Perception of drought and local responses by farmers: a perspective from the Jucar River Basin, Spain

Julia Urquijo* & Lucia De Stefano

Departamento de Geodinámica,

Facultad de Ciencias Geológicas,

Universidad Complutense de Madrid

C/ José Antonio Novais, 12, 28040, Madrid, Spain

(*) Corresponding author

Abstract

Farmers play a key role in water management at all levels and their role becomes even more relevant during droughts, when water systems are under increased pressure. This paper presents a study based on interviews to farmers in eastern Spain using different types of water sources, to explore how that factor influences perceptions and actions during droughts. Results show that farmers often perceive droughts through non-climatic factors, e.g. the volume of water stored in the reservoirs or water restrictions, rather than through meteorological parameters. The type of water source highly influences farmers' perception of drought and the type of strategies implemented to face it, confirming the key role of groundwater in buffering drought. In areas using surface water, practices to mitigate impacts include temporary changes in cropping practices, temporary modification of water distribution shifts or the use of emergency wells. In areas irrigated with different water sources – groundwater, reclaimed water – farmers' actions address mainly permanent water scarcity problems and their concerns are focused on the long term viability of their activity – in terms of cost of water or water quality – rather than on variability of rainfall. Both in surface and groundwater-based irrigation areas, local responses often require close cooperation among users, as they may involve redistributing the available resources, sharing extra costs, or combining water from different sources to achieve the desired water quality.

Key words: Drought, Perception, Farmers, Responses, Irrigation community, Vulnerability

1. Introduction

"Perception refers to a range of judgments, beliefs and attitudes" (Taylor et al. 1988, p. 152) and, in the case of drought, it is influenced by the characteristics of the dry spell as well as by the context of whom experiences it (Patt and Schröter 2008; Dessai and Sims 2010; Higginbotham et al. 2014). Thus "drought means different things to different people, and there are probably as many definitions as there are users for water" (Heathcote 1969, p. 176).

The diversity of drought definitions makes it important to understand stakeholders' percep- tion of it, as that will influence their actions and their acceptance of mitigation actions (Giordano and Vurro 2010; Stoutenborough and Vedlitz 2014). Moreover, understanding people's perception can help identifying barriers to behavioural changes that are needed to achieve sustainable water management (Dessai and Sims 2010) and it is a necessary condition for the effective formulation and implementation of policies (Patt and Schröter 2008; Sherval and Askew 2012).

The first studies of drought perception were developed by Saarinen (1966) in Australia, and by Heathcote (1969) and Taylor et al. (1988) in the USA. Since then, a number of studies have been undertaken in those two countries (Raphael et al. 2009; Sherval and Askew 2012; Higginbotham et al. 2014; Diggs 1991; Dagel 1997; Keenan and Krannich 1997; Woudenberg et al. 2008; Knutson et al. 2011), in Africa (e.g. Slegers 2008; Patt and Schröter 2008; Noemdoe et al. 2006), Asia (e.g. Habiba et al. 2012; Mehta 2001), and Europe (e.g. Dessai and Sims 2010; Giordano and Vurro 2010). In Spain, Morales Gil et al. (2000) analysed the perception of drought by the Spanish society, while Ortega-Reig et al. (2014) studied farmers' perception of drought as part of a research on conjunctive water use and drought management. March et al. (2013) focussed on the perception of drought in the city Barcelona, while other Spanish authors (e.g. Ruiz Sinoga and León Gross 2013) studied drought perception through the analysis of mass media.

Most of these studies focus on the analysis of differences in drought perception within a given group of water users, mainly among different types of farmers (e.g. rangers, Dagel 1997; irrigated vs non-irrigated farmers, Habiba et al. 2012), different geographic locations (rural – coastal areas, Higginbotham et al. 2014) or different farming methods (Knutson et al. 2011). However, few previous works have been found that explore how the type of water source influences drought perception and response practices, and even less have used in-depth interviews as a means to let water users guide the researcher to those themes and concerns that are relevant to them.

This paper aims at filling this gap by using in-depth interviews to explore drought perception among farmers that use different water sources in the Jucar River Basin District (JBRD, eastern Spain). The study also provides insights into individual and collective response to drought, thus complementing existing studies that focus mainly on governmental response to drought. Moreover, it also offers empirical evidence about what factors influence farmers' vulnerability to drought, which is critical information when designing vulnerability assessments (González Tánago et al. 2015).

2. The Study Area

The JRBD (42,989 km2) has a permanent population of 5.1 million people and stretches over four regions (Valencia, Castilla-La Mancha, Aragón and Catalonia). The Jucar River Basin Organization (JRBO) is the main governmental agency responsible for water management and is in charge of developing and implementing the River Basin Management Plan and the associated Drought Management Plan (DMP).

According to the JRBO (CHJ 2014), the average annual precipitation is 485 mm and the total renewable water resources are 3842 Mm3/yr. Reused water amounts to approximately Mm3/yr, while desalinated water is about 3.5 Mm3/yr. The JRBD also receives 50 Mm3/yr from other basins, to supply several urban areas on the Mediterranean coast.

The main economic activities in the area are related to tourism and agriculture, with over 380,000 ha under irrigation dedicated mainly to citrus (42 % of the total irrigated area), vegetables (11 %), grain cereals (10 %) and vineyard (9 %). Agriculture employs 81,000 people and generates approximately 3 % of the total Gross Value Added of the JRBD.

Total gross demand for agriculture is 2512 Mm3/yr (or 79 % of the total demand). Over 53 % of water resources for agriculture are surface water, while 43 % is withdrawn from aquifers and only 2.6 % are treated wastewater. About 36 % of the irrigated area uses flood irrigation, while drip irrigation accounts for 38 % and sprinkle irrigation accounts for near 25 % of the total irrigated area (CHJ 2014).

This study focuses on two main irrigation areas: (i) an area of surface water irrigation that receives water from the Júcar and Turia rivers; (ii) an area of groundwater irrigation in the watershed of the Vinalopó river (Fig. 1). Within these two areas, we studied seven Irrigation Communities (ICs), whose main characteristics are summarised in Table 1.

Surface water irrigation farmers (SW) grow mainly fruit trees. The JRBO supplies surface water to the different irrigation areas by operating several reservoirs and distribution channels. During drought, the JRBO can apply water restrictions if needed to better meet water needs of all the users in the river basin. In these areas, farmland abandonment is a reason for concern and is attributed to the progressive decrease in plot size (due to the traditional land-heritage scheme) and the reduced benefits of traditional crops (García-Molla et al. 2013).

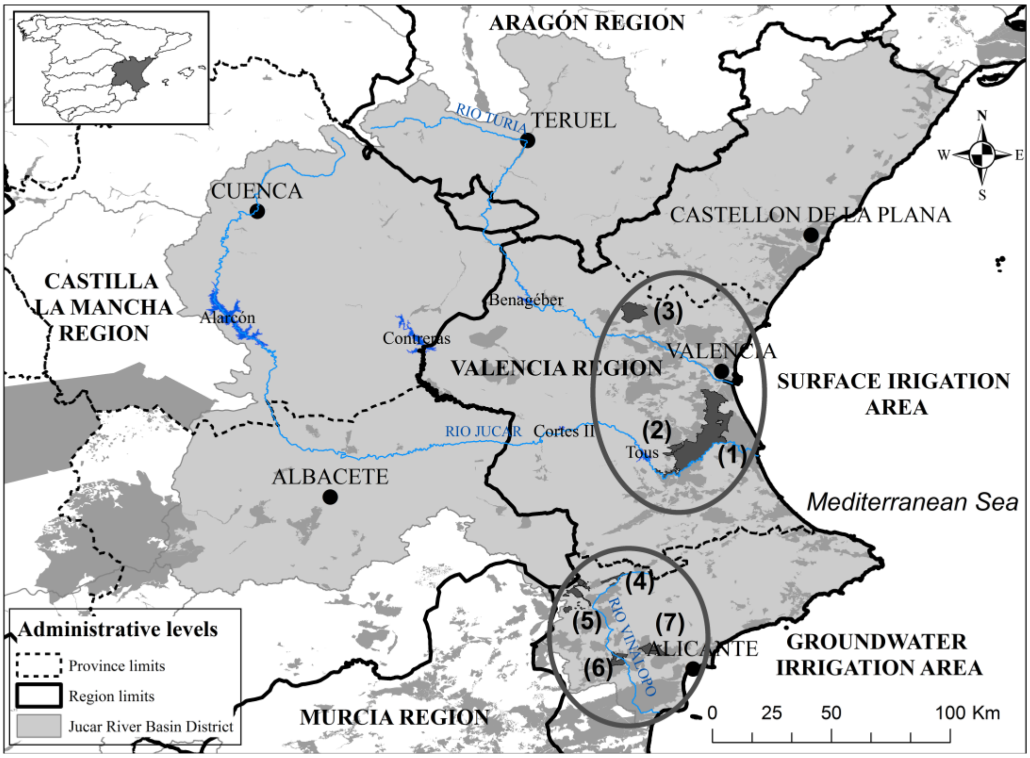

Figure 1. Location of the Irrigation Communities: (1) Acequía Real del Júcar, (2) Canal Júcar – Turia , (3) Casinos, (4) Benejama, (5) Villena, (6) Novelda, (7) Agost.

In the Vinalopó basin, farmers using mostly groundwater (GW) cultivate mainly vegetables, vineyard and olive trees and rely on a complex network of groundwater pumping stations and irrigation ponds to drip-irrigate their crops. Within the basin there is also a system of pipelines that transfer groundwater abstracted from wells in Upper Vinalopó to the middle Vinalopó. Intensive aquifer exploitation has caused the progressive decrease of water table levels and degradation of water quality, and is a major reason for concern among users and water managers (Rico Amorós 2002; López Ortiz and Melgarejo Moreno 2010).

Table 1. Main characteristics of the Unit of Agricultural Demand (UAD) where the ICs are located (CHJ 2014).

Irrigation Community	Unit of Agricultural Demand	Irrigated area (ha)	Main water use	Allocation (Mm^3/yr)	Water sources in 2009 (Mm^3/yr)	Irrigation methods in 2009 (%)	Average net demand ($m^3\ ha^{-1}\ yr^{-1}$)	Main crop types (%, average net demand in $m^3\ ha^{-1}\ yr^{-1}$)
Acequía Real del Júcar (ARJ)	Regadíos Tradicionales del Júcar - Acequía Real del Júcar y AC particular de Antella	20,329	Agriculture	224.3	SW= 223.95 GW = 0.05 Other = 0.3	Flood: 94 Drip: 6	5,282	Citrus (67%- 4,050), rice (22% - 9,400), vegetables (11%- 4,600)
Canal Júcar Turia M.D (CJT)	Regadíos del Canal Júcar Turia M.D.	10,888	Agriculture and Urban Supply	94.29	SW= 80.15 GW= 14.14	Flood: 46.35 Drip: 53.65	3,972	Citrus (55%- 4,050), Fruit trees (39% - 4,050), vegetables (6%- 2,744)
Casinos	Regadíos del Canal del Campo del Turia	18,470	Agriculture	89.50	SW= 40 GW= 49.5	Flood: 29 Sprinkle: 1 Drip:70	3,324	Citrus (70,3% - 3,568); Fruit trees (11,7% -2,016); Other crops (18%-3,219)
Benejama	Riegos Mixtos del Alto Vinalopó	917	Agriculture	3.32	SW= 1.96 GW= 0.73 Reused= 0.63	Flood: 4 Drip: 96	1,963	Olive trees (35.7%- 686), Vineyard (wine) (20.1%- 1,650), cereals (12.4% - 2,650), vegetables (11.5%- 5,450); Fruit trees (11.1% - 1,350); Other crops (9.3% - 3,030);
Villena (VIL)	Riegos Subterráneos del Alto Vinalopó	13,198	Agriculture	27.67	SW= 0.3 GW= 27.08 Reused= 0.29	Flood: 23.7 Sprinkle: 25.6 Drip: 50.7	2,328	Olive trees (33.1 %- 686 , Vineyard (wine) (27.7%- 1,650), vegetables (16.3%- 6,812); Other crops (22.9% - 2,331);
Novelda	Riegos del Vinalopó Medio	10,890	Agriculture	29.63	SW= 0.5 GW= 26.31 Reused= 2.82	Sprinkle: 10 Drip: 90	2,658	Table grape (49.8 %- 3,100), Vineyard (wine) (21.3%- 1,650), Fruit trees (11.9%- 1,715); Other crops(17% - 3,292);
Agost	Riegos del Alicantí	2,963	Agriculture	13.12	SW= 0.07 GW= 6.03 Reused= 7.03	Flood: 55 Drip: 45	3,093	Table grape (25.4 %- 3,098), Fruit trees (21.9%- 2,162); Olive trees (13.4% - 1,410), Citrus (10.9%-4,186), Other crops (28.4% - 4,176)

3. Methodological approach

The analytical framework of this study is based on the elements that shape perception according to Taylor et al. (1988): Experience, Memory, Definition, and Expectation (Fig. 2). We aim to understand not only farmers' perception of drought, but also their behaviour during drought as reflected in the measures they implemented. Due to space constraints and while acknowledging the important role of governmental actions in managing drought, this paper focusses only on farmers' individual and collective actions during dry spells.

Experience refers to the episodes of drought that have hit a given region. Memory refers to "those drought events that were part of the farmers direct experiences and could be recalled" (Taylor et al., 1988; p.154). As Heathcote (1969) explains, "not all water shortages are droughts, and, unless some economic setback results from the shortage, drought may not be recognized" (p. 176). This implies that farmers may not recall a drought episode, simply because it did not affect them. Definition refers to the way a drought episode is characterized by farmers using "a set of criteria (…) for classifying a time period as a drought" (Taylor et al. 1988; p.155). The analysis of drought definition contributes to understand why some events are remembered and others are not. Behaviour is captured through the type of measures implemented to address water shortages. Additionally we explore the vulnerability factors that influence such perception and farmers' concerns about the future. These elements were studied in both SW and GW ICs to detect whether and how the type of water source influences perception and behaviour during droughts.

The conceptual framework was applied through semi-structured in-depth interviews. This is a qualitative research technique considered to be a flexible, interactive and generative tool (Legard et al. 2003) that promotes the emergence of relevant themes during the fieldwork and allows researchers to explore a given issue through the personal experiences and opinions of the interviewees. The sample of interviewees was not chosen to seek a statistically represen- tative sample of the studied population. As remarked by Mason (2010), the "sample size in the majority of qualitative studies should generally follow the concept of saturation (…), when the collection of new data does not shed any further light on the issue under investigation" (p.10). We met saturation after 24 in-depth interviews, which is also in line with the indicative number of interviews suggested by different authors for qualitative studies (Creswell 1998; Guest et al. 2006; Charmaz 2006). Generating quantitative data for statistical analysis – e.g. through a survey – and to complement the information obtained in the interviews proved to be unfeasible since no list of the irrigation communities was available for a random sampling of the participants.

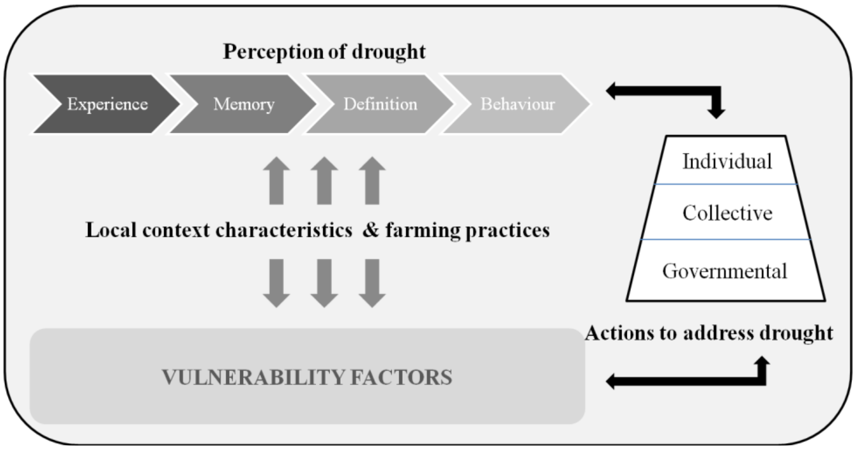

Figure 2. Conceptual framework (adapted from Taylor et al 1988)

Interviewees were selected in consultation with key informants in the study area, and included farmers (n = 20) and irrigation technicians (n = 4). Seventy-five percent of the interviewees worked in SW irrigation areas and 25 % in areas where groundwater was the main water source. All the interviewees but two were male and their age ranged between less than 45 and over 75 years (<45, 21 % of the interviewees; 46–55, 37.5 %; 56–65, 16.5 %; 66– 75, 21 %; >75, 4 %). The interviews were carried out between June and July 2013 in the premises of the farmer associations or on the farmer's plot. They lasted between 1 and 2 hours and included ten open-ended questions (see Supplementary Material) to capture information on the analytical categories defined in Fig. 2. Interviews ended when speech saturation was reached (Glaser & Strauss, 1967).

Interviews were tape-recorded, transcribed and coded for analysis and interpretation. Following Dagel (1997), we analysed the discourse of the interviewees using content and cluster analysis. Content analysis permits replicative extraction of perception data from qualitative communication, while cluster analysis allows the formulation of conclusions from those data.

4. Results and Discussion

4.1. Experience and Memory of Droughts

According to the DMP in the past thirty years the JRBD experienced four drought episodes: 1983/84–1985/86 (extreme), 1992/93–1995/96 (extreme), 1997/98–2000/01 (mild) and 2004/05–2007/08 (extreme)1 (CHJ 2007). This can be understood as the experience of drought in the area and can be compared with farmers' memory of drought events.

The memory of drought differs among farmers depending on their main water source. Only one of the interviewed GW farmers recalled suffering a drought. All the SW farmers stated having experienced at least one drought, 66 % two, and only 20 % of them recalled three episodes. Sixty percent of the interviewed farmers mentioned the 1992/96 drought, 55 % the 2005–2008 drought and 20 % the one in the 1980s. Thus, the most frequently-mentioned drought was the 1992–96 event and not the most recent one. This could be due to the fact that, according to several farmers, drought impacts were more severe in the 90s than in 2005–2008.

This is in line with the fact that water reserves decreased more in the 90s than during the 2005– 2008 drought, even if rainfall levels were similar in both events (Fig. 3). The 1997/98–2000/ 2001 drought, classified by the JRBO as "mild", was not recalled by any of the interviewees, corroborating the idea that "intermediate years and droughts are lost from memory" (Saarinen 1966). The low number of farmers that recall the drought in the 1980s confirms that"the farther the year in the past, the fewer identified it as a drought year" (Taylor et al. 1988; p. 160). Most of the interviewees had difficulties in determining the exact onset and end, or the duration of the drought episodes, which is consistent with the fact that drought is a creeping phenomenon (Wilhite and Glantz 1985).

4.2. Farmers' definition of drought

Farmers defined drought mainly as a time when they suffer negative impacts, meant as losses in agricultural production (55 % of the interviewed farmers) or changes in their cropping practices due to water restrictions (65 %). Among traditional SW farmers, changes in irrigation shifts are seen as a clear symptom of drought: they usually irrigate their plot every 20 or 25 days, while, during drought, irrigation shifts take place every 32 or even 40 days.

[1] The Júcar DMP defines drought as an "unpredictable extreme hydrological phenomenon that: entails a significant decrease in water resources during a sufficiently prolonged time period; affects a large area; and can impede fully meeting water demands and has adverse economic consequences". Drought severity is: Extreme (SPI < −1.65), Severe (SPI < −1.28), Moderate (SPI < −1.84).

Cropland fallowing and the risk of tree death were the most frequently mentioned impacts, followed by the reduction in quality and volume of agricultural production.

Dagel (1997) found that rangers often described drought as “when ranch operation is affected” (p.197), while other studies mention crop rotation or selection of crops, changes in crop and land management practices, diversification of farming activities and income sources (Slegers 2008; Habiba et al. 2012; Knutson et al. 2011). In our study, the role of impacts in the perception of drought is particularly evident in the case of GW farmers, who stated that they did not experience any drought as they never suffered temporary water shortage or impacts for lack of water: “So far we have irrigated our fields every year” (GW2); “So far we have had any problems related to whether it rains more or less because we pump groundwater” (GW1).

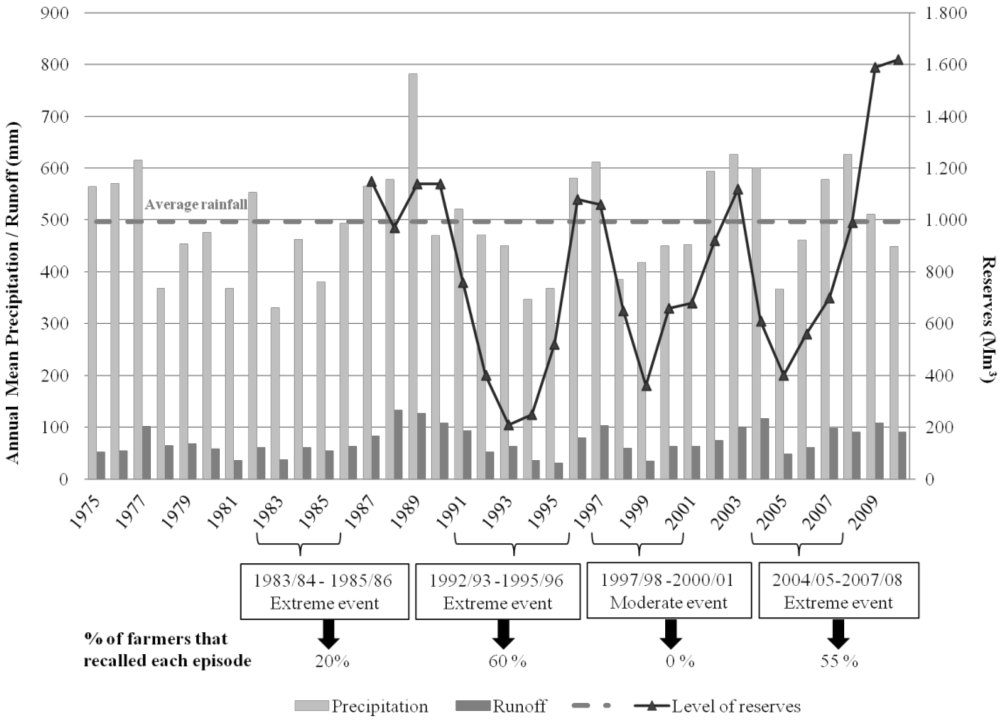

Figure 3. Precipitation, runoff and surface water reserves in the JRBD.

The second most common way of referring to drought (50 % interviewed farmers) is as a time when the level of water reserves in the reservoirs or the flow in the river (or in the irrigation channel) are low. Thus, these farmers perceived a hydrological drought, meant as “the effects of dry spells on surface or subsurface hydrology” (Wilhite and Glantz 1985, p. 115). This definition suggests that the visibility of the resource is a factor that influences drought perception and the attitude of farmers. On one hand, if the irrigation channels or reservoirs have low water levels, farmers will be aware of the problem and act accordingly. On the other hand, high water levels in the distribution channels or the riverbed due to releases from reservoirs may induce the wrong perception that reserves are abundant.

The third way of defining drought is as a time of low precipitation (25 % of the interviewed farmers). Several farmers mentioned that the real problem is when there is a lack of rain during a couple of years, either locally or in the headwaters of the river. Some farmers seemed to confuse drought with intra-annual variability: “Here we have drought every year from March to October because it never rains” (SW5 and SW6). Other perception studies found that drought definition is more closely related to rainfall than to impacts. For example, Slegers (2008) found that 65 % of the descriptions of drought referred to precipitation reduction.

These different ways of describing the same dry period confirm that drought is a relative concept, influenced by context and values at stake, and that drought perception has an impact on farmers' behaviour. The definitions used by farmers roughly correspond to socioeconomic drought, hydrological drought and meteorological drought (Wilhite and Glantz 1985), respec- tively. In particular, this study shows that impacts play a prominent role in shaping drought perception, and thus confirms the relevance of initiatives that record impact data (e.g. Drought Impact Reporter, Wilhite et al. 2007) and of studies looking for correlations between hydro- meteorological indicators and impact records (e.g. Bachmair et al. 2014; Blauhut et al. 2015). Indeed, linking drought severity thresholds and drought perceptions "could lead to more socially transparent definitions of drought severity thresholds and have a direct impact on drought-related policies and programs" (Smakhtin and Schipper 2008, p. 141).

4.3. Contextual factors influencing vulnerability

During the interviews, farmers mentioned several issues that determine or at least influence the vulnerability level that they experience during drought (Table 2).

The amount of water available for irrigation is at the heart of the concerns of SW farmers. During dry spells, the RBO can impose restrictions on surface water use that are determined taking into account the existing water rights and the water availability in each exploitation system. As in the study area SW rights are often higher than the actual water needs, these restrictions do not always cause important impacts on SW farmers. GW farmers do not face water restrictions during droughts because aquifers buffer rainfall variability and because groundwater pumping is difficult to control. Their major concern, though, is water availability on the long term, due to the high level of aquifer overexploitation in the area.

Water quality is a major concern for GW farmers, as stated by one farmer of the Middle Vinalopó: "Here we have water, if you dig a well you find water, but its quality is poor", GW2). This induces some ICs to build their own treatment plant to enhance groundwater quality. Moreover, some GW farmers use treated wastewater, which has a rather poor quality.

In contrast, in the study area SW farmers are reluctant to use other water sources because of their lower quality relative to surface water.

As remarked also by Wilhelmi and Wilhite (2002) and Knutson et al. (2011), the diversi- fication of water sources is a key aspect in managing vulnerability to drought, as different sources are affected differently by rainfall variability. In the study area, SW farmers have little diversification of their water sources during average or wet periods. During drought, however, some of them get access to groundwater through common wells or get extra treated wastewater to complement the available surface water. On the contrary, GW farmers have developed a stable portfolio of water sources, including transferred groundwater and treated wastewater. For instance, the Agost IC, in the Middle Vinalopó, holds a water right to use 1.75 Mm3 of treated wastewater from the coastal area, even if water has to be pumped 400 m up to reach the plots of the IC. This entails an additional cost for farmers that increases the final price of water to about 0.5 €/m3.

The use of each type of water has a different cost. For farmers using groundwater (GW farmers but also SW farmers during drought), the high cost of energy for operating the wells constantly acts as an incentive to optimize water use, as the energy bill can jeopardize the economic profitability of their crops:"Here, since water is expensive, we do not start the pumps if it is not necessary…If others paid the electricity bill, maybe we would pump more but, since that is not the case, we do not" (GW1). SW farmers, and especially those still using flood irrigation, are reluctant to use any alternative water source as "Every alternative to the traditional channel system is more costly, thus we ask for treated water only when there is a drought" (SW2).

Table 2. Factors influencing farmers' vulnerability to drought. % indicates the proportion of farmers that mentioned that topic during the interviews.

Vulnerability Factors	Description	% SW farmers	% GW farmers
Water quantity	Major reductions in water supply increase vulnerability to drought	93%	80%
Water quality	Higher water quality reduces vulnerability	40%	80%
Diversification of water source	When alternative water sources exist vulnerability to drought decreases	33%	80
Cost of water abstraction	High price of energy for groundwater abstraction increases vulnerability to economic losses	40%	60%
Type of irrigation system	Drip irrigation permits a more efficient use of water resources (relative to flood irrigation) and avoids spaced irrigation shifts	53%	80%
Type of crops	Vegetables are more vulnerable than fruit trees during short droughts; Fruit trees risk to dry during prolonged droughts, this may cause an irreversible damage; Rice is less vulnerable than other crops as in the area it is culturally and environmentally important	40%	--
Plots characteristics and management	A correct maintenance and cleaning of plots and distribution network increase water use efficiency Soil types (e.g. clay and sandy) have different water infiltration and retention characteristics	53%	--
Plots location	Proximity to the main distribution channel and to protected wetlands increases water guarantee	20%	--

Another recurring theme in the interviews is the type of irrigation system and, in particular, how the shift from flood to drip irrigation influences the level of vulnerability to drought. SW farmers that have already moved to drip irrigation assert that they need much less water than before and, most importantly, that they do not have to follow strict irrigation shifts, as their share of water is available on demand.

The type of crop is another element that influences vulnerability to drought since different crops have different water needs (Knutson et al. 2011; Slegers 2008). In SW districts, vegetables are very vulnerable to drought, and they are not planted when there is no guarantee that water be available during the whole irrigation campaign. Several interviewees stated that they had decided to shift from vegetables to fruit trees after the 1995 drought because they had lost their entire vegetable harvest. The loss of trees, however, is seen as the major risk during prolonged droughts. Reduced fruit production due to water stress is another major reason for concern. Among fruit trees present in the area, kaki and citrus are more resilient to drought than peach trees, which are extremely sensitive to water shortage during the flowering and fruit setting seasons. Interestingly, rice was not seen as a very vulnerable crop despite its high water requirements. Indeed, water supply to rice farming is always guaranteed because of the environmental role of rice ponds close to the Albufera wetland2 and because rice is a traditional crop with high cultural value in the area.

Plots management practices (e.g. weeding) and the maintenance of the irrigation channels are two recurrent issues mentioned by SW farmers. Several authors remark that the characteristics of the soil has direct impact on its water holding capacity (Wilhelmi and Wilhite 2002; Slegers 2008; Knutson et al. 2011), and therefore influences the adaptation capacity of farmers. However, in our study only three farmers mentioned soil characteristics as a factor of vulnerability.

A recent systematic review of 46 drought vulnerability assessments (González Tánago et al. 2015) showed that most of the DVAs do not include the characteristics of water resources and of water uses among their vulnerability factors. This is in contrast with the picture resulting from our interviews to water users on the ground, which revealed that these are key determinants of vulnerability.

4.4. Local responses and adaptation to drought

The interviews led to the identification of 21 different types of practices implemented by farmers to mitigate or preempt problems associated with drought (Table 3). Measures can be grouped into three broad categories (demand management, supply management, user self-organization) and can be individual or collective. In the case of GW farmers, practices mentioned by the interviewees were presented as actions to face water scarcity rather than temporary water shortages.

A first group of measures consists in actions to reduce water demand. The most common practice is the temporary decrease of the frequency of irrigation shifts. This strategy is implemented by SW irrigators based on collective decisions on how to manage water restrictions imposed by the JRBO. Other measures include postponing the start of the irrigation season, ridge maintenance and irrigation of alternated furrows (see also Ortega-Reig et al. 2014).

In the SW ICs, the progressive shifting from flood to drip irrigation systems has been promoted through the National Irrigation Program3 issued in 2002 and the subsequent Plan for Irrigation Modernization4, passed in 2006 to increase resilience to drought (among other stated objectives). The progress of modernization is slow and its outcomes have not yet been

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[2] The Albufera wetland is a freshwater lagoon with high biodiversity value, declared Natural Reserve and Ramsar site.

[3] Royal Decree 329/2002, of 5th April, for the approval of the National Irrigation Plan.

[4] Royal Decree 287/2006, Royal Decree 287/2006, of March 10th, through which urgent works of improvement and consolidation of irrigation are regulated, in order to achieve water savings to mitigate the damages provoked by drought.

assessed. However, some studies evaluating the effects of modernization projects in other areas (e.g.; Gómez and Perez Blanco 2014; Soto- García et al. 2013; WWF/ADENA 2015) have found evidences of a rebound effect in water consumption.

Table 3. List of local strategies identified in the case study area

Measures: Category	Measures: Sub-category		Type of farmers (#)	Focus	Type of action	Timeframe
Reduction of demand	Changes in water and land use practices	Postponement of the start of the irrigation season	SW (3)	D	C	T
		Establishment of strict irrigation shifts and decrease of their frequency	SW(10)	D	C	T
		Cleaning of plots from weeds and irrigation of alternated furrows	SW(7)	D	I	T
		Emergency irrigation to ensure the survival of trees and field fallowing	SW(9)	D	I	T
Increase supply	Increase groundwater abstraction & use of non-conventional resources	Connection of springs to the irrigation channel	SW(2)	D	I/C	T
		Activation of existing drought wells and drilling of new ones	SW(13)	D	I/C	T
		Maintenance of drought wells	SW(6) /GW(1)	D	I/C	P
		Re-deepening of existing wells	GW(3)	D / WS	I	P
		Increase in the use of recycled water	SW(2) /GW(2)	D/WS	C	T/P
	Water transfers	Purchase of water from other irrigation communities	GW(2)	D / WS	C	P
		Internal and external water transfers	GW(3)	WS	C	P
	Improve efficiency	Improvements of distribution networks	SW(4) /GW(1)	D / WS	C	P
		Shift to drip irrigation system	SW(4) / GW(2)	D / WS	I/C	P
		Development of irrigation ponds system for water regulation	GW(3)	D / WS	C	P
	Enhance quality	Improvement of wastewater treatment to increase reuse	GW(1)	D / WS	I/C	P
		Combination of different water qualities from different sources to improve water quality standards	GW(2)	D / WS	I/C	T
Economic and organizational measures	Cost-sharing	Distribution of electricity costs among farmers	SW(1) / GW(2)	D	C	T/P
		Joint purchases of electricity to obtain lower prices	SW(1) /GW(1)	D / WS	C	P
	Self-organization	Strict enforcement of internal rules	SW(4) /GW(1)	D	C	T/P
		Strategic planning of the use of wells and irrigation ponds	GW(2)	D / WS	C	P
		Interfacing with the River Basin Authority to negotiate water restrictions (through the Permanent Drought Commission)	SW(2) / GW(1)	D	C	P

A second group of actions is oriented to increasing water supply. During drought, SW farmers seek to augment water availability by drilling and pumping drought wells with the support of the regional Government or the JRBO, or, to less extent, by using treated wastewater. Water supply measures are at the core of the strategies of groundwater users to face permanent water scarcity. They include optimizing the use of available resources through networks of water ponds, using highly efficient irriga- tion systems, and re-deepening existing wells. When the IC's capacity to increase groundwater resources reaches the boundaries of economic viability, farmers seek other water sources, such as treated wastewater and surface water transfers. Combin- ing different sources helps also addressing water quality problems. Thus, these measures represent a local adaptation strategy to allow cultivating vegetables and grapes every year, rather than only during dry spells.

A third group of measures implemented by both types of farmers is related to sharing electricity costs of groundwater abstraction. In the CJT IC (SW), when farmers pump groundwater into the distribution network during droughts they equally split the associated costs. In the Vinalopó area (GW) farmers also make a careful planning of their wells operations to optimize energy costs.

Most of the measures listed above require cooperation among farmers, both in GW and SW irrigation areas. This confirms that it is crucial for farmers to work jointly to effectively manage limited water resources. Cooperation, however, is not exempt from tensions and problems, especially in relation to surface water restrictions, when farmers, worried about losing their harvest or even their trees, vigorously complain to the watermaster about irrigation shifts, and even withdraw water without authorization.

According to the interviews, connections between the measures implemented by the farmers and other actions promoted at RBD or national level are limited. Farmers barely mentioned the JRBD Drought Management Plan or the exceptional laws approved at national level to address drought (Urquijo et al. 2015). Their main concern regarding other management levels was their representation in the Drought Permanent Commission of the RBO. SW farmers were especially concerned about negotiations on water releases from the reservoir and how they would affect their production. GW farmers were concerned by the negotiation of measures to solve their problem of overexploitation. Interestingly, none of the interviewees mentioned the agricultural policy of the Valencian regional government, which has full competences on agriculture, as a factor influencing their farming activity.

5. Conclusion

Traditionally, drought research has focused mainly on physical aspects of the phenomenon and has rarely considered how it is actually perceived by water users on the ground. Our analysis showed that drought is far from being perceived in a homogeneous way among water users, even within the same river basin. Moreover, it revealed that, in parallel to the development of a response to drought by the water authorities, there are a number of local behaviours and decisions that influence the actual management of drought on the ground. It also confirmed that cooperation among users is key to mitigate and adapt to water variability.

This study has shown that vulnerability to drought is dynamic, and that technological and institutional solutions to increase flexibility in water availability are the main drivers of the evolution of vulnerability over time. Moreover, it has confirmed that the type of water source used for irrigation clearly affects vulnerability to drought and the response that farmers implement to face water shortages.

In-depth semi-structured interviews have allowed the study of drought starting from farmers' personal experience, since relevant topics were brought up by farmers during the interviews rather than being predefined by the researcher. This has produced a qualitative dataset that, where a random sampling of farmers is possible, could be complemented by a survey to combine qualitative and statistical analyses.

This paper aimed at shedding light on the granularity of drought and drought response in a specific context, as an example of the value of undertaking also local studies in order to grasp the full picture of response to drought. We believe that showing these aspects can be useful for water management in at least four ways: a) it points to the value for water managers to combine the traditional hydro-climatological perspective of drought with the analysis of its social aspects, as a way of better understanding what happens on the ground and which intangible factors can influence the behaviour of water users; b) it leads to the identification of vulnerability factors that are relevant to water users but that often are not considered in drought vulnerability assessment (e.g. type of water source, sources diversification, water quality). This information can help better tailor strategies and policy options to the actual needs of water users on the ground; c) it highlights that impacts play a significant role in defining drought, thus underscoring the value of current incipient efforts in creating inventories of drought impacts; and d) it strengthens the idea that governmental actors need to reach out to users and effectively communicate with them in order to enhance coordination and coherence of drought response.

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