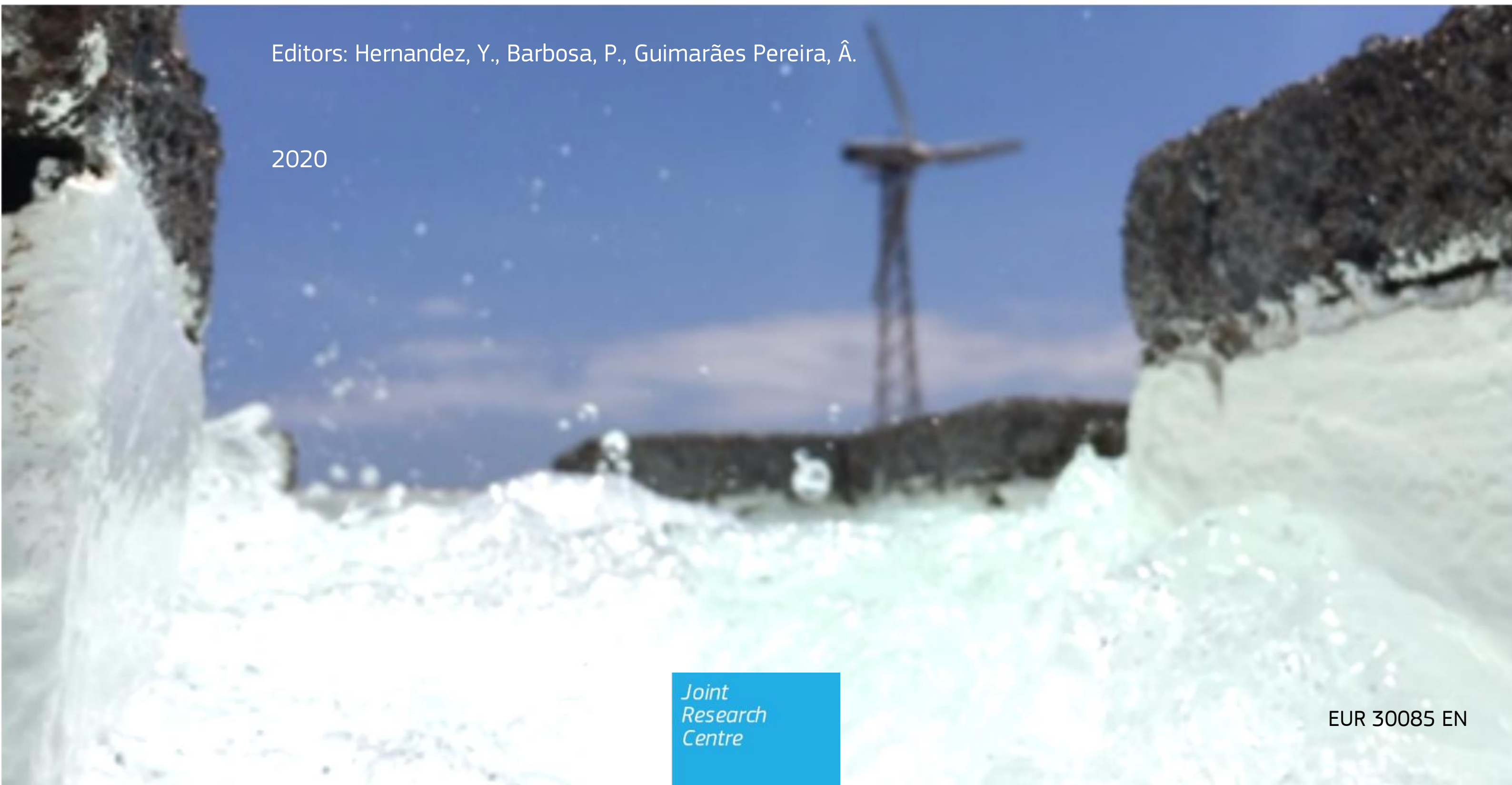
European Commission

JRC TECHNICAL REPORT

Acequia report: climate change, droughts and water uses

A LOGIC proposal for action



Editors: Hernandez, Y., Barbosa, P., Guimarães Pereira, Â.

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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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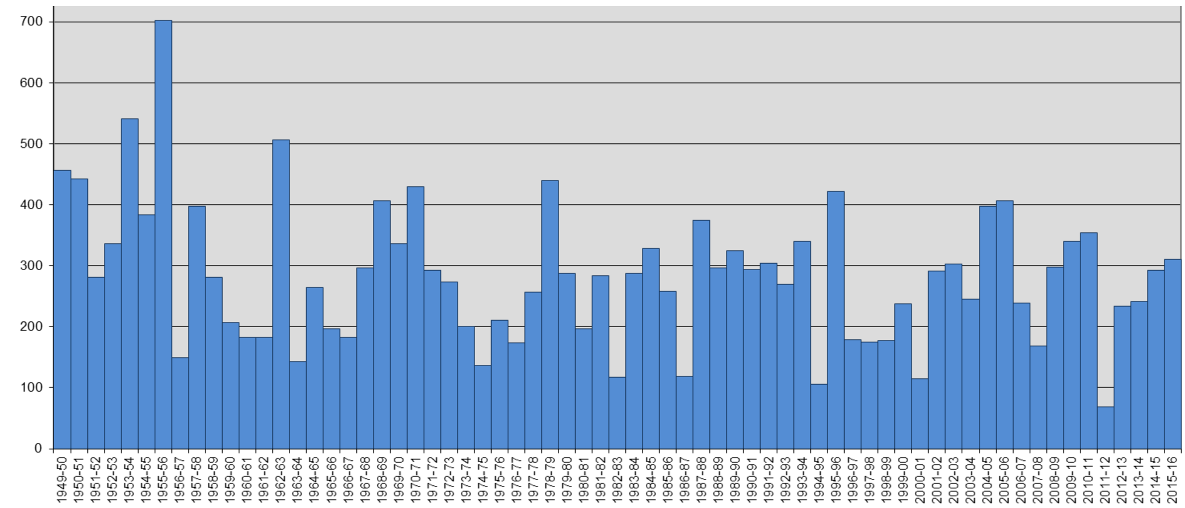
Meteorological drought events have been a normal pattern in the Canary Islands in recent centuries (García et al., 2003; SPA-15, 1975); however, rainfall patterns seem to have reduced in Gran Canaria (Figure 1). Nowadays, the average annual rainfall is reducing, either if the baseline year is 1949 (442 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.

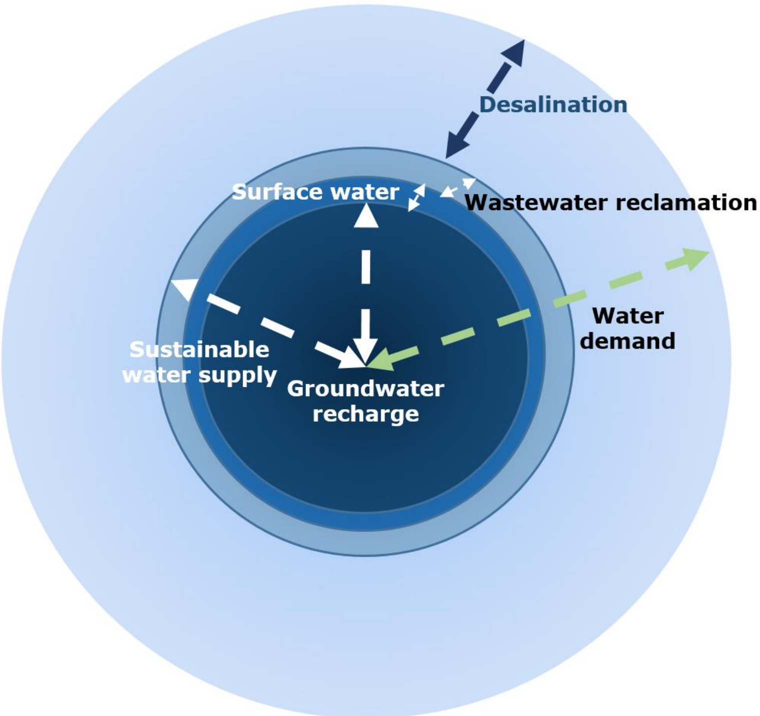
Table 2. Water demand and water allocation (hm³) in Gran Canaria, 2014 data and 2021 estimates

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 planning and to design solutions. This last method has been applied to enhance the contribution of IPCC practitioners (Howarth et al., 2017).

The Acequia workshop consisted of a 3-day session in which (1) presentations, and round tables were organised, (2) 'futuring tours' were implemented as participatory process, and (3) a final debate among the mayors of Gran Canaria belonging to the Covenant of Mayors initiative. In the following sections each technique will be further explained.

3.2 Presentations and round tables

A total of 73 people were registered at the Acequia workshop. Each session was attended by approximately 50 people (see Figure 3, right photo, and breakdown in Figure 4).Five round tables were organised. Each one was composed of five people, all experts in their fields. An hour and a half was allocated to each round table. Initially, each member of the round table gave a talk of 7 minutes to explain the state of the art regarding their area of expertise. Then half an hour was dedicated to debate among the members of the round table and, at the end, the public could intervene, either commenting or asking questions to the board during the last 25 minutes (see Figure 3, left photo).

Figure 3. Round table on desalination and renewable energies

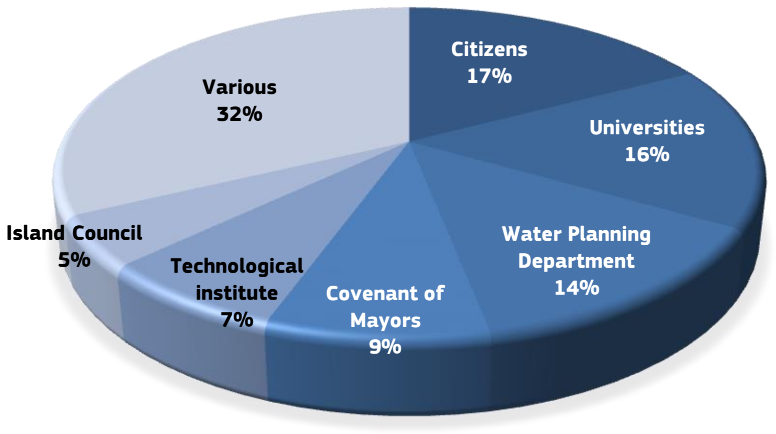
Source: photos taken by Yeray Hernandez.

The round tables and their members are listed below:

— impacts of droughts in the primary sector:
  - expert in water management from the Water Planning Department of the Government of the Canary Islands,
  - cash crop farmer oriented to export,
  - agro-ecological farmer oriented to short supply chain,
  - representative of the Farmers' Union of the Canary Islands,
  - expert in the primary sector of the Island Council of Gran Canaria;

— climate, pluviometry data, models and projections:
  - expert in climate change adaptation from a Technological Institute,
  - expert in climate models from the University of Castile-La Mancha,
  - meteorologist from the Spanish Meteorological Agency,
  - expert in precipitation modelling,
  - expert in hydraulic modelling and precipitation from the University of Las Palmas de Gran Canaria;

Figure 4. Participants in the Acequia workshop



Source: JRC. 'Various': Energy Planning Department, JRC, private companies, farmers, Water Planning Department of the Regional Government, irrigation organisations, private water suppliers, public companies, non-governmental organisations, Spanish Meteorological Agency, town councils and journalists.

— state and sustainable management of aquifers:
  - expert in groundwater from the University of Las Palmas de Gran Canaria,
  - representative of a water supplier company,
  - representative of the Water Planning Department of the Island Council of Gran Canaria,
  - representative of an irrigation association of north-west Gran Canaria,
  - economist specialised in water management from the University of Las Palmas de Gran Canaria;

— desalination and renewable energies:
  - expert in environmental planning from the Island Council of Gran Canaria,
  - expert in desalination and renewable energies from a technological institute,
  - expert in desalination from the University of Las Palmas de Gran Canaria,
  - representative of a company specialised in water treatment,
  - expert in sustainable development from the University of Las Palmas de Gran Canaria;

— wastewater regeneration:
  - three experts in wastewater regeneration from the University of Las Palmas de Gran Canaria,
  - representative of the Water Planning Department of the Island Council of Gran Canaria,
  - expert in wastewater regeneration from a technological institute.

3.3 Dry walks: Futuring tours and conversations on droughts and the WEF nexus

This exercise was meant to develop visions of adaptation to potential impacts of droughts on food production considering the interlinkages between water, energy and food –the so called WEF nexus–. The futuring tour is a participatory exercise, aiming at reimagining food production in insular territories affected by drought and other impacts of climate change. The full dry walk encompassed two stages. In the first stage, the participants were divided into groups that walked in the territory on a pre-chosen route, equipped with a photographic device: smart phone or digital camera (see Figure 5). During this physical tour of the 'present', 'past' and emerging futures of drought related sites, participants had both a visual and tactile experience of those sites. They were guided with a set of initial questions that helped them look, experience and notice in the territory instances of past, present and incipient futures of practices, infrastructure and other elements that reflect food production and its dependency on climate and social context.

The method works through using photography, conversation with the community and any other types of enquiry that reflect experience of the issue of concern. Photography was used as the working method and it was the main resource used in the second stage of the dry walk.

This structure allowed participants to make sense of their own concerns and visions about adaptation, exploring environmental aspects, social practices and economic and historical issues that have led the region to its present state.

Figure 5. Participants of the 'dry walks' talk to farmers during the tour of different places connected to the droughts and agriculture

Source: photos taken by Yeray Hernandez. The left-hand photo was taken during a conversation with a farmer, who was describing how his farm is adapting to drought risks. The right-hand photo was taken during a visit to a natural wastewater management system, representing meteorological droughts.

The second stage consisted of proper futuring, i.e. imagining visions, using a 'backcasting' approach to adaptation strategies for food production in Gran Canaria taking into account the water–energy–ecology nexus. The point of departure was the photographies that participants in groups characterised as present, persistent past or incipient future with regard to food production and its dependency on climate and other environmental and social events and conditions (see Figure 6). Participants imagined a desirable or plausible – or both – adaptation story, and work on drivers and values that could lead to those futures, illustrated with photography, drawings and other materials, possibly but not necessarily with a timeline. Flipcharts were used, where a collage of relevant photos composed the storylines displayed with explanatory text. The visions were shared with all the participants at the end of the event.

Figure 6. Groups at work during the 'futuring' exercise: making sense of what each other had noticed during the field tour and own knowledge

Source: photos taken by Ângela Guimarães Pereira.

3.4 Debate among the Covenant of Mayors of Gran Canaria

This debate was moderated by a researcher from the JRC. The Covenant Territorial Coordinator (CTC) of the Island Council of Gran Canaria took part, with three mayors from Gran Canaria who have become signatories of the Covenant of Mayors initiative. All the mayors and the CTC discussed how their municipalities are adapting to drought risks and presented measures already implemented or proposed. Section 4.7 will be devoted to discussing how to integrate the actions proposed in the workshop into the Covenant of Mayors of Gran Canaria.

4. Results

The following sections describe the information presented and discussed in the different round tables.

4.1 Drought modelling: past and present for Gran Canaria

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In Gran Canaria, there is a major concern about the impacts of droughts because the island is overexploiting water resources (Morales Gil et al., 2000). In particular, 2017 was an extremely hot and very dry year ([4]). In addition, water reserves in public reservoirs were less than 8 % of their total capacity ([5]). Consequently, it is necessary to assess the water regime in Gran Canaria.

([4]) http://www.aemet.es/es/noticias/2018/01/Resumen_climatico_2017
([5]) https://www.laprovincia.es/gran-canaria/2017/02/05/presas-isla-acercan-peor-sequia/905936.html.

This need can be addressed using different drought indices, such as the Standardised Precipitation Index (SPI) and the Standardised Precipitation Evapotranspiration Index (SPEI). To obtain these drought indices, monthly mean temperature and precipitation data from the Spanish Meteorological Agency are used. Furthermore, these indices can be calculated at different timescales to monitor droughts. In this case, the SPI and SPEI were obtained at timescales of 3, 6, 12 and 24 months because these indices on short timescales are related to soil moisture, which determines water availability for vegetation and agriculture. At longer timescales (24 months), the drought indices can be related to groundwater and reservoir storage.

The SPI was developed by McKee et al. (1993) to quantify the precipitation deficit for any timescales. This index can be defined as the number of standard deviations by which a normally distributed random variable deviates from its long-term mean. Negative SPI values represent rainfall deficit, whereas positive SPI values indicate rainfall surplus. Table 3 depicts the classification of wet and drought periods according to the SPI index provided by the National Drought Mitigation Center ([6]).

Table 3. Classification of drought according to the SPI index

SPI values	**Drought category**
SPI ≥ 2.00	Extremely wet
1.5 ≤ SPI < 2.00	Very wet
1.00 ≤ SPI < 1.50	Moderately wet
– 1.00 ≤ SPI < 1.00	Near normal
– 1.50 ≤ SPI < – 1.00	Moderately dry
– 2.00 ≤ SPI < – 1.50	Very dry
SPI < – 2.00	Extremely dry

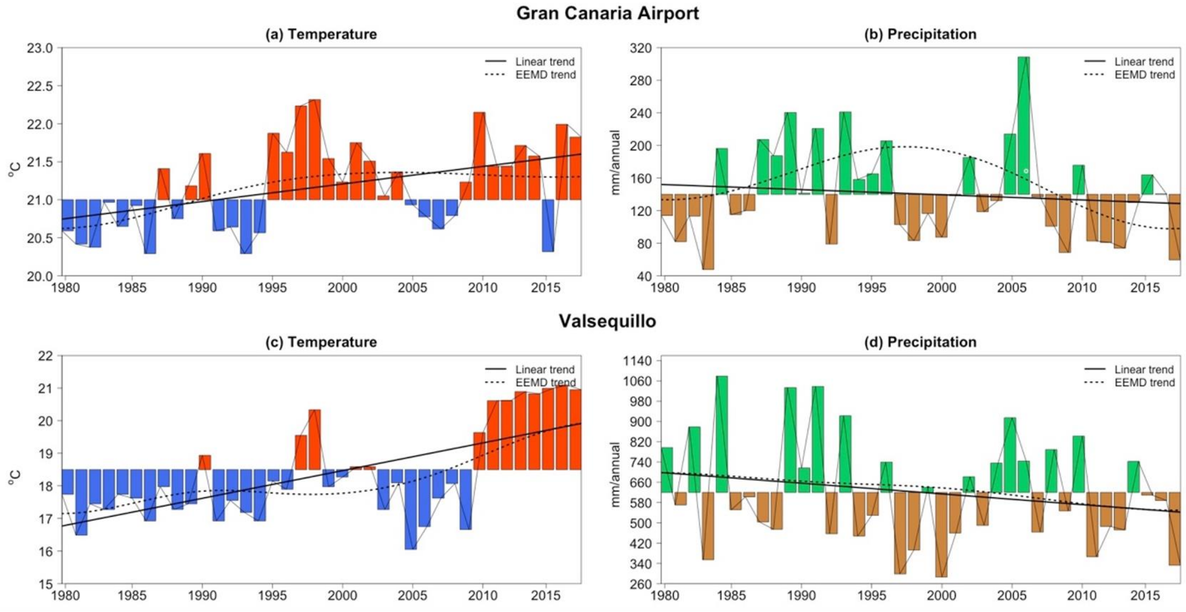
Source: McKee et al. (1993).

The SPEI is similar to the SPI. This drought index is based on precipitation and temperature data, and it is obtained by calculating the difference between precipitation and potential evapotranspiration. This represents a simple climatic water balance (Thornthwaite, 1948) that is calculated at different timescales.

Before the current water regime of Gran Canaria is characterised, annual mean temperature and precipitation trends are analysed for the period 1980 to 2017 because this result can help with the interpretation of the drought indices. For this, on the one hand, a linear regression method was applied to determine the linear trend and, on the other hand, ensemble empirical mode decomposition (Huang and Wu, 2008; Wu and Huang, 2009) was applied to obtain the non-linear trend. The findings show significant increases in the mean temperature trend, which varies from 0.2 ºC to 1 ºC. However, the precipitation does not display significant trends (see Figure 7).

([6]) http://www.ndmc.unl.edu.

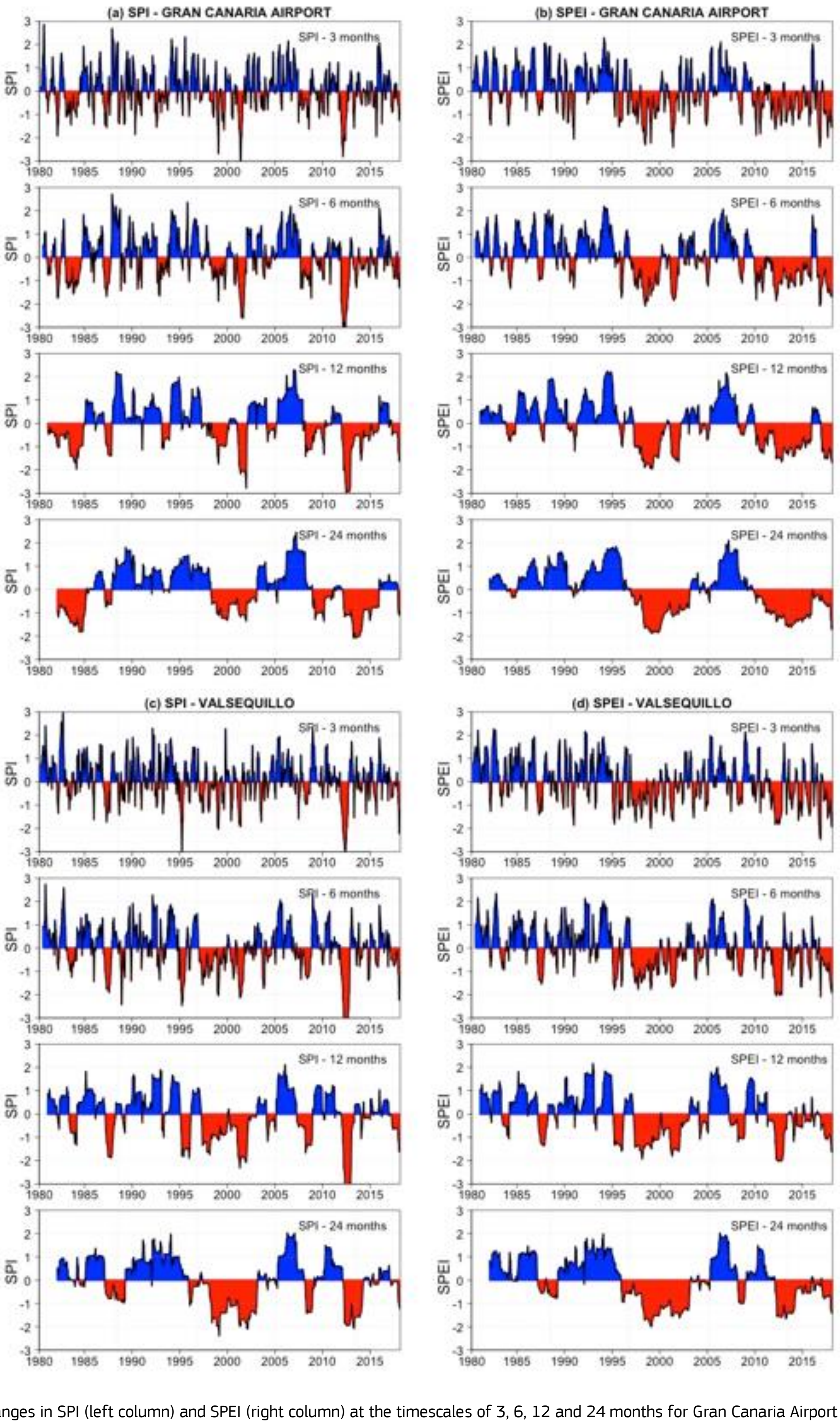
Figure 7. Time series of the annual mean temperature and precipitation for the period 1980-2017 for the observatories of Gran Canaria Airport and Valsequillo



NB: time series of annual mean temperature (°C) and precipitation (mm) for Gran Canaria Airport (a and b) and Valsequillo (c and d) observatories for the period from 1980 to 2017. The solid line represents the linear trend and the dashed line indicates the non-linear trend.

Once mean temperature and precipitation trends were obtained, the drought episodes were identified for the period 1980 to 2017. The 3- and 6-month SPI and SPEI present a similar development. However, for the timescales of 12 and 24 months these differences are more significant. On the other hand, both indices detect drought periods at the end of the 1990s, at the beginning of the 2000s and from 2010 on. These drought episodes are most significant for the SPEI index, as shown in Figure 8. Consequently, temperature can be a determinant factor of drought in Gran Canaria besides precipitation.

Figure 8. Changes in SPI and SPEI at Gran Canaria Airport and Valsequillo observatory between 1980 and 2017



NB: changes in SPI (left column) and SPEI (right column) at the timescales of 3, 6, 12 and 24 months for Gran Canaria Airport (a and b) and Valsequillo (c and d) observatories.

4.2 Impacts of droughts on the primary sector

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4.2.1 Droughts and their consequences

There is an extreme water deficit in Gran Canaria in most of its agricultural land. Dry years may occur because precipitation levels drop lower than 100 mm/year, especially in agricultural areas located below 600 metres above sea level (m.a.s.l.).

Except in the midlands of the north central region [7], which usually have precipitation averages above 300 mm/year, in Gran Canaria – especially below 600 m.a.s.l. in the southern, eastern and western regions – there are usually drought conditions. These are produced by the succession of dry years (< 100 mm/year), which forces farmers to depend almost 100 % on desalination plants, sewage treatment plants, wells and infiltration galleries.

In fact, there are areas in the south of the island [8] where farmers have stopped irrigating crops for lack of water, especially when dams were emptied (Chira, Las Niñas, Soria, etc.) as a consequence of shortage of precipitation for several years. For example, the valley of La Aldea de San Nicolás, which has several dams to allocate water for irrigation, enjoys a dry subtropical climate characterised by the alternation of dry and wet periods, with great variability of seasonal and annual precipitation. The average rainfall in the period 1980 to 2005 was about 160 mm/year, exceeding 250 mm/year in wet years and below 100 mm/year in dry ones (Cruz-Fuentes et al., 2015). These periods of dry years create situations of scarcity of water for irrigation, causing uncertainty among farmers, who must look for other supplies for irrigation.

In the last 10 years, taking as an example the GC03-Vecindario Meteorological Station, 90 mm/year has been exceeded in only 4 years, with a maximum of 178 mm/year in 2010. During the remaining years, the cumulative rainfall has not exceeded 90 mm/year. Furthermore, in 2002-2017, considering only the 5 months from May to September of each year, evapotranspiration amounted to only 994 mm. During the remaining 7 months, this amount reached 791 mm. That makes a total of 1 784 mm of evapotranspiration per year.

Therefore, while the average rainfall is scarcely 100 mm/year, in only the 5 months considered the evapotranspiration reaches 1 000 mm, indicating a water deficit, similar to desert conditions.

4.2.2 Meteorological drought prevents self-supply and food sovereignty

From the point of view of food sovereignty, water deficit together with the shortage of water for irrigation, as well as high water prices, among other reasons – such as lack of technical skills and low farming income – means that many agricultural areas with the potential for crop production are not cultivated. The total area of Gran Canaria island amounts to 155 673 ha, of which, in 2013, about 32 546 ha, 21 % of the island territory, corresponds to agricultural land. However, the cultivated area did not exceed 10 370 ha, i.e. 7 % of the island surface (see Table 4).

The abandoned agricultural land in 2013 (20 662 ha) reflects the theoretical growth potential of agricultural production, since only 32 % of that agricultural land was cultivated in 2013 (10 372 ha). That abandoned 20 662 ha could be considered a potential area for crop production. However, a significant percentage of this area does not have access to water for irrigation, since there is no distribution network or regulatory deposits there.

However, there are other regions with agricultural potential that only have a single source of water, usually a well or gallery, belonging to a private owner that imposes high water prices (higher than EUR 0.50/m^3).

(7) This includes the municipalities of Valleseco, Teror, Moya, Firgas, Santa Brigida, Valsequillo, Artenara and Tejeda and the highlands of Gáldar and Guía.

(8) Such as Lomos de Pedro Afonso, Barranco de Ayagaures and Barranquillo Andrés.

Table 4. Rural land use in Gran Canaria, 2013

Category	ha	% of island surface	% UAL
Agricultural land (a)	32 546	21	—
Cultivated area	10 372	7	32
Grassland surface	1 513	1	5
Abandoned area	20 662	13	63
Rest (b)	123 127	79	—
Island surface (a + b)	155 673	—	—

Source: Rural Land-use Planning. Government of the Canary Islands.

4.2.3 Water resource planning and pricing

At the island level, adequate planning for the integrated management of water resources is necessary, since the island does not have enough natural water resources to meet its water demands (agricultural, residential, tourist, industrial, etc.). Unconventional resources have been incorporated, such as desalinated seawater (see Section 4.3), desalinated subterranean brackish water and reclaimed wastewater (see Section 4.4).

In Gran Canaria there are periods of drought that affect reservoirs' water reserves, which lose more than 90 % of their capacity. This leads to supply restrictions and uncertainty, especially in cultivated areas in the south of Gran Canaria that depend almost 100 % on dams. Consequently, farmers' approach consists of limiting the area of their crops to achieve maximum water savings and avoid significant water stress to their crops.

Should it be allowed to allocate water from the dams located in the middle of Gran Canaria (such as Las Niñas and Chira) to supply economic activities of the coastal area (hotels, gardens, etc.), knowing that the irrigators of those central areas have no other source of water, while the tourist areas might be allocated desalinated water? Action by the Island's Water Planning Council is necessary to solve these problems (see Section 4.6.1 for some proposals for action).

There is a great disparity in water prices for irrigation in Gran Canaria. Thus, the cost of irrigation water is one of the largest costs for farmers, between EUR 0.50 and EUR 1 per cubic metre, which means between EUR 3 500 and EUR 7 500 per hectare per year, depending on the area, the type of crop and the type of water. Water price can be a reason to abandon arable land. On the one hand, there are private owners of groundwater and *heredades* that charge for the water distributed, and not for the quantity that actually reaches farmers (which can be considerably less than what was invoiced), because of losses in transportation. Consequently, if this is the only source of water, the farmers are forced to accept the price because they must irrigate their crops.

Public water does not have a uniform price on the Island either, since the upper island pays more for the water than the coastal areas. Why does the same treated water cost much more to a farmer located 400 m.a.s.l. than another located at 70 m.a.s.l.? The objective would be to achieve a reasonable price of water for the farmers, so that crop costs can be reduced (see Section 4.6.1).

4.2.4 Water quality for irrigation

Very few agricultural areas of Gran Canaria have acceptable water quality for irrigation, excluding some springs or surface waters. On the one hand, the overexploitation of the insular aquifer has notably worsened the quality of groundwater. The wells and galleries located below 500 m.a.s.l. have been affected by salinisation. On the other hand, the regenerated waters supplied are usually very poor in nutrients, since the tertiary process (with desalination in most cases) has eliminated calcium, magnesium, potassium, nitrogen, phosphorus, etc. and, in addition, they are usually rich in sodium and chlorides, which affect water quality. Consequently, are tertiary treatments with conventional desalination required?

4.3 Desalination and the use of renewable energies in Gran Canaria

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Lack of access to drinking water affects approximately 2.1 billion people in the world (WHO and Unicef, 2017), and over 1.8 billion consume water that has been contaminated, either by organic waste or by toxins used in industry, agriculture and incorrect treatment of waste water. To these figures should be added over 4.5 billion persons, or approximately 60 % of the world's population, who lack even the most elementary water facilities. This fact is made even more serious because 80 % of the waste water generated by people in the world returns to the natural environment without treatment, causing a serious health risk involving many illnesses (WWAP, 2017).

But the problem is becoming aggravated in many regions of the planet because of global warming, of which the effects and impacts make drinking water supply even more difficult. Population growth will increase food and water demand while climatic conditions increase the frequency and intensity of drought risks year after year, affecting the production of food and access to drinking water.

In this context, seawater desalination is and will be an excellent solution to deal with this challenge in coastal areas. In fact, it already is on the island of Gran Canaria as well as the other islands of the Canaries. The inhabitants of Gran Canaria consume an average of 203 litres per day, and consumption rises to 513 litres per day for tourists, giving rise to an average equivalent to some 233 litres per day per inhabitant (CIAGC, 2018). These are unsustainable figures from any rational point of view (see footnote 3). And this is without counting the consumption of desalinated water by local agriculture.

Desalination was started on Gran Canaria as a technique to aid water use planning in 1960 (see also Section 2). Then technological models were developed based on certain premises which is now the moment to reflect on (Sadhwani, 2018). The Canary Islands have been an example, at both the national and the international level. Fifty years later, the desalination process implemented is highly optimised from the point of view of technological development.

We have gone from natural water resources to technological solutions thanks to the incorporation of desalination to lessen the scarcity. Desalination is now deeply rooted as a permanent habit, which has allowed access to water. The times of interruptions of water supply and water use restrictions have been forgotten. But it is necessary to be conscious that conditions have changed drastically in comparison with the past, given that the population has doubled, and the amount of water used per person has also increased.

Around the world, there is a total of some 15 000 desalination plants in operation with a capacity of more than 95 million m^3/day (Arenas Urrea et al., 2019). In Spain, the Canaries are the leaders in the extraction of desalinated water. Gran Canaria desalinates about 72.8 hm^3 of seawater and about 6.3 hm^3/year of brackish water (CIAGC, 2018). On Gran Canaria, 43 % of the water used is desalinated, which is equivalent to 5 % of the primary energy consumed on the island (ITC, 2013). There are both public and private water desalination plants, while those for brackish water from wells are all privately owned.

Nowadays, on Gran Canaria, the majority of the desalination plants are based on reverse osmosis processes with standardised designs that are reproducible between one facility and another. The other technologies in use are reverse electrodialysis plants. A commitment has been made to maximise energy efficiency, with pumping systems, membranes and energy recovery systems that have the best performance on the market (Sadhwani, 2018). It is important to emphasise the effort of private investment in desalination on the island, which is usually more open to technological development than public investment.

In general, the introduction of technological improvements makes it possible to increase productivity and reduce energy consumption in the process. In Gran Canaria, the energy efficiency of the desalination plants is high. The industry consumes the same amount of energy as in 2000 but has twice the capacity. Obviously, the total annual energy consumption is a significant quantity, requiring water demand control, as well as the application of the best energy efficiency improvements and alternative energy supplies. Current desalination technology makes it possible to desalinate a cubic metre of seawater for less than 2 kWh on a medium or large scale, considering only the desalination process (Arenas Urrea et al., 2019). Future research and development efforts are effectively needed to improve the process. Currently, the Canaries Technological Institute (ITC) is leading the European platform called DESAL+ Living Lab, a Macaronesian platform to increase excellence in research, development and innovation in water desalination, and knowledge of the nexus between desalinated water and energy ([9]).

On the island, a total amount of approximately 250-300 MWh/year is consumed in desalination processes and for pumping desalinated water to its final points of use: urban, tourism, industrial and agricultural, mainly around the island's coast (ITC, 2013). Nevertheless, it is possible to allocate desalinated seawater for agriculture at an altitude of 600 metres. For the urban and tourism sectors, it is not normal to exceed 300 metres. In general terms, desalinated seawater devoted to urban use, at the end of its life cycle, has an energy dependency of nearly 6 kWh/m^3, with over 50 % of this consumption being attributable to desalination.

Therefore, one of the main factors limiting desalination is energy dependency, which requires the burning of hydrocarbons with an environmental and economic cost. The use of this technology generates a high and permanent carbon footprint, which contributes to aggravating climate change, quite apart from the price of fossil fuels which, in Gran Canaria, amount to some 1 400 tonnes a day of fuel oil (70 %) and diesel (30 %), i.e. about 511 000 tonnes a year (3IDS, 2016).

Despite the island's having token experience of desalination powered by renewable energy, it is obvious that desalination with renewable and clean energy will come as a result of economic factors and to reduce the causes of anthropogenic climate change. It is not a matter of technology or cost, but of time and the will of all the parties involved. The Canary Islands are a historical example to the world in desalination technologies, and the next challenge is to continue obtaining drinking water from seawater by means of renewable energy sources, which are (almost) free of emissions, but also implementing indispensable efficiency measures for consumption and in the reuse of the resource.

Among the desalination facilities that use renewable energy on the island, several that are pioneering medium-scale (< 10 000 m^3/day) desalination for agriculture stand out, associated with on-grid wind energy in the private sector. There is also a bank of knowledge of small-scale (< 500 m^3/day) use of renewables in systems isolated from the electricity grid, with knowledge transfer outside the Canaries (Peñate et al., 2015; Subiela et al., 2009).

Many research experiments in isolated desalination making use of renewable energies have been carried out in the Canaries, which make this geographical area in the Atlantic an international example (Calero, 2018). From the first solar desalination plant installed in El Cotillo, Fuerteventura, in 1975, onwards, a multitude of facilities have been designed and tested. The experiment in electrodialysis with wind energy in Los Moriscos, Gran Canaria, in 1984, stands out. So do those with reverse osmosis (50 m^3/d) in Puertito de la Cruz, Fuerteventura, in 1981, the international prize winner at the Hanover Expo in 2000; several projects with wind energy by ITER-Enercon and the ITC; and the largest desalination project with wind energy carried out in the Canaries, the European SDAWES (1996-2000) project, which operated an isolated system with wind energy to desalinate using reverse osmosis, steam compression and electrodialysis (Carta et al., 2004). It would nowadays be feasible to achieve the desalination of water on Gran Canaria with the exclusive use of wind energy; 100 MW generated by wind would be capable of generating 80 hm^3/year of desalinated water, which could be stored in reservoirs of 18 hm^3 (see Section 4.6.2). The south-eastern district of Gran Canaria a is taking steps to close the integral water cycle, desalination included, making use of renewable energies.

Outstanding among the facilities installed on the island by private initiative is that of the company Soslaires Canarias, S.L. This company built a facility in 2002 in the south-west of the island that used wind power to supply the energy consumed by the desalination plant and water pumping. A pioneering venture on the island, it made it possible for an agricultural property to move from growing tomatoes exclusively to start diversifying its crops as a result of desalination. Nowadays the cultivation of tomatoes amounts to 10 % of the farm's total production.

([9]) This platform has been created in the framework of the DESAL+ project, co-funded by the Interreg MAC Programme (FEDER funds) with the aim of creating and consolidating a joint research, development and innovation platform (DESAL+ Living Lab) in Macaronesia with high capacities and research infrastructure of international excellence in the field of water desalination, knowledge of the desalinated water–energy nexus and exclusive use of renewable energies (www.desalinationlab.com).

This facility, producing 5 000 m^3/day, is associated with a property that requires 800 m^3/day. Desalinated water is produced when there is wind, and the excess water produced is pumped to a reservoir where water is stored until necessary. Normally, the system works 250 days a year with optimum wind conditions. This facility does not use any chemicals, and the brine generated, with a concentration of less than 58 g/l, is held in a filtration well beside the sea with a low impact on the coastal environment. In this wind desalination complex, water is generated without any subsidies, using wind power at a cost of EUR 0.60/m^3, and it is sold to farmers at EUR 0.83/m^3, adding the costs of pumping and distribution. These are reasonable prices in the area and Soslaires can see in wind energy a business opportunity comparable to its water business (Serrano-Tovar et al., 2019).

In conclusion, it is necessary to emphasise a series of challenges to and observations on the efficient development of desalination, as an alternative to the resources of natural origin. It is necessary to think about operating technology that makes use of renewables, given that the intermittence of wind is a challenge that is still not resolved. It is possible to desalinate all the water the island needs with the exclusive use of wind energy. We have the research and technical potential on the island to overcome all these challenges. What is necessary is a boost from politics, modifying regulatory aspects that would prevent the technological development and dealing with the policies of subsidising the energy produced on the island from fossil fuels (see Section 4.6.2). Desalination with renewable energies generates a saving in the national energy system thanks to its low energy cost.

There are also a number of topics of concern in relation to this subject: obsolescence of desalination plants, aspects regarding the quality of desalinated water (for agriculture), management of brine, minimising the environmental impact and being able to obtain by-products (sea salt, chlorine, etc.) instead of dumping the brine in the sea.

4.4 Wastewater management

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In the Canary Islands, as in other semiarid islands, the foreseeable consequences of climate change will be predictably characterised by (1) global increase in temperatures, (2) change and displacement of precipitation patterns – increase in dry periods and extreme rainfall phenomena – (3) increase in the natural evaporation process in soils, (4) change in the regime of trade winds – desertification and greater frequency of heat – and (5) competition for water between various economic sectors and environmental uses ([10]). Furthermore, it is important to consider agronomic effects, such as (6) significant impact on soil erosion (i.e. floods, drought, etc.), (7) changes in pests and diseases (Yohanes, 2016), (8) modification of soil properties, including a reduction in the availability of nutrients (Adeyeye et al., 2018), and (9) increase in crops' water and nutrient needs. On the other hand, high temperatures can increase the water use efficiency, calculated using the ratio of dry mass per area and the amount of water consumed (Mendoza-Grimón et al., 2015). Moreover, the progressive decrease in unusually cold days and nights, together with the increase in unusually warm nights (IPCC, 2014), raises the possibility of introducing C4 species in areas where the temperature are limited for their cultivation or to advance sowing dates to grow them in times of lower water demand. These plants are more productive and efficient in the use of resources such as water (Mendoza-Grimón et al., 2015), light or nitrogen (Fatima et al., 2018).

([10]) https://climatique.itccanarias.org/es/

Although a higher concentration of CO_2 can have a positive influence on photosynthesis under optimal growing conditions (Sombroek and Gommes, 1996), under predictable climate change scenarios rural areas will have less water and nutrients available. In this context, reclaimed water (RW) resources can be used as an alternative that can contribute to partially solve the abovementioned problems. In addition, the availability of alternative resources (RW, desalinated seawater and desalinated RW) at a foreseeable price will allow farmers to design the optimal infrastructures adapted to their needs (Palacios-Diaz et al., 2008a). As an example, maralfalfa (*Pennisetum hybridum* or *Pennisetum sp.*) production could be competitive against imports, being financially viable with RW prices in a range of EUR 0.20-0.30/m^3 (Palacios-Díaz et al., 2015).

Water reuse presents environmental, economic and social benefits but also potential drawbacks. The risks presented by water reuse have to be addressed in order to ensure health and environmental safety. Several key potential benefits and risks (environmental health and economics) have been identified (AMEC et al., 2016). As they are influenced by multiple factors, reuse projects must be analysed on a case-by-case basis according to site-specific conditions. There are no guidelines, regulations or good management practices at European Union (EU) level on water quality for water reuse purposes, although ISO 16075-1:2015 ([11]) contains good practices from health, environmental and hydrological points of view regarding operation, monitoring and maintenance of water reuse projects for unrestricted and restricted irrigation of agricultural crops. Various guidelines (Pescod, 1992; EPA, 2012) also include agronomic parameters.

To substitute RW from conventional water resources in agriculture, water treatment technologies must provide water to end users with enough quality (safe for human health and the environment but also agronomically adequate in the long term) and at affordable prices (economically feasible but avoiding socioeconomic and legal and/or institutional constraints). In this context, in Gran Canaria, as an example of the Canaries in general, treated water reuse has been stable for the last 20 years at about 0.08 hm^3/day ([12]), only 20 % of its treated water. The rest of the water is poured into the sea, which represents a resource waste. While agricultural water represents 53 % of in the total consumption in the Canary Islands, it is only 32 % in Gran Canaria. In 2014, RW was only 7 % of the water consumed by agriculture, while desalinated water was 45 % ([13]). Palacios-Diaz et al. (2008a) observe that optimal water desalination plants use about 2.5 kW/m^3 of electricity. It can be estimated that 0.5 kW/m^3 is used to raise water by 100 m. Therefore, as altitude increases, higher energy consumption is necessary to provide desalinated water to rural communities. In our mountainous island, RW from small villages could be reused *in situ* for irrigation, instead of transporting the effluent to high-tech treatment plants. Therefore, the use of RW is an alternative way to provide water for agricultural irrigation, decreasing energy consumption. Regarding economic considerations, the cost of desalinated water production (EUR 0.59/m^3) has to be increased by the pumping costs, so it is obvious that mountain villages have difficulties in being supplied with desalinated water. Comparing the costs of RW (EUR 0.20/m^3) shows that there is an advantage of *in situ* reuse. RW is a more sustainable option for agricultural production but some institutional decisions are needed to improve RW capacity to increase its consumption (Palacios-Diaz et al., 2008b).

The problems described related to reuse are far from the optimistic forecasts of the 1990s: the pollutant load, price and salinity are high and the reuse network is only available in Gran Canaria, Tenerife, Lanzarote and Fuerteventura (Delgado et al., 2008, 2012). Other problems can be mentioned: management difficulties, lack of training and information, inadequate legislation and problems in marketing irrigated products.

The initiative of a regulation on minimum quality requirements for reused water in agricultural irrigation and aquifer recharge will encourage efficient resource use and reduce pressures on the water environment, provide clarity, coherence and predictability to market operators, and complement the existing EU water policy (Alcalde-Sanz and Gawlik, 2017). The main barriers to promoting alternative water resources have been identified by the Partnership on Research and Innovation in the Mediterranean Area ([14]): (1) safety risks (environment, human health) have been linked to the use of improperly treated wastewater, (2) treatment costs are particularly linked to the energy needed and (3) public acceptance of RW varies depending on its potential use.

In relation to health hazards, guidelines from the World Health Organization and the Food and Agriculture Organization of the United Nations (Winpenny et al., 2013) recommend defining realistic health-based targets and assessing and managing risks along the continuum from wastewater generation to consumption of what its produced by cultivating with wastewater, to achieve these targets. This allows a regulatory system in line

([11]) www.iso.org/standard/62756.html
([12]) http://www.gobiernodecanarias.org/istac/jaxi-istac/tabla.do?uripx=urn:uuid:ca78f0d4-dc73-4fcd-8109-4b7ee61eae47
([13]) http://www.aguasgrancanaria.com/pdfs/PlanHidro/PHart47_MemInfo.pdf
([14]) http://ec.europa.eu/research/environment/index.cfm?pg=prima

with the socioeconomic realities of the country or locality. The document analyses different options for using recycled water for irrigation.

According to Winpenny et al. (2013), subsurface drip irrigation (SDI) demands less treatment than any alternative, improving health security by preventing contact between water and stems and leaves and, thus, minimising sanitary risk. SDI has other advantages: it enables water-conserving production practices and mechanised cultivation of high-yield crops ([15]), and uses the soil for advanced treatment of the water (Mendoza-Grimón et al., 2019). Furthermore, considering that farming the land is compatible with SDI reusing RW, this irrigation system can be proposed as the best one for reusing naturally treated livestock effluent (Palacios-Díaz et al., 2009).

As mentioned above, one of the main barriers to the reuse of RW is consumers' lack of information about its water quality. Consequently, it is necessary to generate knowledge to answer all those doubts. It is necessary to ensure the safe use of RW, thereby encouraging water reuse at EU level and enhancing public confidence (European Commission, 2018). One good way to generate this knowledge is using experimental plots. In these plots, many specific agronomic parameters necessary to provide guidelines about the best water management practices can be monitored, as the water management modifies the spatial distribution of substances (Palacios-Díaz et al., 2009) that are well adapted to crops, agroecological zones and farming practices, and thus, avoids RW dumping and land contamination.

Nowadays soil studies are focused on the soil's physical and chemical properties (organic matter content, pH, electrical conductivity, macro and microelements), but the soil biota, which plays an important role in the fertility of the soil, is usually forgotten. The consequence of the lack of measures is that farm managers do not take soil fertility into account in their decisions, since it is impossible to assess what is not measured (Buckwell, 2014). RW can contain considerable amounts of inorganic substances, such as heavy metals and salts that may have negative effects on agroecosystems (Frenk et al., 2014). Besides, RW can contain small quantities of emerging compounds. Soil biodiversity is an important indicator of soil tolerance and resilience (Guo et al., 2018). These organisms contribute to the sustainable functioning of all ecosystems by acting as the primary drivers of nutrient cycling, the regulation of the dynamics of soil organic matter, the sequestration of soil carbon and the emission of greenhouse gases, modifying the physical structure of the soil and the water regime, and improving the quantity and efficiency of nutrients ([16]).

In addition to the soil, both the root system and the rhizosphere represent a barrier between emerging compounds and the plants, detecting diverse factors of bioconcentration (with respect to the concentration detected in the soil) in various plants, measuring values from 0.02 to 21.72 (Eggen and Lillo, 2012). They also contribute to the biodegradation of toxic compounds (Huang et al., 2007).

([15]) http://www.fao.org/tempref/docrep/fao/010/i0112e/i0112e07.pdf
([16]) http://www.fao.org/tempref/docrep/fao/010/i0112e/i0112e07.pdf

4.5 Dry walks: future stories of adaptation in Gran Canaria

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In this section we report some reflections on process and results from the application of the methodologies described in Section 3.2. During the group discussions, the participants (either explicitly or implicitly) established critical dimensions and driving forces relevant to the development of future scenarios (Table 5).

Table 5. Key elements for scenario development

Critical dimensions (1)	Driving forces (2)	Strategic invariants (3)	Critical uncertainties (4)
Environment	Climate-related droughts	✓	
Society	Awareness and education		✓
Governance	Political will		✓
	Water management		
	Stakeholder and citizen engagement		
Technology	Renewable energies		
	Desalination	✓	
	Natural water-filtering systems		
Economy	Circular economy		

(1) Critical dimensions are the multidimensional space from which the scenarios can be built and unfolded (Gallopín and Rijsberman, 2000). (2) Driving forces are the 'key factors, trends or processes which influence the situation, focal issue, or decisions, and actually propel the system forward and determine the story's outcome' (Gallopín and Rijsberman, 2000, p. 3). (3) Driving forces that remain the same in all scenarios are called strategic invariants (Gallopín and Rijsberman, 2000). (4) Critical uncertainties are driving forces that imply deep uncertainties in their future development.

Five very classical critical dimensions were considered relevant during the discussions: environment, society, governance, technology and economy. Each dimension is associated with at least one driving force (only the driving forces common to all groups were considered). Two driving forces are assumed to be strategic invariants, i.e. drought events and water desalination (see Table 5). Last but not least and interestingly, critical uncertainties are anticipated for awareness and political will only.

The four groups of participants produced an equal number of visions of the future of Gran Canaria in 2040; the visions focused on the energy–water–agriculture nexus in a context of climate change and possible increase of drought events. The results point to one pessimistic vision and three optimistic ones (see Table 6, for a summary). All these four visions were described as 'caricatures' to make the participants reflect on possible pathways and corresponding actions for the future.

Unchanged (a pessimistic vision): this story of the future was developed by group 3, but one can find in the other groups' stories a pessimistic view as well. According to the group's rapporteur, this vision represents "*a whole reality of drought ..., desertification, loss of awareness of ecology and a misuse of resources ... There is technology but based ... on ... individualism... Policies do not help much*". This dystopian scenario develops in a context of climate change, in which more intense and frequent heavy rains and drought events occur (see also

Section 4.1), hand in hand with increasing zones of aridity and soil degradation. Individualism is a prominent social value. Local communities use existing technologies to enhance self-adaptation to drought conditions. Local communities do not perceive the climate and ecological crisis as a relevant issue for their societies. On the other hand, decision-makers give little support to innovation, research and development programmes; therefore, the deployment of renewable energies remains below the island's potential. Consequently, desalination technologies will continue using fossil fuels, increasing the island's external energy dependency. Most reclaimed waters are lost because of farmers' distrust in their water quality as a consequence of poor information and legislation unfit to the potentialities of natural water-filtering systems. The participation of stakeholders and citizens in water governance is poor, since it continues under the 'information and consultation' logic. The economy increasingly relies on oligopolistic markets where large corporations impose their prices and rules. In general, the local communities feel comfortable with this situation, encouraging the *statu quo* to remain unchanged.

The second vision proposed by group 1 is called **Integrated**. Their rapporteur indicated that "*we consider … the Tirajana area as an oasis in danger due to climate change, at risks of … torrential episodes … [and] drought leading to a responsible management of water … We saw irrigation techniques with regenerated and desalinated water …; this leads us to use alternative resources for agricultural production … We see in the area of Santa Lucia a natural purification system, already existing, which can be used on a small scale … There is soil degradation and a lack of awareness in society … Finally, we have the visions of the future, [based on] … three basic ideas: 1) energy systems with renewable energies … 2) water management inclined to enhance the use of reclaimed water 3) integrated management of resources for agricultural, social and environmental purposes … The first barrier is the lack … of [water] culture. Political barriers to the development of renewable energies … The drivers of change are… education and technology transfer, as well as efforts in social communication. That is … to give more … education to the population … to make better use of water*". As seen in the quotation, the environmental conditions are the same as described for the "Unchanged" vision: as a consequence of climate change, more intense and frequent extreme weather events are expected, including drought conditions (see Section 4.1). Educational systems and strong social communication (e.g. media) are key social driving forces. Local communities are more aware of the climate and ecological crisis, as well as the need for sustainable use of water. As a consequence of this, local communities are more interested in decision-making, i.e. besides stakeholder engagement also citizen participation is promoted. Governance encourages water recycling (see Section 4.4) by means of legislation adapted to the specificities of the island. Governance boosts the integrated management of resources towards sustainable agriculture, society and environment. The technological dimension relies on the deployment of renewable energies that compensate for the energy use of water desalination (see Section 4.3). Technologies also use know-how about natural water-filtering systems at small scales for irrigating crops.

The third vision called **Sustainable Society** was defined by group 2. According to its rapporteur, this vision consists of "*a society that deals with the integral water cycle, taking into account the … agriculture-energy-water-ecosystems nexus … [It] … is a society with justice and equity in access to resources …, local self-sufficiency, and … circular economy. That society also requires the best possible management, which is efficiency and savings … We must rescue … [the] water culture …, awareness, consciousness of resources. We must not forget how … research, development and innovation … must be part of the society we want in 2040. Among all the negative … factors that can [prevent] us to [reach] that society, I will mention … economic powers and the lack of interest in changing the economic model … Then we also have limited natural resources…, lack of awareness, information and training, which is more than we need to achieve these objectives… What else …? … The lack of identification of all the agents involved, there are many … different interests… Among the positive aspects…, we believe in public-private cooperation …, in social movements …; social movements are … the ones that help us change trends, to reverse the thinking of society… A better access to information will give us … a citizenry with … a critical spirit … Environmental education is the factor … to obtain positive environmental objectives*". Again, the environmental conditions described above remain the same. This scenario envisages a circular economy and all dimensions indicated in Table 4 are oriented towards this objective. The energy–water–agriculture nexus is consistent with the goals of the circular economy. Social justice and social equity in access to all resources is a key social driver in this vision. The ecological limits of Gran Canaria are made clearly visible in this vision, and the 'water culture' (see Section 2) is seen as foundational condition in this vision. Societal actors organise themselves in social movements and associations driving change. Governance supports increasing investments in innovation, research and development programmes, as well as awareness-raising campaigns. Technology facilitates the deployment of natural water-filtering systems for crop production, as indicated in the integrated management scenario. The circular economy developed on the island pursues local self-sufficiency, based on efficiency and water saving strategies. The economy relies on public–private partnership, including as a strategy to manage conflicts.

The last vision developed by group 3, as well, was named **Action**. According to its rapporteur, "***Action** can take us to a completely different scenario, where there is an adequate management of resources, in quality, in quantity, transparency: a total integration in the environment; we can live together with biodiversity, with sustainable economy, with renewables, with production … We return to agriculture, … use the customs of the past with the technology of the present; therefore, we can talk about a certain food sovereignty for specific goods, that is, not a complete food sovereignty … We need technology, we must promote and continue promoting research and development and, therefore, rely on it to achieve economic and environmental sustainable scenarios … **Action** implies having people committed and united to achieve the objectives*". A broad range of societal actors is committed to acting on the climate and ecological crisis, rooted in deep social awareness and education, to make the system less unsustainable for all. Green energies are deployed to the extent of the existing capacities of Gran Canaria, pushed forward by a strong political will. In this scenario, it is decision-makers who are the key driver of change. A Climate Change Agency is created to give scientific and technical support to the changes to come. This agency is also in charge of coordinating public and private administrations towards sustainable goals. The agriculture sector adopts approaches of the past (understood as sustainable practices) using the technologies available at the time. Since the agricultural sector is promoted, self-sufficiency in a certain number of crops is reached (those crops being selected after participatory discussions).

Table 6. A descriptive comparison of scenarios' outcomes

Scenario performance	Unchanged	Integrated	Sustainable Society	Action
Inclusiveness	Individualism prevails. Local communities use technologies to enhance self-adaptation to drought conditions. Local communities do not recognise the climate and ecological crisis and the consequences for the territory and lifestyles, feeling comfortable with the situation. ↘	Education and strong social communication (e.g. media). Local communities are aware of the climate and ecological crisis, as well as the need for sustainable use of water. ↗	Rooted in social justice and equity in access to all resources. The 'water culture' is assumed and local communities are aware of the ecological limits of the island. The society is organised in social movements and associations. ↗↗	Committed to acting on the climate and ecological crisis, rooted in deep social awareness and education. ↗
Political will	Little support to innovation, research and development. Legislation is not adapted to the current needs. →	In line with inclusiveness. ↗	Increasing support to innovation, research and development programmes, as well as awareness rising. ↗	It is the driver of change. Decision-makers strongly support renewable energies. ↗↗
Stakeholder and citizen engagement	Information and consultation level. People are informed and listened to. →	Public concerns and aspirations are considered in decision-making. ↗	Collaboration level. Partnership between stakeholders and citizens in decision-making. ↗↗	Partnership between the public and decision-makers in each aspect of the decision process, including the development of alternatives and the pr eferred solution. ↗
Renewable energies	Remain below the island potentialities. →	Renewable energies are deployed to the maximum extent possible. ↗↗	Dependency on the research and development programmes. ↗	Renewable energies are deployed to the maximum extent possible. ↗↗
Natural water-filtering systems	Most of the recycled waters are lost because farmers distrust water quality. ↘	Water-recycling technologies are deployed, and recycled waters are used for crop production. ↗	Water-recycling technologies are deployed, and recycled waters are used for crop production. ↗	Depends on the political will. →
Circular economy	Undeveloped. Oligopolistic markets remain. Large corporations impose prices and rules. ↘	The economy increasingly relies on small-scale production and short food supply chains. ↗	Developed. It pursues an increasing local self-sufficiency, based on efficiency and water saving. ↗	Oriented to self-supply of certain crops and products. ↗

From the scenarios presented above, some conclusions can be highlighted. Firstly, the participants imagined a dystopian vision which represent BAU; a sort of projection of the current situation (see also Section 2) in slightly less than a decade. This is a vision that all groups wanted to avoid at all costs. Secondly, another three diverse visions (similar in some aspects) have been imagined for 2040 in Gran Canaria: they are **Integrated**, **Sustainable Society** and **Action**. All these visions and scenarios offer potentially better future visions than the dystopic one, even if different groups imagined the drivers of change in different ways, emphasising different aspects of the same dimension. For example, the inclusive character discussed in **Sustainable Society** point to societal engagement as an engine of change. Political will appeared to be more relevant in the action scenario, reflecting the need for better (climate) governance. Stakeholder participation reaches higher levels in **Sustainable Society**, thanks to the collaboration among public and private stakeholders. The deployment of renewable energies is strongly considered in both the **Integrated** and **Action** scenarios as a way to mitigate climate change and gain independence from external energy sources. Natural water-filtering systems are adopted especially in the scenarios of integrated management and sustainable society as a key source of water for crop production. Lastly, it seems that all groups might agree on the development of and support for a circular economy, even if the details of what such idea is was not really discussed.

As explained above, the dry walks activity was illustrative of a participatory style of governance and therefore the visions described in this section, even if resulting from a collective reflection exercise cannot be seen as representative visions for Gran Canaria. However, they have been useful to make visible some invisible imaginations among the participants. They helped participants to reflect and negotiate among each other on a structured way different insights, concerns and tensions, and what needs to be changed in the present to attain or not plausible or implausible futures. Hence, besides being an inspiration to run a proper inclusive process, also concrete actions have to be proposed and implemented to achieve desirable futures. In the following section, many of the participants actually attempt to do so through what they called a "LOGIC proposal for action".

4.6 A LOGIC proposal for action

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In the following sections, a list of possible LOGIC (no water **LO**sses, wastewater re**G**enerat**I**on and de**C**arbonised desalination) actions to enhance the resilience of the food–water–energy nexus in a context of increasing flood risk is presented.

4.6.1 Agriculture sector

The following actions are based on Section 4.2.

1. It is necessary to improve water treatment, so that these waters with nutrients, but lower sodium absorption ratio levels, can reach farmers.
2. It is necessary to guarantee irrigation water to farmers in all agricultural regions and unify water prices for irrigation.
3. It would be helpful to analyse the areas of Gran Canaria with agricultural potential that present difficulties in accessing water resources. The possible acquisition by the council's Water Planning Agency of certain private wells located in strategic places should be evaluated in order to improve water irrigation management.
4. It is important to expand the distribution network of treated water to ensure that, at least, water supply is guaranteed at reasonable prices.
5. A professional farmer should not spend more than EUR 1 500 per hectare per year in water costs for irrigation, implying a price of EUR 0.25/m^3).

4.6.2 Desalination and the use of renewable energies in Gran Canaria

These actions are based on Section 4.3.

1. It would be helpful to have an updated georeferenced census of desalination plants on the islands, listing their water capacity and production, power demand and energy consumption.
2. The island should have ecoregulation related to desalination implementation (optimum energy consumption, renewable energy penetration, minimum environmental impact, etc.) and recommendations for the operators (led by the Water Planning of Gran Canaria).
3. Further research is needed for better operational understanding of isolated desalination plants or large-scale plants using renewables (performance, costs and energy backup).
4. It is necessary to go from the current installed capacity for desalination of 300 000 m^3/day to 420 000 m^3/day (Calero, 2018). Making these decisions is a matter of political will (not technical ability) as well as a question of changing specific regulations for the good of adaptation and mitigation to climate change in such a manner that the island's agriculture can be safeguarded from extreme climate events.
5. The use of renewable energies should be obligatory to desalinate water in the Canary Islands given the potential of sun and wind resources. A positive net balance should be the goal.
6. The existing legislation on renewables should deal with particular cases of self-consumption so as to produce water either for public supply or for agriculture by means of desalination.

4.6.3 Wastewater management

Based on Section 4.4, the following actions should be implemented ([17]).

1. Raise awareness and promote water reuse.
2. Improve the image of reuse.
3. Promote and build confidence in the reuse of reclaimed water.
4. Provide training/information on good irrigation practices.
5. Establish technologies for regeneration. Water treatment technologies must provide water to end users with enough quality (safe for human health and the environment but also agronomically adequate in the long term) and at affordable prices (economically feasible but avoiding socioeconomic and legal and/or institutional constraints).
6. Adapt uses and quality control to different scales, and ensure that they are economically viable and capable of producing effluents of sufficient quality for reuse.

([17]) http://adaptares.com/es/

7. Unite research efforts in the area of regeneration and reuse technologies. There are not enough long-term studies focused on this issue. Therefore, it is necessary to develop *in situ* experimental plots to evaluate the changes in soils, from the physical, chemical and biodiversity points of view, as well as the effects of reclaimed water use on crops' yields and on their disease tolerance.

8. Promote demonstration projects for reuse.

9. Regarding economic considerations, increase the social price of desalinated water production (currently EUR 0.59-0.65/m^3). It attracts a grant from the Council of Gran Canaria, which does not include the total cost of the desalination process or the pumping costs, since mountainous areas are more difficult to supply with desalted water. Comparing it with reclaimed water costs (EUR 0.20/m^3) shows that there is an advantage to *in situ* reuse. Reclaimed water is a more sustainable option for agricultural production but some institutional decisions are needed to improve RW capacity to increase its consumption (Palacios-Diaz et al., 2008b).

10. Introduce a regulation on minimum quality requirements for reused water in agricultural irrigation and aquifer recharge, to encourage efficient resource use and reduce pressure on the water environment, providing clarity, coherence and predictability to market operators (Alcalde-Sanz and Gawlik, 2017).

4.6.4 Water losses

According to the European Environment Agency (EEA), water losses – which include production losses (abstraction and treatment processes), distribution losses (much larger than production losses), unbilled consumption (e.g. firefighting) and apparent losses (meter inaccuracies and illegal use of water) – should be minimised (EEA, 2014). Therefore, water loss control is one of the key actions to reduce the impact of unsustainable water management (EEA, 2009, 2018). However, especial attention should be paid to distribution losses (EEA, 2014). According to the EEA, two kinds of actions could be implemented, i.e. technological developments and fiscal policies:

1. The technological developments include network improvement by means of preventative maintenance and network renewal (EEA, 2009, 2014). New technologies are able to detect leaks, such as sensors that use noise generated to locate the leak in the network, or ground radar devices to identify disturbed ground or cavities around the pipe, as well as tracer gas and devices that use radio signals to detect flowing water (EEA, 2009).

2. Fiscally, fines should be imposed when agreed reduction rates are not met (EEA, 2009).

4.7 Integrating adaptation actions into the Covenant of Mayors of Gran Canaria

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The Council of Gran Canaria, through the Insular Council of Energy, has been the coordinator of the Covenant of Mayors on the island since September 2016, providing technical and strategic assistance to the signatory municipalities for the development, implementation and control of their sustainable energy and climate action plans (SECAPs), including the baseline emission inventory (BEI) and the risk and vulnerability assessment (RVA). The council also provides financial support to the signatories either in the form of direct support, such as grants, or by assigning personnel for technical assistance, sharing experiences and knowledge among the signatories of the covenant (existing and potential).

Currently, 10 municipalities of Gran Canaria (Agüimes, Firgas, Gáldar, Ingenio, Moya, Santa Brígida, Tejeda, Telde, Valleseco, Valsequillo de Gran Canaria) have completed their SECAPs, which are under review. In October 2019, 10 other municipalities became part of the initiative (Agaete, La Villa de San Nicolás, Artenara, Arucas, Mogán, San Bartolomé de Tirajana, Santa Lucía de Tirajana, Santa María de Guía de Gran Canaria, Teror, Vega de San Mateo). The municipality of Las Palmas de Gran Canaria is evaluating how to collaborate with the Local Energy Agency of Las Palmas de Gran Canaria on the preparation of its action plan.

The SECAP is a key document that shows how the signatories of the Covenant of Mayors will fulfil a commitment by a scheduled time limit. This plan uses the results obtained from the reference emissions inventory (IER) to identify the best actions in order to reduce CO_2 emissions at least 40 % by 2030, using 2012 as baseline. In addition to the IER, an RVA has been carried out, in which both existing and other indicators have been selected. These indicators have been used to identify and establish the three levels of risk evaluation regarding the average island situation: climate risks, vulnerabilities and impacts.

The activity sectors included in the emissions inventory are:

- buildings, equipment and facilities in residential, commercial and municipal/institutional buildings and facilities, and agriculture/forestry/fisheries;
- transport, direct emissions from fuel combustion and indirect emissions due to consumption of grid-supplied energy;
- other, non-energy-related activities from disposal and treatment of waste generated;
- energy supply.

The mitigation actions contemplated in the action plans have been agreed through different methods of citizen participation, defining strategies and objectives that are grouped as follows:

- municipal buildings/facilities:
  - street lighting,
  - water cycle savings,
  - waste;
- residential and tertiary buildings:
  - residential buildings,
  - tertiary buildings (non-municipal),
  - primary sector buildings;
- transport and mobility:
  - promotion of public transport,
  - private and commercial transport,
  - sustainable urban mobility plan;
- promotion and management of energy:
  - creation of an energy office,
  - pilot projects and energy studies,
  - promotion and production of renewable energy and local heating/cooling;
- administrative management, governance and urban planning measures:
  - awareness-raising and training campaigns,
  - planning and management of the urban fabric,
  - hiring mitigation officers.

With regard to the adaptation pillar, different indicators were used to identify the following components of the RVA:

- climate risks;
- vulnerabilities;
- impacts.

The sectors evaluated in the RVA have been:

- buildings;
- transport;

- energy;
- water;
- waste;
- land use planning;
- agriculture and forestry;
- environment and biodiversity;
- health;
- civil defence and emergencies;
- tourism and socioeconomic status, the latter only in the vulnerability assessment.

In view of the results of the indicators applied, different climatic risks and vulnerabilities were identified for the various municipalities of Gran Canaria. The proposed actions for the municipalities are in response to expected impacts that are either moderate or high. Some examples of water-saving actions, already included in the SECAPs, related to the Acequia workshop are the following:

- water cycle savings:
    - perform a water audit in the municipal buildings that use most water,
    - study the implementation of diverse networks for the use of rainwater,
    - install networks for the use of rainwater in existing municipal buildings,
    - perform a feasibility study for the installation of variable-speed drives in pumping stations,
    - replace pumps with more efficient ones,
    - improve energy efficiency in water treatment plants and desalination plants,
    - carry out a study to determine water-saving capacity in the domestic sector of each municipality,
    - study the integral use of wastewater,
    - take advantage of reclaimed water for irrigation,
    - study the supply network to minimise water losses;
- primary sector:
    - implement a one-stop advisory service on energy saving, self-consumption and climate change for local farmers.

With regard to the adaptation actions proposed in Section 4.6, it has to be noted that several actions are already planned or to be included in the SECAPs of the Covenant of Mayors, since they can be carried out at municipality level. However, the rest of the actions involve the island or regional level, being therefore beyond the powers of the municipalities. The actions that can be covered at local level are listed below:

- agriculture sector (Section 4.6.1):
    - 4 – expansion of the distribution network of reclaimed water;
- desalination (Section 4.6.2);
    - 2, 5 and 6 – penetration and use of renewable energy through self-consumption in desalination;
- wastewater management (Section 4.6.3):
    - 1, 2 and 3 – awareness and promotion of, and trust in, reclaimed water,
    - 4 – training/information on good irrigation practices;
- water losses (Section 4.6.4):

- 1 – study of the supply network to minimise water losses.

5 Discussion

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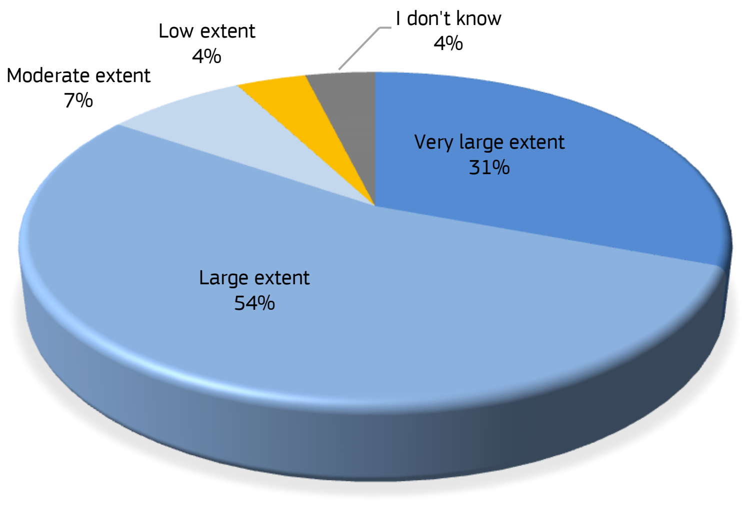
5.1 Presentations and round tables

As mentioned in Section 3.1, five round tables, each composed of five experts in their fields, were organised. Each member of the round tables gave a talk of 7 minutes to explain the state of the art in their area of expertise. Then half an hour was dedicated to debate among the members of the round tables. The public could also intervene at the end of each session to either comment or ask questions of the members of the round tables.

According to Figure 9, 85 % of participants considered the round tables highly valuable for the topic of climate change, drought and water uses in Gran Canaria. The method applied for these round tables was valuable not only for further exploring the state of the art of drought risks in a changing climate, but also to enhance public participation and make them part of the co-creation of knowledge. As summarised by a member of the 'Climate, pluviometry data, modelling and projections' round table, who was a representative of the Spanish Meteorological Agency, 'the idea of [this type of] round tables is very good. I'm more accustomed to giving talks, maybe of 10 to 15 minutes, where there is [some] room for a small debate of half an hour at the end, but nobody remembers what was said at the beginning. I think that this format is very good, because there's a small introduction by the speakers and then we move on to debate and discuss [along with the public]'.

Figure 9. To what extent did the round tables give valuable information about the state of the art?



Source: own elaboration based on a questionnaire issued after the workshop to all participants.

5.2 Futuring tours and focus group discussions

As described in Section 3.2, this activity was meant to develop visions of adaptation to address the impacts of droughts on food production in view of the water–energy–food nexus. The futuring tours were based on participatory methods and were aimed at reimagining food production affected by drought and other possible impacts of climate change. The full dry walk encompassed two stages. Firstly, the participants were divided into groups that walked through the territory on a pre-chosen route, equipped with a photographic device –

smart phone or digital camera. Photographs taken in the first stage were used as the main resource in the second stage of the dry walk. The second stage consisted of using a 'backcasting' approach to imagine adaptation strategies for food production in Gran Canaria taking into account the water–energy–ecology nexus.

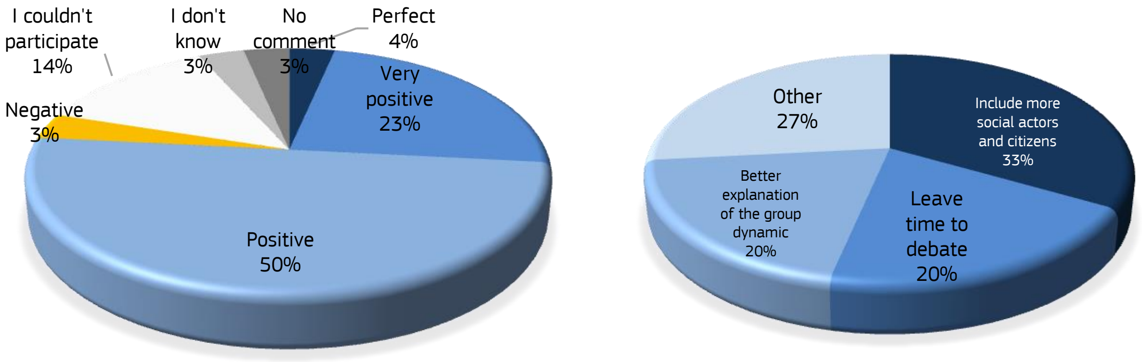
5.2.1 Participatory methods

According to the results presented in Figure 10 (left pie chart), 77 % of the futuring tours' participants indicated that the participatory exercise was positive, very positive or perfect. One participant, from an agroecological farm, stated that the dynamic was 'funny, fantastic and affordable'.

A participant from the ITC argued that these social methods enhance creativity: 'I wanted to vindicate this type of format, or participatory methods, … because it has very interesting effects … : first of all, since we have many people from different fields working in parallel, the creativity that is generated … becomes very productive, i.e. in very little time we get many things. [This] is very productive and enriching, i.e. very efficient.'

Similarly, it was stated that participatory methods equalise all participants: 'a very important aspect of this type of methods is that it levels everyone out: it doesn't depend on your position, it doesn't depend on whether you know more or less … A non-academic expert, or an expert, or someone with political power or responsibility is on an equal footing with another person who, perhaps, doesn't have as much experience … that's irrelevant … In that sense, I think it is a very interesting method'.

Figure 10. Left: What is your assessment of the participatory exercise? Right: How would you improve the participatory exercise?



Source: own elaboration based on a questionnaire conducted after the workshop to all participants.

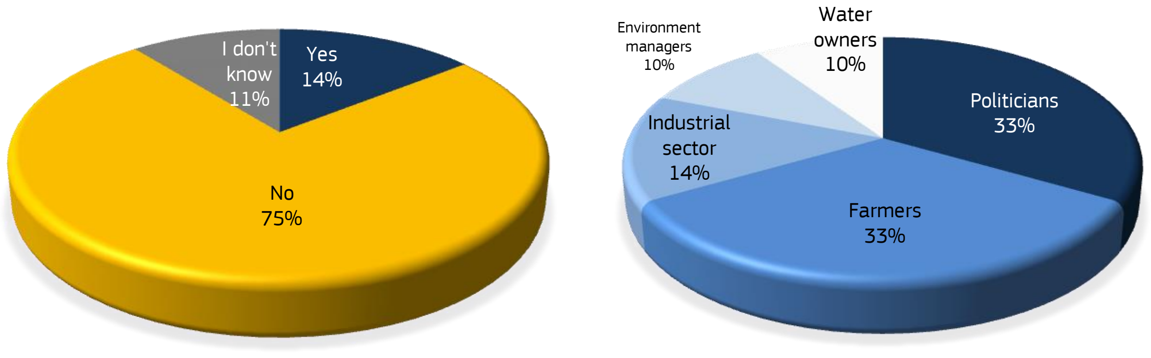
Lastly, the importance of the field visit before having the focus group discussions was mentioned as a technique that paves the way towards consensus: 'the field visit is fundamental … [since it] levels the knowledge of all … Consensus … comes out almost naturally, and this is difficult to find in the general society'.

Negative aspects, or aspects to improve, were also mentioned. According to the participants (see Figure 10, right pie chart), the participatory process should have engaged more social actors (discussed in the following section), left more time for the group discussion and improved the explanation of the group dynamic.

5.2.2 Stakeholder and citizen engagement

According to Figure 11 (left pie chart), 75 % of the participants stated that not all the relevant stakeholders and citizen organisations were present in the workshop. Furthermore, more politicians, farmers, industrialists, environmental managers and water owners should have been present (see Figure 11, right pie chart). As seen below, the missing stakeholders were a cause of participants' complaint.

Figure 11. Left: Do you think that all relevant social actors and key persons in the matter were present in the workshop? Right: What people or sectors should have participated?



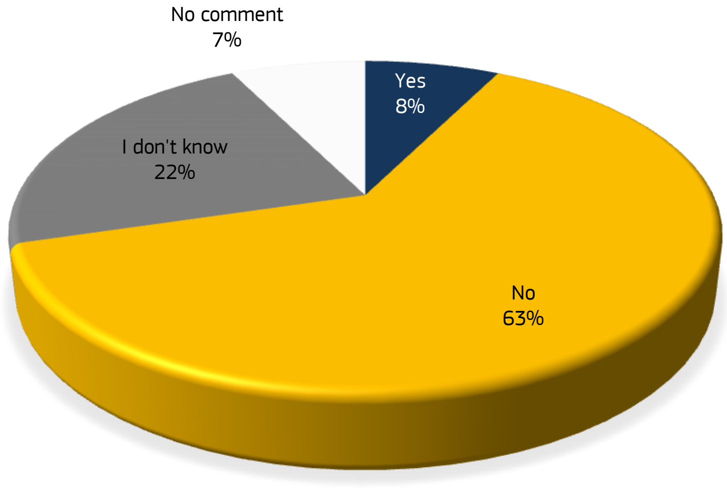
Source: own elaboration based on a questionnaire issued after the workshop to all participants.

Some participants were particularly displeased with the fact that decision-makers did not participate. For example, a professor at the University of Las Palmas de Gran Canaria declared: 'here we're only people of good will, as my grandmother used to say'. In the same line, a researcher from the ITC stated 'it's not the first time … We have joined participatory events and, generally, the weakest part is the lack of decision-makers … Those who really have to implement the policies, or make them happen, normally don't appear in these events'.

The representative of the agroecological farmers complained about the costs associated with participating in this kind of event, especially if the results are not shared and transmitted to decision-makers: 'one last thing, because I can't keep it to myself … I'm delighted to have participated in this [event], to be able to be here. Really, for me this has been very productive … So much so that farmers who didn't want to know anything about reclaimed water are already interested, at least, in visiting the water treatment plants. Well, having said that, the time we spend here doing this kind of work [is remarkable], we're always the same [people]. I don't think this should be [like this] any more … If this doesn't [reach politicians] … it's very expensive for me to be here. And I think it's for everyone'. These comments reflect the perception that these events may have little consequence at the decision-making level (see Figure 12).

However, this negative vision, although it was perceived by the majority of participants, was not shared by all. For example, the representative of the Spanish Meteorological Agency stated that 'when we're talking about politicians or managers missing, this isn't true: there were [politicians] at the opening of the event and now they're going to be at the close. [What we should care about is] if these ideas are going to be transmitted [to them]'. This view was shared by another researcher from the ITC, who said: 'we're technicians, university students, the Water Planning Agency is present, but after all, those who organise and make decisions on how we move forward don't work in this type of forum. So, from my point of view, maybe it's good that these results are shared on that scale'. A decision-maker from the Council of Gran Canaria expressed a similar opinion: 'I've been present in all [sessions] I could be. … I simply tell you to visit my department and see what we have there. We have exactly two technicians and one administrator. And with that [level of human resources] we have to manage a budget of about EUR 100 million. I say this because, well, I believe that I do many things that are beyond my remit. … Our intention is to incorporate the conclusions [of this event] into the Climate Risk Assessment and Action Plan. And, well, the first consequence that this assessment is going to have, is that the action plans for climate and sustainable energy are going to be incorporated into the Covenant of Mayors. … I believe neither that all politicians are equal, nor that all governments are equal; I believe that, in short, there're substantial differences'.

Figure 12. Do you think the workshop has had consequences at the political level?



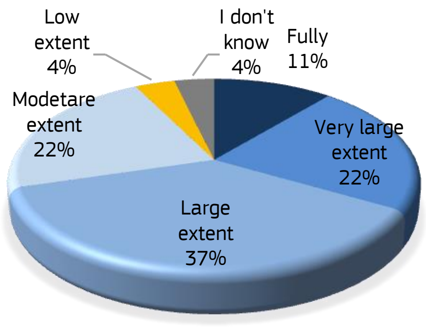
Source: own elaboration based on a questionnaire issued after the workshop to all participants.

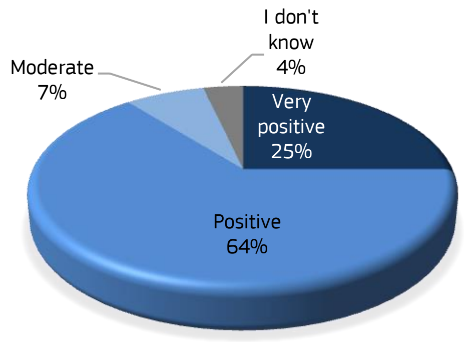
Another researcher from the ITC closes this topic adding: 'I think that what [we] can do is keep doing what we are doing. I'll explain: … in our plots, where we work, we have somehow incorporated this philosophy of work, which we have seen here, and we do our bit to help in our environment, right? At a technical level, … when we divulge, when we get together with someone who has power, we can transmit it to them, influence that process. And we're constantly working persistently day by day. The advantage of this event … is that somehow it empowers us even more. Why? … It does empower us to fill ourselves with strength for our work. I think we should continue doing what we are doing, but with a broader and more collective vision, right? … [We] are almost more important than political power.'

5.2.3 Overall assessment of the workshop: a networking tool

In general, the participants were pleased with the goals of the workshop, i.e. to define the state of the art of climate change, droughts and water uses in Gran Canaria. Thus, 70 % of participants thought that the workshop met its goals to a large or very large extent or fully, and 89 % of participants assessed it positively or very positively (see Figure 13). As the representative of the Spanish Meteorological Agency said, the workshop 'served to get in touch [with other colleagues]. We have exchanged data … , what is called networking. And I think that's a positive point … I've met people I didn't know and, from that, I think interesting things are going to come out … I think it's a good starting point'.

Figure 13. Left: To what extent did the workshop meet its goals? Right: How do you assess the workshop?





Source: own elaboration.

6 Conclusions

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The Joint Research Centre was invited by the Council of Gran Canaria to explore adaptation strategies for Gran Canaria Island in a context of possibly increasing drought risks. Hence, the researchers of the JRC designed a 3-day workshop intended to co-create strategies with local actors including stakeholders and citizens of Gran Canaria island. The activities aimed at (1) taking stock: i.e. sharing knowledge about meteorological and hydrological droughts on the island (Sections 4.1 to 4.4) so that the participants could get acquainted with not only the physical phenomena but also current governance options as far as water management is concerned, (2) exploring future visions for Gran Canaria: i.e. scenarios of water–food–energy nexus under climate change conditions and, (3) proposing adaptation actions that could be adopted by the Covenant of Mayors of Gran Canaria.

The JRC's researchers put together a number of participatory activities to respond to this set of objectives and participants found the space provided quite adequate to pursue the objectives – see box 1.

Box 1. Evaluation and feedback

Evaluation: Of the participants who responded to the questionnaire, 89 % were satisfied with the workshop; 67 % thought that the goals were met; 85 % declared that the framing of the state of the art was worthwhile; and 77 % rated positively the participatory scenario exercise in which different visions of Gran Canaria in 2040 were explored and actions were proposed.

Feedback: However, many participants complained about the explanation of the collective scenario work following the physical tour, which, according to them, should have been clearer than it was, and that the time allocated to debate should have been longer.

The results obtained in this 3-day workshop -and summarised here- could be adopted by both the Council of Gran Canaria and the Covenant of Mayors of the island. This to us constitutes success, as a key feature of participatory work is follow-up.

The researchers of the JRC are also aware of the limitation of this study. For example, not all the relevant actors were present in the sessions: more decision-makers, farmers, industry sector representatives, environmental managers and water owners would have been desirable for even more plural outcomes.

All in all, it can be said that the workshop was a useful space to start a process and illustrate how participatory work can initiate long due conversations and exchanges about a complex issue such as climate adaptation in an island context. What was started needs to be deepened with an actionable plan, as recommended by all participants of the workshop including decision-makers. As the cartoonist *El Roto* has stated in one of his cartoons: 'They searched for gold in the water, not knowing that water was itself gold'.

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