



An institutional analysis to address climate change adaptation in Tenerife (Canary Islands)

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ABSTRACT

Heat waves and Saharan dust outbreaks have been acquiring more frequency and intensity in the Canary Islands during the last decades. Both climatic hazards are known to produce impacts on human health such as mortality (due to heat waves) and morbidity (due to dusty weather). This work addresses possible climate adaptation policies in Tenerife assuming the increasing impact of heat waves and Saharan dust outbreaks in the island under a climate change scenario. It explores the institutional setting of climate change adaptation planning in Tenerife and evaluates the statu quo of adaptation planning in the island through the engagement of key social actors. An historical review of the local and regional press articles and legislation, an in-depth round of interviews, together with questionnaires to the main social actors allows framing the social and political context in which climate change adaptation in Tenerife is embedded. Key social actors were engaged, including international organisations, atmospheric research centres, local Universities, regional and insular governments, trade unions, and environmental NGOs, among others. The main obstacles mentioned by the social actors that hinder the development of an effective climate adaptation policy address scientific knowledge, data collection and policy making, focusing on the uncertainty of climate models, the lack of epidemiological data and contrasting opinions regarding the existing climate adaptation policies. Public participation, mainstreaming of climate policies and an integrated approach between mitigation and adaptation plans were identified as key policy issues. The outcomes of this study could be meaningful for climate adaptation initiatives at local or regional level, such as the Global Covenant of Mayors, that intend to promote climate resilience through the setup of climate adaptation strategies and plans at municipality level.

1. Introduction

1.1. Objectives

This work focuses on possible climate adaptation policies in Tenerife assuming the increasing impact of heat waves and Saharan dust outbreaks in the island under future plausible climate change (CC) scenarios. Furthermore, it explores the institutional setting of CC adaptation planning in Tenerife and evaluates the statu quo through the engagement of key social actors.

1.2. Heat waves and Saharan dust outbreaks in Tenerife

Climate in the Canary Islands is mild, due to the influence of the

NNE trade winds and the cool waters of the subtropical North Atlantic. Periodically, cool trade wind weakens and easterly Saharan air reaches the Canaries with high temperatures -dropping relative humidity- (Dorta, 1991) and suspended desert dust. The combination of these two factors, high temperature and desert dust, is known locally with the name of "calima".

Heat waves can reach temperatures of 44–45 °C (Dorta, 1991), bringing tropical nights of 26–30 °C (Dorta, 2007). Whilst Alonso Pérez (2007) argues that these episodes might have become more intense and frequent in the Canary Islands since 1970, Sanz et al. (2007) states that the average number of heat waves has quadrupled since 1994 and five out of the ten strongest heat waves recorded over the whole period have been detected during 2004–2007. Recent heat waves in the Canary Islands have left 13 premature deaths, more than any other

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meteorological hazard (Dorta, 2007). Several authors point out that a general rise of temperatures is expected in the future for the Canary Islands (Martín et al., 2012), intensified in the upper parts of the islands (Expósito et al., 2015; Martín et al., 2012). Meanwhile, the number of warming days is expected to increase from a minimum of 7% to a maximum 36% by 2070–2099 with respect to 1961–1990, depending on the global warming scenario (Cardós et al., 2007).

There are two Saharan dust seasons in the Canary Islands, one in winter and another in summer. During winter, dust events are associated with the easterly winds prompted by the occurrence of high pressure expanding from the North Atlantic over Western Europe and North Africa (Alonso-Pérez et al., 2011). These events may induce extremely high dust concentrations at ground level (up to 2000 $\mu\text{g}/\text{m}^3$) and are not necessarily associated with high temperatures. During summer, dust events are associated with the circulation of the dusty Saharan Air Layer, resulting in hot, dry and dust air between 500 and 5000. a.s.l., whereas trade winds prevail at lower altitudes. Recent long-term analysis (1941–2013) shows that there is an important multidecadal variability in summer dust export (García et al., 2016). The islands have historically received Saharan dust as a consequence of large scale meteorological processes (Cuevas et al., 2016) but episodes have acquired more frequency and intensity since 1970 (Alonso Pérez, 2007), leading to a dusty and “naturally” polluted air with particulate matter (PM_{10}).

In terms of socio-economic impacts, reduced visibility tends to affect both Tenerife's airports and their transport services (Dorta, 2007). However, the impacts on human health are amongst outstanding ones, since respiratory pathologies, anxiety disorders, and atypical thoracic pain usually affect local population (García-Carrasco et al., 2001), leading to increased use of air liquid as a respiratory therapy (Belmonte et al., 2010). Saharan dust events might also be related to the introduction of microbial communities in the Islands (González-Martín et al., 2013).

Even though a seasonal change has been reported and associated with CC (Alonso Pérez, 2007), several authors suggest that a clear connection between Saharan dust outbreaks and CC cannot be argued (Dorta et al., 2005). Rodríguez et al. (2015) indicate that, in order to establish a clearer connection between Saharan dust outbreaks and CC, a better understanding of the North African dipole would be needed. Therefore, climate change-related impacts on Saharan dust outbreaks may be said to be under discussion (Alonso-Pérez et al., 2007).

1.3. Climate change policy in the Canary Islands

Institutional arrangements can either hinder or strength CC adaptation. Diverse case studies have reflected on these issues, referring to power relations, politics and values as possible constraints, at both local and regional level. For instance, and institutional analysis carried out in Semarang (Indonesia) concluded that the absence of local reports on CC has led to unclear communication and poor coordination among stakeholders (Artiningsih et al., 2016). Francesch-Huidobro et al. (2017) pointed out (after reviewing the cases of Hong Kong, Guangzhou and Rotterdam) that the practice of climate adaptation depends on the level of exposure to flood risks, as well as the approach and methods applied. It has also been highlighted that political corruption might lead to low coverage and poor quality of adaptation (Gebreyes, 2018). Mandryk et al. (2015) concluded that the heterogeneity of social actors' interests and the lack of resources are the main barriers for agriculture adaptation in Flevoland (the Netherlands). The lack of funds for hiring coordination personnel has also been indicated in an analysis developed in North-Rhine-Westphalia, Germany (Roggero, 2015).

A case study carried out in Norway on flood adaptation, point out that local power structure increases the rapidity of measures implementation when powerholders' interests are represented, whereas the same power structures tend to slow down the process of social learning when their stakes are at risk (Næss et al., 2005). An

institutional analysis carried in Mozambique highlights the lack of data, low institutional continuity, and the lack of financial resources as the main constraints for mainstreaming CC adaptation into development assistance (Sietz et al., 2011). A coastal management analysis implemented in Coastby (Sweden) concluded that building capacity is hampered by a combination of factors, such as poor vertical and internal coordination of administrations (leading to lack of coherent policy), tensions and trade-offs between policy agendas, values and political priorities (Storbjörk and Hedrén, 2011). Lastly, an institutional analysis of water governance in Pakistan indicated that the lack of trust between provinces to share water resources hinder the capacity of food production to adapt to CC (Yang et al., 2014).

The institutional arrangements of the Canary Islands share most of the constraints presented above due to the lack of a clear climate governance in the archipelago. In April 2009 a CC Agency was created by law in the Canary Islands. It was intended to promote, encourage, orient and coordinate local policies, initiatives and measures to reach sustainable development, including mitigation and adaptation to CC (BOC, 2009). This Agency developed a CC strategy, including a CC mitigation plan (Gafo-Fernández, 2009), and a CC adaptation plan (Martínez Chamorro, 2010). The 25th of June 2012 the Government of the Canary Islands launched a regional law adopting measures aiming at reducing public administration expenditure in order to respond to the financial crisis. Consequently, the CC Agency was dissolved so as to “guarantee public expenditure sustainability” (BOC, 2012) and the Canary Islands CC Strategy was consequently paralysed.

To compensate this lack of climate governance, the Gran Canaria Island Council (the second most populated island of the Canaries) created a Climate Action Group in 2016 with the aim of taking over the process of developing a climate strategy.¹ This strategy is currently being developed along with the collaboration of social actors and citizens. Conversely, the Island Council of Tenerife has not followed Gran Canaria's approach and remains without a CC strategy of its own: only a civil protection plan and a disaster risk management plan are currently into force (see Table 2 in Section 2). Notwithstanding, an Observatory for CC has been established in Lanzarote by the Government of the Canary Islands in April 2017, replacing the former CC Agency. However, this Observatory does not have the necessary resources to develop an updated CC strategy for the region.² Nowadays, the islands still lack a common climate adaptation strategy in a context of high vulnerability to the effects of CC (López-Díez et al., 2016).

2. Institutional analysis and participatory approach

Environmental governance often concerns long time horizons and multiple social actors, which further complicate the governance processes, increasing the uncertainties involved in it (Kangas and Kangas, 2004). Environmental governance is characterised by values in dispute, high stakes and urgent decisions (Funtowicz and Ravetz, 1991). These values in dispute are further aggravated by the uncertainties related to the environmental systems (Corral Quintana, 2004; Corral and Hernandez, 2017; Funtowicz and Ravetz, 1993; Guimarães Pereira and Corral Quintana, 2009; Hernández González and Corral Quintana, 2016; Hernández-González and Corral, 2017). All these elements complicate the traditional scientific approach, where a mixture of (partial) knowledge, assumptions, and ignorance are the rules rather than the exception. In these cases, institutional analysis might be of use to shed light on all these “backstage” elements.

Institutional analysis might be considered as a fact-finding procedure to examine different structures and social relationships (Corral Quintana, 2004), providing a more detailed approximation to the prevailing social and institutional arrangements, assumed as the social

¹ Personal communication obtained from the in-depth interviews.

² Ibid.

context shaped by institutions that delimit citizens' rights and responsibilities (Bromley, 1989; Commons, 1961; Schmid, 1972). Institutional arrangements have also been considered important for the understanding of CC adaptation strategies (Eisenack, 2016).

An analysis conducted in the Netherlands for agriculture adaptation, concluded that both the heterogeneity of actors' interests and the unavailability of resources were two relevant obstacles to implement adaptation measures (Mandryk et al., 2015). In effect, local power structures do shape adaptation decision-making. Næss et al. (2005) detected that when powerful social actors coincide in the necessity of adapting to CC, adaptation measures are quickly implemented. Other authors indicate that the lack of coordination among institutions might also lead to reduced adaptation capacities (Storbjörk and Hedrén, 2011). Conversely, small islands tend to be more resilient as a consequence of dense social networks, such as collective action, reciprocity and relations of trust, being all this particularly relevant for CC adaptation (Petzold and Ratter, 2015).

Consequently, the understanding of the social structures and institutional arrangements by means of institutional analysis becomes crucial. Institutional analysis is generally carried out through the employment of diverse social research methods, including participatory approaches. CC adaptation strategies require the active participation of social actors in adaptation planning (EEA, 2016; Kuik et al., 2016) in the form of deep engagements from the very beginning of the process until the monitoring of the results (Hernández-González and Corral, 2017). It is known that engaging all the social actors involved in environmental issues brings potential benefits to the process, such as ownership of policies, better decisions in terms of sustainability, the inclusion of community values, governmental credibility and faster implementation (Giering, 2011). Inclusive approaches of social actors in environmental planning have been proven to be effective to deal with different climatic adaptation issues, such as coastal erosion and floods (Stocker et al., 2012), agriculture resilience (Dumenu and Obeng, 2016; Schaap et al., 2013), resilience against diseases (Dovie et al., 2017), residential building adaptation (Glaas et al., 2017), urban water supply systems (Kingsborough et al., 2016), adaptation frameworks for tourism destinations (Wyss et al., 2014) and grassland-based farming systems (Sautier et al., 2017).

In the present research, a historical review of the local and regional press articles and legislation, an in-depth round of interviews, together with questionnaires to the main social actors involved in CC adaptation allowed framing the social and political context in which CC adaptation in Tenerife is embedded (Table 1).

2.1. Press and policy review

This step includes a local press review regarding the case study at hand. The review of existing policies and local press articles allows having a first approach to the social and political context of CC

Table 1
Institutional analysis, methodologies and types of information collected.

Press and legislation review	Framing: a preliminary overview of the problem at hand A preliminary map of key social actors and their positions A map of the existing CC policies
In-depth interview	Framing: deeper overview of the problem at hand Map existing reports and scientific articles on the issue at hand Map the position of the social actors Identify adaptation actions and possible obstacles for its implementation Map new social actors
Questionnaire	Collect existing reports and scientific articles on the issue at hand Check the consistency of interviewees

Table 2
Climate change adaptation-related policies identified.

Issue	Geographical Scope	Policy
Adaptation	Canary Islands	Climate Change Adaptation
Civil protection	Canary Islands	Civil Protection and Emergency Management Civil Protection against Extreme Weather Events Disaster Risk Management Civil Protection and Emergency Management
Population health	Canary Islands	Prevention of Negative Effects of High Temperatures

adaptation, understanding the current and past relevant social actors related to the issue, and giving a historical perspective of the actors involved with respect to climate policy (Corral Quintana, 2004; Gamboa and Munda, 2007). Hence, a press review is a valuable source of information since it allows for a wider and plural view of the issue; plural because different opinions are put forward; and wider since it helps the analysts to approach the issue from different perspectives. It may also be more balanced because different press articles narrate the issue in different ways depending on their ideology, target audience, and scale (local, regional or national).

Press reviews have been successfully applied to different case studies on environmental policies, such as air quality (Corral Quintana, 2004), water resources management (De Marchi et al., 2000; Paneque Salgado et al., 2009), and sustainable mobility (Hernández González and Corral Quintana, 2016). According to the structure presented in Table 1, the local press review allows for:

- *Framing the issue.* Heat waves and Saharan dust events could be seen as frequent climatic phenomena in the Canary Islands. Several experts were identified, and indicated that there are relevant policy gaps and a lack of multiple risk assessment in the island. Some media press articles have reported increasing mortality and overuse of medical services, as a consequence of increasing morbidity.
- *Mapping of relevant social actors.* A certain number of experts and social actors have been detected through the local media, allowing for potential contacts to be considered for the following participatory techniques (see Section 2.2).
- *Mapping CC adaptation-related policies* (see Table 2).

To our knowledge, few are the authors who have defined what a press analysis can achieve to identify the social actors. Hernández González and Corral Quintana (2016) indicate that this social technique can be of use to elicit the main social actors involved in environmental policy-making over a long period of time; it also allows identifying those social actors who have remained active during the whole period and those who discontinued their participation. However, care must be taken in case some relevant social actors are unrepresented in the media (Hernández González and Corral Quintana, 2016). This drawback can be addressed by other social techniques, such as in-depth interviews to the active actors that can lead to the identification of further actors not appearing in the press review.

2.2. In-depth interviews and questionnaires

In-depth interviews to experts and social actors have been considered useful to carry out institutional analyses (De Marchi et al., 2000; Paneque Salgado et al., 2009). Initially, experts identified through the press review were interviewed in order to have their feedback, as well as to build an additional list of relevant social actors to be engaged. All the additional social actors identified were contacted by phone or video-conference (the list of social actors is given in Section

Table 3

Guiding interview questions to social actors.

- 1 What organization do you belong to and what is its scope: local, insular or national?
- 2 Heat waves are becoming more frequent in general. Is this happening in Tenerife as well? Are there any other problem derived from heat waves or associated with it that needs our attention?
- 3 Are there official data/statistics about the impacts on population health? Is there any epidemiological monitoring? If so, where could this information be retrieved from?
- 4 Do you consider that the policies mentioned in Table 2 are enough to deal with heat waves and Saharan dust outbreaks?
- 5 If the answer to question 4 is negative, what complementary or alternative measures would you propose?
- 6 What are the main obstacles to implement these policies and measures?
- 7 Which expert, institution or key person should we contact and engage in this work? Could you provide us with his/her contact details?

2.3). All these semi-structured interviews were performed to collect relevant information such as existing reports and scientific publications on the issue, as well as the positions of the social actors regarding the issue under analysis (see questions on Table 3).

Each interview lasted between 30–35 minutes on average. The qualitative data analysis involved a detailed reading of the collected material (i.e. interview transcripts). Through this process, the qualitative information was structured as follows: 1) framing CC (potential) impacts in the island, 2) framing the existing policy context (suitability of current plans for dealing with heat waves and Saharan dust outbreaks), 3) mapping policy gaps and 4) possible obstacles to fill them up. This information was also used to detect possible divergent and/or convergent discourses about CC that might imply obstacles for developing CC adaptation strategies. The qualitative data were not coded, though.

Apart from the in-depth interviews, a complementary questionnaire was used to collect more precise information (such as attached reports and academic articles), as well as to analyse how consistent the social actors were during the in-depth interviews. The answers transcribed were compared to answers given in the questionnaire and proved to be consistent in all cases.

2.3. Social actors contacted

There were different groups of social actors that have been contacted and agreed to participate. The participants were experts in CC from different organisations and sectors such as the Regional Government and the Island Council, research centres, trade unions, and environmental groups (see Table 4). Although the initial invited group was large and plural some social actors decided not to participate for several reasons:

- An expert in cardiology: declared to have a tight agenda to attend this participatory process.
- Municipalities' organization union: replied the invitation letter, but did not answer any phone call.
- Employers' organization: declared not to have a person in charge of environmental issues. Therefore, preferred not to participate.
- Company specialised in technological and renewable energy appliances: they could neither attend the in-depth interview nor the questionnaire, claiming that this company was having issues that required full-time attention.
- A local environmental group did not reply the official invitation letter.

3. Results: social actors' opinions on obstacles to policy action

The main obstacles mentioned by the social actors that hinder the development of an effective climate adaptation policy address scientific

knowledge, data collection and policy making. Although there are a number of contrasting opinions regarding the different issues discussed, most of the social actors argued that existing policies are not appropriate to deal with CC adaptation issues and there is the need to have a clear climate governance for Tenerife and the Canary Islands, including public participation, mainstreaming of climate policies in all the economic sectors and an integrated approach between mitigation and adaptation plans. A summary of the results is described in the following sections and summarized in Table 5.

3.1. Uncertainties in climate modelling

Modelling is a key element to imagine the possible future evolution of climatic hazards. Without proper models, estimating the potential climatic impacts would be rather difficult. Although the modelling of CC projections has been continuously improving over the past 40 years in terms of better parametrization and also spatial resolution, there is still margin for improvement; higher resolution regional models from initiatives such as CORDEX (Jones et al., 2011) will bring added value compared to global models; however, this added value is expected to be more important with regard to precipitation than to temperature (Di Luca et al., 2013) for which global models are relatively well suited. Hence the analysis of climate projections of temperature and derived heat waves can be obtained from global models even if applied at lower spatial scale like for the Canary Islands, while being aware that local processes may alter and be in contrast with larger scale signals.

Modelling has actually been pointed out by a climate modelling expert as a key issue since climate in the Canary Islands is characterised by many microclimates; as stated by PHY: *"if something characterizes the climate [in the Canary Islands] are microclimates; that is, we can have a radiant sunny day in La Laguna and a severe storm, even with fatalities, in Santa Cruz de Tenerife. The question of orography is fundamental. So, for any adaptation plan, key climate projections with the right resolution is crucial"*. As a consequence of this, most climate experts declared that the increasing frequency of heat waves and Saharan dust outbreaks are not totally clear, even though some studies indicate this possibility, as explained in Section 1.

For example, with regards to heat waves, the climatic expert from the ARC stated that: *"under a scenario of climate change, the possibility that heat waves will worsen or not is currently unknown; what is however appreciated is that the African continent is warming and Northern Africa is getting drier"*. The expert of GEO expressed similar thoughts: *"the fact that heat waves are becoming more frequent in the Canary Islands as a consequence of climate change is not clear; although, there are climatic models indicating that possibility"*.

Similar statements were made by DPP: *"the fact that heat waves are becoming more frequent in the Canary Islands due to climate change cannot be suggested; however, some studies are mentioning this possibility"*, PHY: *"I cannot sustain that heat waves are becoming more frequent due to climate change in the Canary Islands, even though it is the general impression"*, and ME: *"it is not sure that heat waves are becoming more frequent in the Canary Islands due to climate change"*.

There were divergent opinions whereas heat waves and Saharan dust are connected climatic events. The representative of the TDRC as well as the one for the DFCP stated that these two climatic events occur simultaneously in the Canary Islands. While the former stated that *"Saharan dust outbreaks are associated with high temperatures"*, the latter declared that *"heat waves are caused by certain meteorological conditions in the Canary Islands that are related to Saharan meteorological events (such as atmospheric stability, thermal inversion, and low ventilation)"*. However, the expert of the ARC indicated that: *"heat waves and Saharan dust events do not necessarily occur simultaneously; in fact, most heat waves in summertime occur under high stability, low temperature-inversion, high sea surface temperatures, and air stagnation conditions, sometimes, following Saharan intrusions"*.

Table 4
Actors participating in the definition of the institutional setting of climate change adaptation planning in Tenerife.

International Organization (IO)	Expert in CC mitigation and adaptation policies with emphasis in urban planning, renewable energy resources and CC initiatives. This expert has collaborated with one of the Canary Islands' Universities in the development of policies for increasing resilience in the Canary Islands.
Atmospheric Research Centre (ARC)	Two experts have participated from this research centre. The first one is an expert of the Global Atmospheric Watch Programme, dust storms, meteorology and CC in the Canary Islands. The second expert is, on the other hand, specialised in atmospheric aerosols, Saharan dust and air quality.
Mechanical Engineer (ME)	Expert in sustainable development projects as well as renewable energy development plans.
Tropical Diseases Research Centre (TDRC)	Expert in vector-borne diseases, who is working on different projects to analyse the effects of CC on the arrival of potential vector-borne diseases.
Academic Geographer (GEO)	Expert in resilience and disaster risk management plans, as well as in local climatology, Saharan dust events and aerosols.
Academic Physicist (PHY)	Expert in atmospheric aerosols who works on high-definition climatic models that might be useful for the specific micro-climates of the Canary Islands.
Academic Ecologist (ECO)	Expert in forest dynamics, restoration ecology, impacts of forest fires, and exotic species.
Teide National Park of the Island Council (TNP)	Expert in global warming issues of the Teide National Park. This expert is also skilled in conservation biology, CC, and management of protected areas.
Department for Pollution Prevention of the Regional Government (DPP)	Expert in charge of environmental pollution prevention. His/her Department has developed regional and local air quality plans.
Department for Public Health of the Regional Government (DPH)	Expert in charge of risk assessment, as well as regional and local air quality plans.
Department for the Environment of the Island Council (DFE)	This expert participated in the development of the regional Climate Change Adaptation Plan.
Department for Civil Protection of the Island Council (DFCP)	The correspondent is in charge of this Department, as well as the development of the two existing Island's plans on civil protection and disaster risk management.
National trade union "A" (NTUA)	The correspondent is in charge of environmental issues.
National trade union "B" (NTUB)	The correspondent is in charge of workplace risk prevention, and has a deep knowledge of the workers' conditions at the public hospitals of the islands, especially when extreme weather events occur.
Local trade union (LTU)	The correspondent is in charge of health issues, and also has a deep knowledge of the doctors and nurses conditions in the island's public hospitals.
Environmental NGO (ENGO)	They have been defending the natural heritage of Tenerife, as well as the promotion of sustainability projects for the Island.

Table 5
Summary of barriers and opportunities identified.

Uncertainties in climate modelling	- Specific climate models are required, due to the existing microclimates in the island
Divergent opinions on the relation among hazards	- Heat waves and Saharan dust outbreaks are not necessarily associated climate events
Lack of epidemiological data	- The impacts of climate risks, such as heat waves and Saharan dust concentrations are not available
Adaptation policy	- Lack of public participation in the development and implementation of existing plans
	- Climate change adaptation has not been mainstreamed into existing sectoral policies
	- Lack of integration between mitigation and adaptation to climate change
	- There is no agreement among the social actors about the need to develop new climate change adaptation policy
	- Current plans might not be properly implemented or even ignored

3.2. Lack of epidemiological data

Most social actors complained about the lack of information on climate impacts on health, concretely epidemiological data. The expert of the ARC stated that: *"this information does not exist, and this is a serious issue"*; whereas the ENGO representative declared that *"the Department for Health of the Government of the Canary Islands should be responsible for this information"*. Other social actors, such as the experts of GEO, ME, NTUA, TNP and DFCEP ignore whether this epidemiological studies are being conducted or not.

On the other hand the DPH representative claimed this data is collected and published: *"official information exists, and it can be retrieved from the mortality statistics of the Government of the Canary Islands, the Spanish Statistical Office, as well as the Department for Epidemiology of the Government of the Canary Islands"*. The LTU representative confirmed that: *"there is direct data regarding the increase and worsening of allergic and respiratory pathologies"*.

3.3. Adaptation policy

3.3.1. Lack of public participation in adaptation planning

It might be possible that the plans mentioned in Table 2 lacked public participation according to NTUB: *"these plans should have been developed in a participatory way, i.e. engaging the social actors; furthermore, if these plans had been implemented within private companies, the*

economic sectors would have been more resilient to climatic hazards".

3.3.2. Lack of an integrated view of climate policy

In this regard, CC adaptation has not been mainstreamed into existing sectoral policies as indicated by TNP: *"adaptation is not usually considered in the existing plans for climate change"*. Meanwhile, according to ENGO, it might be possible that *"these plans [see Table 2] are insufficient [to deal with CC] since, in most cases, they do not deal with the causes of the problems [i.e. greenhouse gases emissions]"*, referring to the need to integrate adaptation and mitigation to CC as indicated elsewhere (Göpfert et al., 2018; Ürges-Vorsatz et al., 2018).

3.3.3. Divergent views on the implementation of climate adaptation

One of the sharpest divergent opinions has been produced in the policy-making arena. Two different views have been depicted: a) current policies (indicated in Table 2) are enough to adapt to heat waves and Saharan dust outbreaks, and b) they are not enough. In the first group of social actors we may find the DFE and the NTUA. *"If all these plans [in Table 2] are updated and implemented, they would be more than enough to adapt to climate change"* stated the former and *"these plans may have positive impacts on adaptation to climate change"* declared the latter.

Meanwhile, the group of social actors belonging to the second discourse is much larger. GEO, supported by TNP, considers that *"current adaptation planning is outdated and unused; most of the civil protection plans do not consider climate change in a scientific way; more efforts on risk*

reduction instead of civil protection is needed”; PHY highlighted that “the current adaptation plan has been however based on continental climatic models; this is not valid”. DFCP stated that “the existing disaster risk management plan does neither consider adaptation to heat waves nor Saharan dust outbreaks; (...); generally speaking, current civil protection plans are neither sufficient to deal with Saharan dust outbreaks nor heat waves”. It was also mentioned by IO that “nowadays, there is a dispersion of different plans and sometimes they are unnecessarily overlapped”. Lastly, ECO claimed that “not much has been done in terms of sustainability in the Canary Islands” and ME stated that “an integrated sustainable development plan is however needed”.

According to ARC, urban areas would require more green infrastructure since “the effect of heat waves in summer time could be attenuated, in part, through green urbanization of cities, implementing smart-plans that include shade trees plantings and awning placements in order to reduce pavement and parked vehicles heating”. Whereas, the existing CC adaptation plan should consider more “specific measures to deal with climatic hazards” (declared DPP). Furthermore, “most of these plans [see Table 2] are good ones, but they are not implemented and sometimes even ignored” (stated LTU).

4. Discussion

4.1. Uncertainties in climate modelling

From the results presented in Section 3.1 the uncertainty of climate models emerge as one constrain for developing an effective climate policy for Tenerife, highlighting the need for appropriate local climatic models adapted to the many island micro-climates. Uncertainties regarding climatic modelling are related to Tenerife’s specific climate variability, linked to its altitude range, the presence of a thermal inversion in altitude, the incidence and dominant wind Alisios, the cold current of the Canaries, the occasional Saharan winds or the Atlantic storms, that imply the presence of a significant number of different microclimates (Fernández-Palacios et al., 2004). Therefore, the uncertainties inherent to global and regional climatic models can be probably amplified within the island context. Detailed information about CC and its variability for smaller areas such as islands can be obtained from local to regional climate models, with higher spatial resolutions (< 50 km²) keeping in mind that these models tend to be noisier and hence need a larger number of ensemble models to better understand their uncertainty (Hawkins and Sutton, 2011).

4.2. Lack of epidemiological data

The results described in Section 3.2 suggest that the knowledge on impacts of climate risks, such as heat waves and Saharan dust concentrations, on health are constrained by either inexistent or unpublished epidemiological data related to morbi-mortality. This lack of epidemiological data obliges to indirectly estimate these relationships with the consequent underlying uncertainties. The mainstreaming of CC adaptation could facilitate the co-operation and coordination between different social actors, such as research institutions, agencies and official institutions in order to encourage either the publication of existing epidemiological data in case of availability, or allocate a specific budget to epidemiological monitoring studies.

4.3. Adaptation policy

According to the results presented in Section 3.3 the social actors have identified three main constrains regarding CC adaptation policy in Tenerife: low public participation in adaptation planning, lack of an integrated climate policy, and divergent views on the implementation of climate adaptation.

In general, there seems to be a poor commitment from public administrations towards public participation on the definition of an

adequate CC adaptation strategy that should be based on deep participatory discussions (Hernandez et al., 2018). However, the engagement process carried out in this case study showed that several social actors declined to participate when invited. This could be related to the absence of trust between citizens, governments and corporations (Carson, 2009) or they do not feel listened by governments and agencies (Booth and Halseth, 2011). Furthermore, powerful social actors usually do not participate when they are not interested in a concrete issue -possible related to low stakes- (Schusser et al., 2015) or when they do not need to participate to have an influence in decision-making (Teder and Kaimre, 2018).

Results showed concern with the lack of an integrated mitigation and adaptation climate policy as well as the need for mainstreaming adaptation to CC across sectors. A proper climate governance should consider the synergies between mitigation and adaptation as well as mainstreaming the implementation of these two pillars of climate action within and across sectors.

Although there were divergences among the social actors, it seems clear that an updated climate policy is needed in Tenerife. Some of the actors indicated that risk reduction policies should substitute civil protection plans, whereas specific action plans for adaptation to CC should be addressed. Although existing policies regarding CC are diverse and disperse, i.e. they are split up into regional and local levels, they are somehow dealing partially and indirectly with CC. It seems reasonable that the Government should carry out discussion sessions with social actors and citizens to clarify what has to be done in the policy arena.

5. Conclusions

Heat waves have quadrupled since 1994 and half of the strongest heat waves have occurred during 2004–2007 in the Canary Islands. In the meantime, winter dust seasons, not necessarily associated with high temperatures, have duplicated since 1980. Heat waves have become the most dangerous meteorological hazard in terms of mortality, whereas Saharan dust outbreaks have been associated with serious health problems and air transport disruptions.

This work addressed possible climate adaptation policies in Tenerife assuming the increasing impact of heat waves and Saharan dust outbreaks in the island under a CC scenario. Furthermore, it explored the institutional setting of CC adaptation planning in Tenerife and evaluated the statu quo through the engagement of key social actors.

An historical review of the local and regional press articles and legislation, an in-depth round of interviews, together with questionnaires to the main social actors involved in CC adaptation, allowed framing the social and political context in which CC adaptation in Tenerife is embedded.

Key social actors were engaged, including international organisations, atmospheric research centres, local Universities, regional and insular governments, trade unions, and environmental NGOs, among others. The main obstacles mentioned by the social actors that hinder the development of an effective climate adaptation policy address scientific knowledge, data collection and policy making.

The uncertainty of climate models emerged as one constrain for developing an effective climate policy for Tenerife, highlighting the need for appropriate local climatic models adapted to the many island micro-climates. The development of local to regional climate models were seen as a solution to obtain detailed information about CC and its variability for islands such as Tenerife.

Knowledge on impacts of climate risks, such as heat waves and Saharan dust concentrations, on health was also identified as a constrain due to the inexistent or unpublished epidemiological data related to morbi-mortality. Mainstreaming CC adaptation could facilitate the co-operation and coordination between different social actors, in order to promote the publication of existing epidemiological data and the setup of a sustained epidemiological monitoring.

Although there are a number of contrasting opinions regarding the different issues discussed, most of the social actors argued that existing policies are not appropriate to deal with CC adaptation issues and there is the need to have a clear climate governance for Tenerife and the Canary Islands, including public participation, mainstreaming of climate policies in all the economic sectors and an integrated approach between mitigation and adaptation plans.

The outcomes of this study could be meaningful for climate adaptation initiatives at local or regional level, such as the Global Covenant of Mayors, that intend to promote climate resilience through the setup of climate adaptation strategies and plans at municipality level.

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