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Resilient futures of a small island: A participatory approach in Tenerife (Canary Islands) to address climate change

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ABSTRACT

Adaptation to climate change has been considered to be crucial to current societies, especially for small islands. In this paper the case of Tenerife (in the Canary Islands) is analysed. Tenerife is a small island located northwest of the African continent, in the Atlantic Ocean. Tenerife presents a high vulnerability to heatwaves and Saharan dust events as a consequence of its closeness to the Saharan desert. In fact, increasing frequency of heatwaves and Saharan dust events has been reported and could worsen in the future due to global warming. An exploration of adaptation strategies to an increase of the frequency and intensity of these phenomena is therefore needed. Different social actors have been engaged in a participatory process aiming at exploring pathways for adaptation to extreme weather events. Resilience was argued as the relevant framing to address those hazards. Four focus group sessions were carried out in order to explore key transformative elements necessary to make resilient futures for Tenerife. The results highlight the need for broader climate-based policies across all sectors to assure that the island becomes resilient to climatic and non-climatic shocks.

1. Introduction

Small islands are already being affected by climate change (CC): morbidity and mortality are a consequence of extreme weather events, as well as vector- and food- and water-borne diseases (Nurse et al., 2014). Those extreme weather events refer to tropical cyclones, storm surges, flooding, and droughts leading to effects on human health, including drowning, injuries, disease transmission, and health effects derived from poor water quality (Nurse et al., *Op.cit.*).

Heatwaves are also seen as an increasingly dangerous climatic hazard since both, warm days and nights have increased globally (EEA, 2016; IPCC, 2014). Heatwaves are expected to occur more often and last longer (IPCC, *Op. cit.*), and Southern Europe is expected to be the most affected area in terms of hot weather, experiencing the highest heatwave exposure (IPCC, *Op. cit.*).

The work presented here refers to a case study for the Tenerife Island (Canary Islands) focused on heatwaves and strategies to cope with plausible yet uncertain developments. As heatwaves' effects are sometimes connected to Saharan dust events and local air pollution episodes, these will also be considered. This paper describes an engagement activity carried out in Tenerife that sought to get insights from different actors about possible CC adaptation strategies and their implementation. The main objective of this work was to provide insights from different actors about the institutional and societal desirability and feasibility of adaptation strategies to CC in an island like Tenerife. We shall argue that establishing what and for whom is desirable and feasible requires the involvement of the “extended peer community" (Funtowicz and Ravetz, 1993). Four focus groups were carried out across the island with different social actors, including stakeholders and citizens. The ultimate aim of those group discussions was to develop visions of resilience and CC adaptation of Tenerife having heatwaves as the starting point. We first introduce the case study, followed by a review of cases on adaptation and resilience. The participatory methodology is then introduced followed by a discussion of the results, where we provide insights from the participatory process into strategies, practices, and institutional arrangements to address CC adaptation in small islands.

2. Heatwaves in Tenerife

Heatwaves are not only impacting on human health, but also on other species and ecosystems, as well as critical infrastructure, such as hospitals, transport and energy infrastructure, as a consequence of material overheating (IPCC, 2014). For instance, the heatwave of 2003 occurred in Western and central Europe produced damages to road and rail transport systems, interrupting energy supply, and increasing

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waterway transport prices as a consequence of low water levels associated to hydrological drought (IPCC, *Op.cit.*).

The hottest summer in Europe in the last 500 years was observed in 2003, leading to high death rates that caused 70,000 deaths in 12 European countries (EEA, 2015). By 2050, heatwaves are expected to produce 120,000 additional deaths annually in the European Union, especially among elderly people (EEA, 2015). A recent study from Forzieri et al. (2017) mentioned heatwaves as the most lethal weather-related hazard in Europe leading to an increased mortality rate of 5400% by the end of the century in a "business as usual" scenario and no climate adaptation measures. Morbidity is also co-related to warm spells. In fact, it is known that skin eruptions, fatigue, cramps, syncope, heat exhaustion, and heatstroke might occur as a consequence of heat exposure (WHO, 2004). The importance of these phenomena for the Canary Islands is also quite prominent as we will see.

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. These conditions prevent these Islands to suffer from the extreme weather conditions of the nearby Sahara desert, the largest and among the hottest deserts in the world. Episodically, cool trade wind weakens and easterly Saharan air reaches the Canaries. These Saharan air masses may prompt high temperatures, drops in relative humidity down to ~15% (Dorta, 1991) and the presence of suspended desert dust. These heatwaves are mainly produced between spring and autumn (Dorta, 2007), usually reaching temperatures of 44–45 ° Celsius (Dorta, 1991); whereas night heat events reach maximums between 26 and 30 ° Celsius (Dorta, 2007).

The most dangerous documented heatwaves took place in August 1990 and July 2004 (Dorta, 2007). According to Alonso Pérez (2007), such episodes might have increased in intensity and frequency in the Canary Islands since 1970. In fact, the average number of heatwaves has quadrupled since 1994 and among the 10 strongest heatwaves recorded over the whole period, 5 have been detected during 2004–2007 (Sanz et al., 2007). Other authors also mention that a general rise of temperatures is expected for the Canary Islands in the future, intensified in upper parts of the islands (Martín et al., 2012). The last heatwaves registered in the Canary Islands have left 13 premature deaths, more than any other meteorological hazard (Dorta, 2007).

Other climate hazards that might be related to the effects of heatwaves are dust events. There are two dust seasons in the Canary Islands, one in the winter and another in the summer. In the winter dust season (November – March), Saharan 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 concentrations at ground level (up to 2000 $\mu g/m^3$ have been recorded) and are not necessarily associated with high temperatures. Dust concentrations have duplicated since 1980.

However, in the summer season (July and August) dust events are associated with the circulation of the dusty Saharan Air Layer (SAL) – i.e. the hot and dry airstream that expands from North Africa to the Americas – over the Canary Islands. The SAL results in hot, dry and dusty air between 500 m.a.s.l. and 5 km.a.s.l. above the Canary Islands, whereas trade winds prevail below. Recent long-term analysis (1941–2013) of aerosol optical depth retrievals shows that there is an important multidecadal variability in summer dust export connected to the North African Dipol Intensity (NAFDI) and the North Atlantic ocean temperature long-term variability (García et al., 2016). These islands have historically received Saharan dust as a consequence of large scale meteorological processes that involves mid-latitude waves, the NAFDI and the Saharan Heat Low (Cuevas et al., 2016). Thus, when this event takes place, the Canaries become dusty and «naturally» polluted with particulate matter (PM_{10}).

Socio-economic impacts include reduced visibility which tends to affect both airports and their transport services, such as air traffic control and communication disturbance, including the closing of airports in extreme dust conditions (Dorta, 2007). However, the impacts on human health are amongst the most relevant, since respiratory pathologies, anxiety disorders, and atypical thoracic pain usually affect local population (García Carrasco et al., 2001). Other studies have reported respiratory allergic diseases leading to increased use of air liquid as a respiratory therapy as much as 600% (Belmonte et al., 2010). It has also been suggested that Saharan dust events might be related to the introduction of microbial communities, such as bacteria and viruses (Gonzalez-Martin et al., 2013).

Furthermore, summer dust events are associated with meteorological conditions that have several environmental implications. Aircraft measurements and satellite observations (Tsamalis et al., 2013) have shown that the dusty, hot and dry SAL typically expands between 1 and 5 km.a.s.l. Atmospheric soundings have shown that during intense events, the SAL occurs above 500 m.a.s.l. over Tenerife, shifting the typical inversion layer associated with the trade winds to lower altitudes and resulting in high temperatures in the forest of the Island that typically occurs between 600 and 1800 m.a.s.l. These high temperatures represent an increased risk of forest fires, whereas the shifting to low altitudes of the inversion layer is typically associated with severe pollution episodes of industrial origin in the metropolitan area, due to the emissions of the oil refinery and shipping in the harbour of Santa Cruz de Tenerife (CSIC-AEMET-UHU, 2010).

The most important sources of air pollutants in Tenerife are located along the Eastern coast of the Island (harbour and oil refinery in Santa Cruz de Tenerife, Caletillas and Granadilla power plants). The prevailing NNE trade winds coupled with the inland sea breeze blowing during daylight prompts the inlands transport of these pollutants. In Santa Cruz de Tenerife, the inland sea breeze blowing results in the inland transport of the SO_2 plumes from the refinery and from harbour, prompting fumigations of SO_2, sulphuric acid and ultrafine particles to the population of the city from 10 to 17 GMT (González and Rodríguez, 2013). This situation worsens under summer SAL conditions due to the concentration of air pollutants at low altitudes linked to the downward shifts of the inversion layer and to heterogeneous reactions between pollutants and Saharan dust (CSIC-AEMET-UHU, 2010).

Furthermore, the *Hospital Universitario de Canarias* and the Izaña Atmospheric Research Centre found that hospital admissions due to heart failure are associated to exposure to ultrafine particles (Domínguez-Rodríguez et al., 2011), whereas black carbon has been associated with Acute Coronary Syndrome (Domínguez-Rodríguez et al., 2016). Other studies have also observed relationships between NO_2 and the ejection capacity of the heart (Dominguez-Rodriguez et al., 2013a) and between SO_2 and obstructive lesions and Acute Coronary Syndrome (Domínguez-Rodríguez et al., 2013b).

A CC Agency was created in April 2009 by means of a regional law (BOC, 2009). The aim of the Agency was the promotion, encouragement, orientation and coordination of policies, initiatives and measures to reach sustainable development as well as the mitigation of and adaptation to CC. The 25th of June 2012 the Government of the Canary Islands launched a regional law intended to adopt measures to reduce public administrations expenditure in order to respond to the financial crisis. The preface of the law indicated that budget cuts were required so as to «guarantee public expenditure sustainability» within an economic crisis that obliged the public administration to accomplish the objectives of budgetary stability (BOC, 2012). As a consequence of this law, the CC Agency was shut down.

During those three years the Agency was able to develop a CC mitigation plan for the Canary Islands (Gafo-Fernández, 2009), which is currently approved, as well as a CC adaptation plan, which has not been passed into law yet (Martínez-Chamorro, 2010). However, both climate policies are currently considered to be out-dated by local climate experts (Hernández-González et al., 2016), leaving the islands without a CC adaptation strategy in a context of high vulnerability to the effects of CC (López-Díez et al., 2016). An Observatory for CC has however been established in April 2017 in Lanzarote (Canary Islands), to compensate