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Scenarios for resilience and climate adaptation strategies in Tenerife (Canary Islands)

Three pathways towards 2040

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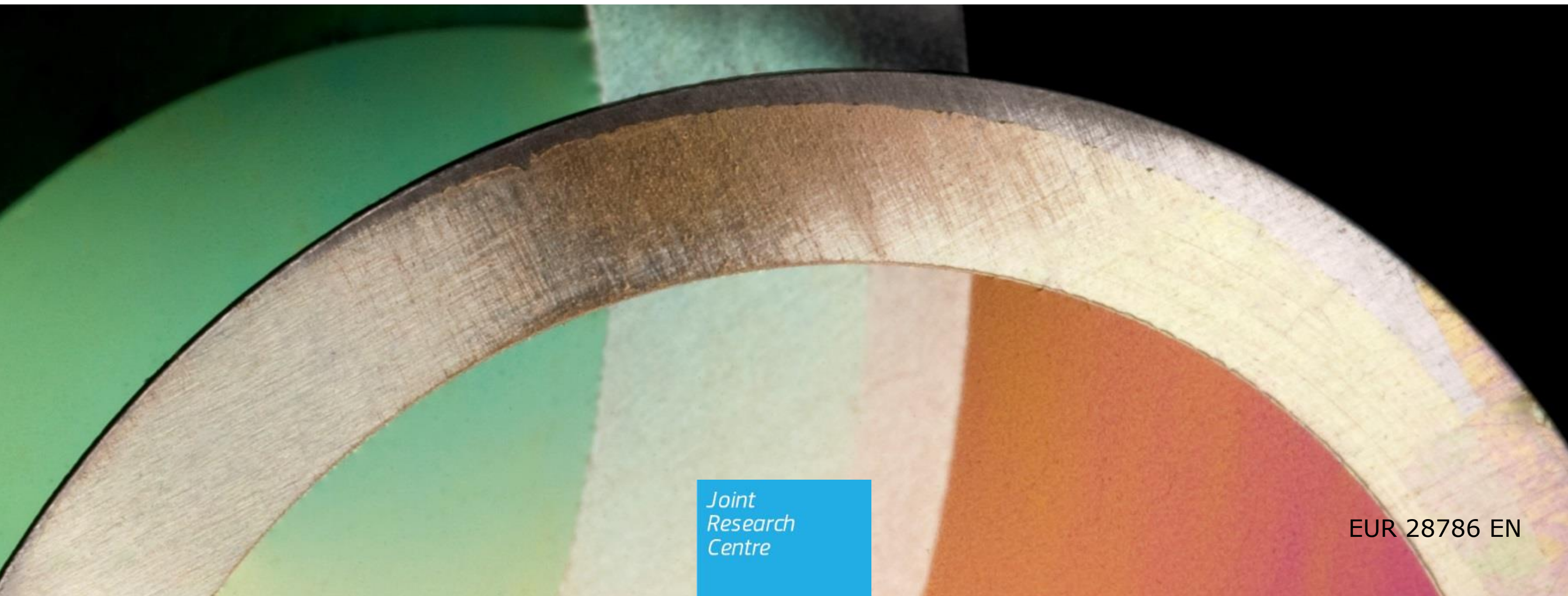

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Abstract

A participatory scenario building process for small island resilience is carried out for the Tenerife Island (Canary Islands, Spain). The plot of the scenarios is based on institutional analyses and participatory techniques where key local stakeholders and citizens were engaged. A press analysis was done in order to identify the main narratives regarding the current level of resilience and its potentialities in the future, as well as to identify the stakeholders involved in the discourse. Meanwhile, in-depth interviews, questionnaires and focus groups were carried out to engage the stakeholders and local citizens in the exploration of future scenarios for resilience in Tenerife. The scenarios brought out three potential pathways for 2040. The first scenario prolongs the current business-as-usual situation where the island may be defined as highly vulnerable to external shocks, especially due to its high external dependency on food and energy production, as well as the need for energy allocated to water desalination. The second scenario relies on an active local community that encourages increasing rates of local food production and a 100 % renewable energy system such that desalination may no longer depend on fossil fuels. Lastly, the third scenario depicts a pathway where several active groups of people engage in building resilience without the umbrella of local governments, due to politicians who are no longer seen as part of the solution, but part of the problem. Now, collaborative community networks in bio-agriculture, fog-water collection, and cooperative-based renewable energy production become increasingly important. Findings show that resilience is understood as the reinforcement of the nexus between water-energy-food sovereignty that might imply a change in the local economic model such that poverty can be reduced and climatic shocks can be buffered.

1 Introduction

The purpose of this report is to explore future scenarios of resilience for a small European island (Tenerife, Canary Islands). Three scenarios are explored for 2040, which work as an excuse for the researchers to approach the concept of resilience as well as its meaning for small-island contexts. This report is the continuation of previous works developed by the Joint Research Centre regarding adaptation to climate change. Thus, Hernández-González et al. (2016) explored policies and measures that could be undertaken in Tenerife to increase the adaptation capacity against heatwaves and Saharan dust outbreaks. In-depth interviews, questionnaires and focus groups were conducted to key local stakeholders and experts in climate change so that problems and actions could be identified and explored in-depth. The conclusions obtained in Hernández-González et al. (2016) highlighted the lack of institutions in charge of climate policy and uncertainties in climate modelling as the main concerns. These conclusions were however confronted with local citizens' perceptions by means of three focus group sessions carried out across the Tenerife Island (Hernandez et al., 2017). Local citizens did not perceive the lack of climate policy as the main *problematique* of the island, but the lack of policy measures oriented to increase the resilience of the island against potential external shocks, no matter if they might involve economic shocks, energy shortage or climatic risks. Meanwhile, the lack of adaptation was conceived as one more issue to be dealt with among others, such as food, energy, and water external dependency, which also need attention within the local resilience discourse.

This is the scope of this investigation: to explore how those 'other' issues may evolve and interact in the future. Even though resilience is multidimensional, as shown in the report, special attention will be given to the nexus energy-water-food produced locally, as well as the link between economic models and poverty.

2 Literature review

2.1 What are scenarios?

Scenarios consist of describing stories about the future with a logical plot and narrative (Gallopín and Rijsberman, 2000; Raskin et al., 2002). «Scenarios can serve as self-fulfilling attractors, desirable visions of the future that help galvanize effective actions for their realization» (Raskin et al., 1998, p. 4). Scenarios elucidate alternative world visions and values, and encourage deliberation (Gallopín et al., 1997). Their goal is to provide informed and coherent action by means of insight into the scope of the possible (Raskin et al., 2002).

Scenarios may be thought of as comprehensive and possible stories expressed in words and figures, about possible co-evolutionary pathways of combined human and environmental systems (Swart et al., 2004). Well-articulated scenarios will certainly include quantitative insight from scientific models in order to provide discipline and rigor (Gallopín et al., 1997). Scenarios can provide a broader perspective than model-based analyses, by means of qualitative scenario narratives that also give a voice to important non-quantifiable aspects such as values, behaviours and institutions (Raskin et al., 2002). Thus, narrative scenarios offer texture, richness and insight, while quantitative analysis provides structure, discipline and rigour (Swart et al., 2004).

Scenarios can either be descriptive, which plot possible developments starting from what we know about current conditions and trends, or normative, constructed to lead to a future based on subjective values given by the authors (Swart et al., 2004). Normative scenarios represent organised attempts to evaluate the feasibility and consequences of trying to achieve certain desired outcomes or avoid the risks of undesirable ones, whereas descriptive scenario analysis, tries to articulate different plausible future societal developments, and explore their consequences (Swart et al., 2004). The choice between descriptive or normative scenarios depends on the objectives of the scenario development exercise (Swart et al., 2004).

Scenarios generally include: (a) a definition of problem boundaries; (b) a characterisation of current conditions and driving forces; (c) an identification of critical uncertainties and assumptions on how they might be resolved; and (d) images of the future (Swart et al., 2004). The scenarios should: (a) have regional disaggregation, (b) be comprehensive (with an integrated treatment of major environmental, social and economic issues and interactions), (c) be analytically sound (use of data and scientific theory), and should also be diverse (representation of a range of future visions, values, and world views) (Gallopín et al., 1997).

Scenario building should be intensively participatory, or else it fails (Raskin et al., 1998; Schwartz, 1991). Scenarios should evolve from different rounds of discussions, feedbacks and subsequent improvements. There should also be interaction between the scenario developers, modellers, reviewers and the groups working on visions for sectors and regions (Gallopín and Rijsberman, 2000). The development and discussion of qualitative scenarios work as a platform for consultation among many stakeholders from different disciplinary backgrounds and perspectives (Gallopín and Rijsberman, 2000). The scenario approach can also deliver a shared agenda for varied stakeholders to map and address the critical concerns and, therefore, detect alternatives as well as a scene for discussion and debate (Gallopín and Rijsberman, 2000).Here, in this report, the authors define scenarios as a puzzle composed of existing and dispersed information regarding a certain issue (in this case resilience) that needs to be brought together in a single piece in order to explore which pathways a community may walk through in the future of that specific issue.

2.2 Some applications

Schwartz (1991) defined three global scenarios based on the possibility of having war/peace, prosperity/depression, and an atmosphere of freedom/restraint. The first scenario he planned was 'New empires'. It consisted of regional alliances that protect each other, meanwhile those outside the alliance are economic rivals. There is a strong fight for the control of natural resources. Arm trade is booming and each block possesses nuclear weapons. As a consequence, the world enters in one of the most tragic wars of history. The second scenario was 'Market world', which consisted of an entrepreneurial, multicultural world and full of hope and harshness. It is a capitalistic open market, although there are top countries and those left behind. A 'sustainable growth' becomes the rule and even though there are increasing communities at the bottom of the social scale, they have the possibility of climbing out of poverty. His last scenario is called 'Change without progress'. He defines it as a future of chaos and crisis, in which people see themselves as fighting the system, and the system falls apart. It is a scenario with fast-paced economic activity, but also corruption, high inflation, high unemployment, overvalued currencies, high interest rates, social conflict, poverty and environmental decay.

Gallopín et al. (1997) begin with three broad classes of scenarios which they call 'Conventional Worlds', 'Barbarization', and 'Great Transitions'. For each class, they define two variants though, for a total of 6 scenarios: (1) Conventional worlds reference scenario; (2) Conventional worlds policy reform; (3) Barbarization breakdown; (4) Barbarization fortress world; (5) Great transitions to eco-communalism; and (6) Great transitions to new sustainability paradigm. Within the Conventional worlds, the reference variant incorporates competitive markets, rapid economic growth, social and environmental stress, and the convergence of global regions. The policy reform scenario achieves greater social equity and environmental protection by means of rapidly diffusing environmental-friendly technology. Barbarization breakdown leads to conflict, institutional disintegration, and economic collapse. The Fortress world features an authoritarian response to the threat of breakdown. Great transitions explore visionary solutions to the sustainability challenge, including new socioeconomic arrangements and fundamental changes in values. These scenarios depict a transition to a society that preserves natural systems, provides high levels of welfare through material sufficiency and equitable distribution, and enjoys a strong sense of social solidarity. Raskin et al., 1998 defines in their *Bending the curve* the possibilities for sustainable development by pushing for important changes within an evolutionary 'Conventional worlds' context developed by Gallopín et al. (1997). The first scenario is based on larger urban populations and global economic growth. The values of materialism and individualism are the worldwide rules. Significant income disparity between rich and poor countries and between the rich and poor within countries remain. Pollution is an issue as a consequence of rapid economic growth. According to the authors, this scenario is environmental and socially unsustainable. That is why they define the other scenario called 'Policy reform', where poverty reduction goals are achieved through initiatives to increase the incomes of the poor. Greater international equity between rich and poor countries and greater national equity within countries are also considered. Energy, water and resource use efficiency increase substantially. Renewable energy, ecologically based agricultural practices, and integrated eco-efficient industrial systems become the norm.

Gallopín and Rijsberman (2000) focused on the development of qualitative scenarios for future global water management. They defined three scenarios: (1) 'Business as usual'; (2) 'Economics, technology and private sector'; and (3) 'Values and lifestyles'. The first scenario refers to a future trajectory where no major policy or lifestyle change takes place. The second scenario is a result of policies that rely on the market, the involvement of the private sector and technological solutions. Lastly, the third scenario is the one that could materialise through human values, strengthened international cooperation, heavy emphasis on education, international mechanisms and rules, increased solidarity and changes in lifestyles and behaviour.

Raskin et al. (2002) explored the scenarios of 'Great transitions' developed by Gallopín et al. (1997). They developed four scenarios: 'Market forces', 'Policy reform', 'Fortress world' and 'Great transitions'. 'Market forces' is a world of accelerating economic globalisation and minimal environmental and social protection. Technological innovation reduces the environmental impact per unit of human activity, but the increase in the scale of those activities triggers larger impacts. Economies in poor regions grow rapidly, but with social disparities. The result is a continued erosion of environmental health and the persistence of poverty. 'Policy reform' features government initiatives to constrain the economy in order to attain a broad set of social and environmental goals. Sustainability policy shapes the planetary transition. Rapid deployment of alternative technology, such as eco-efficient industrial and agricultural practices, highly resource efficient equipment and renewable resources. It also targets programs to reduce poverty. 'Fortress world' envisions a period of crisis leading to an authoritarian and inequitable future. Tyranny shapes the global transition. In 'Great transition', a connected and engaged global citizenry advances a new development paradigm that emphasises the quality of life, human solidarity, and a strong ecological sensibility. New values shape the planetary transition, such as rapid penetration of environmentally technologies, a shift toward less material-intensive lifestyles, consumerism abates, populations stabilise, growth slows in affluent areas, and settlement patterns become more integrated and compact.

Özkaynak (2008) explored four local scenarios for the city of Yalova (Turkey), regarding economic, social, and environmental issues. The author presents a first scenario 'Yalova within free markets' in which Turkey is engaged in Europe under a deregulation and privatisation environment, with reduced social and environmental protection. The second scenario is called 'Yalova within social Europe', in which the European Union is concerned about social and environmental protection. The third scenario unfolds the 'Business as usual in Yalova' in which the European Union cannot accept Turkey's membership. And a last scenario 'Inward-looking Yalova' in which the European Union does not accept Turkey's membership but accepts a special treatment.

Resilience has also been subject to scenario building. Thus, Gerst et al. (2014) proposed three scenarios for global resilience: (1) 'Conventional development'; (2) 'Policy reform'; and (3) 'Great transition'. The first one represents mid-range population growth, urbanisation, economic growth and technological change. A lack of coordinated action on environmental issues remains the norm. The trends would lead to a massive increase in stress on important Earth system processes. The second scenario pretends to achieve sustainability goals. A comprehensive set of internationally-binding initiatives are implemented, such as global sustainable development goals, together with widely-held social targets, strong policy instruments (such as eco-taxes, market mechanisms, regulation, social programs, and technology development). The last scenario is a structural shift to a new development paradigm, based on a re-assessment of lifestyle, values, and human well-being towards material sufficiency for all, leisure time, family, and community.

Campos et al. (2016) described climate change adaptation planning for protecting a vulnerable coastal system. Scenario workshops and adaptation pathways in the context of a participatory action were designed. A Scenario A referred to 'do nothing' and maintain existing coastal defence structures, resulting in serious flooding events and damage to human settlements and infrastructures with great economic losses. Scenario B protects with massive investments through a series of constructions (dykes and breakwaters), which changes the natural landscape, as well as economic and social life in the region. Scenario C relocates some local settlements, gaining ecological value by means of sea advance and coastal erosion to continue at will.

Corral-Quintana et al. (2016) proposed two scenarios for desertification in the Canary Islands. One is called 'Desert' and the other 'Oasis'. Both were aimed at demonstrating different ideas about the Canary Islands within the next 30 years with regards to the desertification process. The 'Desert' scenario pretends to narrate a business as usual evolution of the Canary Islands. This scenario reflects the results of an expansion of desert areas, a deficient living conditions and a decrease in the gross domestic product (GDP). However, climate change and economic recovery impose large uncertainties. Whereas the 'Oasis' represents a positive image of the future that would lead to a reduction of desert areas, an improvement of living conditions, and GDP increases. Climate change and economic recovery impose large uncertainties as well.

To our knowledge, there is only one work plotting scenarios for small islands that flirt with the concept of resilience, although they are more focused on sustainability paths (Kaltenborn et al., 2012). Some definitions of resilience for small islands are given in Box

1. Kaltenborn et al. (2012) explored four scenarios for the future (2025) of the Vega island (Norway), engaing stakeholders and citizens by means of workshop and survey techniques. The participatory process applied engaged the actors from the beginning of the process until its end, i.e. the local communities not only participated in the elaboration of the scenarios, but also could reflect on the scenario results. Even though the scenarios reflected the potentiality of tourism as an economic activity, the islanders showed little faith in the tourism sector and prefer to rely on its traditional sectors such as agriculture and fisheries.

In Table 1, a summary of the examples presented above is given. Three are usually the number of scenarios explored, whereas six are usually the number of driving forces considered.

Table 1. Summary of the examples reviewed

Number of scenarios	Number of driving forces	Representation	Source
3	—	Narratives	Campos et al., 2016
2	5	Narratives, data and scenario unfolds	Corral-Quintana et al., 2016
6	7	Narratives, data and scenario unfolds	Gallopín et al., 1997
3	6	Narratives, data and scenario unfolds	Gallopín and Rijsberman, 2000
3	3	Narratives and data	Gerst et al., 2014
3	8	Narratives	Kaltenborn et al., 2012
4	14	Narratives	Özkaynak, 2008
2	6	Narratives and data	Raskin et al., 1998
4	6	Narratives and data	Raskin et al., 2002
3	7	Narratives	Schwartz, 1991

Source: own elaboration.

Box 1. Some definitions of resilience for small islands

— «[It] is the capacity to create stable equilibria between the elements that interact within a landscape and the capacity to survive and avoid negative effects in the face of hazards. As a consequence, sustainability should be interpreted not only as a future scenario but as a way of building resilience. Thus, the linkage between and interdependence of the two terms appears very strong» (Bonati, 2014, p. 519).

— «[It] refers to the ability of the overall system to absorb unspecified disturbances, even those that are novel, unforeseen, or infrequent»' (Lauer et al., 2013, p. 49).

— «[It might be understood as] flexibility, as adaptation interventions shift from attempting to respond to particular stresses or hazards to building systems that are adaptable in the face of any kind of disturbance» (Popke et al., 2016, p. 74).

3 Material and methods

The methodology used in this case study, intended to unfold scenarios for resilience in Tenerife, is presented in Table 2. The methodology is composed of both a backbone approach and development methods.

Table 2. Methodologies to unfold the scenarios

Backbone	Development methods
• Characterisation of current state ○ What is the problem?	1. Institutional analysis ○ Literature review ○ Press review ○ Questionnaires ○ In-depth interviews ○ Focus groups with stakeholders and citizens 2. Power-relation analysis ○ Literature review ○ Press review ○ Focus groups
• Identify critical dimensions ○ What are the *attributes* of the future images?	
• Identify driving forces ○ What are the *key factors* influencing the situations?	
• Identify strategic invariants ○ What are the *invariant driving forces* that remain the same for all scenarios?	
• Identify critical uncertainties ○ What are the *driving forces* that entail an uncertain evolution?	
• Unfold the images of the future ○ What are the *scenarios* to be unfolded?	

Source: the backbone methodology is based on Gallopín et al., 1997 and Gallopín and Rijsberman, 2000. The development methods are based on Corral Quintana, 2004; De Marchi et al., 2000; Guimarães Pereira and Corral Quintana, 2002; Hernández González and Corral Quintana, 2016; Gamboa and Munda, 2007; Paneque Salgado et al., 2009.

In the next section both techniques will be presented.

3.1 Development methods

3.1.1 Institutional analysis and participatory techniques

Institutional analysis (IA) should be considered as a fact-finding procedure to examine different structures and social relationships (Corral Quintana, 2004). Theoretical aspects of IA either to justify the necessity of these approaches (Ostrom, 1990, 2005) or suggest guidelines (Ingram et al., 1984) or frameworks of analysis (Imperial, 1999; Koontz, 2006) have been discussed. IA provides a more precise approximation to the prevailing social and institutional arrangements, assumed as a social context shaped by institutions that delimit citizens' rights and responsibilities (Bromley, 1989; Commons, 1961; Schmid, 1972). Meanwhile, economic powerholders can also have an influence over institutions and decision-making (Abad, 2016).

Institutional arrangements have been considered important for the understanding of climate change adaptation strategies. Thus, severity of heatwaves, in terms of either intensity or frequency, shape institutional arrangements among interest parts (Eisenack, 2016). Other studies have detected that even though the synergies between mitigation and adaptation to climate change are underpinned in legislation, the interpretation of that pieces of legislation does not consider these synergies, leading to isolated analyses and missed opportunities (Larsen et al., 2012). It has also been said that 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 climate change adaptation (Petzold and Ratter, 2015). Other studies detected lack of coordination among institutions leading to a reduced adaptation capacity (Storbjörk and Hedrén, 2011).

Institutional constraints are also relevant to understand the associated complexities of climate change adaptation. An analysis conducted in the Netherlands for agriculture adaptation, concluded that the heterogeneity of actors' interests on the one hand, and the availability of resources on the other, were two relevant obstacles to implement adaptation measures (Mandryk et al., 2015). In effect, local power structures shape adaptation decision-making. Næss et al. (2005) detected that when powerful stakeholders coincide in the necessity of adapting to climate change, adaptation measures are quickly implemented. Furthermore, Næss et al. also argue that local institutional relations and power structures act like filters of new currents in adaptation so as to slow down the process of community learning.

IA is generally carried out through the employment of diverse social methods and participatory approaches. Thus, in the present research, a historical review of the local and regional press articles and legislation, together with an in-depth round of interviews allowed framing the social and political context in which climate change adaptation in Tenerife is embedded. In this sense, IA enables an evolutionary analysis of the role and standpoints of each stakeholder and citizens, providing a map of the relevant stakeholders and their positions. Thus, the information that could be collected through IA is presented in Table 3.

Table 3. Potential information that could be collected from experts and stakeholders

Framing	A definition of the *problematique* at hand. Existing climate change policies. Stakeholders' objectives and strategies (e.g. hidden agenda). Uncertainties.
Proposal of stakeholders	Each stakeholder recommends the inclusion of other key social actors.
Preliminary proposal of policy packages	Potential policy options for adaptation. Obstacles to the implementation of those policy options.
Preliminary proposal of evaluation criteria	Indicators to evaluate policy packages.

Source: own elaboration based on questionnaires and in-depth interviews.

Therefore, IA has been used to develop the framing phase of the scenario building, as indicated in Table 3. The next sections will be devoted to provide more insight on the concrete methods carried out during the IA process.

3.1.1.1 Press review

It consists of the review of the local press that make reference to the case study. According to Corral Quintana (2004), press review is a valuable source of information since it allows for a wider an objective view of the issue at hand; wider because different opinions are seen; and objective because it helps the analysts to approach the issue from different perspectives. This social technique has been successfully applied to different environmental assessment case studies, 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).

For the purpose of this case study, local press analysis has allowed the analysts for the possibility to access the next sources of information:

— **Framing**. It could be seen that heatwaves and Saharan dust events are a frequent climatic phenomena in the Canary Islands. Moreover, local experts in climate change were identified, and indicated that there are relevant policy gaps and a lack of multi-risk policy foresight in the island. Air pollution is not so deeply covered by the media, even though there are severe problems related to this (see Hernández-González et al., 2016). However, some media press articles have reported increasing mortality and overuse of medical services, as a consequence of increasing Morbidity.

— **Identification of experts and relevant stakeholders.** A certain number of local experts in climate change and relevant stakeholders could be detected, allowing for contacts to be considered for in-depth interviews.

3.1.1.2 In-depth interviews to experts and stakeholders

In-depth interviews to experts and stakeholders have been considered appropriate to implement IA (De Marchi et al., 2000; Paneque Salgado et al., 2009). Initially, experts are interviewed first (Corral Quintana, 2004) in order to have a preliminary list of stakeholders to be engaged and contacted (Hernández González, 2014). Thus, experts are then 'used' as 'keys that open certain doors that otherwise cannot be opened'. Then, once all relevant stakeholders were identified, they were contacted by phone.

By means of open questions, relevant information is collected, such as policy gaps and new alternative policy options (Corral Quintana, 2004; Guimarães Pereira et al., 2003; Paneque Salgado et al., 2009). In the present case study, in-depth interviews have been used to; (1) frame the issue; (2) collect existing reports and scientific publications on the subject; (3) propose resilience policy strategies; and (4) map the positions of the stakeholders regarding the issue under analysis.

A part from the in-depth interviews, a questionnaire was also conducted in order to collect more precise information, as well as to analyse the consistency of the answers given in the in-depth interviews.

3.1.1.3 Focus groups

Morgan (1996, p. 130) defines focus groups «as a research technique that collects data through group interaction on a topic determined by the researcher». It has also been defined as a social event (Bloor et al., 2001) or a form of group interviewing (Gibbs, 1997) that pursues the collection of qualitative information intended to answer research questions (Morgan and Krueger, 1993). It helps the researchers to detect attitudes, feelings, beliefs, experiences, and reactions that would not be collected by other social research method (Gibbs, 1997; Kitzinger, 1994).

Focus groups have been considered useful tools to learn more about the degree of consensus of a certain topic, as well as the opinion of the stakeholders involved, and their reasons to answer certain research questions (Morgan and Krueger, 1993). Focus groups are also useful to collect information on tensions between opposing parties (Kitzinger, 1994; Morgan and Krueger, 1993). Similarly, focus groups might be appropriate to shed light on uncertainties and ambiguities related to the issue at hand (Bloor et al., 2001), being an effective and economical way to collect relevant information in a short period of time (Gibbs, 1997).

For all these reasons, focus groups have become attractive techniques for citizen participation, since they are flexible tools that can be used at any step of a decision-making process (Bloor et al., 2001); flexible because groups can be sorted, for example, by age (Guimarães and Funtowicz, 2013). Just to mention some examples, focus groups has been applied to improve governance of water resources (Guimarães Pereira et al., 2005;

Paneque Salgado et al., 2009), to assess windfarm location (Gamboa and Munda, 2007) and sustainable mobility policies (Hernández González and Corral Quintana, 2016). However, it has to be noted that focus groups are not representative of what the community think about a certain issue (Gamboa and Munda, 2007); it is rather a social research method (Bloor et al., 2001; Morgan and Krueger, 1993).

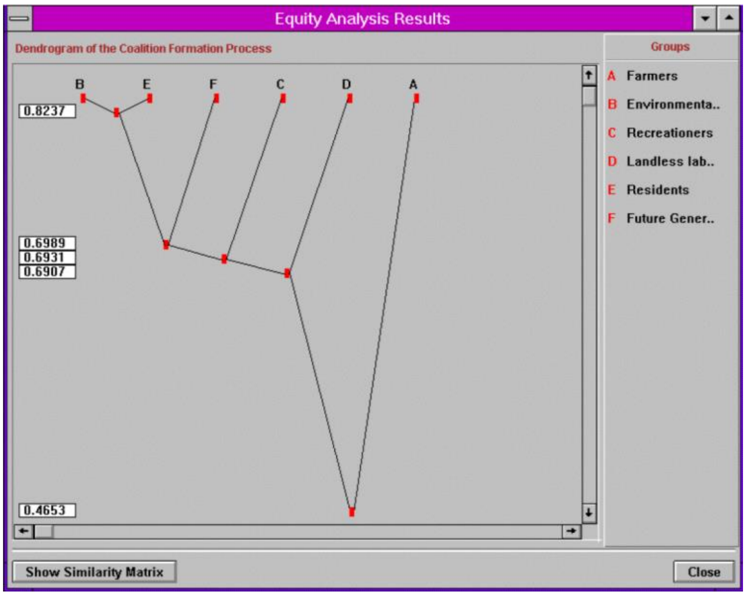
In the current analysis, four focus group sessions were carried out. The first one was developed along with experts in resilience and social actors in order to: (1) frame the issue at hand, i.e. is climate change perceived as a risk in Tenerife? Is there a lack of climate change adaptation policies in the island? and (2) if so, what can be done to increase the island resilience? (see Hernández-González et al., 2016). The second series of focus groups consisted of three sessions with local citizens, aimed at: (1) framing and understanding local climate change perceptions; (2) exploring future images of Tenerife in 2040; and (3) exploring specific actions that might be implemented to increase resilience in Tenerife (see Hernandez et al., 2017).

3.1.2 Power-relation analysis

Corral Quintana (2004) defines power relations as the combination of different available resources to be used by certain stakeholders as well as their ability to use them well. These resources are related to legal, political, economic, administrative, knowledge and information assets. Thus, the more resources available (and properly used), the more level of power a stakeholder might have.

Furthermore, Corral Quintana (2004) also suggests that the level of power can also be stronger if powerholders form coalitions, as shown elsewhere (Abad, 2016). Coalitions can be forecasted as well as its intensity by means of a dendrogram, as presented by Munda (1994); see Figure 1. Therefore, the more powerful the coalition is, the more capabilities they have to shape decision-making in their favour.

Figure 1. Example of dendrogram of coalitions



Source: JRC, 1996.

Power relations will be considered as a relevant driving force in the proposal of scenarios for resilience. The next section is devoted to present the backbone approach.

3.2 Backbone approach

3.2.1 Characterisation of current state

The current state helps to represent the conditions of the socio-ecological system as well as other major factors propelling the system forward (Gallopín et al., 1997). It has been defined as 'the historical context, key characteristics of the study areas, events, main issues of concern and actors' (Özkaynak, 2008, p. 55). Therefore, a definition of the problem at hand and its main characteristics is needed.

The IA carried out is a key element to detect what the current state is (although it will be further analysed in the 'Business as usual' scenario, unfold in the next section). Tenerife is seen as a low resilient island, due to its vulnerability to external shocks, including climatic, economic and energy ones (Hernandez et al., 2017). The island is highly dependent on external fossil fuel energy sources, since nearly 98 % of primary energy consumption comes from oil imported by ship, as well as food production. Furthermore, water supply requires desalination techniques by means of fossil fuels such that water demand can be satisfied. Meanwhile, local governance is not committed towards resilience.

3.2.2 Critical dimensions

Critical dimensions are the multi-dimensional space from which the scenarios can be built and unfold (Corral-Quintana et al., 2016; Gallopín and Rijsberman, 2000). Critical dimensions are, therefore, the important attributes of the scenarios (Gallopín and Rijsberman, 2000). Critical dimensions may be demography, science, technology, economy, society, education and culture, governance, social values, and the environment and natural resources (Corral-Quintana et al., 2016; Speth, 1992). However, following the IA carried out in the case study (Hernández-González et al., 2016; Hernandez et al., 2017), the critical dimensions considered in this case study are the following:

- demography
- economy
- society
- governance
- technology
- environment.

Once the critical dimensions are presented, each dimension may be composed of different driving forces. These are presented below.

3.2.3 Driving forces and strategic invariants

Driving forces (or drivers of change) have been defined as the «persistent and dominant phenomena and processes already in the pipeline» (Gallopín et al., 1997, p. 8). They could also be seen as «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). It has also been said to be the «point of departure for all scenarios» or a set of «trends that currently condition and change the system» (Raskin et al., 2002, p. 19). Driving forces have also been called 'initiative forces' (Corral-Quintana et al., 2016, p. 95) defined as «factors, tendencies or key process, which may influence the situation or decisions made, as well as those that drive the system and co-determine the unfolding of the future scenario».

Examples of driving forces can be population growth, economic growth, trade, technological change, lifestyles, culture, poverty, inequality, decentralisation of authority, power structure, level of conflict, resource depletion, pollution and environmental change (Gallopín et al., 1997; Gallopín and Rijsberman, 2000; Raskin et al., 2002).

These driving forces can be split up into two different kind of drivers: (1) initial drivers; and (2) drivers subject to change (Gallopín and Rijsberman, 2000; Raskin et al., 2002). The former are drivers that remain the same to all scenarios (population growth and technological change for example). Gallopín and Rijsberman (2000) call these drivers 'strategic invariants', whereas Corral-Quintana et al. (2016) use the term 'pre-determined elements'. The second kind of driver, however, refers to drivers that may change when a scenario is unfolding (economic output, environmental quality, etc.).

Furthermore, driving forces can either be external or local, or both, as well as can be global, regional, national or local (Özkaynak, 2008). To the ends of this case study, and following the IA carried out in Hernández-González et al., (2016) and Hernandez et al., (2017), the following driving forces and strategic invariants (the latter in *italics*) will be used:

— Demography:
  - *population growth*
  - *ageing population*

— Economy:
  - *recovery/recession*
  - *employment/computerisation*
  - food sovereignty
  - tourism sector sustainability

— Society:
  - poverty and inequality
  - social values and lifestyle

— Governance:
  - *power relations*
  - politics and decision-making

— Energy and technology:
  - energy and green technologies

— Environment:
  - *heatwaves*
  - *Saharan dust events*
  - land-based transport planning
  - air quality
  - water governance

Driving forces may imply acknowledging deep uncertainties in their future development. In this case, we refer to critical uncertainties.

3.2.4 Critical uncertainties

Critical uncertainties may represent some driving forces that will fundamentally alter the course of events (Gallopín et al., 1997). They represent «important factors or processes that 1) have an important role in determining the unfolding of the scenarios in terms of the dynamics of the issue at hand, and 2) have values or outcomes which are very difficult to anticipate today. In other words, they refer to trends or events which could make major difference in the likelihood of the materialization of one or other scenario, and which are currently very difficult to anticipate» (Gallopín and Rijsberman, 2000, p. 4). Critical uncertainties have also been defined as «those initiatives forces whose progression cannot be anticipated, but are fundamentally known to affect a set of events, determining principal differences between scenarios» (Corral-Quintana et al., 2016, p. 96). Examples of critical uncertainties could be major political decisions, or environmental and social tensions (Özkaynak, 2008).

In the case study under analysis, the next critical uncertainties have been identified:

- social values and lifestyle: it cannot be foreseen if the local society of Tenerife will react to the 'business as usual' scenario and would be willing to change to more resilient lifestyles and change to a more politically proactive society;
- tourism sector sustainability: it cannot be foreseen if, for example, a revolutionary technology could be able to transport passengers from abroad to Tenerife by means of planes powered by renewable energies;
- recovery/recession: it cannot be foreseen if the current economic recovery will continue or not;
- Saharan dust events: even though this extreme weather event has become more intense and frequent in the last decades, its future evolution is unknown or poorly understood.

In Table 4, a summary of the backbone structure to develop the scenarios for resilience in Tenerife is presented.

Table 4. Backbone structure to unfold the scenarios

Critical dimensions	**Driving forces**	**Strategic invariants**	**Critical uncertainties**
Demography	Population growth	✓	
	Ageing population	✓	
Economy	Recovery/recession	✓	✓
	Employment/computerisation	✓	
	Food sovereignty		
	Tourism sector sustainability		✓
Society	Poverty and inequality		
	Social values and lifestyle		✓
Governance	Power relations	✓	
	Politics and decision-making		
Energy and Technology	Energy and green technologies		
Environment	Heatwaves	✓	
	Sustainable mobility		
	Saharan dust events and air quality	✓	✓
	Water management		

Source: own elaboration.

4 Scenarios overview for 2040

Numerous of the deep changes Tenerife is now experiencing are unavoidable and permanent. Others are more difficult to forecast and will appear without warning. Tenerife can either act as a spectator to those changes or it can try to find their own way forward. It has to be decided.

The three scenarios presented below could help boosting a debate on the future of Tenerife's resilience. Therefore, they are descriptive pathways to incite thinking. The scenarios are neither detailed guidelines nor policy recommendations. The scenarios are thought to shed light on the capabilities of Tenerife by 2040 to become more resilient depending on the choices to be made from now onwards.

These three scenarios are the following: (1) a first one representing the reference scenario, or the 'business as usual', leading to increasing vulnerabilities and low resilience; (2) a second scenario called 'awakening', representing deep changes in social values and the way of doing politics and environmental governance, leading to increasing levels of resilience; and (3) a last scenario called 'collaborative communities" that describes what could be done when a part of the society decides to become more resilient in a context of governmental apathy.

4.1 Business as usual

The 'business as usual' scenario unfolds an image of Tenerife that assumes deteriorated politics, the economic situation and environmental policies. Poor governance is increased by degraded politics, powerful stakeholders' influence (together with a certain social approval) and corruption. Public participation in decision-making is low and scarce. Poor governance keeps public participation away from decision-making since the public is seen as a threat to mainstreaming governance.

The economic model relies on reduced agricultural activities, and a higher importance of both construction and tourism sectors. The first consequence is a decreasing local agricultural production that, due to both the increasing local population and tourism arrivals, will at least prolong the external food production dependency, leading to a vulnerable situation in terms of food sovereignty.

The use of water remains unsustainably managed. The island cannot provide groundwater resources due to its exhausting situation. Water use is increasingly dependent on desalination technologies to provide islanders (and economic sectors) with fresh water. Therefore, water policy is seen as a technological problem that needs solving, based on increasing use of fossil fuels that leads to increasing water prices due to the expected rise in the international price of fuel. Consequently, water abstraction and water use will continue depending on external energy resources, leading to a vulnerable situation in terms of water sovereignty.

Poor governance will also lead to a continued low renewable energy investment. This lack of governmental commitment produces increasing use of fossil fuels. Transport policy will continue relying on car use, however, the increasing use of electrification in cars may slow down the use of energy for this purpose, partially improving air quality. However, this car-oriented policy will induce road congestion and other associated impacts of land-transport; meanwhile, road infrastructure is foreseen to expand, leading to increasing environmental impacts. The tourism sector might also be affected by increasing fossil fuel prices, due to the fact that there is no substitution for oil-powered plains.

Economic costs may increase since fossil fuel prices are foreseen to rise in the coming decades, pushing up the energy bill. Furthermore, since the economic model will continue relying on both construction and tourism sectors (both potentially subject to increasing computerisation), low quality of employment and salaries will linger on, whereas high unemployment and poverty rates may become structural. Local population will therefore be more vulnerable to extreme weather events not only because of ageing, but also due to the lack of resources (income) to deal with climatic threats.

4.2 Awakening

The 'awakening' scenario shows an image of Tenerife that assumes a deep change in social values as well as the approach to politics and environmental governance. Now, both good governance and an environmentally-friendly lifestyle become essential to unfold the scenario. Good governance is encouraged by a more active and participatory society that demands more participation in decision-making. This participatory approach becomes crucial to keep powerful stakeholders' influence under control and eradicate corruption.

The economic model begins to change towards renewable energies and efficient technologies, as well as agro-ecological production, and high added value within the tourism sector. The first consequence of this transitional economic model is an increasing local agricultural production. The private sector is now encouraged by governmental incentives, reducing external food production dependency that leads to a less vulnerable situation in terms of food sovereignty.

Water culture changes. Now, the unsustainable water management of the past is recognised and assumed to change, i.e. islanders and local governments become aware of the exhausting situation of water resources. Water is therefore consumed more efficiently due to the deployment of new technologies, but especially due to efficient water-pricing. Desalination technologies might be understood as a transitional process that helps the aquifer to recover in the long term from the current exhausting situation. Therefore, water policy changes from the traditional supply-side approach to a demand-side one. The increasing use of renewable energies, as seen below, makes desalination a more environmentally-friendly activity, gaining water sovereignty as well.

Good governance leads to increasing levels of renewable energy investments. The government assumes the capability of becoming 100 % renewable by 2040, whereas the governmental energy planning is adapted to this new target. This governmental commitment produces an increasing use of renewable energies leading to remarkable drops in air pollution. Transport policy moves to non-motorised transport and public transport systems. Cycling and walking infrastructure is promoted within municipalities, whereas bus transport is improved in terms of both infrastructure and services. Private transport is discouraged by means of pricing and charging schemes when other sustainable options are available. In those cases where private transport cannot be substituted, car electrification and alternative-fuelled cars are promoted. The tourism sector is subject to a public debate while moving towards more sustainable activities. However, this sector might be affected by increasing fossil fuel prices since there are no alternative fuels for aviation.

Economic costs might be reduced since Tenerife tends to be a fossil fuel-free economy. Due to the economic model now being mostly based on green technologies, high skilled jobs are required (jobs unexpected to be replaced by computerisation). High-skilled workers are therefore well-rewarded and the level and quality of employment improves. Poverty and 'low-paid workers' are reduced as a consequence of more stable jobs and higher salaries. The local population might, however, be vulnerable to extreme weather events due to population growth and ageing.

4.3 Collaborative communities

The 'collaborative communities' scenario unfolds an image of Tenerife that assumes a slow change in social values produced only within certain groups of organised islanders. The way of doing politics and environmental governance remain the same as for the 'business as usual' scenario. Poor governance is encouraged by degraded politics, powerful stakeholders' influence and corruption, as well as a lack of public participation in decision-making. Again, decision-makers see public participation in environmental governance as a threat to the mainstreaming economic model.

The economic model relies on a reduced weight of agricultural activities, and a larger importance of both construction and tourism sectors as well as the 'business as usual" scenario. Decreasing local agricultural production may occur, due to increasing local demand and tourist arrivals, leading to increasing external food production dependency. This panorama encourages Community Supported Agriculture to be expanded fast and become relatively relevant by means of small groups of collaborative agricultural economy.

Water culture changes partially. The unsustainable water resources management of the past endured and desalination becomes increasingly relevant, especially fuelled by fossil energy sources. However, the alternative collaborative community networks also expand to the water sector and start exploring the options of fog-collecting technologies, such that the irrigation of agri-food alternative networks could become self-sufficient.

Poor governance continues and leads to increasing fossil fuel dependency. As a consequence of this energy policy apathy, alternative sustainable energy networks become more relevant such that alternative movements get organised onto energy sovereignty programmes, providing green energy to those alternative community networks. Transport policy continues depending on motorised transport due to local Governments are committed to expand road infrastructure. Alternative networks may also organise transport alternative networks based on car-sharing initiatives. Meanwhile, cycling and walking may become increasingly used. The tourism sector continues relying on sun-and-sand resorts, and quantity is still preferred than quality. This sector might be affected by increasing fossil fuel prices since there is no alternative fuels for aviation.

Economic costs increase since Tenerife relies basically on fossil fuels. Due to the mainstreaming economic model continue depending on construction and tourism sectors, low quality jobs are expected to continue. Low-skilled workers are poorly rewarded and the level and quality of employment deteriorates due to computerisation. Poverty and 'low-paid workers' might increase as a consequence of unstable jobs and low salaries. However, the alternative collaborative networks may exert as a parallel State that might slightly compensate the increasing poverty rates, especially within those alternative networks. Local population might however be vulnerable to extreme weather events because of population growth and ageing.

5 Results: three scenarios towards 2040

5.1 Strategic invariants

The strategic invariants will be presented first, since they represent the driving forces that remain equal to all scenarios (see section 3.2.3).

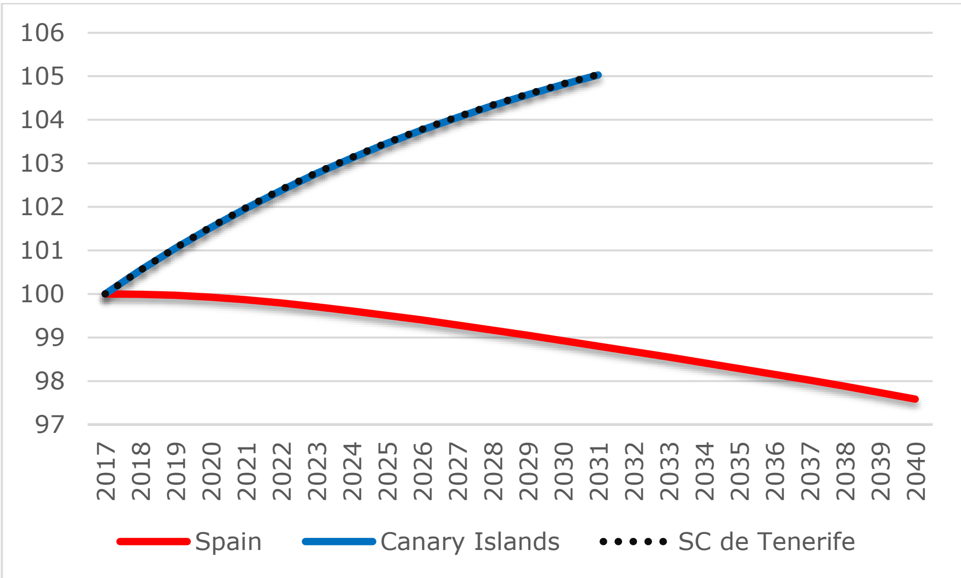
5.1.1 Demography

5.1.1.1 Population growth

Spain is expected to lose 1.1 million inhabitants from current times (2017) until 2040 (INE, 2017b). This reduction will be produced as a consequence of increasing death rate and reduced birth rate. This negative vegetative balance will neither be compensated by migratory balance, even though it is expected to be positive.

The Canary Islands will be among the six regions in Spain that will increase their population from current times until 2031 (there is no population projection beyond this year). The Islands will increase their population by almost 108 000 inhabitants, which means 5 % more than 2017 (see Figure 2). This increase is characterised by a negative vegetative balance and a positive migration. This growth rate is the most intense one in Spain along with the Balearics (INE, 2017b).

Figure 2. Population growth in Spain (2017-2040), Canary Islands and Province of Santa Cruz de Tenerife (2017-2031). Harmonised data (base 2017=100)



Source: INE, 2017b.

A projection for Tenerife is not available, although an estimation for the Province of Santa Cruz de Tenerife (comprised of the islands of Tenerife, La Palma, La Gomera and El Hierro altogether) is presented in Table 5. The expected population increase for the Province is 5 % between 2017 and 2031. Nowadays, the island of Tenerife represents 89 % of the total province population (ISTAC, 2017g).

Table 5. Population projection for the Province of Santa Cruz de Tenerife

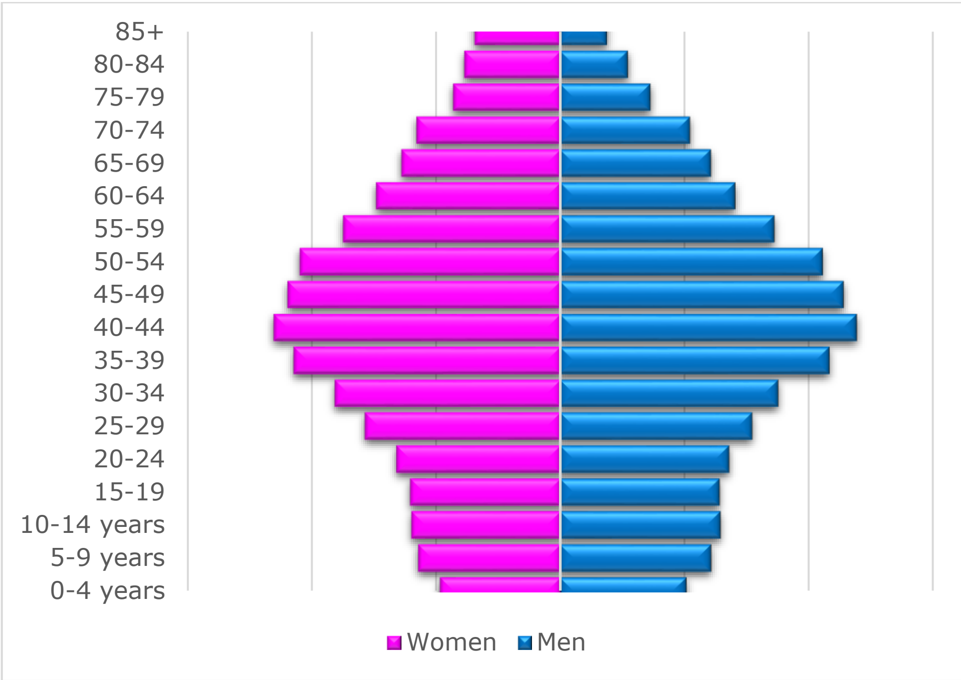
Year	Province of Santa Cruz de Tenerife
2017	1,028,867
2020	1,044,671
2025	1,064,569
2031	1,080,728

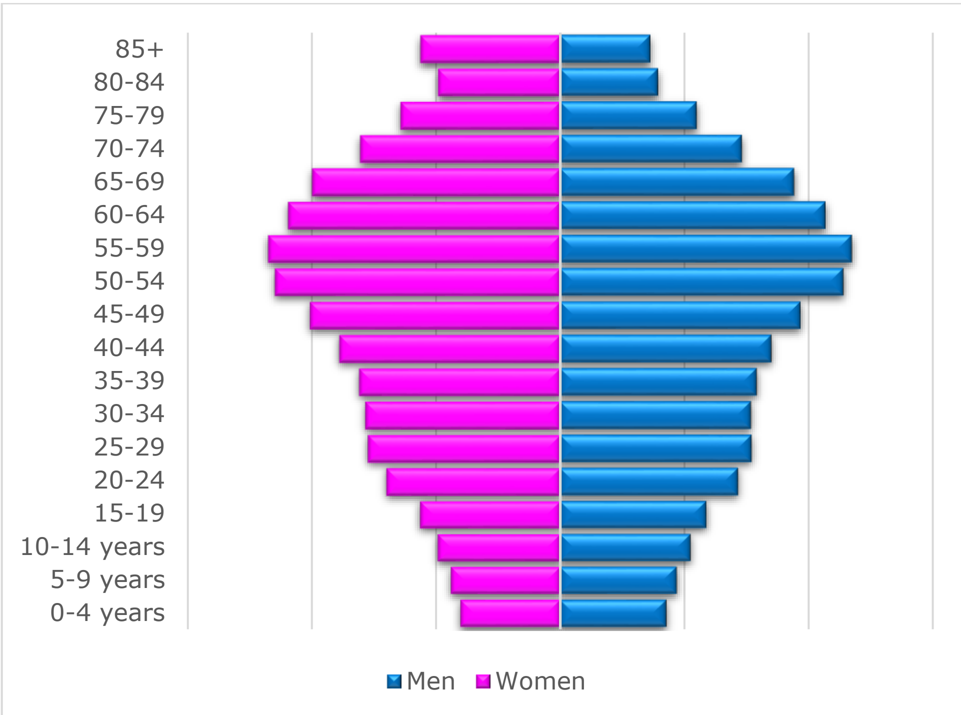
Source: INE, 2017b.

5.1.1.2 Ageing population

According to the projections (INE, 2017b), the Province of Santa Cruz de Tenerife is expected to age in 2031 respective to 2017 (see Figure 3). The population pyramid shown below is inverting; whereas in 2017 the largest group of population is the one between 40-44 years old, in 2031 the larger group will be the one between 55-59. Furthermore, in 2017 there are almost 174 000 people above 65 years old, meanwhile in 2031 an increase to more than 259 000 people is expected, i.e. 49 % more. Regarding young people (considered here as those below 19 years old), the current population is almost 187 000 people, whereas in 2031 this group will be reduced to 156 000, i.e. 16 % less.

Figure 3. Ageing population in the Province of Santa Cruz de Tenerife 2017 (above) and 2031 (below)





Source: INE, 2017b.

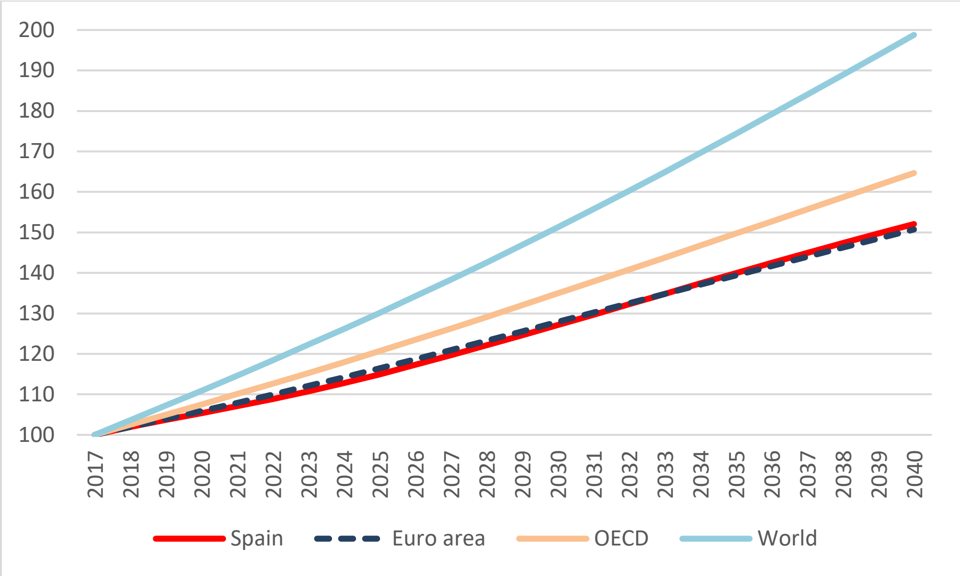
5.1.2 Economy

5.1.2.1 Recovery/recession

Economic recovery has a high level of uncertainty. Possible changes in United States policies, Brexit, monetary policy divergence at the global scale, and upcoming national elections in several European Union Member States might be one of the causes (European

Commission, 2017; UNCTAD, 2016). According to Figure 4, an expansion of GDP at global, regional, and national scale is expected from now on to 2040, although a likely moderation in growth rates might occur after 2020 (PwC, 2015). The fastest growth is expected at global scale, followed by the OECD states. Spain's recovery seems to be attached to the Eurozone economies. Therefore, a certain level of stability is expected in terms of GDP at global, regional, and national level in the long term.

Figure 4. Gross domestic product long-term forecast (harmonised)



Source: OECD, 2016.

Regarding the Spanish situation, GDP growth is expected to be higher than the one of the Eurozone for the next years. The Spanish economic growth will be based on a strong domestic demand, including investment in construction, whereas the commitment with austerity measures remain (MEIC, 2015), even though it is known to undermine recovery (UNCTAD, 2016). Economic growth is expected to decelerate within the next years, although an average level of 2 % for 2011-2030 is forecasted (Johansson et al., 2012). At the same time, Spanish governments' debt ratio of 100 % of GDP is foreseen (European Commission, 2017). The Canary Islands is expected to increase its GDP growth in the coming years, especially as a consequence of both a low oil price context, that reduces air transport costs, and the resulting arrivals of tourists (BBVA, 2016).

Notwithstanding, it has been indicated that the current crisis, due to its systemic character, is expected to endure at least to 2020-2025 (Niño-Becerra, 2015). Meanwhile, the characteristics of the capitalist system will continue and sharpen, i.e. in order to increase efficiency and reduce costs, there will be an increasing trend to create both monopolies and oligopolies, leading to an increasing reduction of actors and, therefore, a concentration of economic power (Niño-Becerra, 2015). According to this author, the scenario for the future of Spain will be the following:

- biased growth: several sectors will experience rapid growth while others will experience a rather slow level;
- demarcated areas and clusters with strong possibilities of economic activity representing an important percentage of GDP;
- development of the 4.0 industrial sector: decoupled from infrastructure and equipment oriented to mass production.

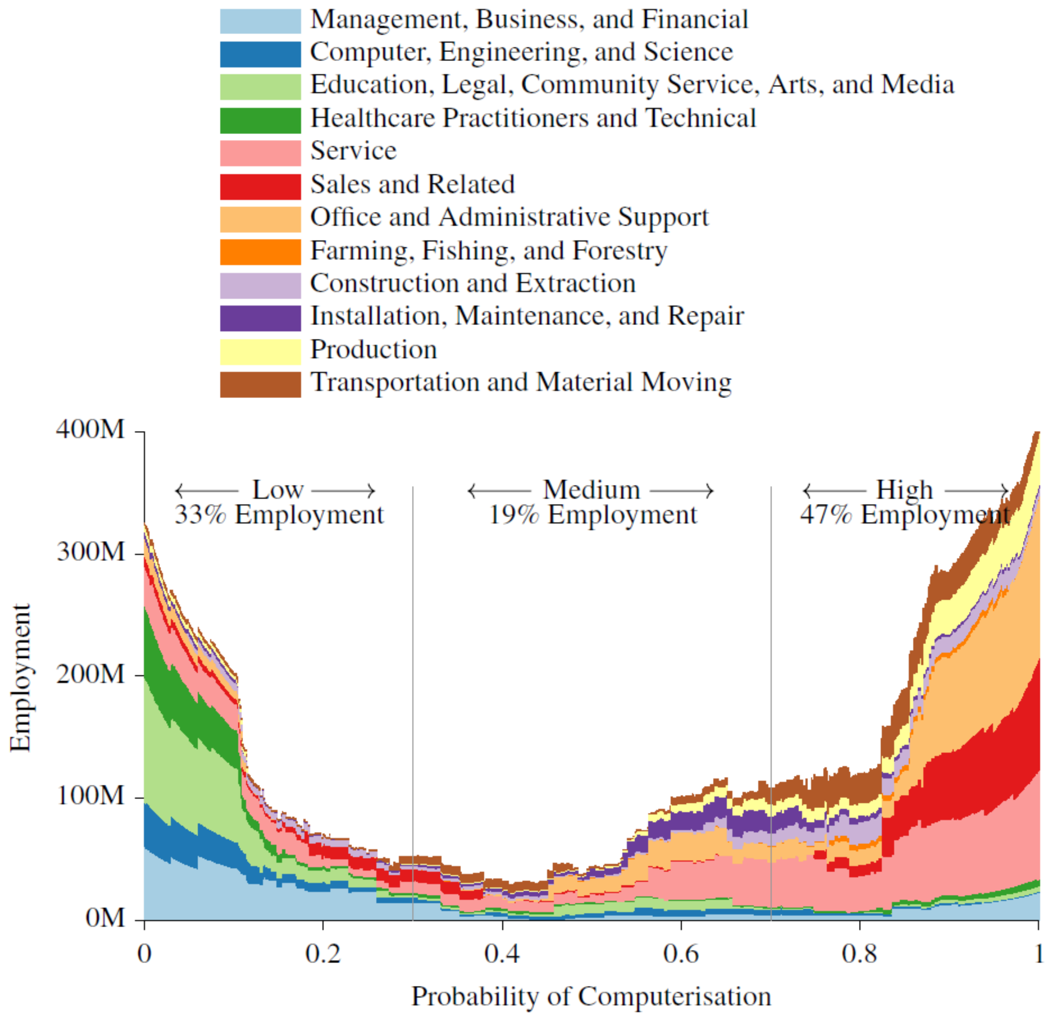
5.1.2.2 Employment/computerisation

According to Frey and Osborne (2017), within 10-20 years, computerisation, machine learning and mobile robotics will progressively substitute human labour, especially those employments of low-wage occupations, whereas high-wage occupation will have a lower risk of substitution (see Figure 5). Thus, the most probable employments affected by computerisation are: workers in transportation and logistics occupations; office and administrative support workers; employment in services; sales and construction occupations; cashiers; counter and rental clerks; as well as telemarketeters.

However, the workers that are quite likely to be protected from computerisation are the ones related to occupations requiring knowledge of human heuristics and creative intelligence, such as fine arts, originality, negotiation, persuasion, education, social perceptiveness, healthcare, and media jobs.

Consequently, an economy based on office and administrative support, sales and, related service (including tourism), such as in Tenerife and the Canary Islands, are more likely to suffer high levels of unemployment in the near future than other economic models specialised in high added-value product and services. For more specific details, the annex given in Frey and Osborne (2017) can be consulted.

Figure 5. Employment affected by computerisation

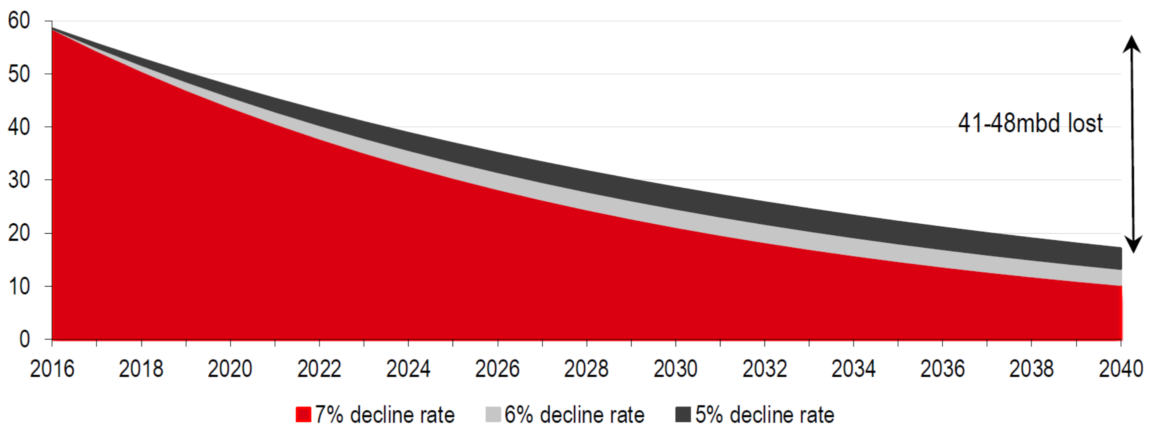


Source: Frey and Osborne, 2017.

5.1.2.3 *Energy and green technologies: the international context*

A 30 % rise in global energy demand is expected for 2040 for all fuels (IEA, 2016). Natural gas consumption is projected to increase by 50 %, whereas oil demand growth rate will slow down but will still reach 103 million barrels a day by 2040 (IEA, 2016). Fossil fuels (gas and oil) will continue to be the backbone of the global energy system for the next decades (IEA, 2016). However, oil and gas extraction will decay due to the declining condition of existing fields (IEA, 2016). In fact, if a 5-7 % decline rate for global post-peak output of conventional liquids supply is assumed (see Figure 6), the supply gap would be around 41-48 million barrels a day (mbd), which is equivalent to four times the Saudi Arabia production capacity (Fustier et al., 2016). Furthermore, if increasing global energy demand is assumed (IEA, 2016), the gap would even be larger: to 55-60 mbd (Fustier et al., 2016).

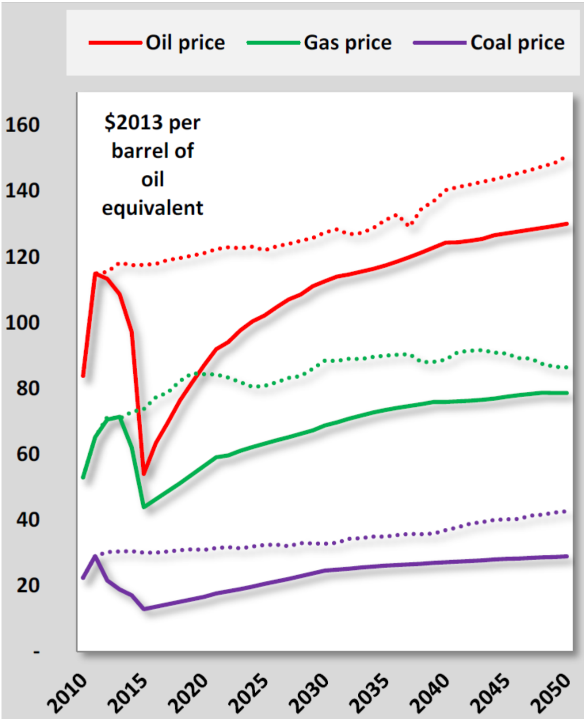
Figure 6. Post-peak production (benign definition) — sensitivity to 5-7 % decline rate to 2040



Source: Fustier et al., 2016.

World oil prices are therefore estimated to increase continually after 2020 (see Figure 7). During 2020-2030 the oil price will rapidly increase at an annual rate of 2.3 % due to both economic growth and increasing world motorisation (European Commission, 2016a). During 2030-2050 world oil price will keep growing but a slower rate (0.7 % annually) due to lower growth of oil consumption encouraged by energy efficiency, deployment of biofuels, hybrid vehicles and the substitution of oil by gas for energy production (European Commission, 2016a). In 2050, the price of Brent would reach USD 130 $_{2013}$/barrel (European Commission, 2016a), whereas gas import prices are foreseen to be maintained (see Figure 7). After 2020, the average European Union gas import price will increase up to USD 69 $_{2013}$/barrel of oil equivalent (boe), whereas in 2050 the price would go up to USD 79 $_{2013}$/boe.

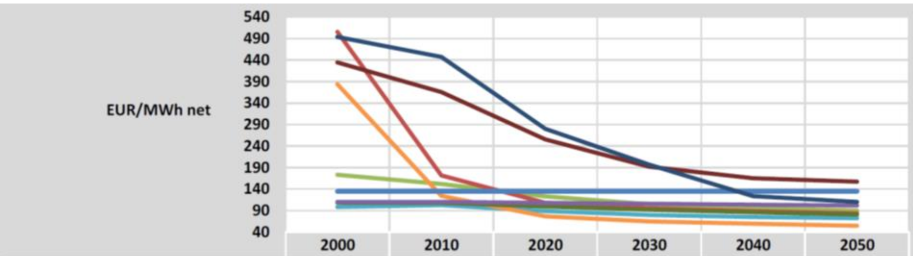
Figure 7. Fossil fuel import prices



Source: EC, 2016a.

Renewable energies are expected to become more relevant in the global energy mix. Almost 60 % of the power generated in 2040 is projected to come from renewables, half of it from wind and solar photovoltaic (PV) (IEA, 2016). There will be a relocation of capital to renewable energies, experimenting a fast growth due to a continued cost reduction (IEA, 2016; see also Figure 8). Solar PV average costs are foreseen to decline by 40-70 % by 2040, whereas onshore wind by 10-25 % (IEA, 2016). Therefore, subsidies might no longer be needed (IEA, 2016).

Figure 8. Indicative costs for renewable energy technologies



	2000	2010	2020	2030	2040	2050
Wind Offshore	173	152	123	105	95	90
Wind onshore	99	103	89	80	75	72
Solar PV - South of Europe	383	124	77	65	59	55
Solar PV - North/Central Europe	505	172	108	95	89	84
Solar Thermal	434	365	255	192	165	157
Geothermal	109	108	99	92	86	81
Large Hydro	135	135	135	135	135	135
Small Hydro	110	110	108	106	104	101

Source: EC, 2016a.

Electricity will have a greater share of final energy consumption (IEA, 2016), whereas electric cars will gain attractiveness (exceeding 150 million in 2040) since the cost gap between conventional cars and electric ones will narrow. However, over the long term, alternative fuels and technologies for freight, aviation transport, and petrochemicals are not expected to appear, therefore, these sectors will experience increasing oil consumption (IEA, 2016).

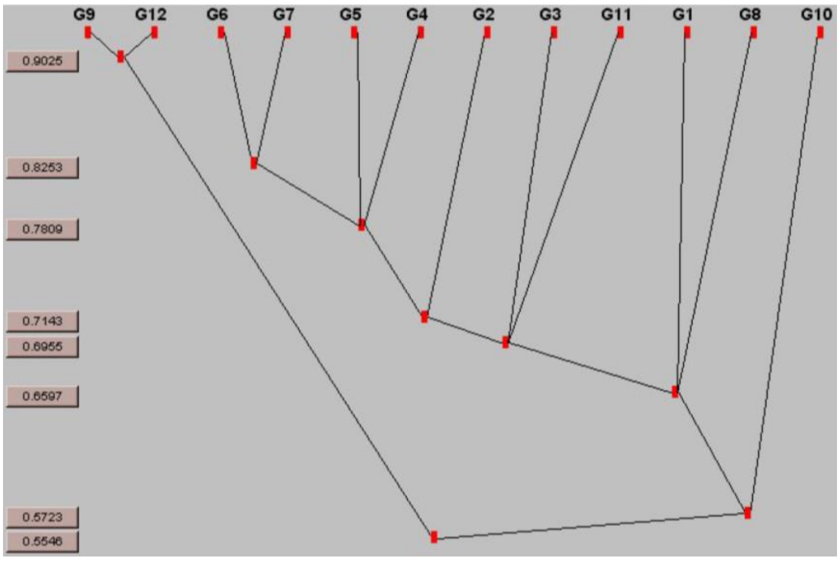
5.1.3 Governance

5.1.3.1 Power relations

According to Corral Quintana (2004) power relations and their influence in decision-making may be constructed on the basis of both individual stakeholders' power and their potential coalitions. The latter may be performed by means of an equity analysis carried out through an equity matrix from which a similarity matrix may be calculated (Munda, 2008). Through a mathematical reduction algorithm, building a dendrogram of coalitions may be possible, which shows possible stakeholders coalition formation.

Two analysis carried out in Tenerife, one for air quality (Corral Quintana, 2004), and one for sustainable mobility policies (Hernández González and Corral Quintana, 2016) may show certain future coalitions and power relations in Tenerife. Regarding the air pollution case study, two coalitions may formed (or may have been already) between the agricultural and industrial sectors on the one hand, and the electricity supplier and tourism sector on the other. However, the energy supplier, the agricultural, industrial, and tourism sector might colligate altogether (see Figure 9). According to Corral Quintana (2004) all these groups supported a 'business as usual' situation regarding the use of renewable energies.

Figure 9. Dendrogram of coalitions in air quality policies in Tenerife

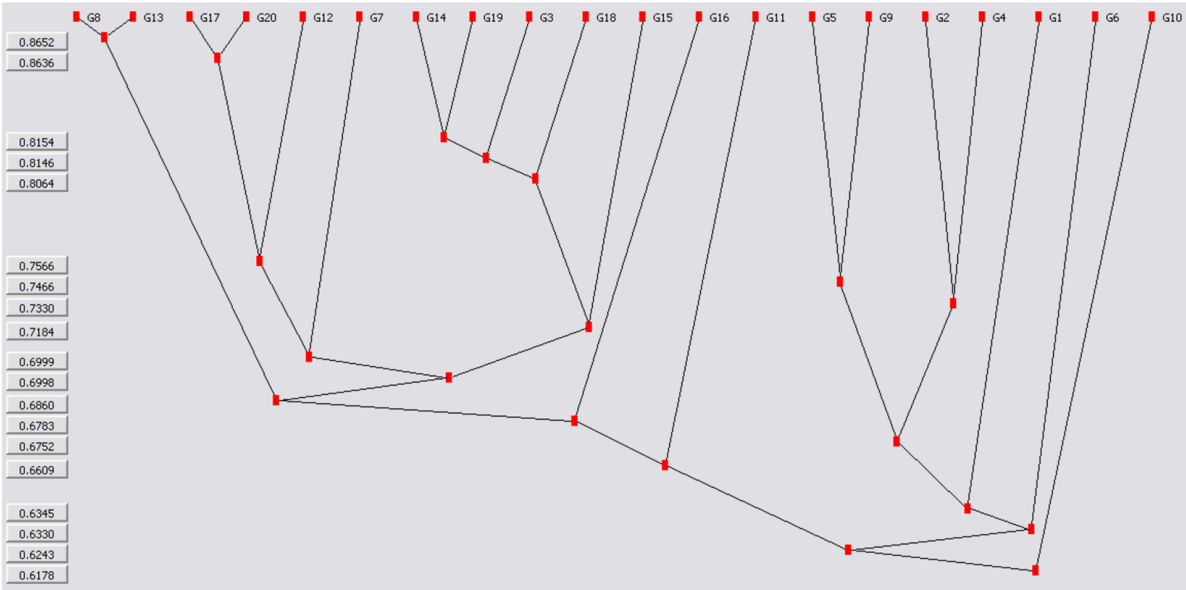


G1. Supranational institutions
G2. Local authorities
G3. Refinery
G4. Unelco (electricity producer)
G5. Tourism sector
G6. Agricultural sector
G7. Industrial sector
G8. Media
G9. Environmentalists
G10. Neighbourhood associations
G11. Local population
G12. Future generations

Source: Corral Quintana, 2004.

The second case study focused on sustainable mobility policies (Hernández González and Corral Quintana, 2016). Using the same approach, these authors came up with a dendrogram of potential coalitions (see Figure 10). The most powerful coalition that might be formed on the basis of transport policies is the one between the conservative party and the construction sector. These two stakeholders might agree on pushing forward a transport policy option focused on the expansion of all road transport infrastructure.

Figure 10. Dendrogram of coalitions in sustainable mobility policies in Tenerife



Legend: G1. Government of the Canary Islands, G2. Island Council, G3. Transport experts, G4. Nationalist party, G5. Conservative party, G6. Labour party, G7. Left party, G8. Green party, G9. Construction sector, G10. Automotive dealers, G11. National trade union (CCOO), G12. National trade union (UGT), G13. Local trade union, G14. Bus Company, G15. Taxi drivers' union, G16. Tram Company, G17. Environmentalists, G18. Mobility-reduced people, G19. Public transport users, and G20. Citizens' organisations.

Source: Hernández González and Corral Quintana, 2016.

5.1.4 Environment

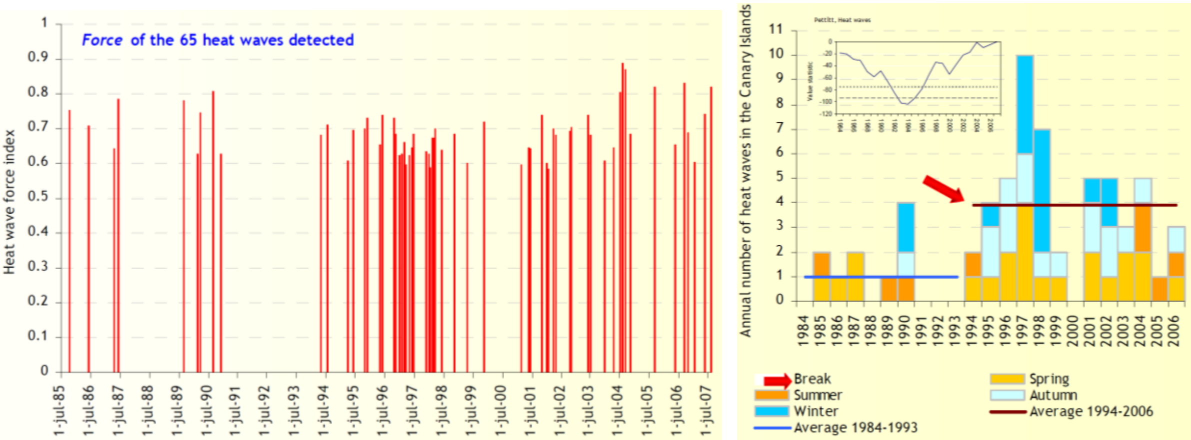
5.1.4.1 Heatwaves

Climate in the Canary Islands is mild, due to the influence of the template NNE trade winds and the cool waters of the subtropical North Atlantic. These conditions prevent these Islands of the extreme weather conditions of the nearby Sahara, the largest and among the hottest desert 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 degrees (Dorta, 1991). However, the Island Council of Tenerife has considered heatwaves as those temperatures exceeding 30 degrees (Council of Tenerife, 2016). Night heat events reach national maximums between 26-30 degrees (Dorta, 2007).

According to Alonso Pérez (2007), these episodes might have acquired more intensity and frequency in the Canary Islands since 1970. In fact, according to Figure 11 (right graph), the average number of heatwaves has quadrupled since 1994. The left graph in Fig. 11 also indicates that among the 10 strongest heatwave's force indexes recorded over the whole period, 5 have been detected during 2004-2007. Other authors also mention that a general rise of temperatures is expected for the Canary Islands (Martín et al., 2012), intensified in upper parts of the islands (Expósito et al., 2015; Martín et al., 2012).

Figure 11. Heatwave frequency and intensity in the Canary Islands (1984-2007)



Source: Sanz et al., 2007.

According to the World Health Organization, the most relevant predisposing factors for heat-related illnesses are being elderly, having impaired cognition (such as dementia), pre-existing diseases, use of certain medications, low level of hydration, living alone, poor housing (such as living in a certain building type or on the top floor), the lack of air-conditioning at home or residential institutions (WHO, 2004). Thus, the last heatwaves registered in the Canary Islands have left 13 premature deaths, more than any other meteorological hazard (Dorta, 2007). According to section 5.1.1.2, the number of elderly people in Tenerife will increase in the future, leading to increasing vulnerability, especially in a context of growing frequency of heatwaves in the Islands (Sanz et al., 2007).

Furthermore, the percentage of inefficient buildings in the Canary Islands is high. More than 84 % of homes are either F of G energy class, i.e. the lowest in terms of isolation efficiency (IDAE, 2015). One apparent solution might be the use of air-conditioning. However, since these devices consume conventional energy in the Islands, this measure might be considered as maladaptation to climate change (Barnett and O'Neill, 2010).

5.1.4.2 Saharan dust outbreaks

There are two dust seasons in the Canary Islands, one in winter and other in 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., 2011a). These events may induce extremely high concentrations at ground level (up to 2 000 μg/m^3 have been recorded) and are not necessarily associated with high temperatures. Dust concentrations have increased by a factor 2 since 1980 due to an enhancement in dust export to the Canaries due to a strengthening and eastward shift of the Azores High (Alonso Pérez et al., 2011b).

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 dust air between 500 m.a.s.l. and 5 km.a.s.l. over the Canary Islands, whereas trade winds prevails below. A unique long term record of aerosol chemistry and dust at Izaña Observatory (Tenerife), started 3 decades ago, have shown that this summer dust export in the SAL has been modulated by large-scale climate related processes by the so-called North African Dipole Intensity (NAFDI), i.e. the intensity of the North African high (over Northern Algeria) to the tropical monsoon (Rodríguez et al., 2015). Recent long-term analysis (1941-2013) of aerosol optical depth retrievals obtained at Izaña Observatory shows that there is an important multi-decadal variability in summer dust export connected to NAFDI and North Atlantic ocean temperature long-term variability (García et al., 2016). The Canary Islands have historically received Saharan dust as a consequence of large scale meteorological processes that involve mid-latitude waves, the NAFDI and the Saharan Heat Low (Cuevas et al., 2016; Rodríguez et al., 2015). Thus, when this event takes place, the air of the Canaries become dusty and 'naturally' polluted with particulate matter (PM_{10}). In addition to the dust events in these two seasons, other scattered and sporadic episodes may occur along the year. The effects of climate change on the evolution of Saharan dust outbreaks are however under discussion (Alonso Pérez et al., 2007).

Summer dust events are associated with meteorological conditions that have several environmental implications. Aircraft measurements and satellite observations (Prospero and Carlson, 1972; Tsamalis et al., 2013) have shown that the dusty, hot and dry Saharan Air Layer typically expands between 1 and 5 km.a.s.l. over the ocean. 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 1 800 m.a.s.l. These high temperatures represented 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 (Alastuey et al., 2005; CSIC-AEMET-UHU, 2010).

In terms of socioeconomic impacts, Saharan dust events reduce visibility, affecting both airports and their transport services (Dorta, 2007). However, the impacts on human health are one of the most relevant ones, since respiratory pathologies, anxiety disorders, and atypical thoracic pain usually affect local population (García et al., 2001). Other studies have reported allergic diseases leading to increased use of air liquid as a respiratory therapy (Belmonte et al., 2010). It has also been testified that Saharan dust events might be related to the introduction of microbial communities (González et al., 2013).

In the next section the scenarios will be unfolded, concretely for those driving forces that may be subject to change in the next decades depending on the scenario analysed.

5.2 Business as usual

5.2.1 Economy

5.2.1.1 Food production dependency

Currently, there is a progressive reduction in the primary sector in the Canary Islands, in favour of both the construction and tourism sectors (CES, 2015). Nowadays, the primary sector represents only a 1.5 % of the Canaries GDP (CES, 2015). The agricultural surface has been reduced in the Islands as well as livestock production (CES, 2015), especially as a consequence of difficult farming conditions for younger generations, poor salaries compared to other sectors (as construction and tourism), loss of rural traditions, and low prestige compared to the tertiary sector (CES, 2008). In Tenerife, agricultural land has been reduced a 20 % between 2000 and 2012, whereas agricultural production for export has decreased a 23 % (ISTAC, 2017d). Livestock production has however experienced both increase (65 % ovine and 8 % porcine) and decrease (71 % rabbits, 28 % bovine, 27 % goat, and 2 % hens) (ISTAC, 2017e).

The primary sector's shrinking condition is said to be produced as a consequence of growing food demand (local communities, immigration and tourism), low competitive prices of local production, high production costs (included land), deficient marketing, the interests of powerful import stakeholders, and the concentration of agricultural export potential in a few products (Godenau and Nuez, 2013; Godenau, 2014), such as banana, tomato and cucumbers (CES, 2015; see also Table 6). Furthermore, increasing competition between economic sectors (agriculture, residence, industry, infrastructure, and tourism) for land-use control have also been pointed out as a barrier for local agricultural development (CES, 2008). Meanwhile, biological agriculture production is not locally promoted (ULL/ULPGC, 2014), representing 6 % of agricultural surface in Tenerife (ICCA, 2017).

The so-called POSEI programme (Programme of Options Specific to the Remote and Insular Nature of the Canary Islands) and SSA regime (Specific Supply Arrangement) have also been appointed as policies that have been discouraging local productive capacity (CES, 2015). Even though, the POSEI was intended to increase local food production by means of subsidies to production and marketing, export-oriented production has captured most of those subsidies (Godenau and Nuez, 2013). Whereas SSA was created to reduce import prices towards the Canary Islands so that local demand could be satisfied at low prices.

The consequence of these policies have brought both positive and negative impacts. Positive because local fruit and vegetables production have increased, but negative because livestock products and their derivatives have been substituted by imports (CES, 2008; see also Table 6). All in all, food external dependency is growing whereas food self-sufficiency has been progressively reduced (Godenau, 2014). Only 6 % of products bought by local inhabitants have been locally produced (CES, 2009), meaning that Tenerife would have supplies for one week in case of blockade (CES, 2008).

Table 6. Self-sufficiency of some products in the Canary Islands

Product	**Coverage level ([1]) (1990-1992)**	**Coverage level (2004-2006)**
Meat	21 %	18 %
Milk	13 %	9 %
Milk, butter and cheese	11 %	7 %
Eggs	95 %	77 %
Honey	27 %	36 %
Vegetables and legumes ([2])	163 %	124 %
Fruits ([3])	214 %	185 %
Cereals	2 %	1 %
Wine	27 %	19 %

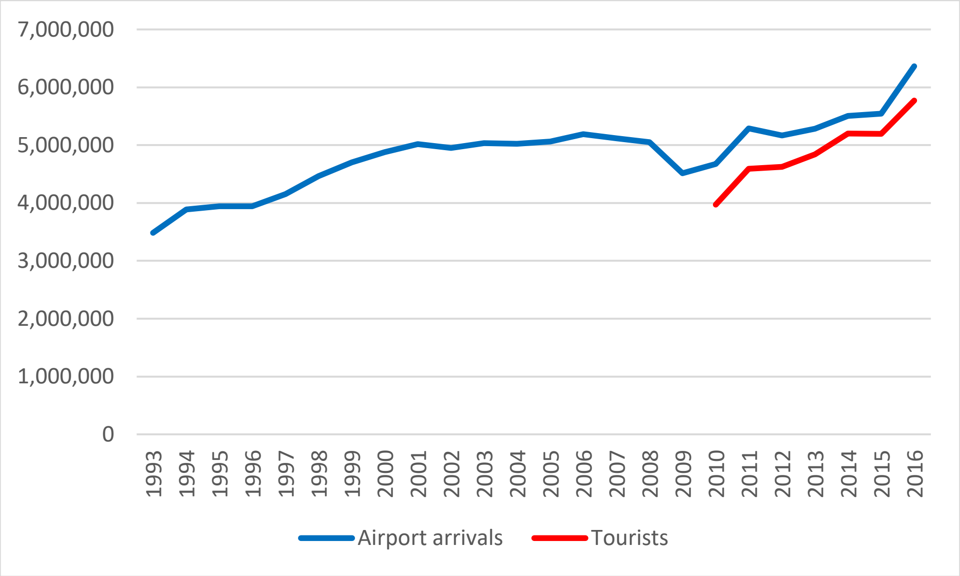
([1]) Local production/available supply (the latter considered as import — export + local production).
([2]) Includes tomatoes and cucumbers for export.
([3]) Includes bananas for export.

Source: CES, 2008.

5.2.1.2 Tourism sector

The evolution of tourism in Spain has been characterised by an increase in accommodation supply mostly concentrated (80 %) in Andalusia, Canary Islands, Catalonia, Valencia, the Balearics, and Madrid (MITC, 2007). The Canary Islands are one of the most competitive tourism resorts within the European Union (Díaz et al., 2005; Fernández and Diaz, 2011; Oreja et al., 2008), based on a conventional mass tourism approach that relies on the sun and beach product (Oreja et al., 2008). The same model of tourism has also been adopted for Tenerife: 5.8 million tourists visited the island in 2016 (see Figure 12).

Figure 12. Number of arrivals (to both airports) and number of tourists in Tenerife



Source: ISTAC, 2017a.

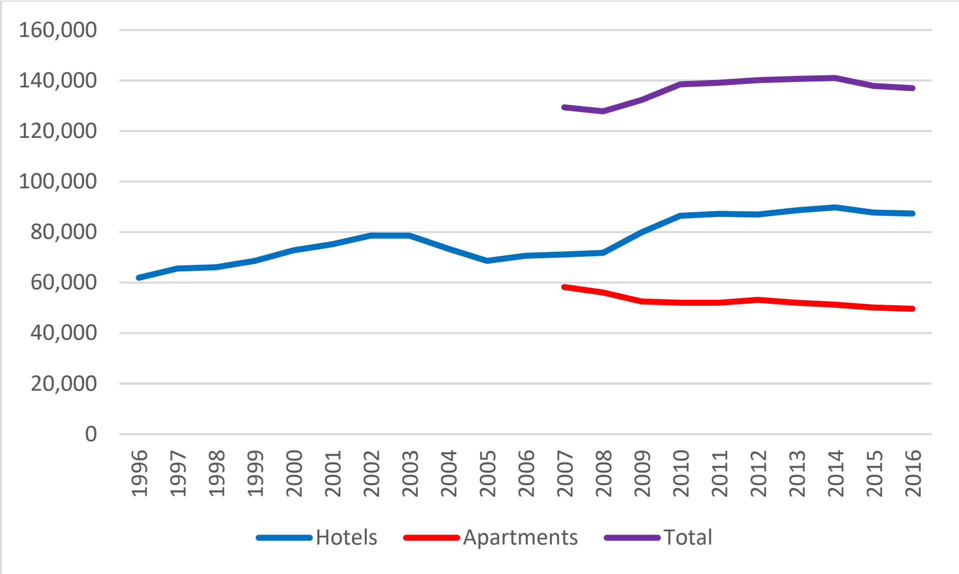
The tourism sector represents in the Canary Islands 32 % of the GDP and this sector accumulate 38 % of total employment (Exceltur, 2015). Furthermore, this sector also produces ancillary benefits on other sectors of the economy: each EUR 100 of added value directly generated in the tourism sector contributes to the generation of an additional EUR 50 in other sectors of the economy (Exceltur, 2015). The tourism sector is currently recovering in the Canary Islands, as pre-crisis levels have been achieved (CES, 2015). In fact, in Tenerife, the number of arrivals has remarkably grown in the last few years (see Figure 12).

However, this model of mass tourism is not sustainable (Martín, 2007). Poor land-use planning has favoured a high tourism development such that natural resources are now at risk, affecting the value and image of these resorts (MITC, 2007). Mass-tourism models externalises pressures on the environment, lost control over waste from cruise ships and increased coastal erosion (ECORYS, 2013). In Tenerife, the model of tourism development has been attractive to the construction sector such that building development linked to tourism have negatively affected the coastline (Oreja et al., 2008). The level of tourism pressure in Tenerife has been said to be high (Martín, 2007), representing Puerto de la Cruz, Adeje and Arona the Municipalities under most pressure (Fernández and Diaz, 2011). One of the consequences of this model of development is overcrowded beaches, traffic jams and damaged landscapes (Oreja et al., 2008). Concretely, according to Martín (2007) this model of mass tourism has associated a set of socioeconomic and environmental negative impacts:

— land speculation and massive coastal development projects;
— pollution by means of air, boat, and land transport, as well as energy consumption;
— increasing needs of transport infrastructures;
— increasing production of waste;
— increasing food demand (see also section 5.2.1.1);
— increasing leisure activities within natural spaces.

Nowadays, there is a clear situation of oversupply in terms of accommodation in the Spanish tourism sector, including the Canary Islands (Exceltur, 2005). However, this situation of oversupply (see total number of beds in Figure 13), as well as their associated negative social and environmental impacts, could worsen if the land available for additional tourism resorts is developed: according to Exceltur (2005) the supply of new beds could be tripled in the future.

Figure 13. Number of beds available in tourist resorts in Tenerife



Source: ISTAC, 2017f.

In terms of vulnerability, the tourism sector has been considered to be vulnerable to certain climatic events, such as the eruption of the Eyjafjöll volcano, which had an impact on tourist demand (European Commission, 2010). Furthermore, tourism services will experience constraints as a consequence of climate change, water scarcity and biodiversity pressure especially in mass tourism resorts (European Commission, 2010).

The tourism sector is also sensible to oil prices, due to the increase in fossil fuel prices produce impacts on both the demand and supply side (Exceltur, 2004). Firstly, the demand is affected in terms of arrivals, i.e. the higher the price, the lower the arrivals. Meanwhile, the supply side is affected in terms of increasing production costs due to the fact that 16 % of Spanish tourism running costs are associated to energy consumption. In fact, oil prices are expected to rise rapidly during the next two decades (as seen in section 5.1.2.3). Furthermore, aviation will not be able to fly with alternative fuels in the coming decades, therefore, the sustainability of this sector is undermined.

In a 'business as usual' scenario, the tourism sector could see «a rebirth of economic activities based on public investment and a gradual increase in private investment resulting from increased confidence of the different social actors. However, [this] revitalization patterns are based on pre-crisis behaviour, and the sectoral structure, the business activities and associated services maintain the same type of activity as before. Therefore, [tourism resorts may recover], but it does not adapt to the new reality of more sustainable tourist destinations, which places [Tenerife] in a position of vulnerability to external contexts and misses the opportunity of a possible transformation» (Corral et al., 2016, p. 13). A sun-and-sand tourism model, even with a certain degree of regulation, would not be capable of moving towards a more sustainable tourism sector (Oreja et al., 2008).

5.2.2 Society

5.2.2.1 Poverty and inequality

The unemployment rate in the OECD countries is expected to return to pre-crisis levels (Johansson et al., 2012). In the next coming years, Spain will undergo employment rate growth close to 2.5 % until 2019 (MEIC, 2015), whereas wages are also foreseen to rise (EC, 2017). However, the current Spanish unemployment rate reaches 18.6 % (INE, 2017a), whereas the level of in-work poverty, or 'low-paid workers', is one of the highest in the European Union (Padrón et al., 2016).

In the Canary Islands, job creation has been growing faster than the national average, at a rate of 2.8 %, especially in the construction and tourism sectors (BBVA, 2016). Nevertheless, the unemployment rate rise up to 24.9 % in the Canary Islands, and up to 24.3 % in Tenerife (ISTAC, 2017c). Furthermore, the average income in the Canary Islands is 18 % lower than the national average, i.e. one of the lowest incomes in Spain (CES, 2015).

27.6 % of the population of the Canary Islands are at risk of poverty (CES, 2015), considered as those households whose income is lower than the 60 % of the median income. This represent one of the six worse regions in Spain (CES, 2015). Moreover, 66.9 % of households in the Islands are not able to cope with unforeseen expenses, the second largest in Spain, whilst almost 60 % are not able to afford holidays, the fourth largest in Spain (CES, 2015). Almost one third of children live in relative poverty in the Canary Islands. Meanwhile, Tenerife presents indicators of poverty even worse than the Canary Islands average (see Table 7). For example, one out of four people are below relative poverty in Tenerife, whereas 80 % of households make ends meet with difficulty.

Table 7. Indicators of poverty for the Canary Islands and Tenerife (year 2013)

Indicator	**Canary Islands**	**Tenerife**
Households with severe poverty ([1])	7.3 %	7.5 %
Households with moderate poverty ([2])	14.1 %	15.3 %
Households below relative poverty ([3])	21.4 %	22.8 %
Population with severe poverty	6.8 %	7.0 %
Population with moderate poverty	15.9 %	16.9 %
Population below relative poverty	22.6 %	23.9 %
Households making ends meet with difficulty	77.4 %	79.8 %
Households with child poverty ([4])	31.3 %	—
Households with elderly poverty ([5])	18.5 %	—

([1]) Under EUR 228 a month.
([2]) Between EUR 228 and EUR 456 a month.
([3]) Under EUR 456 a month.
([4]) Children under 6 years old.
([5]) Elderly above 64 years old.

Source: ISTAC, 2017b.

The cause of poverty in the Canary Islands is not said to be the economic crisis, it is rather a structural problem that already existed before the economic downturn (Padrón et al., 2016). Poverty in the Canary Islands is a structural issue as a consequence of the existing economic model that relies on low labour productivity, concentrated in the service sector, intensive in the use of low-qualified workers (Padrón et al., 2016). Furthermore, the salaries in the Canary Islands are lower than those in the rest of Spain even for the same job and activity. As a consequence, the Canary Islands is one of the Spanish regions with higher levels of in-work poverty (Padrón et al., 2016).

According to Padrón et al. (2016) a 'business as usual' scenario, based on GDP growth reliance and palliative measures, will not solve poverty and inequality. Meanwhile, according to Frey and Osborne (2017), as seen in section 5.1.2.2, an economic model based on low-wage salaries may suffer high unemployment rates in one or two decades as a consequence of computerisation. Assuming, therefore, a 'business as usual' scenario, the social context for the future might be the following (Niño-Becerra, 2015):

- unemployment equilibrium: at least at the beginning, until the quantity of factors of production are required in each concrete period of time;
- underemployment of labour factor: due to surplus labour in a context of decreasing demand for labour;
- high structural unemployment: as a consequence of computerisation;
- end of the middle class: understood as a united group of people with productive employment and a sufficient wage to satisfy their needs;
- progressive evolution to the 1/3 society: 1/3 will be excluded, 1/3 will be partially required for production processes, and 1/3 will be required.

5.2.2.2 Social values and lifestyle

Regarding social values, the 'business as usual' scenario is comprised of a general individual and collective blindness with respect to current social and environmental problems (Aguilera, 2001). Moreover, the perception of the need to protect social and environmental problems might be reduced due to the economic crisis: during economic downturns, local residents tend to underestimate social and environmental impacts of economic activities, whereas they tend to overestimate economic benefits (Garau et al., in press).

Local islanders see the agricultural sector as an activity characterised by a low social prestige, whereas newer generations have already lost the traditional contact with local rural culture (Godenau, 2014).

The lifestyle in the Canary Islands is far from being sustainable. If the whole planet would assume the lifestyle of the Canaries islanders, almost four Earth planets would then be required to satisfy their social and economic needs (Fernández and Diaz, 2011). However, people tend to believe that technology and science will solve all environmental, social, and economic problems (Aguilera, 2001). Therefore, there is no need to change the current lifestyle.

5.2.3 Governance

5.2.3.1 Politics and decision-making

According to Aguilera (2007), decision-making in the Canary Islands, including the island councils and some municipalities, is essentially authoritarian (see its characteristics in Table 8), especially where the expansion of infrastructure is involved, e.g. transport and land-use. These authoritarian decisions do not respond to the public interest (Aguilera, 2003) but to concrete economic ones (Aguilera, 2009; see also section 5.1.3.1). In most cases, infrastructure projects in the Canary Islands are said to be an excuse to invest public funds to pay back previous favours to companies which have funded political parties (Aguilera, 2009). In fact, the Canary Islands have been reported to be the second region in Spain with more corruption cases per municipality, ahead of Madrid and Valencia (Jerez et al., 2012).

On the other hand, there is a deliberate interest in showing that democracy is only the act of voting (Aguilera, 2007), whereas citizen participation is thought as a formality that needs to be mentioned by politicians as an afterthought in land-use planning (Aguilera, 2003). Therefore, the islands are currently in a situation of environmental, social and democratic degradation (Aguilera, 2001).

To sum up, the environmental decision-making panorama for the Canary Islands may be characterised by the following (Aguilera, 2003, 2007):

— lack of public debate in policy-making processes;
— public 'information and consultation' is a formality in land-use planning, two of the lowest rungs on Arnstein ladder of citizen participation (Arnstein, 1969);
— unpunished violation of environmental legislation;
— frequent common economic interests between decision-makers and construction companies, potentially involved in public works;
— wasted public funds in unnecessary infrastructure expansion.

Table 8. Authoritarian versus democratic environmental governance

Authoritarian		**Democratic**	
Options?	**Legitimation**	**Options?**	**Legitimation**
• Solutions are predefined before framing the issue	• Given by 'experts' • Citizens bear the responsibility of testing the viability of the project	• What is the problem? • What are the key questions to be formulated?	• Creation of an space for argued public debate • Project promoters bear the responsibility of testing the viability of the project
• The unique solution has been previously decided and *a posteriori* justified	• Not independent experts • The payer rules • There is no argued debate	• What are the priorities? • What are the alternative options? • Who funds the project? • Who chooses the experts? • What are the values and interests at stake? • Is the project necessary?	• Consultation spaces and deliberation • Citizen juries • Scientific juries with independent experts and citizens • Protest rallies

Source: Aguilera, 2003.

5.2.4 Energy and technology

5.2.4.1 Energy and green technologies

In 2015, the Canary Islands were planned to cover 30 % of their net electricity generation with renewable energies (DGIE, 2007). However, the current level of renewable energy generation on the grid is around 8 % (CEICC, 2016). In the case of Tenerife, 30.6 % of net electricity generation was also planned to be covered by renewables by 2015 (DGIE, 2007), however, nowadays, only 8 % of the renewables generation are introduced on the grid (CEICC, 2016) ([1]). Since the electricity generation on the grid does not consider transport and distribution electricity losses, net electricity renewable production should be even lower.

In terms of primary energy, renewable energies were foreseen to cover 8.1 % of total demand for 2015 in the Canary Islands (DGIE, 2007). Today, the level of renewables in the total primary energy is less than 1.5 % (CEICC, 2016). Regarding natural gas, the Government of the Canary Islands projected a 20 % coverage of total primary energy, whereas the rest would be supplied by oil (DGIE, 2007).

Under this scenario, a continuation of the current energy policy is assumed for 2040, i.e. fossil fuels, either oil or gas, will be the main component of the energy mix.

5.2.5 Environment

5.2.5.1 Land-based transport planning

There are in Tenerife three main urban agglomerations that have the largest populations, most economic activities and the majority of inter-urban trips with distances between 40 km (from the North to the metropolitan area) to 80 km (from the metropolitan area to the Southwest). Thus, the island functions like a large sprawling city that accumulates 4.5 million hours lost in congestion only in the metropolitan area and its surroundings, costing EUR 109 million a year (Hernández González, 2014). Motorised mobility in cities is expected to double between current times and 2050 as well as transport emissions, despite the significant technological improvements within the transport sector (OECD/ITF, 2017). Meanwhile, the European Commission calculates that congestion costs might increase about 50 % by 2050 under business as usual trends (European Commission, 2011b).

According to the regional government, the island's road transport system is a clear example of unsustainable development (Government of the Canary Islands, 2003); however, the same Government has expanded the Island's road infrastructure as a response to high congestion (Ramos, 2005). One of the consequences of this infrastructural-based policy is that the land-based transport public administration expenses surpasses the revenues produced by the own transport system by at least EUR 11 million a year (Hernández-González, 2016).

Work, educational and leisure activities are the main purposes of inter-urban trips, with 62 % of these trips being made by car, while alternative transport means (bus, coach, tram, and taxi) account for 18 % and car-pooling for 19 % (Table 9).

In the late 1990s, the Island Council started to design a tramway as an alternative to road transport that would help improve the public transport system (Council of Tenerife, 2006a). In addition, a new road network was proposed to guarantee traffic continuity on the Island (Council of Tenerife, 2006b). Even though new road infrastructures can encourage new demand patterns and greater car use (Marina and Marrero, 2012), it was considered (and it is still today) the solution to island's congestion issues.

([1]) The authors are aware that the units of measurement are different; but the same units of measurement for proper comparisons could not be found. Thus, net electricity generation represents electricity production, less losses as well as the energy used during electricity generation (DGIE, 2007). Electricity on the grid represents the energy introduced on the electricity grid, less the energy used during the electricity generation; thus losses are not considered (CEICC, 2016).

Table 9. Land-based inter-urban transport patterns in Tenerife

Means of transport		Trip purpose	
Car	62 %	Work	37 %
Car-pooling	19 %	Leisure	14 %
Bus	9 %	Study	14 %
Tram	4 %	Shopping	9 %
Coach	3 %	Personal affairs	8 %
Taxi	2 %	Visiting doctor	4 %
Motorcycle	1 %	Accompany another person	3 %
		Take children to school	3 %
		Work affairs	1 %
		Others	7 %

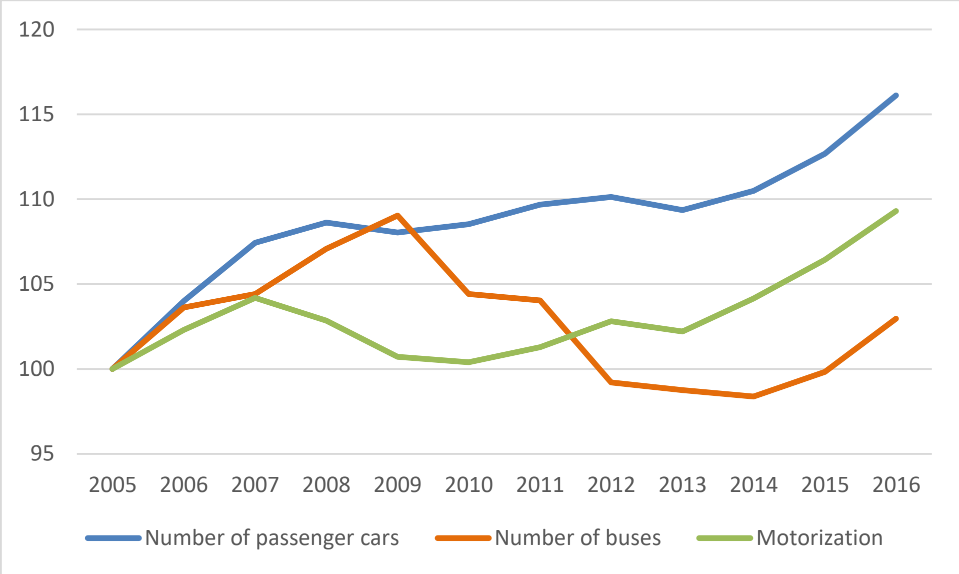
Source: Council of Tenerife, 2012b.

Nowadays, over 15 years later, these two plans have still not been completely implemented. Moreover, newer plans have been developed but not yet applied, due to either financial restrictions or social opposition, such as the southern railway infrastructure (Council of Tenerife, 2015), the northern railway infrastructure (Council of Tenerife, 2012a) and the transport coordination policy (Council of Tenerife, 2012b). Thus, Tenerife's transport policies might be described as a collection of disperse transport policies leading to a range of easily noticeable transport impacts in Tenerife (Hernández González and Corral Quintana, 2016).

This model of transportation has being said to be conditioned by fossil fuel energy limits (Calero, 2016). According to this author, the proposal of railways for Tenerife does not provide any advantage to the sustainability of the local transport system due to: (1) the rigidity of this model of transport; (2) its high environmental impacts; and (3) the need to go through municipalities by means of tunnels, producing isolation to many populated areas of Tenerife, such that many citizens would be obliged to drive their cars until the closest train station, increasing travel time and costs (Calero, 2016).

Under this scenario, a car-centred transport policy is assumed to continue, as presented in Figure 14, as well as its associated environmental and social drawbacks.

Figure 14. Land-based transport indicators for Tenerife



Source: ISTAC, 2017h.

5.2.5.2 Air quality

Regarding air pollution, there is evidence of impacts of air pollution in Tenerife. The *Hospital Universitario de Canarias* and the Izaña Atmospheric Research Centre found that exposure to ultrafine particles is associated with hospital admissions due to heart failure (Domínguez-Rodríguez et al., 2011), whereas black carbon has been associated with Acute Coronary Syndrome (Domínguez-Rodríguez et al., 2015, 2016). Other studies have also observed relationships between NO_2 and the ejection capacity of the heart (Domínguez-Rodríguez et al., 2013a) and between SO_2 and obstructive lesions and Acute Coronary Syndrome (Domínguez-Rodríguez et al., 2013b).

Concentrations of potential pollutant particles in pine forests have also been detected in Tenerife, possibly related to traffic emissions as well as sulphur transported from the industrial areas of Santa Cruz de Tenerife and Candelaria (Tausz et al., 2005). Meanwhile, it is also known that the exposure of vegetation to O_3 might imply injuries in Tenerife's vegetation (Guerra et al., 2004).

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; Rodríguez et al., 2008). This situation worsens under summer SAL conditions due to the concentration of the air pollutants at low altitudes linked to the downward shifts of the inversion layer and to heterogeneous reactions between pollutants and Saharan dust (Alastuey et al., 2005; CSIC-AEMET-UHU, 2010). A similar scenario occurs in the Valley of Güímar, where the inland NNE winds drag the pollutants transported from the metropolitan area and emitted in Candelaria power plant to the interior of the valley to the central ridge that crosses the island. In fact, traces of these air pollutants are transported upward across the forests to Izaña Observatory at 2 400 m.a.s.l., where they are detected during the upward upslope winds (García et al., 2014; Rodríguez et al., 2009). This transport of air pollutants within the Güímar Valley has implications on the residential areas.

Local governmental policies to deal with air pollution are restricted to technological improvements in both transport policies and industrial pollution (SIMAC, 2008). However, car electrification might imply certain improvement in air quality in the island hotspots associated to exhaust emissions, such as Santa Cruz de Tenerife.

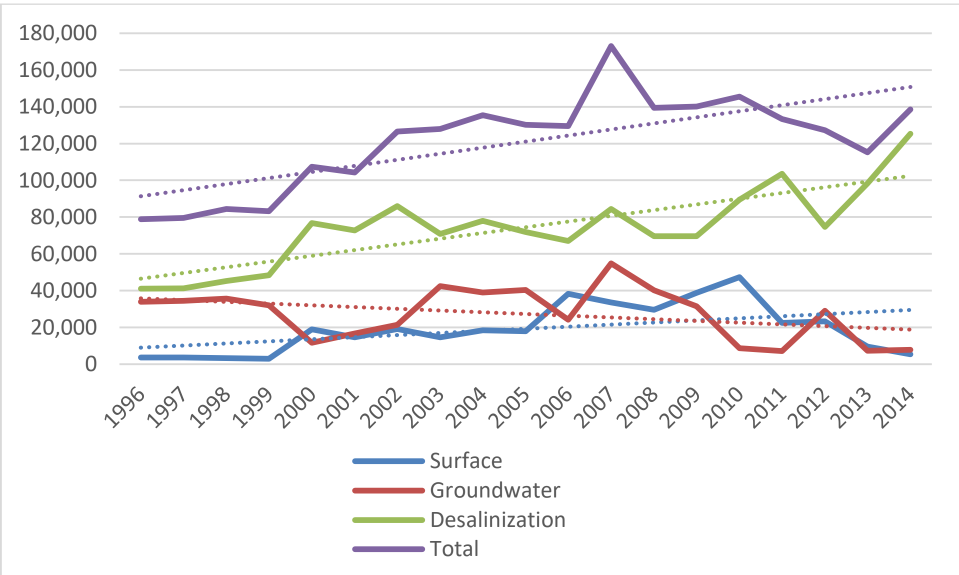
5.2.5.3 Water governance

Historically, water management in Tenerife has been done in a sustainable way, i.e. there was a potential water availability (Aguilera et al., 2000). Until the 19th century, surface water in the Canary Islands was a public and common resource that was then privatised and transformed into a commodity. Then, agricultural export crops induced groundwater pumping to increase profits, leading to the disappearance of most surface water courses. The increasing competition for water resources to be allocated to the export crops industry produced increasing withdrawals that caused aquifer over-exploitation as well as its ecological damage. This is what has been called 'social construction of scarcity' of water resources in Tenerife (Aguilera et al., 2000), which is currently aggravated by continuous drought conditions in the Canary Islands (Veza, 2001).

Nowadays, groundwater reserve depletion has reached about 2 km^3 (Custodio et al., 2016). The exploitation is being so aggressive that if today groundwater abstraction activities cease, the recovery time of groundwater resources would take up to a century (Custodio et al., 2016).

One of the consequences of the over-exploitation and reduced rainfall has been the need for new technologies and desalination of sea and brackish waters with fossil fuels (Aguilera et al., 2000; see also Figure 15). These technologies are intensive in energy use, consuming nearly 12 % of total electricity at a cost of EUR 200 million a year (Schallenberg et al., 2014), even though desalination energy efficiency is improving fast (Sadhwani and Veza, 2008). It is believed that this desalination dependence will continue in the future (Veza, 2001), whereas its dependence on conventional energy is said to be a major drawback (Schallenberg et al., 2014). This artificial abstraction of water has resulted in a lower social perception of the need for water management (Aguilera et al., 2000), leading to a loss of 'water culture' (Custodio et al., 2016).

Figure 15. Water catchment in the Canary Islands, by source (1 000 m^3)

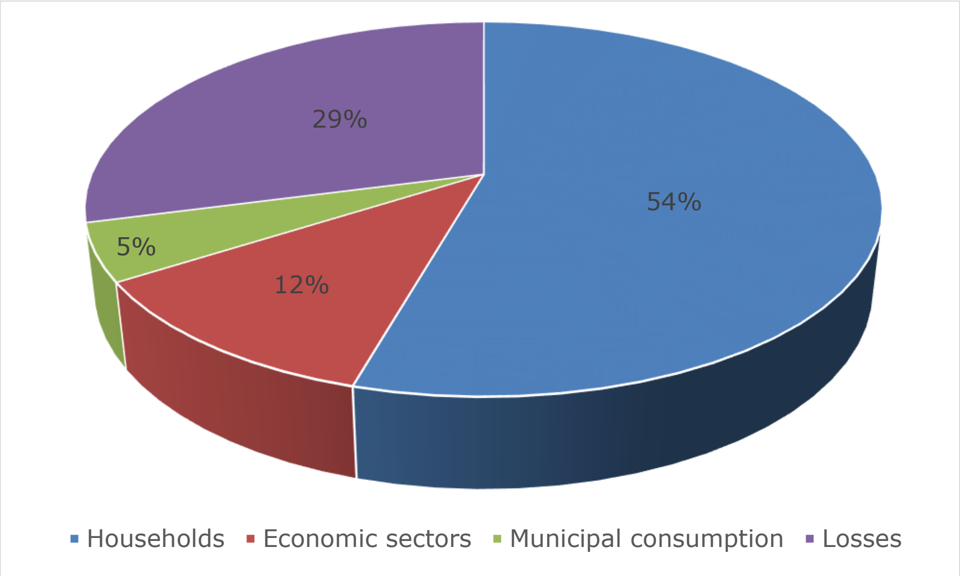


Source: ISTAC, 2017i.

To sum up, this socially constructed scarcity of water resources in Tenerife is characterised by the following aspects (Aguilera et al., 2001; Aguilera and Sánchez, 2005; EEA, 2009b):

— management of water resources focused on a supply-side approach;
— farming centred on bananas, which require large amount of water;
— water losses. Up to 29 % of the water distributed through the network in the Canary Islands is lost before being consumed (see also Figure 16);
— private ownership of water conditioned by the rules of competition among drillings ('first come, first served' approach);
— unequal distribution of ownership. Currently, few powerful owners control most of water resources (80 %), whereas a large number of smallholders possess little;
— lack of public control over water withdrawals such that water rights could be guaranteed;
— lack of control and management practices: until recently, massive amounts of water were dumped in the sea to prevent price reductions in summertime;
— reduced water quality as a consequence of overexploitation, infiltration of fertilisers and pesticides, and lack of sewage treatment systems in many parts of the island. Some municipalities have traditionally had high concentration of nitrates in the public water supply as a consequence of intensive farming activities and the use of nitrated fertilisers (Caballero et al., 2003).

Figure 16. Water distributed in the Canary Islands, by sector (year 2014)

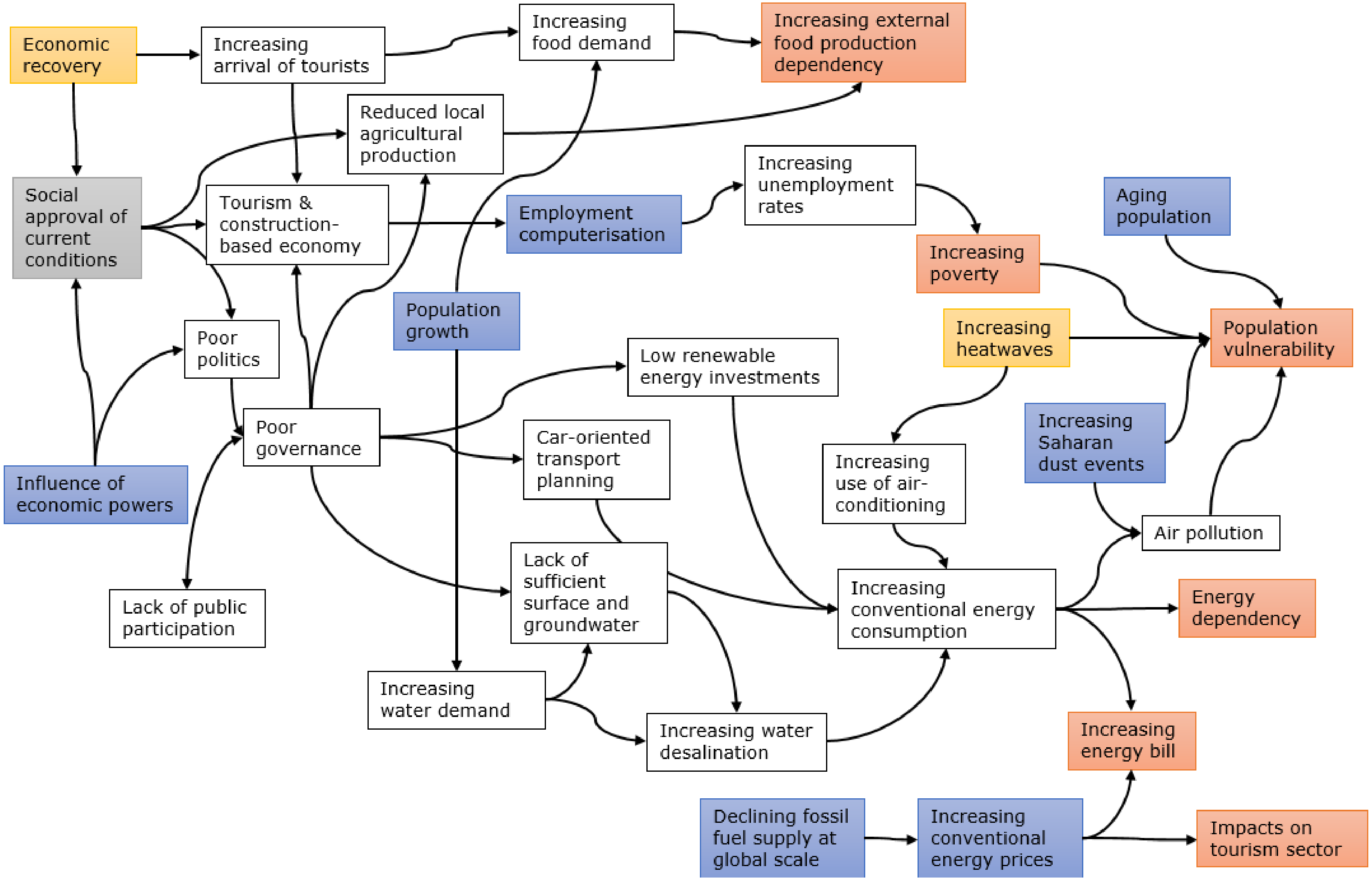


NB: losses refer to the ones produced within the distribution network, failures, fraud, measurement errors and consumption not measured.

Source: ISTAC, 2017i.

In the next Figure 17, the 'business as usual' scenario is unfolded. Blue boxes represent strategic invariants; the grey box represents critical uncertainty; yellow boxes represent driving forces that are both strategic invariants and critical uncertainties; lastly, orange boxes indicate the outcome of the scenario.

Figure 17. Unfolding the 'business as usual' scenario



5.3 Awakening

5.3.1 Economy

5.3.1.1 Reduced food production dependency

This scenario assumes the European Union's declaration on 'A Better Life in Rural Areas' establishing a new agricultural policy for the coming decades (EU, 2016). One of these policy orientations point out the need to strength rural value chains and local productive networks, especially to give support to fossil-free economies; whereas quality of life in rural areas will also be promoted so as to meet the aspiration of younger generations to be well-rewarded in agricultural-related employments.

Even though self-sufficiency in food production can neither be reached to all products nor without assuming high opportunity costs in the Canary Islands (CES, 2008, 2009), an increase in local food production is possible and desired so as to reduce the current external dependency and vulnerability in terms of oil shocks and environmental pollution (CES, 2008). According to Godenau (2014), agricultural resilience in the Canary Islands would probably imply a certain amount of self-sufficiency, which means something in between full independency and full dependency ([2]). Therefore, this 'in-between' scenario is here assumed since it reflects a more flexible economy that may easily adapt to either internal or external disaster-related shocks, e.g. compensating local production by imports when internal shocks are produced and the other way around.

This scenario undertakes concrete self-sufficiency targets as suggested in CES (2015). These targets are collectively established. The 'awakening' scenario also adopts efficient agricultural policies (CES, 2008), i.e. the POSEI and the rural development programme would focus on production intended to satisfy the internal market (Godenau and Nuez, 2013). Rural land will be more protected (CES, 2008), by means of land-use planning oriented to reduce urban sprawl (Godenau and Nuez, 2013). Access to agricultural land is also encouraged (CES, 2008), for example, through land banks managed by local governments (Godenau and Nuez, 2013). Access to water would also be important (CES, 2008), since consumption for irrigation is expected to grow under this scenario. Machín and López (2011) point out that: (1) efficient water distribution (i.e. reduce water losses across the water network); (2) improved irrigation efficiency (water input requirements should decrease per agricultural output); (3) improved water commercialisation system; and (4) increased water treatment would be required, and assumed for this scenario. Furthermore, due to local agricultural production is assumed to increase, the use of fertilisers too. Therefore, an increasing use of manure from livestock, as well as compost would also be needed (Machín and López, 2011).

Commercialisation and fiscal policies are improved. Industrial policies are used to encourage the industrial transformation of the primary sector (Godenau and Nuez, 2013). Short distribution channels are encouraged so as to give more importance to the proximity of local products (Godenau and Nuez, 2013), for instance, facilitating a direct link between producers and consumers by means of street markets, for example (Godenau, 2014). Awareness-raising is also assumed in order to promote the environmental quality of local products, providing information on the added value of local products, such as origin, identity and cultural integrity (Godenau, 2014). Meanwhile, bio-agricultural techniques receive more attention and subsidies so as to consider their external benefits.

Under this scenario, increasing levels of self-sufficiency, more employment and added value, landscape protection, and reduced desertification are therefore presumed (CES, 2008), as well as an increasing contribution of agricultural activities as a keeper of territory protection and 'gardeners of nature' (Custodio et al., 2016).

([2]) Godenau (2014) highlights that full production independency may increase vulnerability due to local production chains may be impacted by extreme weather events (such as droughts and floods).

5.3.1.2 Tourism sector

In this scenario, the tourism sector is assumed to continue relying on the sun-and-beach product, however, several changes are presumed to occur. There is an increasing need to reconcile tourism and sustainability (European Commission, 2010). «Traditional mass tourism, like sun-and-sand resorts, has reached a steady growth stage. In contrast, ecotourism, nature, heritage, cultural, and soft adventure tourism, as well as sub-sectors such as rural and community tourism are taking the lead in tourism markets and predicted to grow most rapidly over the next two decades. It is estimated that global spending on ecotourism is increasing at a higher rate than the industry-wide average growth» (UNWTO, 2012, p. 28-29). Thus, under this scenario, tourism stakeholders would consider climate change impacts and the scarcity of water resources, as well as the need to reduce pressure on biodiversity and cultural heritage (European Commission, 2010). However, to move towards a more sustainable tourism (or less unsustainable one) «would require modification of the flows of mass tourism that occur in a destination with a higher than normal level of control exerted by authorities» (Oreja et al., 2008, p. 56).

Ecotourism might then be seen as an option to attract eco-conscious tourists, by means of offering local products as well as environmental-friendly business practices (European Commission, 2014b; ECORYS, 2013). Under this scenario, several measures are assumed to be taken, such as (European Commission, 2014b): (1) an improvement of resource efficiency; (2) a reduction of waste and emissions; (3) an improvement of water efficiency; and (4) the development of cultural heritage based tourism and nature in coastal areas. Thus, this scenario follows the essential initiatives proposed by the European Commission's tourism strategy regards clean energy, sustainable transport and sustainable water use (European Commission, 2010), as well as the one proposed by the Spanish Ministry of Tourism (MITC, 2007).

Tourists seeking environmental and culturally destinations are willing to pay more (UNWTO, 2012). Therefore, shifting to a more sustainable (or less unsustainable) tourism model may create new jobs, especially related to energy, waste and water efficiency (UNWTO, 2012). This scenario may fit with a proposal for a more sustainable tourism in mature touristic destinations in Tenerife: «after the crisis resurfaces with a proposal of structural changes and a renewed commitment to being a sustainable tourist destination. The previous territorial and sectoral planning is changed radically, and there is a strong commitment to sustainable and innovative activities, […] with high added value» (Corral et al., 2016, p. 13). However, before going any further, this scenario may adopt two measures to divert the pathway to a more sustainable tourism: (1) a strategic management of tourism through the local communities; and (2) an analysis of tourism carrying capacity.

A strategic management of tourism in Tenerife is initially adopted. This strategy includes the various stakeholders' interests and tries to reach a consensus over certain economic, social and environmental objectives (Oreja et al., 2008); whereas the Spanish Ministry of Tourism pointed out the need to develop an assessment of the tourism carrying capacity by means of economic, social, and environmental criteria (MITC, 2007). The same measures have been proposed elsewhere (Martín, 2007). The World Tourism Organization defines tourism carrying capacity as 'the maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic and socio-cultural environment and an unacceptable decrease in the quality of visitors 'satisfaction' ([3]). This measure is currently under discussion among residents so as to mitigate negative effects of mass tourism expansion (Hernandez et al., 2017). Hoteliers may give support to this measure due to prices tend to increase as a consequence of the limitation in the accommodation supply (Oreja et al., 2008).

([3]) Cited in Coccossis et al. (2002).

5.3.2 Society

5.3.2.1 Poverty and inequality

As seen in the 'business as usual' scenario, poverty in the Canary Islands is related to the economic model, instead of lack of resources redistribution. The economic model is currently based on both the construction and tourism sectors, both founded on low labour productivity (Padrón et al., 2016), as well as high substitution risks by computerisation (Frey and Osborne, 2017). Thus, one way to increase the efficiency of the economy might be a structural change towards sectors where jobs are stable and workers are well-rewarded (Padrón et al., 2016). Therefore, the 'awakening' scenario assumes a take-off towards a different economic model that relies, especially, on a high-skilled sector such as the renewable energy industry (see section 5.3.4.1). Moreover, the agricultural (see section 5.3.1.1) and water (see section 5.3.5.3) sectors would also be encouraged under this scenario. Meanwhile, the tourism sector would be subject to an open public discussion to define a more sustainable path (see section 5.3.1.2).

According to the Technological Institute of the Canary Islands (ITC, 2008), there are at least three sectors that may have future opportunities in the Canary Islands (see Table 10). They are water management, renewable energies and sustainable tourism. According to the European Commission, investing in water management, insulation and energy efficiency of buildings, eco-tourism, and organic farming might involve future opportunities for job creation (European Commission, 2014c).

Table 10. Potential technological development

High potentiality		
Priority	Sector	Goal
1	Water extraction	Reduce the environmental impacts of desalination
2	Tourism: reinvent the sector	Innovation and sustainability to improve tourism resorts
3	Water treatment and reuse	Minimise the environmental impacts of water treatment and increase the use of purified water
Medium potentiality		
1	Water consumption	Minimise water use
2	Water distribution	Minimise water losses and produce micro hydro energy from the distribution network
3	Tourism: new markets	Change tourism demand towards eco-tourism
Emerging potentiality		
1	Energy: solar PV panels for buildings	Maximise building space to generate renewable energy
2	Energy: big wind turbines	Maximise renewable energy production in places with slow wind speed
3	Energy: bioclimatic architecture	Minimise the use of energy through passive measures, such as passive solar building design and isolation

Source: Own elaboration based on ITC, 2008.

Meanwhile, the European Environment Agency indicates, in its last report on renewable energies, the outstanding case of El Hierro Island regarding the construction of the hydro-wind power plant (EEA, 2016a). This initiative has increased El Hierro's energy self-sufficiency whereas this new energy system provides ancillary benefits in terms of water supply challenges and pollution mitigation. Increasing the use of renewables would be a source of job creation (European Commission, 2012; EEA, 2016b), whereas an economy based on both water management and renewable energies will need high-skilled workers (European Commission, 2012, 2014c), leading to a more resilient economy to business cycles (European Commission, 2014c).

5.3.2.2 Social values and lifestyle

The 'awakening' scenario assumes exactly the opposite values presented in the 'business as usual' scenario (see section 5.2.2.2). Now, social values and lifestyle are in line with resilience and sustainable principles. These desires have been stated during a series of focus group sessions carried out in November 2016 in Tenerife (see Table 11). Those sessions were used to detect, together with local citizens, scenario pathways for the future of Tenerife in the field of resilience and climate change adaptation strategies.

Table 11. Citizen statements given during focus group sessions in Tenerife

«I see a greater awareness regarding responsible consumption; I think it is essential to be aware of what we can contribute, simply by consuming less. Of course, this has to do with the responsible use, or the sustainable use, of local resources».
«What we have to do is to become aware that we have to change».
«There has to be an important awareness within our society».
«I believe that, by 2040, we will all have another type of consciousness».
«Collective intelligence involves an incredible power».

Source: Hernandez et al., 2017.

Therefore, a more active society in decision-making is assumed, especially when they are called to participate in environmental governance (see the next section 5.3.3.1). These social values demand sustainable policies as well as policies for a more resilient island. Governmental accountability is demanded, whereas local citizens require a strict governmental control over lobbies and political corruption.

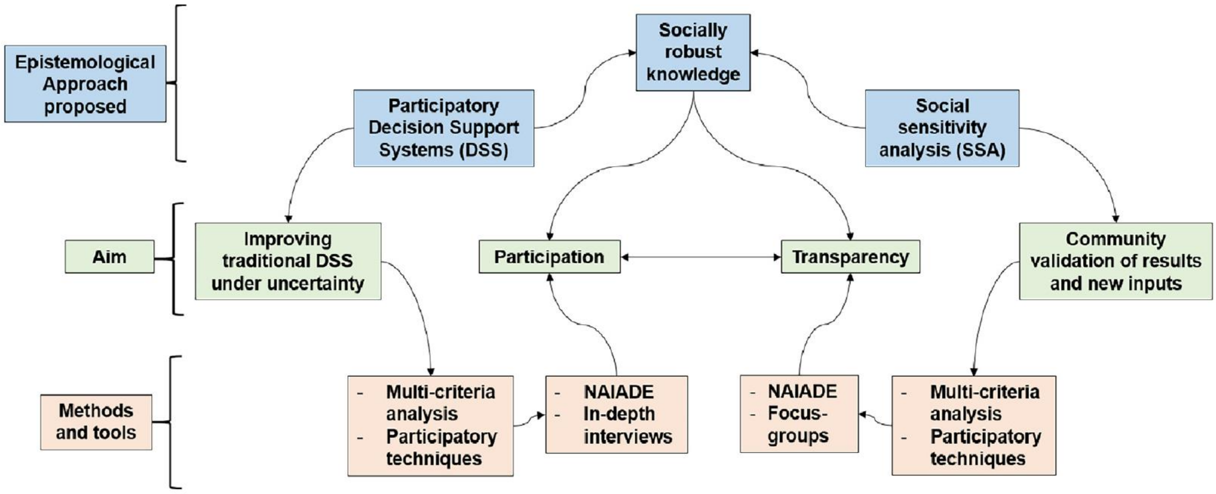
5.3.3 Governance

5.3.3.1 Politics and decision-making

Under this scenario, politics and decision-making represent the opposite of the 'business as usual' scenario (see section 5.2.3.1). The 'awakening' scenario would instead rely on democratic decision-making approaches (right-hand side in Table 8). This alternative way of environmental decision-making is encouraged by the new social values of local society (see section 5.3.2.2). Now, decision-makers are willing to change the way environmental governance is conducted (Aguilera, 2003), such that: (1) key questions are formulated during decision-making processes (what is the real problem to be analysed?), whereas a range of viable alternative options are also considered to solve environmental problems (what are the (full range of) options to solve the problem?); (2) argued public debates are promoted and independent experts are allowed to participate (including citizens), in order to clarify the environmental problems at hand, as well as the existing conflicts and stakeholders' interests.

Environmental decision-making takes therefore the form of a 'social robust knowledge approach' (Hernández-González and Corral, 2017) under this scenario. This approach (see Figure 18) consists of two steps: a first one aimed at developing a participatory process followed by a social evaluation of the robustness of the decision-making procedure outcomes. It is based on the concepts of participation and transparency: (1) participation is produced in both the assessment and post-assessment processes due to stakeholders and interested citizens are engaged in the environmental governmental process from the very beginning of the process until the end of it; (2) meanwhile, even though transparency is also produced in both processes, it becomes more relevant in the post-assessment stage of issues, where a social validation of results take place.

Figure 18. Social robust knowledge approach



Source: Hernández-González and Corral, 2017.

5.3.4 Energy and technology

5.3.4.1 Energy and green technologies

In this scenario, fossil fuel (oil and gas) prices are also assume to rise rapidly in the next two decades (see section 5.1.2.3). Within the international context, the deployment of renewables, energy efficiency, and electric car use are also assumed to become increasingly important. Renewable energy costs are also expected drop and therefore become more attractive.

Contrary to the 'business as usual' scenario, renewable energies are assumed to be explored in Tenerife as much as technologically possible. According to the European Commission, a scenario trend towards decarbonisation by 2050 is possible, and implies, first of all, improving energy efficiency, especially by means of eco-buildings and land-use planning. Whereas, a second minimum requirement is to switch to renewable energy sources. In 2030, the share of renewables may reach 30 % of gross final energy consumption. Whereas, by 2050, wind energy should be the main provider of electricity (European Commission, 2011a). This conclusions are also supported by the European Environment Agency. Thus, for example, economical competitive wind energy potential amounts to more than three times the projected demand in 2020 (EEA, 2009a).

The Canary Islands enjoy a rich supply of renewable energy sources especially from wind and sun natural resources (Ramos et al., 2007; Santamarta et al., 2014). In fact, «if the available roof area is used for PV [photovoltaics] purposes, a considerable part of the electricity demand could be met by solar energy» (Schallenberg-Rodríguez, 2013, p. 238). According to Santamarta et al., (2014), the Canary Islands amount large biomass potential, such that rural areas could become self-sufficient by means of small biomass-powered plants. The case study of El Hierro Island has also been mentioned by the

European Environment Agency as a successful outstanding example of how to implement innovative self-sufficient energy systems (EEA, 2016a).

The Canary Islands have sufficient potential for a fully renewable energy supply of power, heat, and land transport energy demand by 2050, whereas the projected gas infrastructure could be completely substituted by renewable energy technologies (Gils and Simon, 2017). «This changing nature of renewables requires changes in policy parallel to their further development» (European Commission, 2011a, p. 10). According to Gils and Simon (2017), a carbon neutral archipelago, 100 % renewable energy supply could be reached by means of:

- a strong increase in the installation of wind and PV capacities in the short-term;
- doubling wind capacity until 2020 and again by 2025;
- tripling current PV installations by 2020 and doubling by 2025;
- further development of wave energy, floating offshore wind (in case of grid isolation; see Table 12), and stationary fuel cells;
- a strong increase in energy efficiency, especially in the transport sector.

Table 12. Power plant and grid capacities for 2050 in Tenerife (MW)

Renewable technology	RE Base	Grid+
PV	2 876	2 876
Wind offshore floating	1 414	0
Wind offshore fix	428	163
Wind onshore	388	388
Combined cycle gas turbines	197	123
Total	**5 303**	**3 550**

NB: RE Base refers to grid connections between islands limited to those currently available, planned or considered as technically feasible. This implies a possible exchange between Tenerife and La Gomera only. Grid+ refers to an enhanced grid extension between all islands, thus providing one integrated power system over the entire archipelago.

Source: Gils and Simon, 2017.

This scenario could be reached either by connecting all islands in the Canaries (Grid+) or by connecting some islands (as presented in the RE Base). The RE(ference), base scenario, for Tenerife would imply a connection between Tenerife and La Gomera, leading to an increasing need of grid capacities across Tenerife. In a Grid+ scenario the needs would be lowered since excess of demand could be satisfied importing energy from the other islands (Gils and Simon, 2017).

5.3.5 Environment

5.3.5.1 Land-based transport planning

Even though transport demand is assumed to increase, buses and mass transit transport systems might cover more than 50 % of the total future demand (OECD/ITF, 2017). Cities have a great potential to move towards a more sustainable transport by means of developing walking, cycling, public transport and vehicles powered by alternatives fuels (European Commission, 2013a). In order to do so, three strategies are assumed to be undertaken within this scenario: (1) avoid unnecessary transport demand; (2) shift to sustainable transport options; and (3) improve efficiency. These three strategies are called the ASI approach, Avoid, Shift and Improve (EEA, 2016c).

'Avoid' implies to rethink if current transport demand is needed. New technologies may help to reduce unnecessary mobility, such as teleworking, online shopping, etc., whereas an optimisation of closeness between inhabitants and production and leisure activities is assumed to be adopted (Calero, 2016). 'Shift' implies a change from unsustainable transport to more environmental-friendly transport systems, such as walking and cycling, or public transport. First of all, cycling and bus infrastructures would need expansion (Calero, 2016). Secondly, tax distortions and unjustified subsidies are eliminated, whereas urban road pricing schemes are applied in order to encourage more sustainable transport choices (European Commission, 2011b). Fossil fuel taxation (based on the 'polluter-pays principle'), low transit fares and land-use policies limiting urban sprawl are also considered under this scenario (European Commission, 2011b; OECD/ITF, 2017). Public transport choices are widely available as well as walking and cycling infrastructures (European Commission, 2011b).

The 'Shift' actions need sustainable transport planning. Hernández González and Corral Quintana (2016) applied a participatory multi-criteria assessment to five alternative sustainable transport policy proposals. According to their results, a transport system based on: (1) bus infrastructure and bus service expansion; (2) a moratorium on road infrastructure growth; and (3) the establishment of discouraging measures for private transport were suggested to boost the sustainability of the local transport system by 2020. These results have been proven to be robust by means of (social) sensitivity analysis (Corral and Hernandez, 2017).

Lastly, 'Improve' refers to the application of new technologies and fuels to the transport system, especially to private transport, due to car use cannot be fully substituted by public transport systems in the Canary Islands (Calero, 2016). Thus, electric vehicles become a new way forward when neither non-motorised transport nor public transport are an efficient alternative option (EEA, 2016d). As seen in Figure 19, also pointed out in Colmenar et al. (2017), the sustainability of electric vehicles should be in line with the sustainability of the energy system (see section 5.3.4.1).

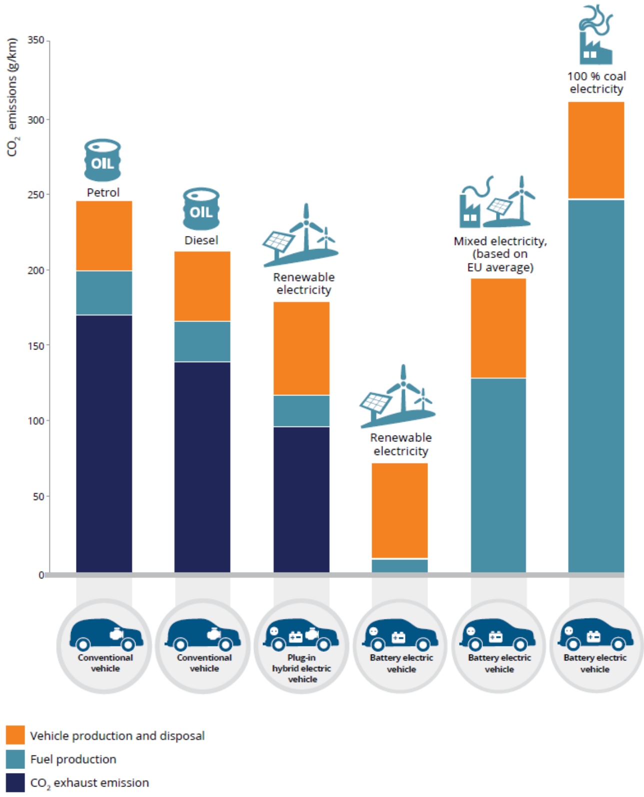
According to Gils and Simon (2017) the combination of a modal shift towards buses, the shift to propulsion technologies and efficiency gains in engines might lead to a reduction of road transport energy demand by around 60 % in 2040. Most fuels may rely on electricity, followed by fossil fuel, hydrogen and biofuels (the latter as well as fossil fuels would be on their way to disappear from the transport energy mix). Fuel cell cars will become relevant around 2030, especially for heavy-duty vehicles.

5.3.5.2 Air quality

As seen in section 5.1.4.2, Saharan dust events are a natural cause of air pollution in the Canary Islands. It is known that winter dust season events have increased by a factor of 2 since 1980. Meanwhile, summer dust events are related to an inversion layer at low altitudes that leads to air pollution episodes as a consequence of local industrial and transport emissions. Both, Saharan dust events and industrial and transport pollutant concentrations are known to produce negative effects on population health. Even though the effects of climate change on the evolution of Saharan dust outbreaks are under discussion (Alonso-Pérez et al., 2007), ageing population may involve a larger exposure to this climatic hazard.

However, this scenario may involve a remarkable reduction of air pollution due to energy and transport renewable energies deployment. As seen in section 5.3.4.1, Tenerife and the Canary Islands may rely fully on renewable energies. Besides, as seen in section 5.3.5.1, land-based transport could also become more sustainable due to energy use reduction, an increasing reliance on non-motorised and bus transport, as well as the introduction of green technologies and electricity to the private transport system.

Figure 19. Life-cycle CO_2 emissions for different vehicle and fuel types



Source: Verbeek et al., 2015 (taken from EEA, 2016d).

5.3.5.3 Water governance

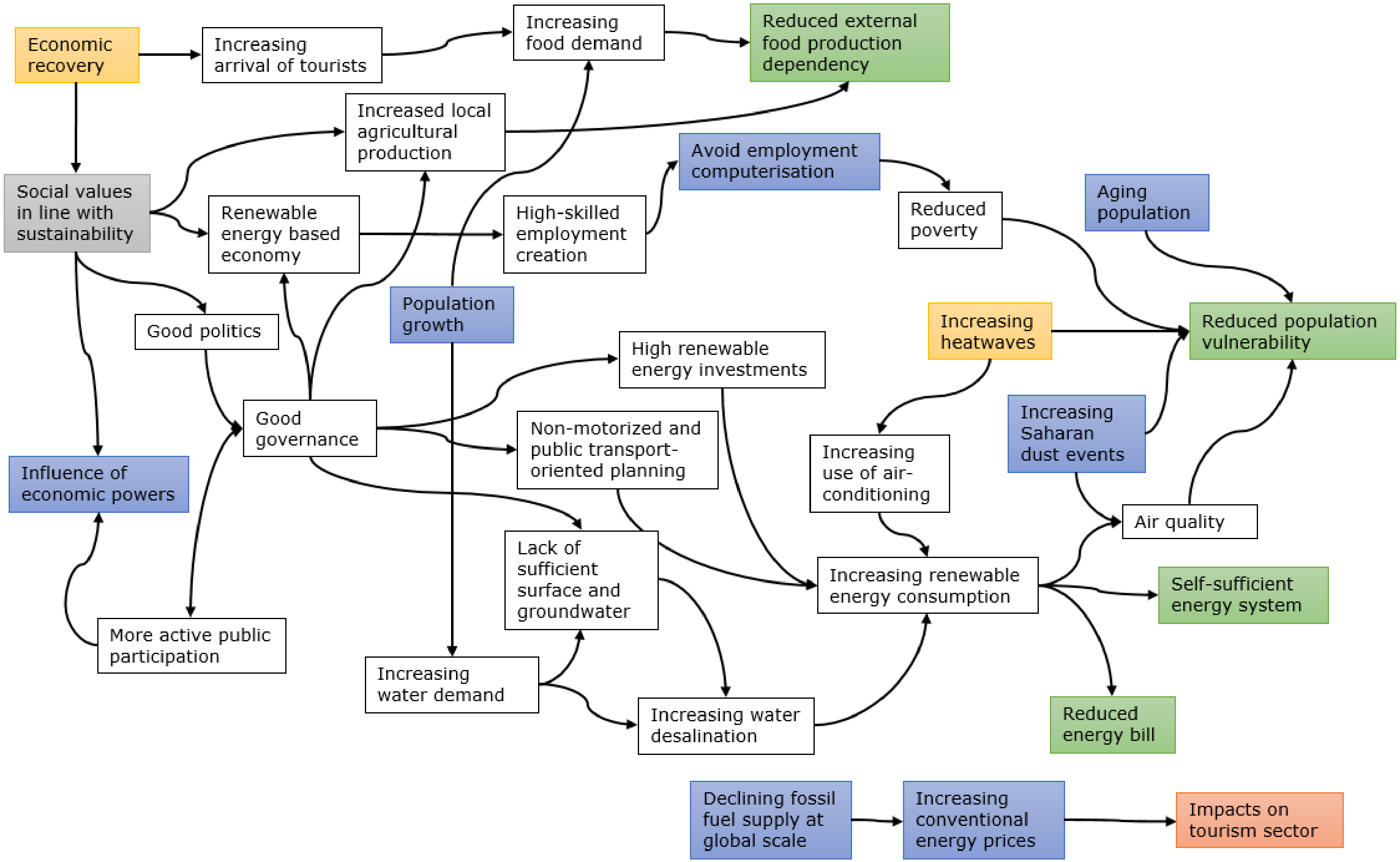
As seen in the 'business as usual' scenario, water resources are currently in a situation of depletion (Aguilera et al., 2000; Custodio et al., 2016) that have led to sea and brackish water desalination infrastructure expansion (see Figure 15). Therefore, the situation is not easy to curb. However, several measures are assumed to be carried out within this scenario. They consist of a sustainable demand-lead approach for water resources management, intended to adapt to climate change and reduce energy consumption from the water sector (EEA, 2009b). This approach is aimed at avoiding that water use exceeds ecosystem biophysical limits in the future (EEA, 2012).

According to the European Commission and the European Environment Agency, actions can take place in different areas in order to improve water quantity and quality (European Commission, 2013b; EEA, 2009b, 2012). They are assumed for this scenario. The first action concerns water accounts. Thus, knowing how much water is available is essential in order to distribute the resources sustainably, whereas leaving enough quantity to nature. Secondly, water efficient targets and water stress indicators are monitored for all water users (agriculture, industry, and households). Third, water pricing is applied in order to reflect the full costs and water resource depletion, which means the establishment of clear links between price and volume of water consumed. Four, water leakage (including illegal water abstraction and use) is reduced as much as economically feasible.

According to Aguilera et al. (2001) and Custodio et al. (2016), a certain number of specific actions can also be carried out within this scenario: (1) public water regulation and control of groundwater conditions as well as private sector activities in order to have (2) a sustainable use of water resources, based on water use restrictions and water consumption reductions aimed at helping the aquifer to be recovered in the long term; (3) a redistribution of rights over water access and use, deciding which water uses are to be provided; and (4) better water governance based on stakeholders, experts and citizen involvement in water planning (EEA, 2014; see also section 5.3.3.1) as well as the establishment of an independent institution in charge of water resources.

Regarding the supply-side, wind driven seawater desalination is assumed as a latent option to reduce the environmental impacts of desalination at reasonable costs (Romero et al., 2005). This is linked to renewable energies deployment, explained in section 5.3.4.1. Figure 20 presents how the awakening scenario unfolds.

Figure 20. Unfolding the 'awakening' scenario



5.4 Collaborative communities

The main idea behind this scenario is the development of a 'collaborative economy' based on 'alternative consumption' approaches. This change is initially led by a small part of an active local society that perceives the vulnerabilities of the 'business as usual' scenario, and does not believe in Governmental-led changes anymore, due to «it is unrealistic to expect the policy and political leaders to lead that social change» (Brown and Vergragt, 2016, p. 314). This 'collaborative economy' is not however seen as new opportunities for entrepreneurs and economic growth (European Commission, 2016b), but as a transition towards sustainability and resilient societies (Martin, 2016).

5.4.1 Economy

5.4.1.1 Food production dependency

The superstructure conceived for the 'business as usual' scenario remains. That is, conventional agricultural land continues to shrink, whereas local food demand increases as a consequence of both population growth and increasing tourist arrivals. Governmental policies remain the same for the agricultural sector, i.e. subsidies are allocated to export crops as well as imported food commodities.

However, a minor part of the local society refuses to assume this panorama and begin to establish alternative networks toward agro-ecological farming. An interesting example is the one undertaken in Belgium (Bloemmen et al., 2015), called Community Supported Agriculture, which is based on organic vegetables production in a peri-urban context, where farmers sell their products directly to a community of consumers. Each member of the community is allocated the same share of production and then a fair price has to be paid for a box of products. Other examples at national level can be found in Spain, such as the *Transition Network* (http://www.reddetransicion.org/).

In Tenerife there are interesting examples implementing collaborative-based initiatives, such as the one undertaken in '*Finca El Mato Tinto*' in Tacoronte (Sánchez García, 2017). It is a non-profit organisation aimed at: (1) disseminating the principles of permaculture; (2) promoting job creation for people with special needs (e.g. with mental illnesses); (3) promoting crop production of native plant varieties and livestock, while conserving and disseminating the natural heritage of the island; and (4) promoting the participation of social engagement in permaculture.

Other example is the so-called '*Ecotribu Con + Conciencia*' in La Laguna (http://www.ecologistasenaccion.org/article30565.html). It is an alternative consumption initiative at local level where users and producers come together twice a month to exchange vegetables for a fair price that guarantee farmers a fixed income over the year. Decisions affecting the group are made democratically between all members during assemblies. The group also promotes awareness-raising campaigns within schools and other educational institutions.

Other alternative agro-ecological farming initiatives can be found in Tenerife. For example, in Arico there is the so-called '*Proyecto San Borondon*' (http://www.proyectosanborondon.es/) and in Puerto de la Cruz the one called '*Grupo de Consumo Espacio Asamblea*' (http://espacioasamblea.com/). Both following the same paradigm than '*Finca El Mato Tinto*' and '*Ecotribu Con + Conciencia*'. All these groups are integrated in the project LASOS (http://www.proyectolasos.com/), an acronym for Agro-ecological Sustainability Laboratory, which is a pilot project for the integration of economic, environmental and social dimensions for a more autonomous island.

5.4.1.2 Tourism sector

The evolution of this sector remains the same to the one presented in the 'business as usual' scenario, i.e. sun-and-sand resorts rule the tourism sector. The economic situation of this sector improves in the coming years in terms of number of arrivals. This sector continues delivering ancillary benefits on the rest of the economic sectors, accumulating around 40 % of total employment.

As seen in the 'business as usual' scenario, this model of mass tourism remains unsustainable, especially damaging the coastal landscapes. The increasing arrival of tourists induces the construction of new infrastructures, such as roads, ports, etc., leading to additional environmental impacts.

Minor alternative activities may take place among the most aware population. A local example of this alternative way of doing tourism is the Association '*Desaplatánate*' (http://desaplatanate.org/es/frontpage/). It is a non-profit organisation aimed at promoting the development of an alternative, social and sustainable tourism model that improves the living conditions of the local population, guaranteeing the respect for the local nature and the cultural values of local communities.

5.4.2 Society

5.4.2.1 Poverty and inequality

As for the 'business as usual' scenario, big changes are not assumed to occur for this scenario. Employment may grow along with the economic activity, but poverty (including in-work poverty) continues to rise, since the economic model remains relying on low labour productivity and low salaries. Whereas computerisation may also put at risk low-wage jobs.

It is also assumed that, as for the 'business as usual' scenario, 1/3 of the population become socially excluded. However, the explosion of 'collaborative community' networks might provide opportunities for those who felt apart providing certain levels of dignity. Now, Community based networks exerts as a 'parallel State' that might reduce poverty and vulnerability of those excluded from the mainstream society. One of the most interesting examples is the one carried out by the agroecological farm '*Ecotribu Con + Conciencia*' (http://www.ecologistasenaccion.org/article30565.html). This group, since its inception, facilitated that people who had lost their jobs during the financial crisis as well as people who had consumed all their unemployment benefits were able to harvest abandoned agricultural land to provide a group of consumers with biofood production (vegetables and fruit especially) in exchange of a fair and stable price along the year. The farmers have therefore guaranteed an income for the years to come, whereas consumers have the option of buying high quality products at fair prices. This network has grown to the extent that those previously unemployed (today's farmers) cannot attend the current demand. A waiting list had to be created as a response ([4]).

5.4.2.2 Social values and lifestyle

The social values assumed for this scenario are aligned with a new framing of wellbeing, consisting of a shift from consumerist lifestyles to stronger sense of community (Brown and Vergragt, 2016). Furthermore, social innovation (understood as meeting social needs more effectively by means of social actors' participation) becomes more relevant (Mont et al., 2014). This social innovation processes are also seen as a positive contribution to local sustainability, due to social values rely on collaboration, local economies, and self-sufficiency (Sekulova et al., 2013).

Now, leisure time is seen as a way to communicate with others, as well as an opportunity to encourage self-development, contribute to the community and professional networks (Mont et al., 2014). Moreover, people are perceived as the engine that transforms the world instead of politicians. However, these values are assume to work very slowly due to these values move against the current dominant imaginary (Romano, 2012), as seen in the 'business as usual' scenario.

([4]) Personal communication.

5.4.3 Governance

5.4.3.1 Politics and decision-making

As for the 'business as usual' scenario, local economic powers and private interests might colligate with mainstreaming political parties to maintain the *statu quo*. Thus, mainstreaming governance would continue implementing policies that might increase the vulnerability of the island.

Politicians show a lack of interest in resilience and sustainability. The backbone of policies is based on the expansion of infrastructure, whereas public participation in decision-making remains the same as presented in the 'business as usual' scenario. Political and corporate corruption may endure at the same pace infrastructure expands.

5.4.4 Energy and technology

5.4.4.1 Energy and green technologies

As seen in the previous scenarios, fossil fuel supply capacity will decline at global scale, inducing an increase in oil and gas prices during the next two decades. Even though renewable energy prices will become attractive, a low renewable energy investment is assumed, as for the 'business as usual' scenario; therefore, energy planning for the Canary Islands will continue to be ignored due to poor environmental governance. The expected consequences are increasing energy bills, air pollution problems (partially compensated by car electrification), and a continuation of external energy dependency.

However, these facts encourage social innovation and social movements to support 'collaborative energy networks'. An increasing amount of conscious people get involved in groups of producers/consumers of green energy. Thus, both consumers and producers are the same agents within those groups.

A group like this already exists in Tenerife, called '*Som Energia*' (https://www.somenergia.coop/es/quienes-somos/#quehacemos). It is a cooperative of consumers producing and distributing 100 % renewable energies by means of the existing network. The cooperative's capital is funded by their members and the energy produced is consumed by the same members. Other existing movements are the so-called 'Proponents for a new energy model for the Canary Islands' (http://www.nuevomodeloenergetico.org/pgs2/index.php/news/nace-la-plataforma-por-un-nuevo-modelo-energetico-para-canarias-px1nmec/), which gives support to a new energy culture in the Islands, based on the concept of energy sovereignty and renewable energy development.

5.4.5 Environment

5.4.5.1 Land-based transport planning

In general, the mainstreaming land-based transport trends are not expected to become sustainable, the same as for the 'business as usual' scenario. Again, both the Government of the Canary Islands and the Island Council are committed to expand road transport and passenger cars, whereas railway infrastructures might also be introduced at high opportunity costs (Calero, 2016). Urban sprawl continues and the island will continue working as a big sprawling city encouraging private cars.

Notwithstanding, social innovation may bring forward alternative modes of transport that might reduce the unsustainable levels of land-based transport. Some initiatives can be mentioned, such as the car-sharing example of BlaBlaCar (https://www.blablacar.es/coche-compartido/santa-cruz-de-tenerife/), intended to bring together private transport supply (in terms of passenger-km) and transport demand at a given social cooperative price. Thus, road congestion may be reduced as well as air pollutant emissions.

An increase in bicycle use, as the mode of transport most often used, might also be assumed for this scenario, especially for those people conscious of resilience, such as the groups '*Tenerife por la Bici*' (http://tenerifeporlabici.blogspot.it/). In fact, there is a huge margin of improvement in this matter due to only 3 % of commuters in Spain use the bicycle every day as a main mode of transport, compared to the 36 % in the Netherlands, 23 % in Denmark, or 22 % in Hungary (European Commission, 2014a).

5.4.5.2 Air quality

As seen in the previous scenarios, Saharan dust events are a natural cause of air pollution in the Canary Islands. However, as indicated, the relation between climate change and Saharan dust outbreaks is still under discussion, highlighting the uncertainties involved in the evolution of this climatic event. What is almost certain is the expected larger exposure to this climatic event due to population growth and ageing.

Again, as for the 'business as usual' scenario, air quality might be improved partially by means of car electrification. However, the energy system will continue relying on fossil fuel sources.

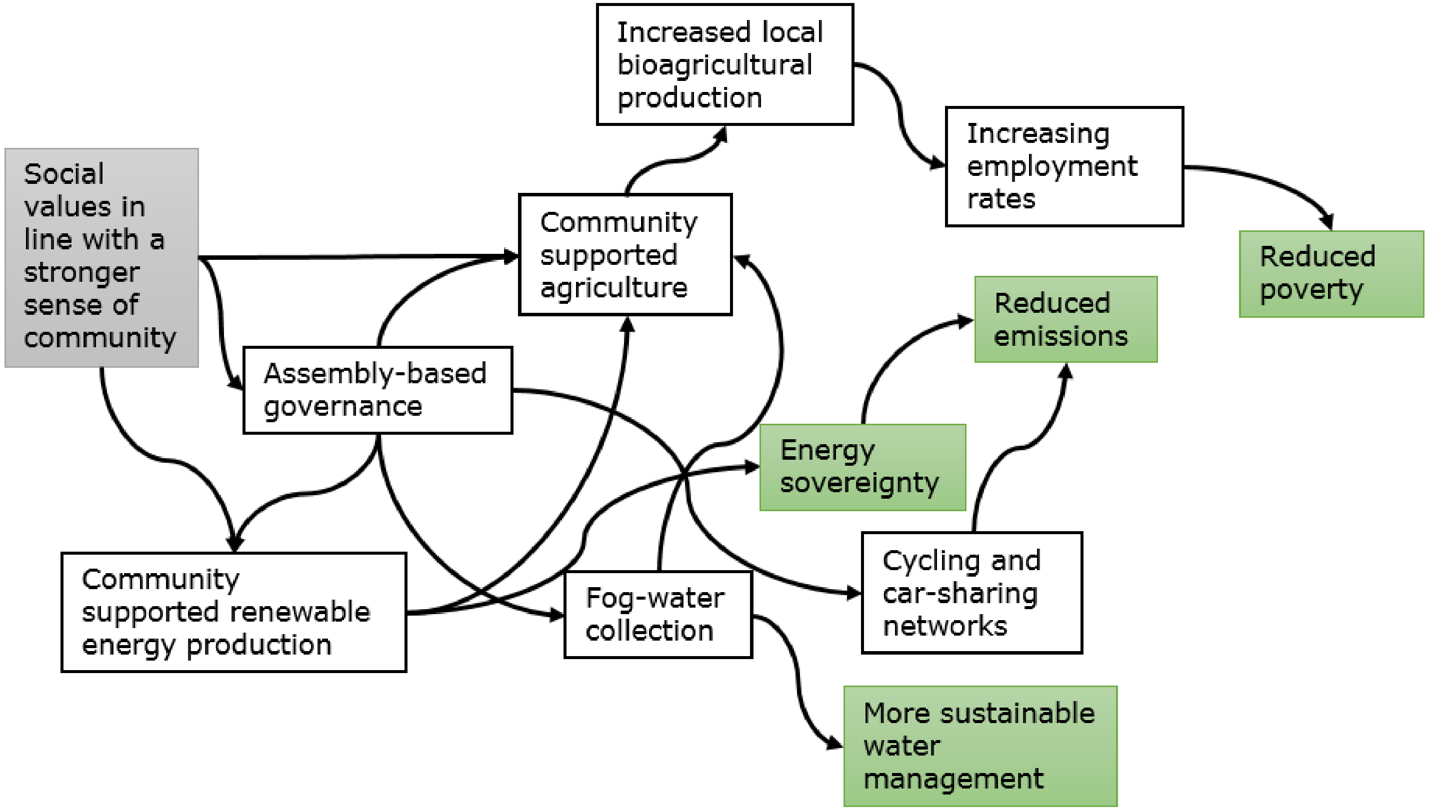
5.4.5.3 Water governance

As for the 'business as usual' scenario, water resources may continue unsustainably managed since the current water demand exceeds the available natural water resources, especially as a consequence of groundwater depletion. The quantity of losses produced within the network may continue in the long term. Again, this situation requires desalination technologies so as to provide the exceeding demand with freshwater. Even though desalination technologies are expected to become more efficient in terms of energy use, the expected fossil fuel dependency may lead to remarkably conventional fuel dependency for water production. Furthermore, water production remains concentrated in powerful stakeholders, whereas the dependence on desalination is assumed to worsen in the long term.

This panorama may encourage social innovation and alternative movements to explore the potentials of fog-collection catchment, especially by collaborative agricultural communities. There is capacity to collect at least 170 m^3 of water from clouds in the Teno Rural Park in Tenerife (Marzol Jaén, 2002), as well as 880 litres of water per m^2 in the Anaga Rural Park (Marzol, 2008). Fog-collection techniques may be further explored by alternative 'collaborative economy' supporters, so as to increase water sovereignty within those alternative groups.

In Figure 21 the scenario is unfold. In this case the scheme does not reflect how the whole system may work in the future; instead, it shows how collaborative communities might interact between them to collaborate and help each other towards the pathway of building resilience.

Figure 21. Unfolding the collaborative communities scenario



6 A descriptive comparison

In Table 13 a qualitative comparison of the scenarios is presented. The horizontal axis present the scenarios, whereas the vertical axes show the outcome of each scenario analysed.

Table 13. A descriptive comparison of scenarios' outcomes

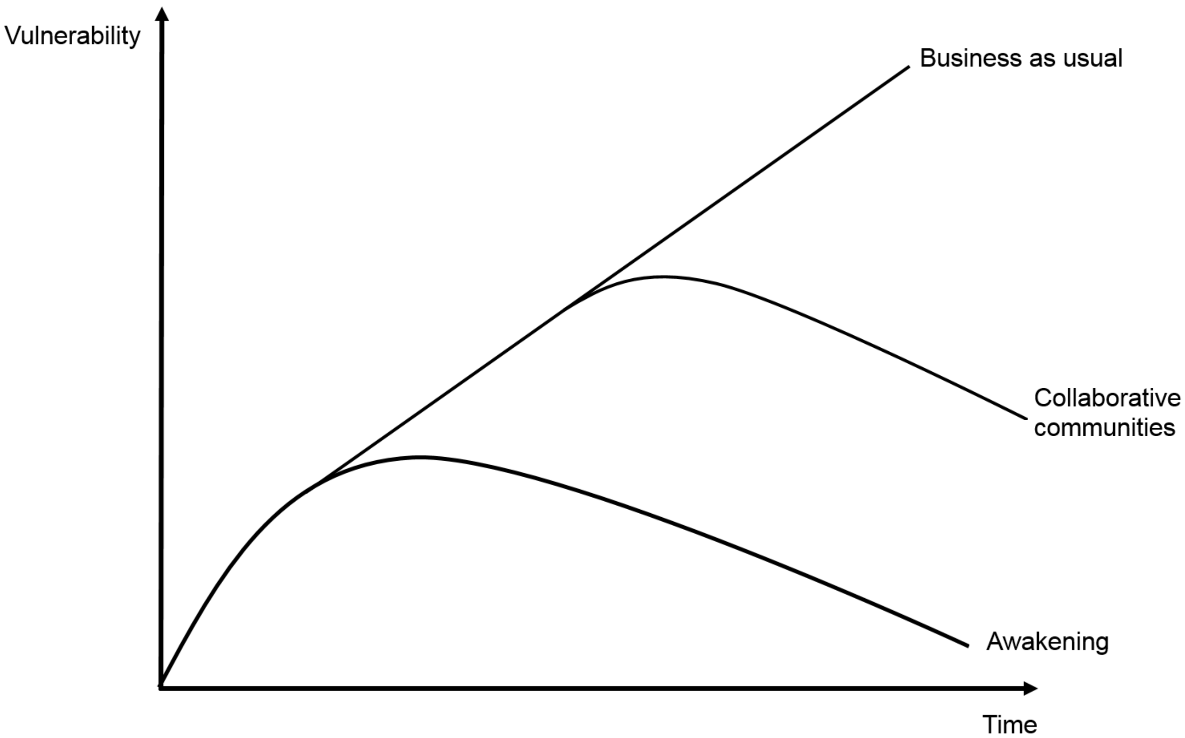
Scenario performance	Business as usual	Awakening	Collaborative communities
Energy management	The energy system remains environmentally unsustainable, depending on fossil fuels. Gas may substitute oil as the main source of energy.	The energy grid, as well as the land-based transport system, become energetically sustainable. PV and wind energy become the main source of energy.	The energy system remains environmentally unsustainable within the mainstreaming economy. However, collaborative communities become producers of green energy to satisfy their own demand.
Energy sovereignty	Depends on fossil fuels (oil and gas) and, therefore, from external supplies. The energy bill increases sharply within the coming decades due to increasing fossil fuel prices.	A fossil fuel-free economy is reached. Both electricity supply and the land-based transport system become 100 % renewable. The island becomes energetically independent, and the energy bill drops remarkably.	The mainstreaming economy depends on fossil fuels (oil and gas) and, therefore, from external supplies. The energy bill increases sharply in the coming decades. Collaborative renewable energy groups growth steadily.
Water management	Water resources are unsustainably managed. Groundwater is depleted and increasing water demand is satisfied by supply-side solutions, such as desalination (powered by fossil fuels).	Unsustainable water management is publicly recognised and demand-side schemes are adopted based on efficient water-pricing. Desalination continues, but relies on renewable energy sources. Groundwater may recover in the long term.	Water resources are unsustainably managed by the mainstreaming economy. Increasing water demand is satisfied by desalination (powered by fossil fuels). However, alternative collaborative communities begin to explore fog-water collection for irrigation.
Food self-sufficiency	Food production dependency grows as a consequence of both increasing local and tourist demand and reduced local supply.	Food production dependency is reduced due to increased local food production. This initiative is encouraged by local governments.	Food production dependency remains high. However, community supported agriculture expands steadily and becomes partially relevant in the island. Energy and water needs may be satisfied by other collaborative networks.
Tourism sustainability	Relies on sun-and-sand resorts. Quantity is considered more important than quality.	Relies on sun-and-sand resorts. However, new trends push for a more ecotourism-based sector. Quality may become more important than quantity.	Relies on sun-and-sand resorts. Minor groups try to provide sustainable alternative options for local and foreign tourism without much success. Mainstreaming tourism lingers on.
Poverty/inequality	Remain or get worse, since the roots of poverty are linked to the economic model. This model is based on low-productivity jobs. Computerisation may produce more unemployment.	Drops since the economic model relies on research, innovation and greener technologies. High-skilled workers and well-rewarded jobs are required, avoiding partially the consequences of computerisation.	Remain or might improve slightly. Even though the mainstreaming economic model persists, the collaborative economy may exert as a parallel welfare State within their alternative community groups.
Environmental quality	Emissions from the electricity grid increase, whereas land-based transport emissions might be reduced due to electrification and new fuels. However, a car-centred transport system may induce additional environmental impacts.	Emissions from the electricity grid and the land-based transport system are reduced to zero. The land-based transport system relies on non-motorised transport, as well as public transport systems. More efficient and environmental-friendly technologies will also improve environmental quality.	Emissions from the electricity grid increase, whereas land-based transport emissions might be reduced due to electrification and new fuels. However, a car-centred transport system may induce additional environmental impacts. Collaborative groups may improve slightly the environmental quality due to their sustainable activities.
Human health	Climate risks rise due to increasing hazards (more frequent and intense heatwaves), increasing exposure (population growth) and increasing vulnerability (ageing and poverty). Air pollution might improve due to car electrification.	Climate risks might rise due to increasing hazards (more frequent and intense heatwaves) and exposure (population growth). Vulnerability increases due to ageing but it is also reduced due to poverty alleviation. Air quality improves remarkably.	Climate risk rise due to increasing hazards (more frequent and intense heatwaves), increasing exposure (population growth) and increasing vulnerability (ageing and poverty). Air pollution might improve slightly due to car electrification, car-sharing and an increasing cycling movements.

In Table 14 a qualitative visual comparison of the scenarios is presented. Green arrows indicate improvement, orange arrows indicate continuity, and red arrows show a decline. Fig. 22 also presents a visual comparison of the scenarios.

Table 14. A qualitative comparison of scenarios' outcomes

Scenario performance	Vulnerability		
	Business as usual	Awakening	Collaborative economy
Human health			
Poverty/inequality			
Tourism sustainability			
Energy self-sufficiency			
Energy sustainability			
Food self-sufficiency			
Water use sustainability			
Environmental quality			

Figure 22. A visual comparison of the scenarios



Source: own elaboration.

7 Conclusions

Scenario building may be described as a puzzle composed of existing-disperse information regarding a certain issue that need to be brought together in a single piece so that future pathways of a given *problematique* can be explored. In this case study, the concept of resilience has been analysed in a small European island (Tenerife, Canary Islands). To the authors' knowledge, this is the first attempt to narrate possible future scenarios of socioeconomic resilience for a small island.

Due to scenario building should be intensively participatory such that the outcomes may be successful and worthwhile (Raskin et al., 1998; Schwartz, 1991), a participatory approach has been applied in this case study in order to explore future pathways along with the extended communities of Tenerife island. Key social actors on climate resilience and citizens were engaged in the process since its inception. A range of social techniques were applied, such as in-depth interviews, questionnaires, and focus groups, in order to identify future pathways as well as the components of scenario building, e.g. critical dimensions, driving forces, strategic invariants and critical uncertainties.

Three future 2040 scenarios were described. A first scenario explored the future of Tenerife under a continuation of current policies and socioeconomic forces. Thus, the external dependency of food, energy, and water (since the latter depends on desalination by means of fossil fuels) produce a low resilience to hypothetical external shocks. An economic model based on sun-and-sand tourism and the construction sector is the base for vulnerability to computerisation (since low skill jobs are more vulnerable to robotisation), potentially leading to unemployment and larger poverty rates, reducing the resilience of local communities, especially to climatic events.

The second scenario images Tenerife under sharp changes in social values. Social values are aligned with the concepts of resilience and sustainability. Therefore, these changes are translated into politics and policy-making. The island becomes 100 % fossil-fuel free, and local agricultural production increases to the extent that a larger amount of local food demand can be satisfied with local products. Water desalination can now be satisfied with renewable energies. The need for research and development to give support to the fossil-free economy works as a catapult towards a transition to an economic model that demands high-skilled workers, much less susceptible to computerisation.

The third scenario narrates how the future of Tenerife could be if a business as usual scenario continues, but a certain part of the local society decides to explore resilient initiatives without Governmental support. This might be the case of collaborative communities encouraged by small groups of residents who become organised in cooperatives of consumption, producing their own bio-agricultural, green energy and water needs. These initiatives might provide with certain coverage and protection to those who felt apart in the mainstream society.

One of the findings of this research, points out the uncertainties involving the sustainability of the tourism sector. It is known that a mass tourism economy based on sun-and-sand resorts have associated negative impacts on the local environment, especially in coastal areas. It is also known that there is neither alternative fuels for aviation nor expected revolutionary technologies; therefore, sustainable transport in the tourism sector is still a utopia.

The second key finding highlights the identification of the concept '*resilience*' as the reinforcement of the nexus between water-energy-food sovereignty. Understanding how these three sectors may become as much self-sufficient as possible, as well as how they may interact sustainably has been identified as a potential research area that might give room to a change in the local economic model so that a high-skilled job economy can be achieved. As seen, these jobs and areas of knowledge are much less vulnerable to computerisation, since these jobs rely on human innovative ideas, a skill that cannot be substituted by algorithms (Frey and Osborne, 2017).

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