1. Introduction

The Joint Research Centre (JRC) organised a workshop in Tenerife Island in 2017 called 'Resilient Tenerife', intended to explore participatory strategies to enhance climate resilience. An environmental expert from the Island Council of Gran Canaria was a member of one of the round tables and participated actively in various activities about the case study that had been developed in Tenerife (Hernandez et al., 2018a, 2018b; Cuevas et al., 2018). Owing to the success of this event, this expert from the Island Council of Gran Canaria communicated those results to his councillor.

In January 2018, the President of the Island Council sent an official letter to the JRC to explore the possibility of carrying out a similar workshop in Gran Canaria with regard to the topic of climate change adaptation. The JRC accepted, and proposed the analysis of drought risks, since Gran Canaria Island had been affected by a severe drought the previous year, in 2017. Both organisations agreed and collaborated to develop the Acequia workshop called 'Climate change, droughts and water uses in Gran Canaria'. It took place in Las Palmas de Gran Canaria from 18 to 20 June 2018.

This report is one of the outcomes of the workshop and has a twofold objective. Firstly, it summarises the main conclusions obtained in the Acequia workshop and, secondly, it also aims to move a step forward in proposing more detailed actions to tackle drought risks in Gran Canaria by means of co-creation practices. This report will be adopted by the Council of Gran Canaria, as well as the island's municipalities that have become signatories of the Covenant of Mayors.

The report is structured as follows: Section 2 will present the case study, with a description of why Gran Canaria deserves to be analysed. Section 3 is devoted to presenting the methods applied in this 3-day workshop. Section 4 presents the results obtained, including a list of actions. Section 5 will discuss the results. Lastly, Section 6 concludes.

2. Case study

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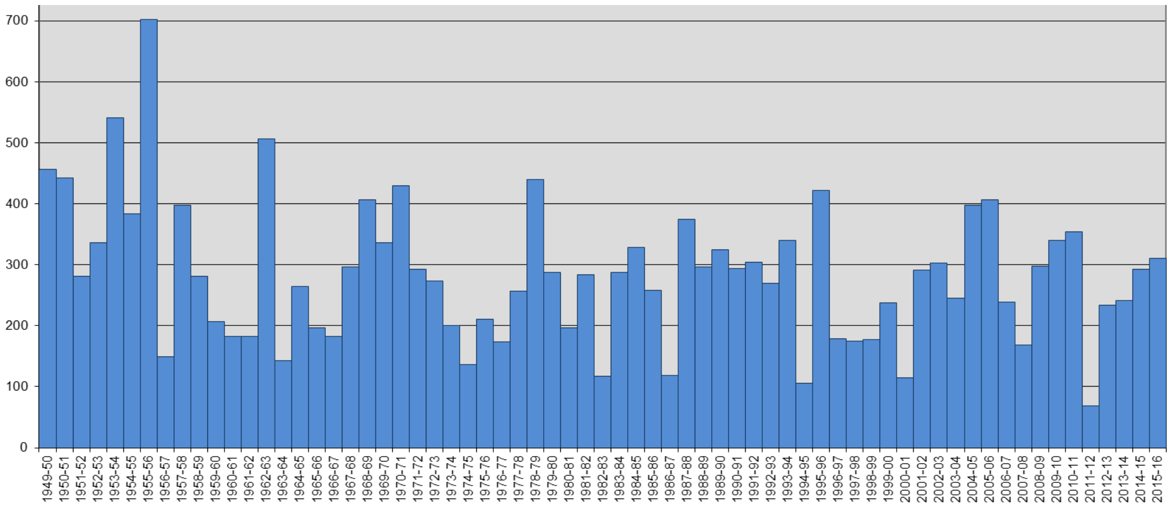
Meteorological drought events have been a normal pattern in the Canary Islands in recent centuries (García et al., 2003; SPA-15, 1975); however, rainfall patterns seem to have reduced in Gran Canaria (Figure 1). Nowadays, the average annual rainfall is reducing, either if the baseline year is 1949 (442 hm^3 less, corresponding to 283 Lm^{-2}), or if the baseline year is 1986 (413 hm^3 less). This might indicate possible meteorological droughts ([1]). For the future, Gran Canaria Island foresees, under an A2 scenario, a decrease in rainfall of – 5 % to – 20 % by 2011-2040, as well as a slight decrease in effective evapotranspiration (ETR) (up to – 10 %) and a stronger decrease in surface run-off (– 10 % to – 25 %) (Cedex, 2012). This fact could partially alleviate water scarcity.

Notwithstanding, hydrological droughts are also recurrent in Gran Canaria for strong historical reasons. Water used to be a common property ([2]) of the indigenous inhabitants of the Canary Islands (Díaz Hernández, 2008), until it was gradually privatised after the Spanish conquerors invaded the archipelago in the fifteenth century (Macías Hernández, 2009; Navarro García, 2008; Suárez Moreno, 2011). Conquerors were allocated land and water resources for cash crop production and export (Macías Hernández, 2009). However, not all the lands suitable for cash crops had water available for irrigation; therefore, water had to be reallocated from landowners with surplus water to those who demanded additional water resources.

([1]) For a critical view of these data, refer to Custodio et al. (2015), who question the reliability of these trends because of incomplete time series.

([2]) Common property is defined as 'a distribution of property rights in resources in which a number of owners are co-equal in their rights to use the resource. This means that their rights are not lost through non-use. It does not mean that the co-equal owners are necessarily equal with respect to the quantities ... of the resource each uses over a period of time' (Ciriacy-Wantrup and Bishop, 1975, pp. 714-715).

Figure 1. Average annual precipitation in Gran Canaria since 1949 (Lm⁻²)



Source: CIAGC, 2018.

This need was the cornerstone for the creation of *heredades de agua*, or masters of water, in 1514 (Macías Hernández, 2009). These masters of water possessed water and were in charge of transporting it through costly canals from areas with surpluses to others with deficits. Since then, water resources have been under their control, in few hands (Pérez Marrero, 1990), in an oligopoly system (Nuez Yánez and Carnero Lorenzo, 2003), showing the relation between water and power (Díaz Cruz, 2013). Soon, the available water was not enough for sugar cane irrigation (Macías Hernández, 2009). The need for additional water resources was aggravated when bananas (which demanded large quantities of water) became the new cash crop on the islands. In order to deal with the induced water scarcity (Aguilera-Klink et al., 2000) *Comunidades de Aguas* (irrigation associations) were created to look for groundwater by means of wells and galleries (Suárez Moreno and Santamarta Cerezal, 2012), following a 'first come first served' water extraction approach (Custodio et al., 2016), causing the overexploitation of aquifers, which reached their limits around 1965 in Gran Canaria (Nuez Yánez and Carnero Lorenzo, 2003).

Nowadays, the overexploitation has decreased. Custodio et al. (2016), using data for up to 2010, pointed out that, whereas groundwater recharge (understood as groundwater recharge less outflow to the sea) was estimated at 50 hm^3, groundwater abstracted amounted to 100 hm^3, i.e. 100 % more than what might be considered sustainable (see Table 1). On the other hand, using current data (see Table 1), the groundwater reserve represents 4 hm^3 (6 %) more than sustainable resources (considering a total groundwater recharge of 36 hm^3 and groundwater abstraction amounting to 65.5 hm^3). Therefore, groundwater reserve depletion depends on the consulted source, resulting in a more optimistic estimation if current data are used (CIAGC, 2018). Agricultural water consumption only represents 38 % of total consumption (see Table 2). The Canary Islands' agricultural sector has the highest percentage of irrigated agriculture on cultivated land (58 %), being a very effective water user, with the highest percentage of localised versus total irrigation in Spain (73 %) (MAPA, 2018). In spite of this, as seen in Table 2, the agricultural sector is the largest groundwater user (63 %), which is related to the higher costs associated with pumping desalinated water from the coastal areas to some of the agricultural fields located in the upper part of the island. Therefore, in these highlands, the water reuse of small wastewater treatment plants is the only source of water that might bring the opportunity to diminish groundwater extraction.

One of the consequences of the historical unsustainable groundwater management in Gran Canaria was the need of desalination technologies, which started their deployment in 1970 (Gómez-Gotor et al., 2018). Today, there are 137 desalination plants in Gran Canaria, 11 public and 126 private (Gómez-Gotor et al., 2018). These technologies have brought advantages and disadvantages to the island. Among the advantages are (1) increased water availability, (2) reduced water prices and (3) some public control of water markets. However, the disadvantages are (1) increasing need of and dependency on fossil fuels and (2) the loss of the historic water (saving) culture among the younger generations. Today, the Canary Islands are one of the Spanish regions with larger water desalination production, amounting to 40 % of the whole country (Suárez Moreno, 2011). As seen in Table 1, seawater desalination and de-brackishing amount to from 72 to 78 hm^3 a year. According to Table 2, most desalination resources are allocated to urban areas, including tourism.

Table 1. Water resources on Gran Canaria island until 2018 (hm^3/year)

Water resources	**(1)**	**(2)**
Precipitation (P)	465	444
ETR	—	301
Surface run-off (Sr)	75	67
Groundwater recharge (1) or effective infiltration (P – ETR – Sr) (2)	90	76
Outflow to the sea	40	30
Recharge less outflow to the sea	50	46
Return flows	—	23.5
Available resources		
Surface water	24	10.7
Groundwater abstracted	100	65.5
Springs (current)	0.1	-
Seawater desalination	60	72
De-brackishing	18	-
Wastewater reclamation	12	12.3
TOTAL	214.1	160.5
Groundwater reserve depletion	50 (*)	– 4 (**)

(1) Custodio et al. (2016) (data from 2010). (2) Own elaboration based on CIAGC (2018) (data from 2015). (*) Groundwater abstracted = recharge less outflow to the sea. (**) Groundwater abstracted = recharge less outflow to the sea, plus return flows.

When water resources are used (along with surface resources), wastewater is produced. This resource has become another additional source of water in the Canary Islands since 1980, especially after the aquifers' depletion (Delgado et al., 2008).

The water allocation figures given in Table 2 may, however, differ across the island, depending on the height considered. For example, population and agriculture located in the upper parts (especially self-supply agriculture) are allocated groundwater and surface waters, whereas the same sectors located on the coastline are usually allocated desalinated water. Export-oriented farmers, located in the coastal areas, may even own a desalination plant to satisfy their water requirements. Consequently, population and economic activities located in the upper island are more vulnerable to droughts (and, consequently, to water price speculation) than desalination-dependent population and sectors located in coastal areas.

Consequently, if we compare water naturally available in Gran Canaria – i.e. sustainable groundwater plus return flows (46 hm^3 + 23.5 hm^3), surface water (10.7 hm^3) and wastewater reclamation (12.3 hm^3) – with water demand, estimated at 160.5 hm^3 a year (see Table 2), we come up with a deficit of 68 hm^3 (amounting to 42 % of water demand), i.e. a water management system that might be considered unsustainable (see Figure 2). This deficit is, as can be seen, covered by desalination that uses fossil fuels mainly.

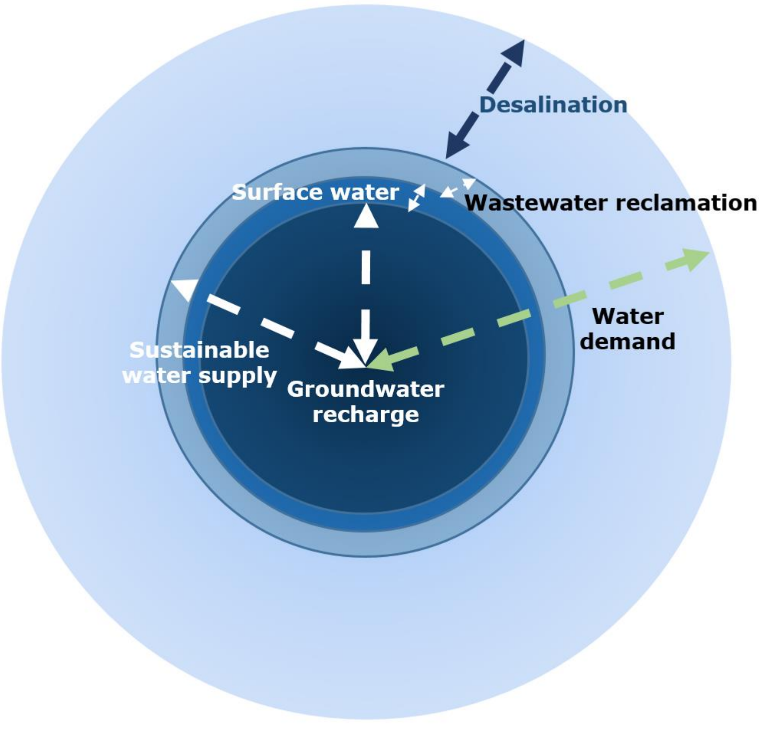
Table 2. Water demand and water allocation (hm³) in Gran Canaria, 2014 data and 2021 estimates

Water resources	Agriculture	Recreation	Urban	Tourism	Industrial	TOTAL
Groundwater	41.5	2.1	14.8	3.8	3.3	**65.5**
Surface water	7.1	0.9	2.1	0.6	—	**10.7**
Desalination	8.7	1.1	45.2	12	5	**72**
Reclaimed water	3.5	8.8	—	—	—	**12.3**
TOTAL (2014 data)	**60.8**	**12.9**	**62.1**	**16.4**	**8.3**	**160.5**
Total (2021 estimates)	**54.4**	**13.9**	**63.5**	**17.4**	**8.3**	**157.5**

Source: CIAGC, 2018.

This panorama is further aggravated by large water losses (25 % average) that may vary as a function of the municipality, e.g. from 14 % in S. Bartolomé de Tirajana to 59 % in Mogán (CIAGC, 2018). These losses amount to 49 litres per day per inhabitant equivalent (including tourists) (³). It is believed that water losses are larger in the upper parts of the island, associated with poor infrastructure.

Figure 2. Illustration of unsustainable water management in Gran Canaria



Source: own elaboration from CIAGC, 2018.

Last but not least, some authors mention that this water management system has been described as a 'spendthrift system that tends to collapse' (Nuez Yánez and Carnero Lorenzo, 2003, p. 392) produced because

(³) According to the World Health Organization (http://www.un.org/waterforlifedecade/human_right_to_water.shtml), between 50 and 100 litres of water per person per day is enough to guarantee population needs and dignity (this includes drinking, personal sanitation, washing of clothes, food preparation, personal and household hygiene). Therefore, around 53 % of those needs (considering only urban losses) are lost while storing and transporting water in Gran Canaria.

‘public administration and the society do not pay attention to signals and try to continue with business as usual until stress breaks the system’ (Custodio et al., 2016, p. 436). They also say that Gran Canaria island has come to this situation ‘due to the erratic behavior of the islands’ public administrations, besides an unclear and poorly-supported degree of intervention in what historically have been and still are private affairs, without defining clearly the roles, responsibilities and limits of each one’ (Custodio et al., 2015, p. 2964). Consequently, ‘the real potential for effective water and groundwater governance resides in active civil society institutions’, not ‘politicians, who still consider water as a political affair’ (Custodio et al., 2015, p. 2965).

Despite everything, and taking into account current data, the situation is promising, probably influenced by the improvement of water governance as a result of European Union legislation.

3. Material and methods: beyond the “workshop”, introducing material and experiential deliberation as co-creation tools

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3.1 On participatory workshops

Workshops are said to be powerful tools for science and policy initiatives. For instance, workshops help to clarify existing scientific understanding, as well as to continue answering important scientific questions (Haberle et al., 2013). They are used to exchange information between academicians, policy officials and decision-makers (Howarth et al., 2017; Legrand and Chlous, 2016). Here we briefly review the use of workshops to address climate adaptation issues.

Participatory workshops are particularly convenient to discuss actions required to tackle environmental problems, such as climate change (Hersh and Stapleton, 2009), motivating participants to continue working together (Haberle et al., 2013). A variation of the latter, are the so-called community-based workshops which have been used to e.g. build adaptive capacity and initiate climate change adaptation strategies. One such workshop conducted in Prince George, British Columbia (Canada), detected that community-based approaches improve the understanding of existing and future climate change impacts (Picketts et al., 2012). The discussions were considered helpful to identify priority actions with regard to forest fires, floods, emergency response to extreme events, water supply and transportation infrastructure. More specific work on flood risks was carried out in two Austrian municipalities (Altenmarkt and Gleisdorf), both located in flood-prone areas (Loschner et al., 2016) to reflect on the determinants of vulnerability, identifying local context conditions, as well as adaptation actions to flood risks.

From a methodological point of view, diverse techniques may be applied during workshops on adaptation to climate change. Thus, the work developed by Shaw and Corner (2017) used (1) values and narratives to build scenarios that might be of help to find out climate actions, (2) pre-prepared narratives in order to identify positive and negative keywords and sentences; and (3) those positive/negative keywords to generate new narratives that might lead to greater consensus and better climate communication. McEvoy et al. (2018) presented different useful tools for workshop sessions, such as group model building, the adaptation support tool and the stress test guideline, and a dialogue-based tool-free approach.

Group model building is an analytical method for structuring and exploring systems in small groups by means of causal loops or diagrams that represent how a system works; see for example, the work of Videira et al. (2003) on participatory modelling and more recently Halbe et al. (2018) for water resources management. The adaptation support tool is a touch-table-based platform where participants can explore adaptation through the selection of geo-referenced adaptation measures -see van de Ven et al. (2016) for urban adaptation-. The stress test guideline is a stepwise technique oriented to assess urban resilience through the collection of vulnerabilities and potential solutions; see for example Loschner et al. (2016), who conducted presentations on flood risk areas, round tables to find out solutions and discussions to prioritise measures, and Picketts et al. (2012), who gave presentations to explain climate action, organised focus groups to identify climate risks and conducted individual work to rank priority actions. Lastly, the tool-free approach is a technique led by the organisers, who sit together with experts to decide on how to approach adaptation