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Sanders, Fred C.; De Oliveira, Ana Cláudia

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# Resilience of coastal cities with accumulating climate-change coupled threats; depends on the cooperation of government, experts and the citizens

F C Sanders<sup>1</sup>, A C de Oliveira<sup>2</sup>

<sup>1</sup> Delft University of Technology, Faculty of Architecture and the Built Environment; Urbanism department

<sup>2</sup> University of Lisbon, Faculty of Architecture, CIAUD

Corresponding author's e-mail address: [FSAdvies@gmail.com](mailto:FSAdvies@gmail.com)

## Abstract

Most cities in the world are coastal cities, especially facing accumulating climate-change coupled threats. These cities are precisely the ones that are growing the fastest, what makes this development a risk for millions of people in our world. These accumulating threats happen when seawater-level rise, clustered heavy rainfall, and meltwater river-level rise fall occur simultaneously. Within the H2020 Marie Curie 'SOS Climate Waterfront' 2019-2021 research program, researchers exchanged between coastal cities in Europe to explore whether they are aware of the need for resilience, and how the resilience in these cities is structured systematically. Aiming for the accelerated adjustment of the research methodology, the situation of three EU islands was examined as a sidekick. Thereby Actions/Actors-diagram is developed as a tool. The conclusions are: this diagram helps to make the positions of actors clear, helps to clarify which measures are being worked on, and can help to identify any obstacles to work on resilience. In relation to the situation on the three islands, the diagram also helped to clarify the reason for the blockade. It has been concluded that for this type of research it is important to first properly visualize the local situation, and to make extra efforts to talk to many experts and make extra additions to interview citizens connected to community initiatives.

**Keywords:** climate change, mitigation, adaptation, built environment, coastal cities.

## 1. Introduction; how infrastructural circumstance blocks solutions.

In January 2019, the H2020 SOS Climate Waterfront project started from-out six founding-father cities spread over Europe: Lisbon (Portugal), Venice (Italy), Thessaloniki (Greece), Gdansk (Poland), Stockholm (Sweden), and Amsterdam region in the Netherlands (SOS climate waterfront|H2020-MSCA-RISE-2018|823901). In 2019, the cities Lisbon, Gdansk, and Thessaloniki were visited simultaneously by multi background groups of secondees. Although reports are not yet available, the first observations of the Dutch participants were:

- a) Lisbon (Portugal); is a coastal city of 2,5 million residents on the Atlantic Oceanfront where the Tagus river ends in the seawater. Although the 1755 tsunami happened more than 250 years ago, the city people are still aware of the potential threat from the sea, because around 15.000 people (one-third of the city population in those days) died. The threat of sea-level rise by climate-change is therefore taken very seriously. Physical interventions to adjust the coastal strip are in preparation; construction in the danger zone remains difficult because the locations on the coast are popular and valuable [source: interviewing APA and the Municipality representatives by F. Sanders) (Sanders, 2019).
- b) Gdansk (Poland); a riverside city of 0,5 million residents, where the Motlawa River ends in Leniwna river, a western branch of the Vistula River, at the Baltic Sea. Here, the canalization of the Motlawa River that made the city accessible for inland shipping in the past, created the situation of an upstream rainfall that often leads to a not acceptable high river water level, resulting in an increasingly city suffer from flooding in recent years – from which the 2001 flooding opened the eyes of the local people and the municipality. It is still unclear how seawater level rise of the Baltic Sea will aggravate the situation. Solutions are not yet in sight, because the expansion of the city takes place along the riverbank. (ARCADIS, 2019).



- c) Thessaloniki (Greece); a city with a little more than 0,3 million residents, where the rivers Axios and Vardar end in the Thermaic Gulf in the northwest corner of the Aegean Sea. The city is increasingly bothered by backwater in the bay, due to the climate-change changing coastal currents and the river rise, by increasing heavy rainfall. Due to the fact that the city is built on the historic old remainings of former cities since its foundation on 315 BC, every physical intervention shows to be blocked by protection rules of monumental artefacts. [source: UNESCO heritage- Ref: 456 - Date of Inscription: 1988].

Two observations can be made by analysing these three city-related results: 1. Climate change makes the situation in these cities more critical, and 2. local conditions block the implementation of measures.

The SOS Climate Waterfront project has a lead time of three years ending in December 2021. Therefore, results and conclusions will become clearer later during the project's development. By the analysis of the research results, and the blockades proved by the three first case situations, it was chosen to explore three parallel isolated cases, for the following reasons: for a better deepening of these first three blockade observations; to methodologically adjust the project where necessary in time; to give the goal of finding realistic action-perspectives more likely, related to the UN Sustainable Development Goals in the built environment.

Therefore, the research question is: *'what measures can be envisaged for coastal cities to deal with the changing conditions of climate change; how are these linked to actors, and is the research method of the SOS Climate Waterfront project methodologically structured enough to recognize the promising measures?'*

## 2. The H2020 SOS Waterfront related side-kick research set-up

Three case-studies were selected as a side-kick off and for support of the H2020 SOS Climate Waterfront program. Three case-studies were selected concerning relatively small EU islands, because the situation of an island is defined with clear boundaries, where climate-change effects and the local reactions and actions can be placed under the magnifying glass of the researcher for making a scientific quick-scan observation and analysis for robust results, in time for the H2020 program starts to manage its own analysis.

Therefore, three islands spread over the EU continent were chosen: Texel in the Netherlands, Madeira in Portugal, and Malta (see Figure 1.). Because these islands are situated in sea areas under pressure of aggressive weather and water related conditions, there are climate-change programs on these islands in operating the stimulation of awareness under the local residents. Their relatively small size fosters the researchers' local scientific contacts to sustain the results during the research progress.



Figure 1. The islands Texel, Madeira, and Malta (from above to below); [using Google Earth].

In the Netherlands, the DCBA conceptual framework was developed in 1993 [www.boondelft.nl], a methodology to clarify sustainable measures to rank these scales (D), a normal level (C), sustainable level (B) and sustainable quality A); to discriminate climate-change-related actions and place these in a scale of varying from 'doing nothing' by maintaining the existing situation, to 'active intervention'. With the insights of today more active in use, are the approaches of 'mitigation' and 'adaptation'; only these are not

placed on a scale like the DCBA framework. For a scientifically responsible analysis of the H2020 SOS Climate Waterfront city situations and circumstances, a more diversified bandwidth scale should be desired. Therefore, the two frameworks for this research are brought together to create a diversified bandwidth based on current concepts, and this is coupled to actors in the diversity of government like municipalities, institutions as research institutes and enterprises, and residents individually and in groups, and initiatives organized (see Figure 2.).

ACTIONS / ACTOR	MITIGATION (D)	ACTIONATION (C)	ACTIONATION (B)	ADAPTATION (A)
GOVERNMENT				
INSTITUTIONS				
RESIDENTS				

Figure 2. Visualizing Actions/Actors by climate-change countermeasures for a situation in a quadrant.

For research on climate-change effects and action handling on these islands, desktop research is done; by which two threats and the local reaction were worked-out, analysed and checked with local informants. The factors used for the analysis were: the threat, accidents on the timeline, the safety of the city and its residents, the chosen action out of the available action possibilities, the effects, the acceptance of the people also related to costs, as related to the UN Sustainable Development Goals 3, 11 and 13, and the challenges of the built environment at coastal cities that are under pressure of climate-change coupled changing circumstances of the worst.

### 3. The three case-studies: Texel (NL), Madeira (Pt), and Malta.

For the various selected EU islands, an inventory has been made of the following: the most critical issues on the islands due to climate change; the countermeasures given by the government, governmental bodies and residents as a population and in the form of resident-initiatives; and the results according to the relevant UN SGD's. Besides clarifying illustrations, the positions of actors with their institutional background, in relation to the type of actions varying from 'mitigation' to 'adaptation' related to climate-change countermeasures, are visualized in the by Figure 2. given diagram, in order to present the mutually different positions of the actors clearly and comparable, to facilitate analysis and comparison of the case-studies chosen for the possible working-out of action-perspectives for similar situations.

#### 3.1 Texel, in the Netherlands

Texel island in the northwest of the Netherlands is surrounded by open water, the North Sea on the west and the mudflat area called 'The Wadden Sea' on the east side. With its population of 15.000 residents, Texel for the Netherlands is a typical tourist location with more than a million visitors every year.

##### *Most critical issues due to climate-change*

Already in 1990, there was the signal that seawater rise by climate change could have a severe influence on the character of the islands' circumstances: the change of seawater current and therewith the morphological change of sediment abrasion and deposition, and the reposition of the natural seaside defence system of dunes and the flooding of dikes (Misdorp et al., 1990). The Delta-commission, the highest governmental advisory organ stated in 2017 – and updated recently – that the Netherlands should take coastal defence precautions because of climate-change, assuming more difficult circumstances than the IPCC indicates: 0,86 instead of 0,46-meter sea-level rise at the end of this century (Ronde, 1993).

Successively, more and more accurate forecasts for the effects of climate change have been mapped in recent years, showing impacting cumulation of negative developments (Ligtvoet et al., 2013), attack on the coastal defence system and salination (Deltares, 2018).

The effect of this is that the Texel island will be confronted with two major developments: a relatively unprotected east side of the island, and an increase in salinization with a negative impact on the agriculture on the island in special tulip bulbs and potatoes – as given attention by the 'North Sea Region Climate-

change Assessment’ (Quante and Colijn, 2016). It will be necessary to strengthen the east side dike and increasing the pump-capacity for getting out the water from the strip of land behind the sea-dike; see the negative salinization forecast in Figure 3. (Pauw et al., 2012).

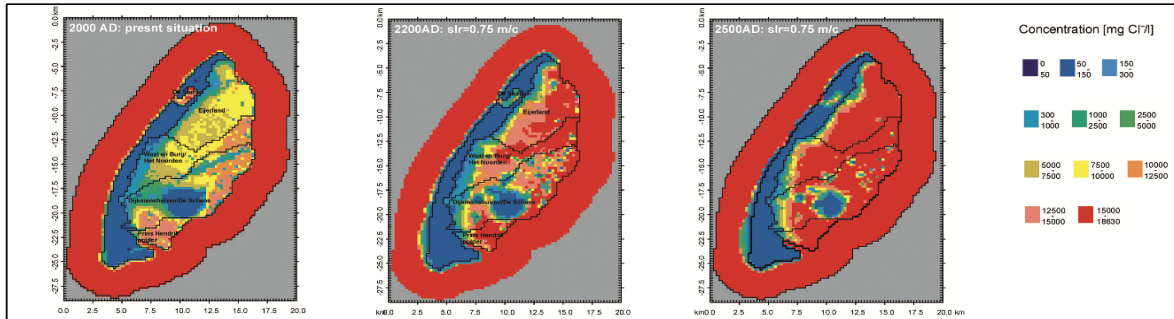


Figure 3. Simulation salt load by sea-level rise of 0,75 meter per century (Pauw et al., 2012).

*Countermeasures by governmental bodies and residents*

According to the HHNK Waterauthority [in Dutch, HHNK stands for Hoogheemraadschap Noorderkwartier], responsible in the area for maintaining the safety of the island, the outside sea-related defence system and the inner island quantity and quality water situation, the reconstruction of the east side sea-dike has started in 2019 and, therewith, the capacity of the polder pumping stations was started to be upgraded [https://www.hhnk.nl/waddenzeedijk] (see Figure 4.).



Figure 4. Reconstruction Texel’s East side sea-dike [right], and pump capacity [left] [Source: HHNK].

In the meanwhile, local farmers started a network of measuring points to accurately follow the salinization in the surface water on the island, because in their opinion the Waterauthority was using a too limited number of measuring points [https://www.texelwater.nl/nieuws/meetnet-voor-honderden-boeren].

By interviewing representatives of the HHNK Waterauthority and the local farmers collective, it has become clear that the situation will still be critical in the coming decennia, even with the major investments in operation. The measures of the Waterauthority have a strong defensive character of ‘mitigation’, in which the formal government target is leading, while the farmers (whose tulips and potatoes depend on the effect) are looking for solutions that provide more long-term security. This creates a situation where a further search for adaptive measures is blocked, although the farmers’ initiative keeps the pressure on to develop new measures in the coming years, by debating among them on the island. Figure 5. shows the position of both actors in the action/actors-quadrant, whereby the farmers’ network of measuring points supports the program of the Waterauthority and their pushing for new more ‘adaptation’ measures.

Texel, NL				
ACTIONS / ACTOR	MITIGATION (D)	ACTION (C)	ADAPTATION (B)	ADAPTATION (A)
GOVERNMENT				
INSTITUTIONS	●			
RESIDENTS		●		

Figure 5. Visualizing Actions/Actors by climate change countermeasures on the island Texel (NL)

*Results according to the relevant UN SGD's:*

1. *UN SGD 3 Good health and well-being: increased risk in the long term of stress among residents.*
2. *UN SGD 11 Sustainable cities and communities: reduced chance to continue living on the island.*
3. *UN SGD 13 Climate action: mitigation and mixed actions by governmental bodies and residents.*

### 3.2 *Madeira, a Portuguese Island*

Madeira is an archipelago with a population of around 250 000 inhabitants in 740 km<sup>2</sup>, and is composed of 2 main islands. Madeira (the largest one) and Porto Santo, more to the Northeast (the smallest one). Madeira island is located at the latitude of the Northern African coast (32° 45'N of latitude and 17° 00'W of longitude), and its terrain is structured by volcanic origin, with rugged orography: high peaks and deep ravines.



Figure 6. Madeira-Marina (culturetrip.com) (left); and Madeira-cruise Funchal (cruisemapper.com) (right)

#### *Most critical issues due to climate-change*

The CIELO model research results indicate that temperatures will rise and rainfall will reduce at Madeira island in the coming decennia. In fact, the changes in precipitation correspond to a significant annual loss of water (of the order of 1/3 of current values) (Santos et al., 2004), with negative influences on the unique flora and fauna and its biodiversity on the island, impacting on several natural ecosystems that may be threatened by a drier climate, namely a large area of protected humid forest (where Laurel-forest is declared to UNESCO World Heritage in 1999) (AMAC&BIO-IN., 2014), which also negatively affects the availability of Madeira's water resources. Secondly, the sea-level rise will harm the seaside tourist facilities, with a negative impact on the economic situation of its residents (Surugiu et al., 2011).

#### *Countermeasures by governmental bodies and residents*

The situation for Madeira is that measures should be developed by the Regional Government of Madeira, supported by the Department for Spatial Planning and the Environment in Lisbon. Although the Portuguese government has worked-out climate-change impact assessments, for the outer islands Madeira and Azores there is no regional strategy on climate change developed yet (AMAC&BIO-IN., 2014). With the focus on tourism, The Regional Government of Madeira has developed a re-qualification plan for the tourism sector to manage the changing tourist circumstances by innovation, without tangible results yet (Jesus, 2017).

In January 2020, Joana Portugal Pereira, IPCC's senior researcher, made clear at Madeira's conference 'Climate Change: Where We Are, Where We Want to Go and How to Get There', that Madeira is very vulnerable to sea-level rise in combination with more heavy rainfall, with an increased risk for floods and landslides. The island should become more resilient by creating more safety to the people and greater public health care – this, besides more effort in renewable-energy and non-carbon mobility.

'Zero Waste Madeira' is the only visible organization in the media, with newsletters and a Facebook presentation [@zerowastemadeira]. Showing a focus, a little wider than 'waste' alone, they also promote eco-friendly local businesses and organize cultural events. Their acceptance is reasonably positive: in November 2019, representatives talked with the President of the Madeira Assembly. What results from the picture: that Madeira's local government has barely started to take measures, they are still in the exploratory phase. The only civilian initiative is working on population awareness mostly.

<b>Madeira, Portugal</b>				
ACTIONS / ACTOR	MITIGATION (D)	ACTIONATION (C)	ACTIONATION (B)	ADAPTATION (A)
GOVERNMENT	●			
INSTITUTIONS				
RESIDENTS	●			

Figure 7. Visualizing Actions/Actors by climate-change countermeasures on the island Madeira.

Results according to the relevant UN SGD's:

1. UN SGD 3 Good health and well-being: should be the main target for better resilience.
2. UN SGD 11 Sustainable cities and communities: as an instrument to create population awareness.
3. UN SGD 13 Climate action: measures must be developed to handle landslides and coastal erosion.

### 3.3 Malta, in the Mediterranean Sea

Malta is situated at the outer post of Europe, near the African coast in the Mediterranean Sea, surrounded by seawater, and consists of the main island of Malta and the smaller neighbouring western island Gozo.

#### Most critical issues due to climate change

According to the Ministry for Resources and Rural affairs [MRRA], the Malta National strategy for climate change and adaption should focus on two main issues: the agriculture capacity on the island concerning local food production, and the availability of freshwater resources. Freshwater production mainly depends on osmosis technology and wastewater recycling (Gatt and Gatt, 2011). The trend is that climate-change increasing heat circumstances places biodiversity and water supply quantity and quality under pressure (MRRA, 2012a). The agricultural situation extra suffers from climate-change due to the invasion of new tropical species (MRRA, 2012b), and the increasing spread of vector-borne illnesses (following the MRA Malta Resources Authority: <https://mra.org.mt/climate-change/adaptation-to-climate-change/>).

#### Countermeasures by governmental bodies and residents

Following the Malta government and based on the "UN Human Development Report 2010", especially for agriculture, the use of natural water resources should be reduced, for example, by reducing the demand for water, by promoting the use of water-efficient appliances, and by using alternative water sources, when it comes to drinking water. Besides, water supplies must be continuously monitored, in combination with a carefully formulated conservation policy, to mitigate the effects of climate change [<https://www.adaptation-undp.org/projects/maltas-second-national-communication-may-2010>].

The local agricultural sector is also taking the initiative, with a mix of 'autonomous' (individual farmers) and more strategic joint measures of which the initiatives on Gozitan are a good example (Bryant et al., 2000), with accommodation strategies like crop diversification, and change of the growth calendar (Wheeler, 2013), and innovative initiatives such as developing crop, heat, salt and drought tolerant crop varieties (Caldies and Caldies, 2016) (see Figure 8.).



Figure 8. Impression of the innovation fields in the Gozo island of Malta (Wheeler, 2013).

Both approaches show to be defensive and adaptive in relation to nature, only the cooperation and mutual coordination seems to be missing – whereby the agricultural farmers are more innovative, as visualized in Figure 9.



Malta	ACTIONS / ACTOR	MITIGATION (D)	ACTIONATION (C)	(B)	ADAPTATION (A)
	GOVERNMENT			●	
INSTITUTIONS				●	
RESIDENTS					

Figure 9. Visualizing Actions/Actors by climate-change countermeasures on the island Malta.

Results according to the relevant UN SGD’s:

1. UN SGD 3 Good health and well-being: economic development depends on innovation.
2. UN SGD 11 Sustainable cities and communities: heat-stress is the most important influence.
3. UN SGD 13 Climate action: the farmers explore adaptive measures more than the government.

4. Analysis and conclusions

For the support of the EU H2020 SOS Climate Waterfront research program, three case-studies concerning the islands Texel, in the Netherlands, Madeira, in Portugal, and Malta are studied. Testing a methodology making blockades more clearly, to facilitate the research methodology of the program to explore and design resilient action-perspectives for dealing with climate-change cumulating coastal effects [chapter 1]. The reason, therefore, is that blockades in creating measures for the program related cities were recognized at the beginning of the SOS Climate Waterfront program.

By researching the situation on the three islands, two methodological approaches (based on the DCBA approach developed in the Netherlands and the SOS Climate Waterfront program approach) were tested: 1. The Action/Actors-quadrant [chapter 2; Figure 2.], and 2. Which possible reasons can lead to blockades. Therefore, firstly, the three case-studies are analysed and evaluated shortly; see Table 11.

The three case-studies

It is striking that each of the case studies has a blockage for the further development or operationalization of measures although these have different causes, see Table 1.

	The blockade	Underlying cause
Texel, Netherlands	‘Adaptive measures’ that give farmers trust in the future to invest long term are not developed.	The points of departure between the governmental institution and the farmers society differ
Madeira, Portugal	Measures are not developed; there are only small-scale citizens' initiatives	The local government is too dependent on the national government; and the island population is too small for counter-measures
Malta	Local government and farmers do not cooperate; they complement each other in the measures they look for	Local government and farmers operate on the different scales respectively; the island and island-zones

Table 1. Analysing the three case-studies on blockades for action and underlying causes.

In each of the three cases, the blockade is mainly caused by the somewhat conservative attitude of the local government, and citizens' initiatives are too small and/or too thematic to change that much. In the situation of Madeira, the cause is also due to the various authorities whose mutual coordination does not show to be effective. Also, in the outlined situations of the three EU cities within the SOS Climate Waterfront program, the blockades appear to arise because governments respond slowly to changing circumstances or do not cooperate. In these situations, civilian initiatives are barely powerful too. The Actions/Actors-diagram proved to be useful for analysing the referred case-studies, because the positions of the three different types of actors concerning the type of measure were well visualized. The conclusions could also have been found without the diagram, but then, the diagram also helps to explain the conclusions. The fact that ‘mitigating’ measures receive the most attention, for instance, can be read in the diagrams very well, and that adaptive relatively more explored on the island of Madeira too.

This makes it clear to the SOS Climate Waterfront program that: 1. It is important to identify as many diverse actors as possible, in order to visualize the local situation; 2. Those efforts should be made to engage in dialogue with local citizens' initiatives, and 3. That the nature of the measures they are working on must be properly discussed. The three side-kick case studies show that the situations can differ (Oliveira, 2017), which should be taken into account when comparing results. Thus, it is critical to first visualize the situation, and it is strongly advisable to interview a local wide range of experts.

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