and credit schemes, increasing employment opportunities in order to increase the financial diversity of rural households, and setting aside land and corridors to facilitate seasonal migration for households and their livestock. Future studies on migration and other drought adaptation strategies can compare rural groups in other areas and their ability to migrate, adapt, and access urban amenities.

Conclusion

While our study was motivated by the goal of identifying which household traits, if any, were associated with which drought adaptation strategies households used, the most consistent finding across all analyses was that the more likely a household lived in the La Paz area (with more urban access), the *less* likely they were to have adapted to the last drought. Less consistently, we found that financial diversity when combined with land ownership and a perception that the weather had been more unpredictable in the last 10 years was associated with adapting to the last drought (in the co-occurrence analysis). What was not as surprising, however, was that since this cultural group has traditional ties to migrating during droughts, the QCA analysis found an association between having a *ranchero* as the head of household and holding a land title (as opposed to the communal *ejido* system common in Mexico) with environmental migration out of the watershed. However, the qualitative work highlighted that even though *rancheros* talked about drought migration in the past, environmental migration was not a key strategy for *rancheros* in the 2006–2012 drought. Instead, *rancheros* in this study tended to adapt “in place” by changing their farm practices and/or acquiring off-farm work, but had varying assets available to maintain traditional livelihoods or conduct sustainable *ranching* practices. The qualitative data revealed the great difficulty *rancheros* have in sustainably maintaining their traditional *ranching* livelihoods under current conditions.

Our study further suggests that spatial inequality exists between the two rural communities. In other words, living in the La Paz region was the one household trait that was important

in all three data analyses, and with La Paz region households *less* likely to have taken any of the drought adaptation strategies under study. It is highly likely that access to fresh water during droughts exists along a gradient with more remote households lacking urban water infrastructure while being exposed to dry (or salt-contaminated) wells and dry streams. It is important to note, however, that the La Paz area interviewees reported that while they were receiving municipal water deliveries during the drought, that these were not sufficient. Future research should look at this phenomenon more closely to examine the interrelationship between water sources, water delivery, and household location, and the impacts of urban growth on the availability of water.

If climate, economic, and urbanization trends continue, it appears highly unlikely that *ranching* can be a sustainable economic livelihood or cultural practice without intervention. *Ranchero* *sudcalifornianos* should ultimately be recognized as stewards of the land and supported as equal participants in sustainable water conservation.

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Compliance with ethical standards

This research was approved by the Colorado State University Institutional Review Board Protocol 12-3573H.

Conflict of interest The authors declare that they have no conflict of interest.

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