Sea Level Rise Scenarios Along the Mediterranean Coasts-2 – SAVEMEDCOASTS-2

Deliverable D4.1 - Report on combined flooding scenarios through the implementation of expeditive methodologies and modelling

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Project title	**Sea Level Rise Scenarios Along the Mediterranean Coasts-2**
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Acronyms

AOI	Area Of Interest
AUTH	Aristotle University of Thessaloniki
CGIAM	Centre of Integrated Geomorphology for the Mediterranean Area
CORR	Correlation Coefficient
DBGT	GeoTopographic DataBase
DBM	Digital Bathymetric Model
DSM	Digital Surface Model
DTM	Digital Terrain Model
FARBAS	Regional Environmental Research Foundation
fp	peak frequency
GDAL	Geospatial Data Abstraction Library
GLM	Generalized Lagrangian Mean
GNSS	Global Navigation Satellite System
HISWA	Hindicasting Shallow WAter WAves
HS	significative offshore wave height
INGV	National Institute of Geophysics and Volcanology
InSAR	Interferometric Synthetic Aperture Radar
IPCC	Intergovernmental Panel on Climate Change
LiDAR	Light Detection and Ranging or Laser Imaging Detection and Ranging
MSEL	Maximum super elevation level
NBI	Normalized Bias
NRMSE	Normalized Root Mean Square Error
POT	Peak Over Threshold
PSMSL	Permanent Service for Mean Sea Level
RCP	Representative Concentration Pathway
RSLR	Relative Sea Level Rise
RT	Return Time
SBAS	Small BAseline Subset
SLR	Sea Level Rise
SROCC	IPCC Special Report on the Ocean and Cryosphere in a Changing Climate
SS	Storm Surge
UAV	Unmanned Aerial Vehicle
VLM	Vertical land movement
WP	Work Package
WRF	Weather and Research Forecasting
WWIII	WAVEWATCH III

1. Executive Summary

This document is the first report of Work Package 4: “Flooding scenarios and cascading effects: definition and assessment”. The report describes the activities carried out by CGIAM and FARBAS, in collaboration with INGV, and results obtained on the flooding scenarios for 2021, 2030, 2050 and 2100 in the targeted areas investigated in SAVEMEDCOASTS-2. Namely the Ebro delta (Spain), the Rhone delta (France), the Venice lagoon and the Metaponto plain (Italy), the Chalastra plain (Greece) and Alexandria (Egypt). For these areas, the Relative Sea Level Rise (RSLR) projections are based on the IPCC climate change scenarios (SROCC Report for RCPs 2.6 and 8.5) and the current rates of vertical land movements (subsidence or uplift) as estimated by geodetic analysis (see WP2 reports and further update, shown in deliverable D2.4), assuming they will continue at the same rates up to 2100 A.D. Similarly, the storm surges scenarios have been analysed for the same reference epochs in ordinary or extreme conditions.

The main products of this report are the following:

1. the maps of potential land inundation scenarios for each study area, based on the RSLR projections estimated by WP2 for 2030, 2050 and 2100 epochs;
2. implementation of expeditive methodologies for riverine and coastal flooding to define possible combined inundation scenarios. The analysis takes into account a) Relative Sea Levels (RSL), b) land subsidence (LS), c) astronomical tide and d) storm-surge (SS), referred to different return times (RT) for 2021, 2030, 2050 and 2100 epochs.

In reference to the time horizons of RSLR projection and consequently of flooding scenarios, we clarify that the nearest future one was initially defined at the time of project submission for 2040. Because the year 2040 is too close to the reference epoch of 2050, the SAVEMEDCOASTS-2 consortium decided to change from 2040 to 2030 during the implementation of the project. Finally, the proposed epochs defined at 2030, 2050 and 2100 have a time distribution which is more suitable for stakeholders. In particular policy-makers, urban or land planners who need short, middle and long-term reference scenarios (at the scale of the mean life duration of humans) to eventually prepare adaptation and risk plans in response to RSLR.

We remark that due to the low resolution of the available topographic data for Alexandria (Egypt), this case study has not been analysed in terms of maps of RSLR and SS scenarios. Subsequently, cascading effects cannot be also analysed in deliverable D4.2. Only RSLR projections up to 2100 for five different coastal zones have been estimated.

2. Task T4.1: Combined coastal flooding scenarios

Based on the RSLR projections for 2030, 2050 and 2100 in the targeted areas, as estimated and reported by WP2 and further upgrade in deliverable D2.4, in this report we provide detailed maps of inundation scenarios resulting from the combined effects of the different drivers. Multitemporal sea levels are estimated for the local mean sea level (static levels) and in storm surge conditions. The combination of a) regional sea level rise (SLR) extracted from the SROCC Report (IPCC, 2019; Oppenheimer et al., 2019), b) rates of land subsidence estimated by InSAR and GNSS analysis (see WP2 and its update in deliverable D2.4), c) amplitude of astronomical tide and d) storm-surge (SS) referred to different return times (RT), is considered in the assessment of the flooding scenarios presented in this report.

The expeditive methodology for coastal flooding risk assessment implemented in the previous SAVEMEDCOASTS project[1] considered the storm-surge component as a static uplift of the sea level due to the maximum run-up occurring during the considered extreme events. In addition, the approach on storm-surge modelling was not applicable in SAVEMEDCOASTS-2, due to the relatively flat morphology of the investigated coastal areas, with the exception of the waterfront of the Venice lagoon. As we will discuss in the next chapters, further hydrodynamic modelling should be required to model in detail the storm surge scenarios. Thus, the adopted methodology provides the coupling of hydraulic expeditive methodologies and modelling to provide the expected inundation scenarios on the project targeted sites for different RT and referring to the projections for 2030, 2050 and 2100.

3. Mapping RSLR scenarios

In the first step of Task T4.1 we used the high-end values of RSLR projections estimated by INGV (Deliverable D2.1, D2.2, D2.3 and the update D2.4) to map the derived scenarios for 2030, 2050 and 2100 in each study area. Estimates are corrected for vertical land movements (VLM) based on combined geodetic analysis of Interferometric Synthetic Aperture Radar (InSAR) from space and Global Navigation Satellite System (GNSS) data collected by ground networks. RSLR projections are provided for the two extreme Representative Concentration Pathways (RCPs) 2.6 and 8.5, being respectively the low and the high-emissions scenarios defined in the reference SROCC report (IPCC, 2019; Oppenheimer et al., 2019), which describe the likely range of SLR in the next decades due to natural and human-induced climate change scenarios. In Task T4.2, the deriving impacts and cascading effects on the environment and anthropic ecosystems, will be assessed.

Each investigated site has been subdivided in different areas of interest (AOIs), characterized by different rates of land subsidence. In this way, the local RSLR projections and flooding scenarios are provided at high spatial resolution and are more representative of specific areas.

[1] ECHO/SUB/2016/742473/PREV16

Thus, multiple flooding scenarios were mapped for each AOI. Topography has been provided by WP3 (see Deliverables D3.1 and D3.2 by AUTH), using high resolution topographic datasets. The latter are mainly based on Light Detection and Ranging (LiDAR) surveys that allowed the realization of Digital Surface Models (DSM) and Digital Terrain Models (DTM). Preliminarily, the inland and coastal waters have been subtracted from the reference topography by applying an appropriate mask to avoid the overestimation of the potential flooded area.

In particular, for Chalastra (Greece), an ultra-high resolution Digital Elevation Model (DEM) obtained by an Unmanned Aerial Vehicle (UAV) survey was provided by AUTH (see Deliverable D3.2), allowing the creation of very detailed scenarios. Conversely, for the area of Alexandria (Egypt), the lack of LiDAR data prevented the realization of high resolution DTM. Therefore, we considered the NASADEM dataset. Unfortunately, its resolution is not suitable to create maps of flooding scenarios, due to its low vertical accuracy (10 m) and the relatively small magnitude of expected high water levels even for the most critical RSLR scenarios.

It is worth noting the case of the Venice lagoon, for which several topographic datasets characterized by different coverage and product types are available. With specific regard to the Venice Island, recent acquisition of LiDAR data and related DSM and DTM datasets provided by the Consorzio Venezia Nuova, supported detailed RSLR scenarios. Multiple datasets allowed us to also make a cross comparison to choose the best one to use as base topographic map for the flooding assessment. An example of the comparison for Piazza San Marco is shown in Figure 1: a) the area is represented in dry conditions (current mean sea level recorded at the nearby tide gauge of Punta della Salute); b) a flooding scenario using the LiDAR DSM as topographic reference, c) the flooding scenario is based on the LiDAR DTM as topographic reference, and d) scenario based on the same LiDAR DTM from which buildings have been subtracted. The main difference between the latest three representations is the extension accuracy of the potential expected flooded area:

- The DSM-based scenario underestimates the flooded areas. The DSM contains the natural elevation of terrain plus human artefacts, vegetation and other disturbances which can be easily recognized in dry conditions (current mean sea level). In addition, being Venice highly urbanized, it becomes mandatory to take into account the area occupied only by ground levels of buildings, thus excluding their cornices and overhanging roofs, that are included in the LiDAR data acquisitions;
- The DTM-based scenario overestimates the flooded area. The DTM contains only the terrain elevation and the exposed flooded areas may also contain buildings and other artefacts due to the interpolation;
- The DTM-based scenario minus the buildings (retrieved from the GeoTopographic DataBase - DBGT - of the City of Venice). This is the more reliable solution to evaluate the flooded area because it represents the best accurate and balanced solution.

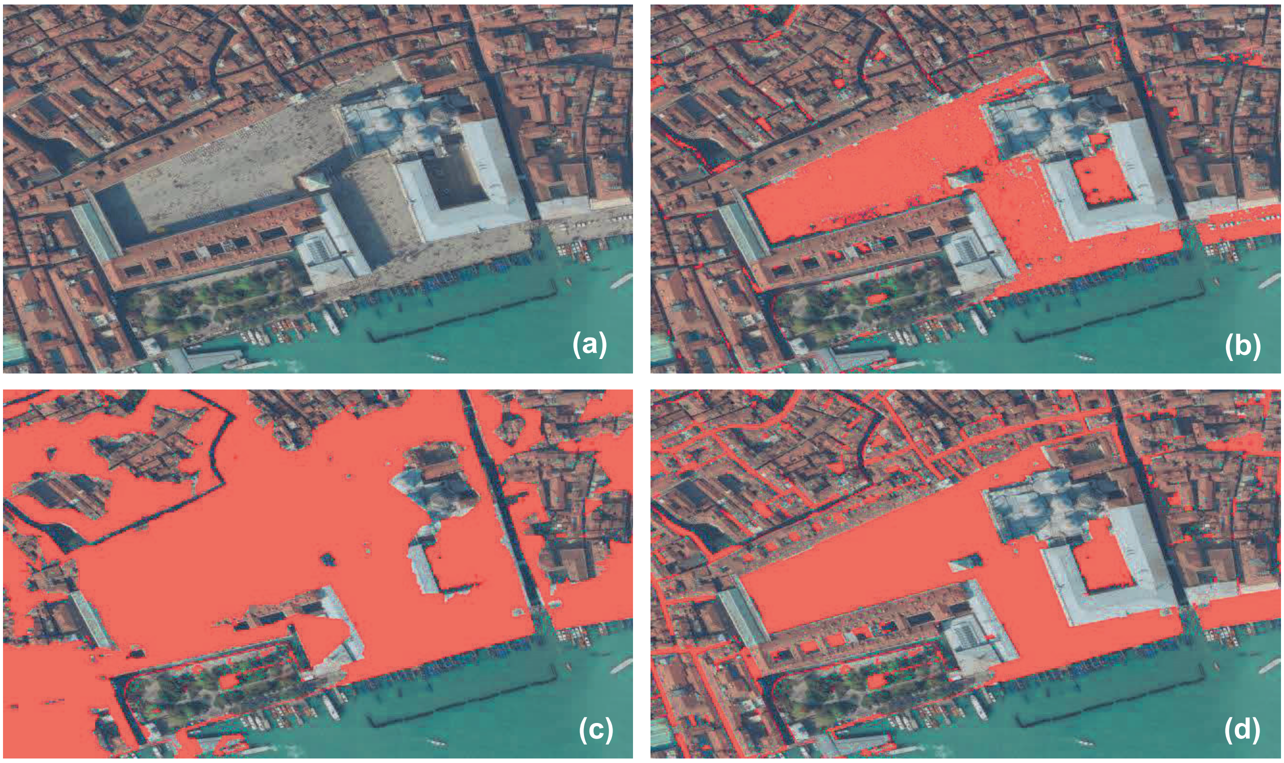

Figure 1 – Comparison between flooding maps using different topographic references at Piazza San Marco in Venice: (a) dry conditions, (b) DSM-based scenario, (c) DTM-based scenario and (d) DTM-based scenario minus the buildings

The method we have used to assess the permanent flooding scenarios only due to static RSLR is a simple "bathtub" approach in which areas that fall below a target water level, which are not necessarily hydraulically connected to the sea, are considered as flooded.

The Geospatial Data Abstraction Library - GDAL (gdal.org) - was used to accomplish some preparatory tasks on topographic datasets (format conversions, coordinate transformations, resampling, cropping, file compression, masking, etc.), calculate the flooding scenarios as a binary mask (1 = flooded, 0 = not flooded) given a specific combination of RPC and time horizon, and then vectorize the results. Finally, the maps of RSLR scenarios were mapped by QGIS (qgis.org). Due to the high number of possible combinations of boundary conditions, the potential RSLR flooding scenarios with regard to AOIs were grouped by different RCPs in order to provide a potential time-series of RSLR projections. To better define the coastal zones prone to RSLR and estimate the expected flooding areas, each targeted site has been subdivided in two or more sub-areas of interest for which the related expected flooding extension is provided. Flooding scenarios for RCP 2.6 and 8.5 are shown in different colours (blue palette for RCP 2.6 scenario and yellow-red palette for RCP 8.5 scenario). The potential flooded areas of RSLR scenarios for specific AOIs of each study area are reported in Annex 1.

3.3 The Venice lagoon (Italy)

The Venice lagoon has been subdivided into 21 AOIs, as represented and numbered in Figure 18. The estimated rates of land subsidence (Vup) and the RSLR values for RCP 2.6 and RCP 8.5 scenarios at 2030, 2050 and 2100 epochs, are reported in Table 3. The potential flooding scenarios are represented in Figures 19-60 which are grouped for the two considered RCPs.

Figure 18 – The Venice lagoon. The red lines define the 21 areas of interest.

Table 3 – The Venice lagoon: RSLR projections for the 21 areas of interest for 2030, 2050 and 2100 epochs.

			RSLR (m)					
			2030		2050		2100	
id	Area of Interest (AOI)	Vup (mm/yr)	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5	RCP 2.6	RCP 8.5
1	Venice	-1.52±0.58	0.06±0.03	0.06±0.03	0.16±0.03	0.21±0.04	0.39±0.06	0.72±0.12
2	Giudecca	-1.65±0.46	0.06±0.04	0.06±0.03	0.16±0.03	0.21±0.04	0.40±0.06	0.72±0.12
3	San Giorgio Maggiore	-0.81±0.56	0.05±0.04	0.05±0.03	0.14±0.03	0.18±0.04	0.33±0.06	0.67±0.12
4	La Grazia	-3.61±0.29	0.09±0.04	0.09±0.02	0.23±0.02	0.27±0.04	0.57±0.06	0.90±0.12
5	San Clemente	-7.93±0.15	0.15±0.04	0.14±0.02	0.37±0.02	0.42±0.04	0.92±0.06	1.26±0.12
6	Sacca Sessola	-2.6±0.65	0.08±0.04	0.07±0.03	0.19±0.03	0.24±0.04	0.48±0.06	0.81±0.12
7	Lido	-2.15±0.79	0.07±0.04	0.07±0.03	0.18±0.03	0.23±0.04	0.44±0.06	0.78±0.12
8	Pellestrina	-1.55±0.89	0.06±0.04	0.06±0.03	0.16±0.03	0.21±0.04	0.39±0.06	0.73±0.12
9	Chioggia	-1.95±1.2	0.07±0.04	0.06±0.03	0.17±0.03	0.22±0.04	0.43±0.06	0.76±0.12
10	Porto Marghera	-2.18±1.11	0.07±0.04	0.07±0.03	0.18±0.03	0.23±0.04	0.45±0.06	0.78±0.12
11	Campalto	-1.63±0.75	0.06±0.04	0.06±0.03	0.16±0.03	0.21±0.04	0.40±0.06	0.73±0.12
12	Tessera & Marco Polo Airp.	-1.97±0.87	0.07±0.04	0.06±0.03	0.17±0.03	0.22±0.04	0.43±0.06	0.76±0.13
13	Mazzorbetto	-1.78±0.28	0.07±0.04	0.06±0.02	0.17±0.02	0.21±0.04	0.41±0.06	0.75±0.12
14	Mazzorbo	-1.26±0.33	0.06±0.04	0.06±0.02	0.15±0.02	0.20±0.04	0.37±0.06	0.70±0.12
15	Burano	-1.59±0.27	0.06±0.04	0.06±0.02	0.16±0.02	0.21±0.04	0.40±0.06	0.73±0.12
16	Murano	-1.78±0.3	0.07±0.04	0.06±0.02	0.17±0.02	0.21±0.04	0.41±0.06	0.75±0.12
17	San Michele	-2.14±0.48	0.07±0.04	0.07±0.03	0.18±0.03	0.23±0.04	0.44±0.06	0.78±0.12
18	La Certosa	-1±0.62	0.06±0.04	0.05±0.03	0.14±0.03	0.19±0.04	0.35±0.06	0.68±0.12
19	Le Vignole	-0.28±0.8	0.05±0.04	0.04±0.03	0.12±0.03	0.16±0.04	0.29±0.06	0.62±0.12
20	Sant'Erasmo	-2.54±1.21	0.08±0.04	0.07±0.03	0.19±0.03	0.24±0.04	0.48±0.06	0.81±0.12
21	Cavallino-Treporti	-2.79±1.03	0.08±0.04	0.07±0.03	0.20±0.03	0.25±0.04	0.50±0.06	0.83±0.12

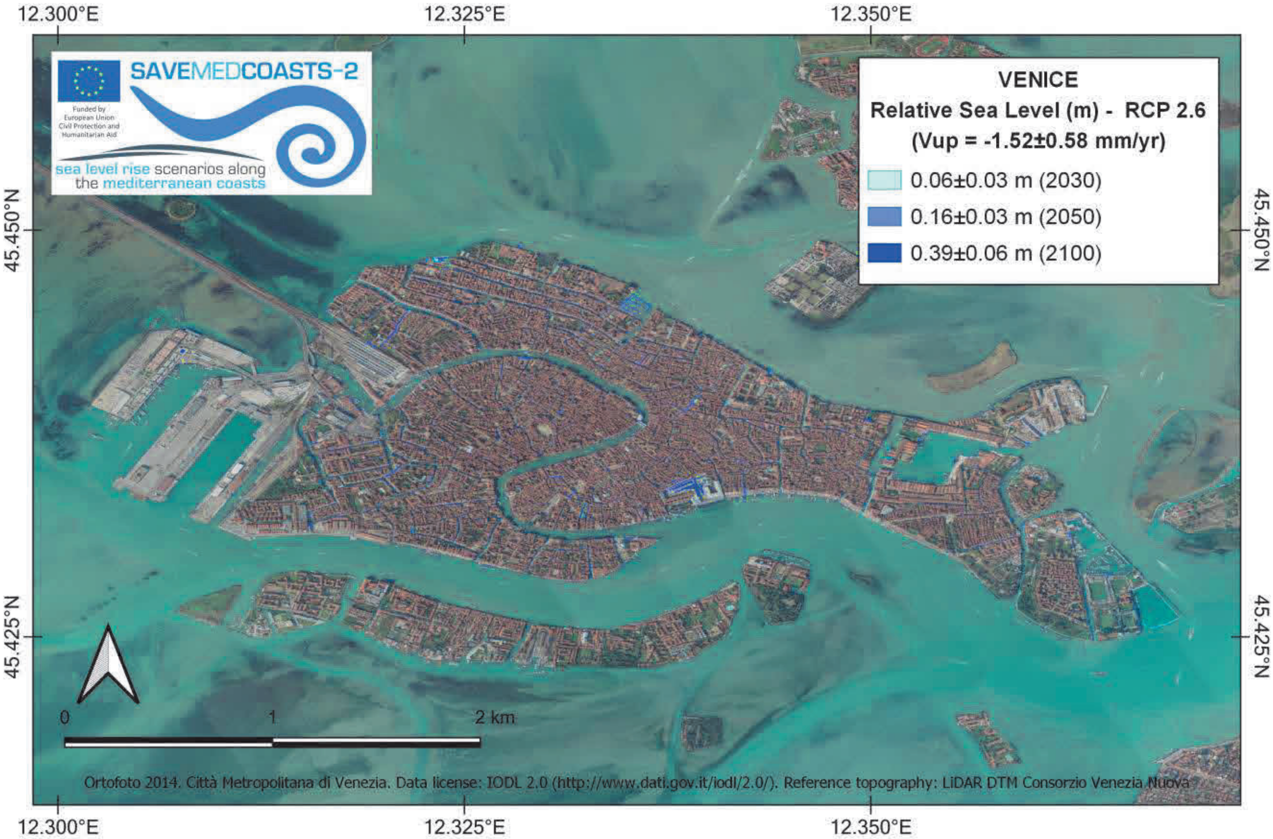

Figure 19 – The Venice lagoon: RCP 2.6 scenario of RSL at Venice.

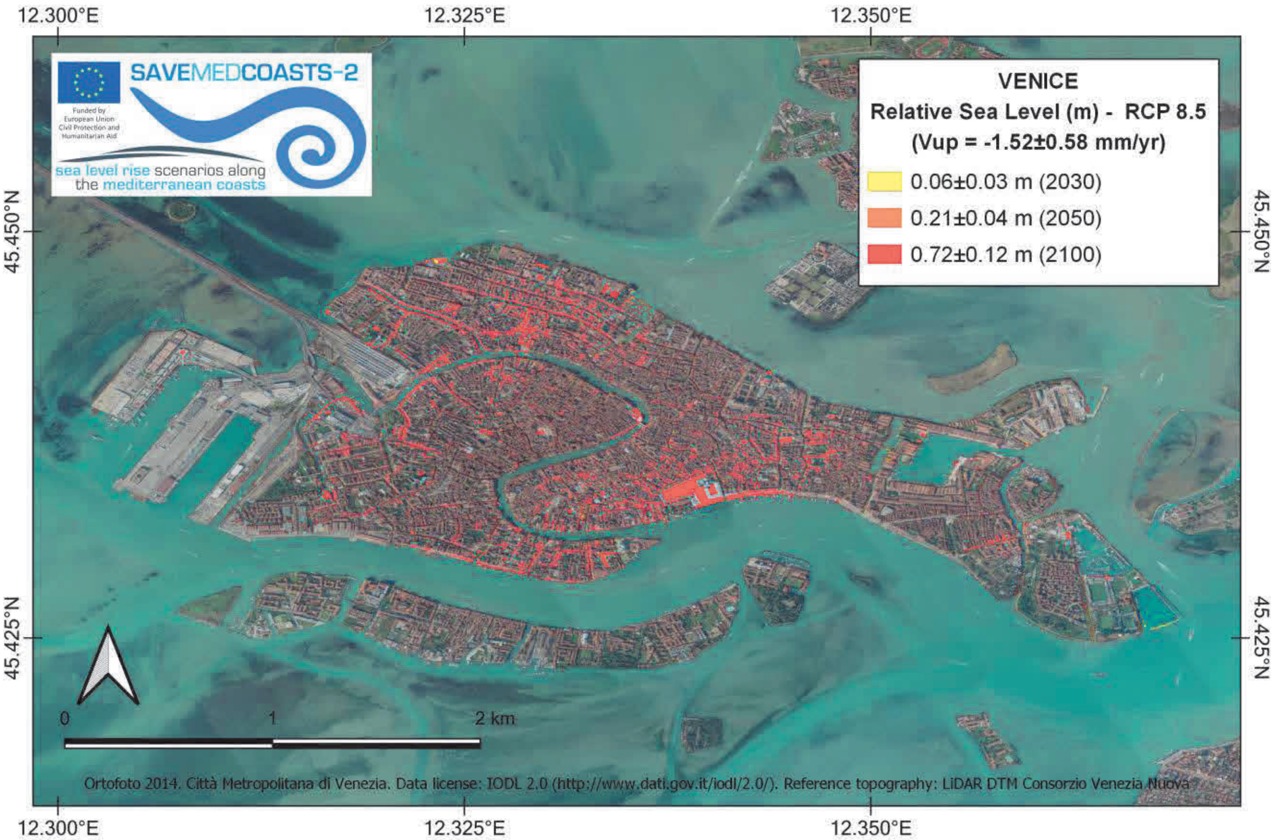

Figure 20 – The Venice lagoon: RCP 8.5 scenario of RSL at Venice.

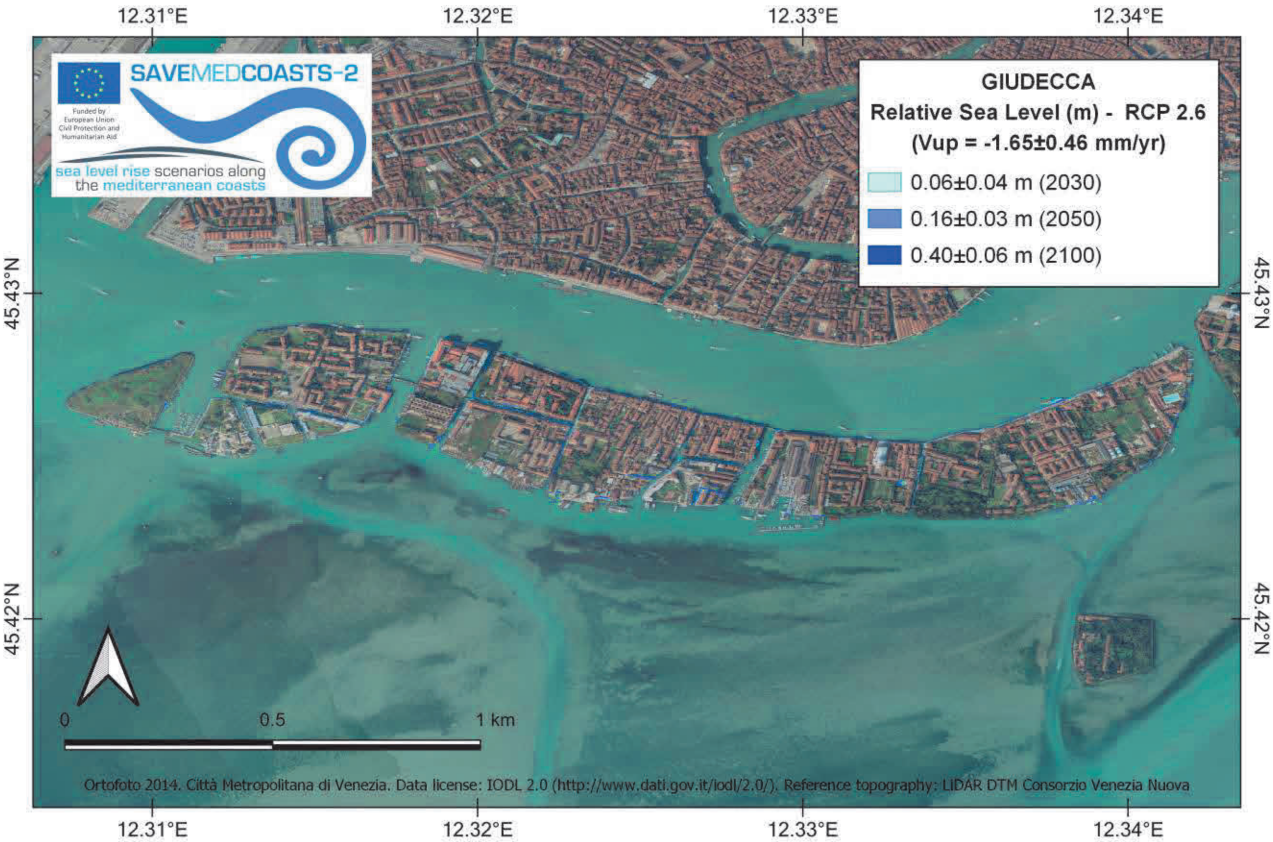

Figure 21 – The Venice lagoon: RCP 2.6 scenario of RSL at Giudecca.

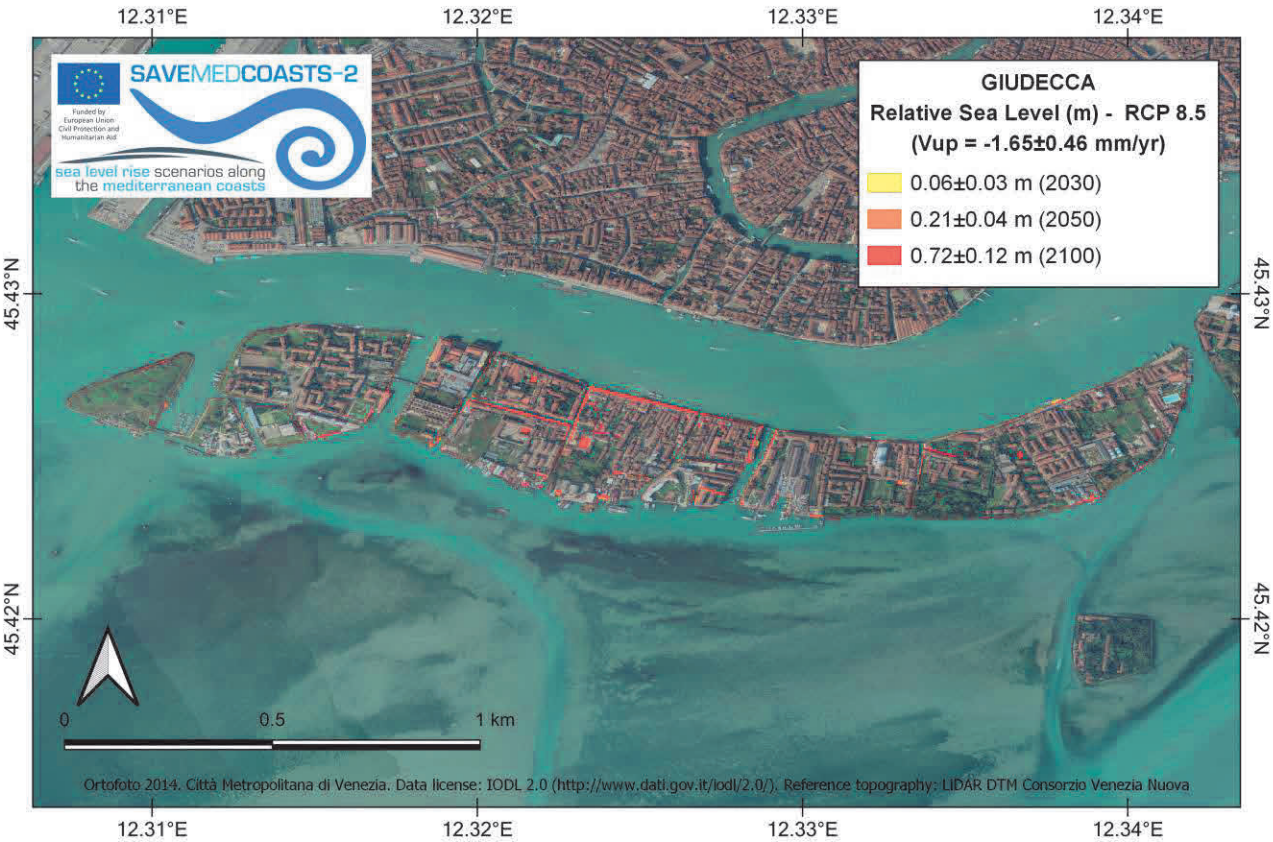

Figure 22 – The Venice lagoon: RCP 8.5 scenario of RSL at Giudecca.

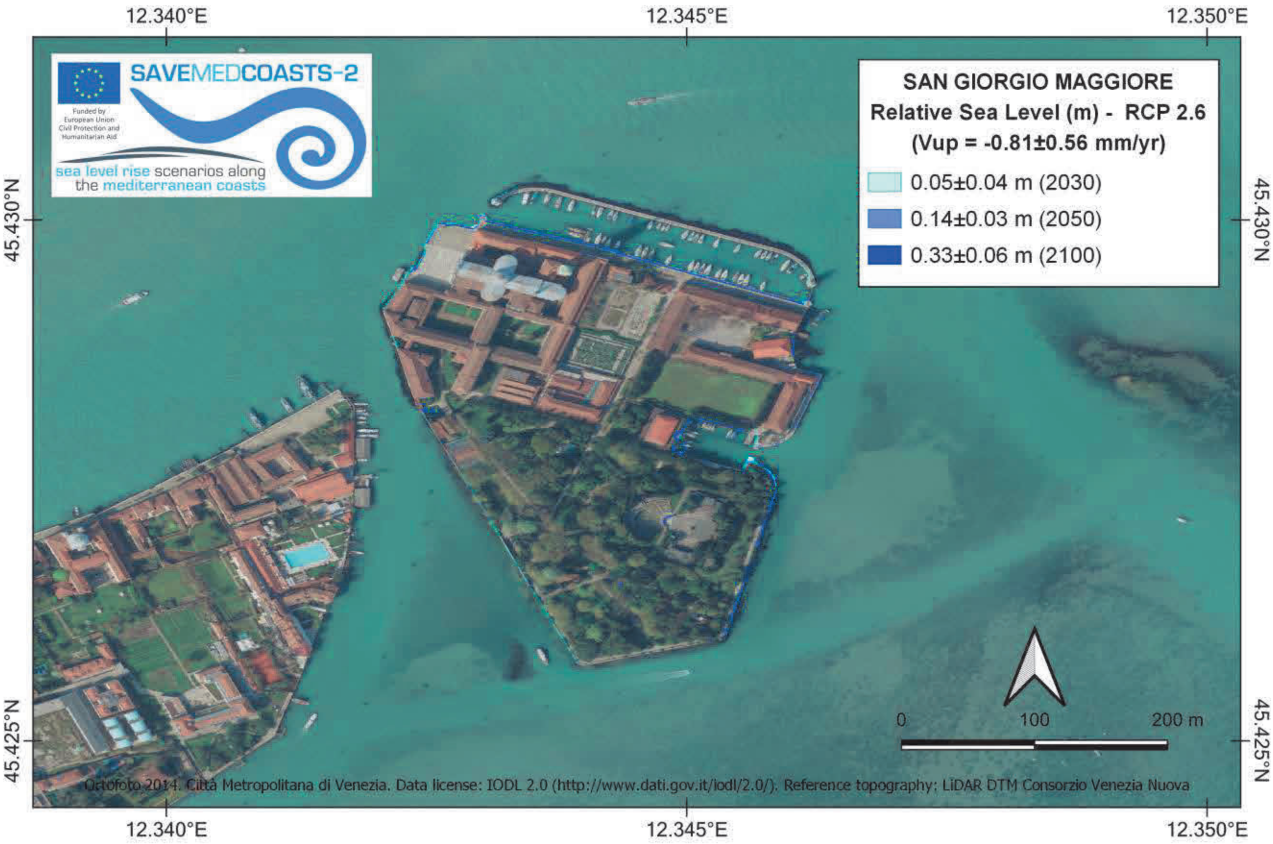

Figure 23 – The Venice lagoon: RCP 2.6 scenario of RSL at San Giorgio Maggiore.

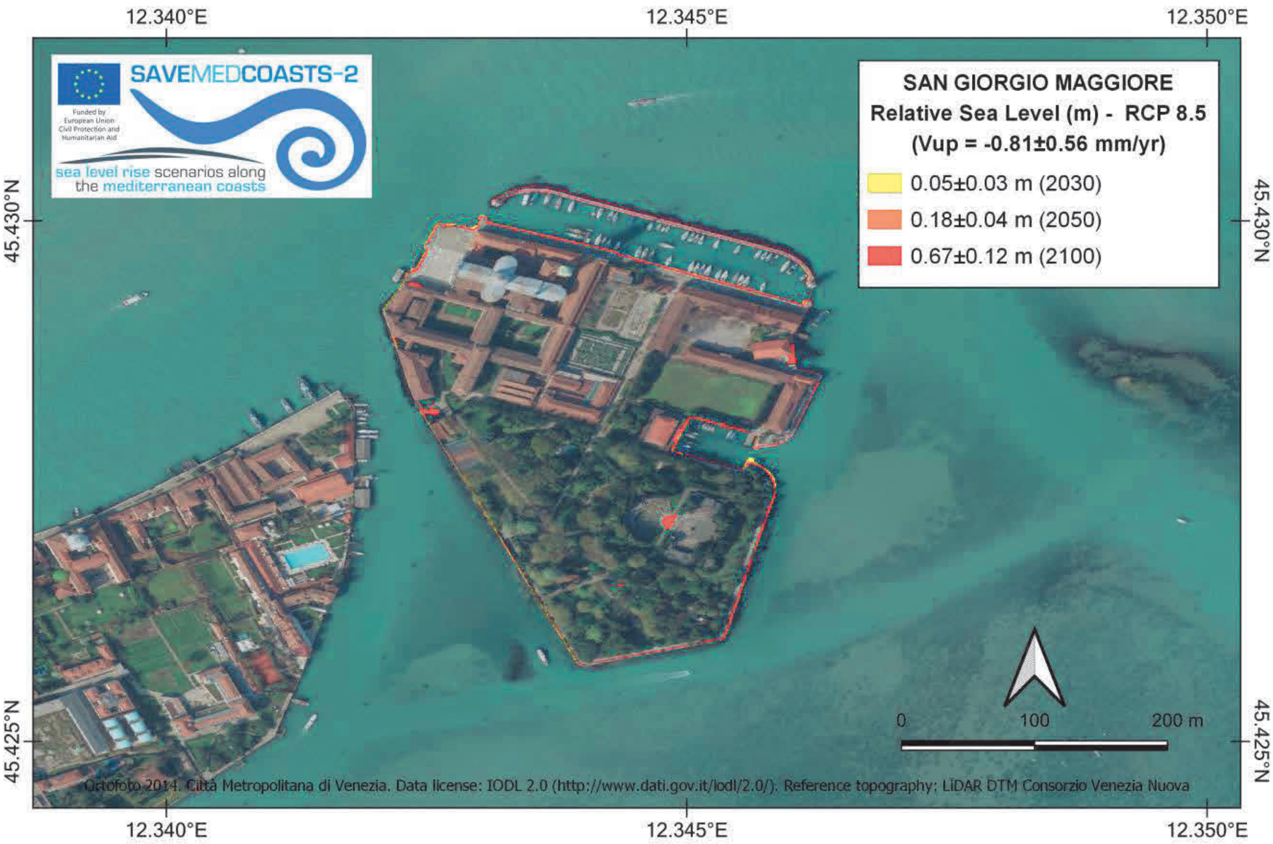

Figure 24 – The Venice lagoon: RCP 8.5 scenario of RSL at San Giorgio Maggiore.

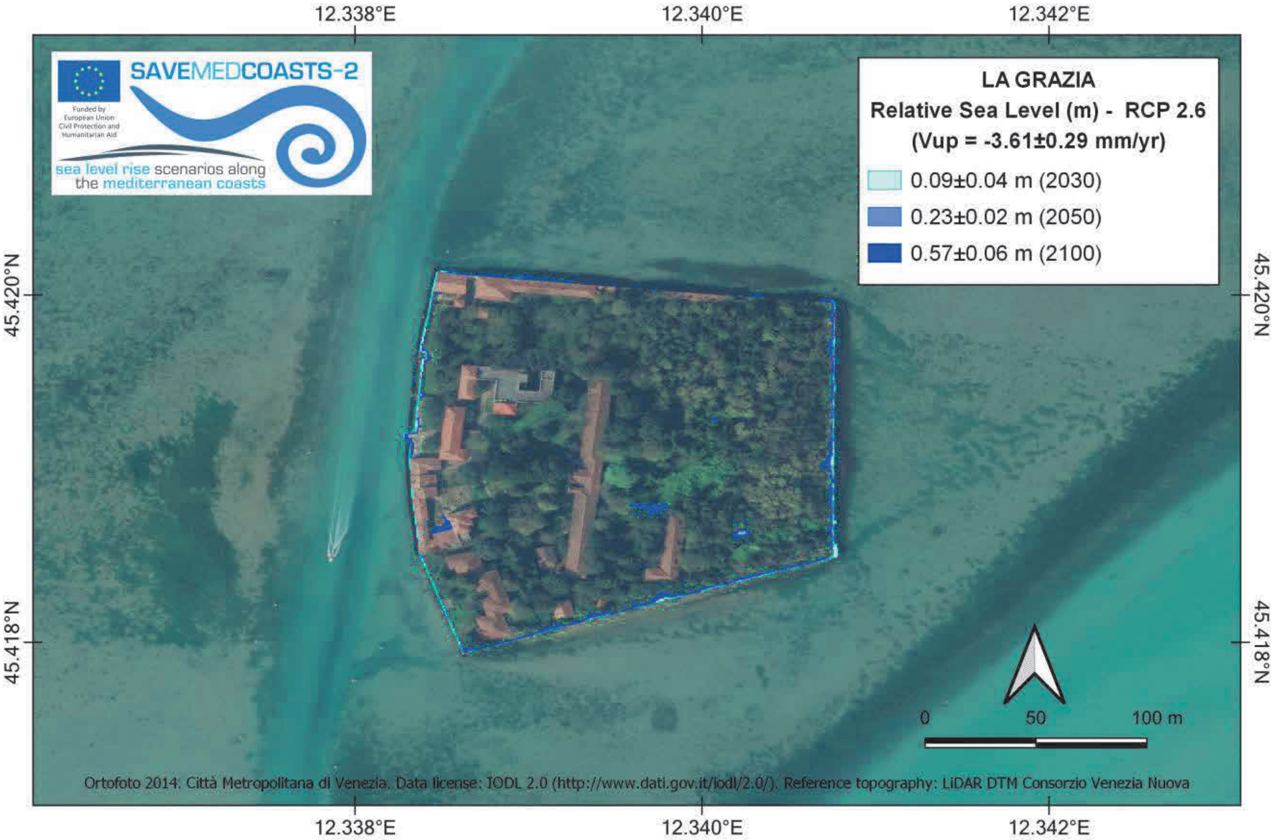

Figure 25 – The Venice lagoon: RCP 2.6 scenario of RSL at La Grazia.

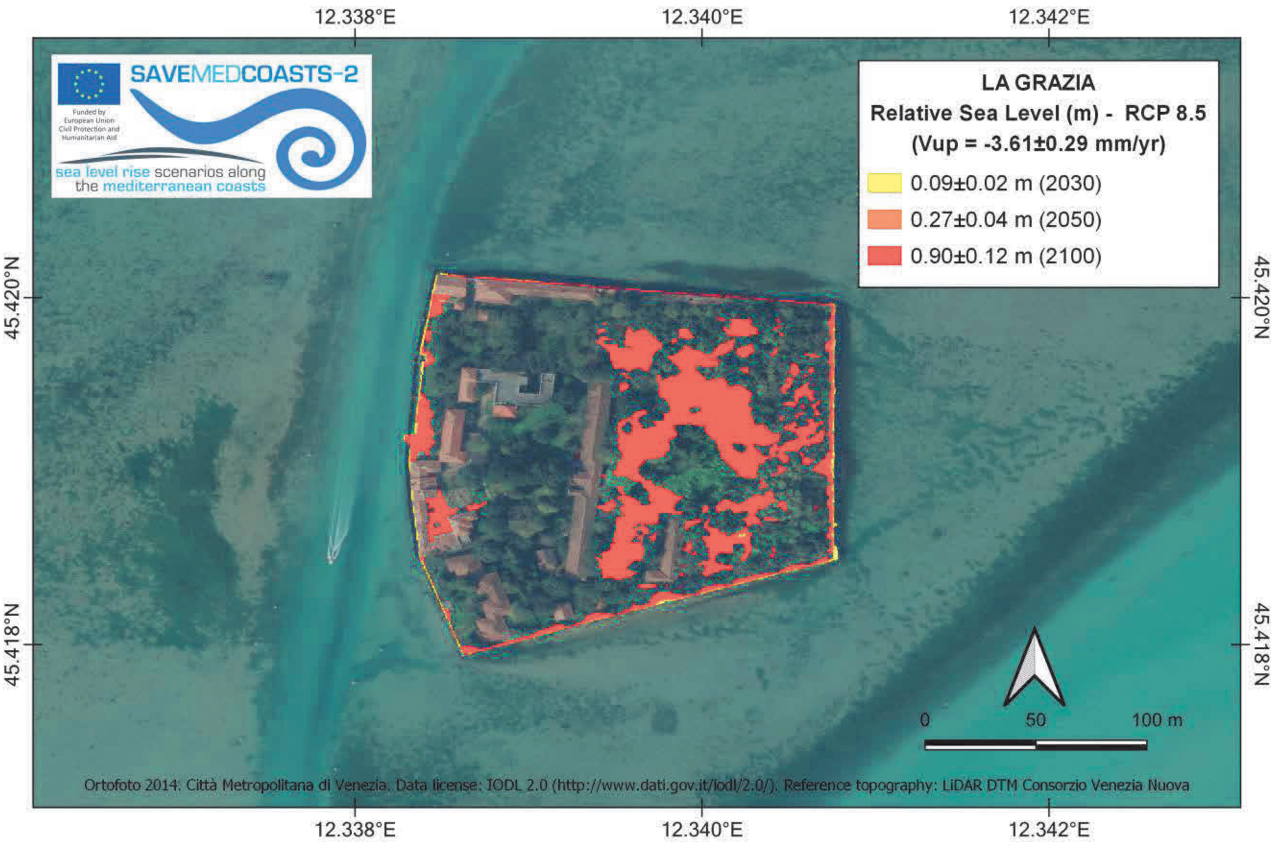

Figure 26 – The Venice lagoon: RCP 8.5 scenario of RSL at La Grazia.

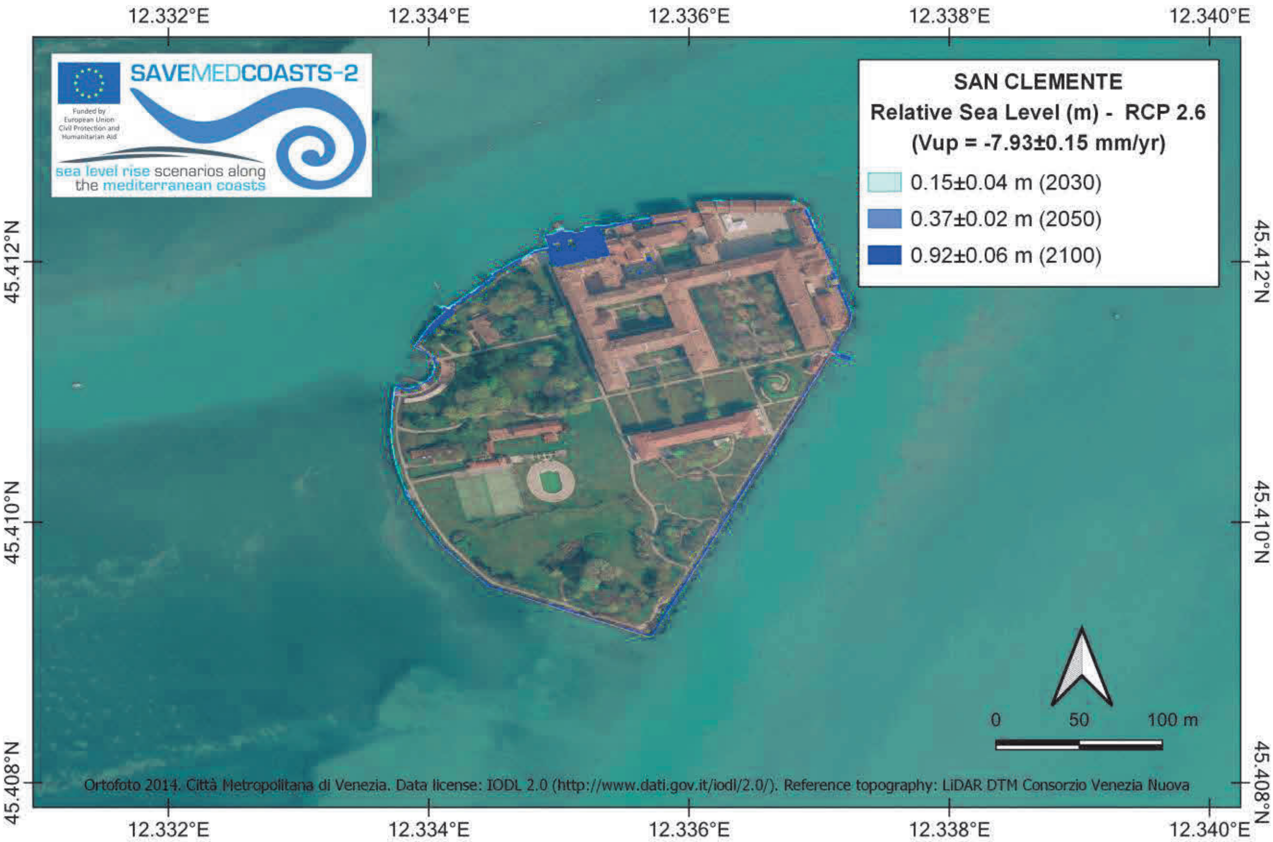

Figure 27 – The Venice lagoon: RCP 2.6 scenario of RSL at San Clemente.

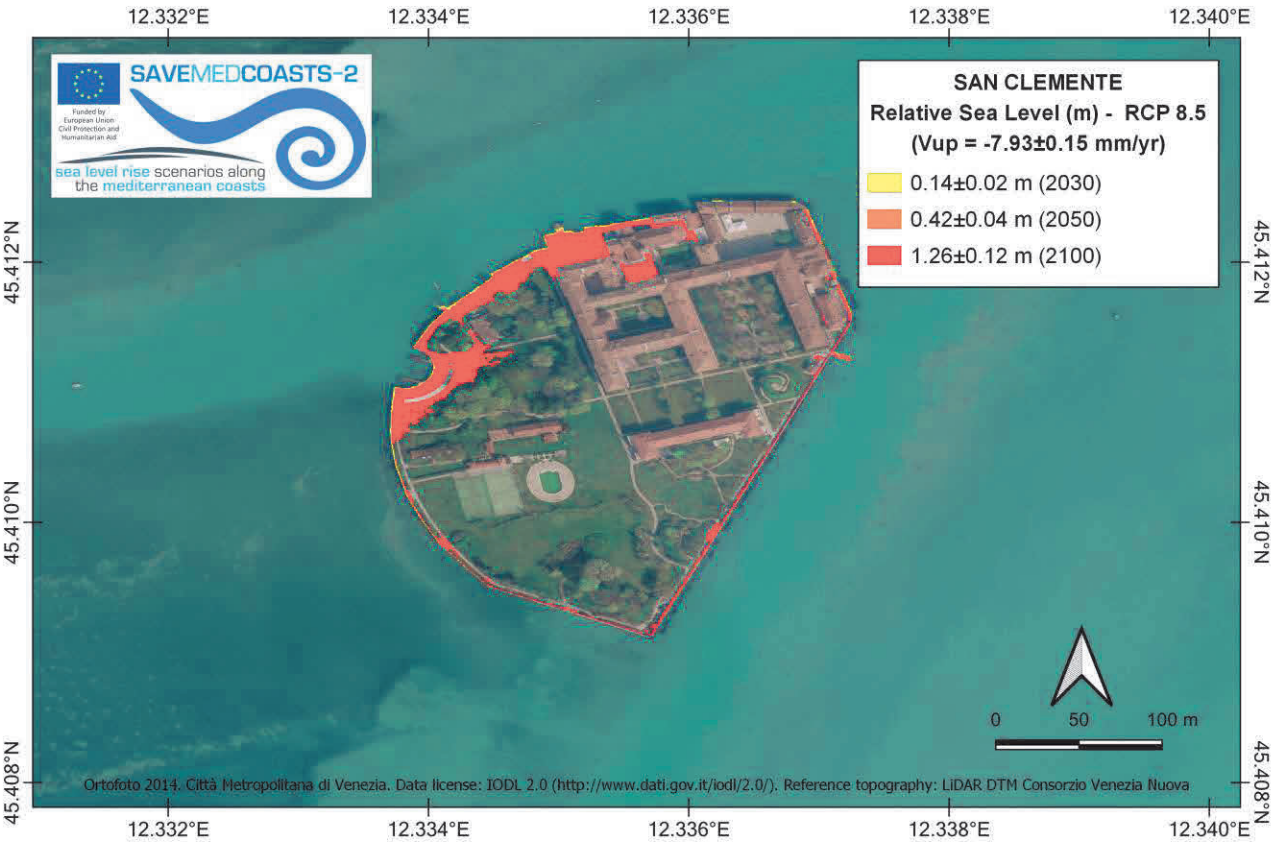

Figure 28 – The Venice lagoon: RCP 8.5 scenario of RSL at San Clemente.

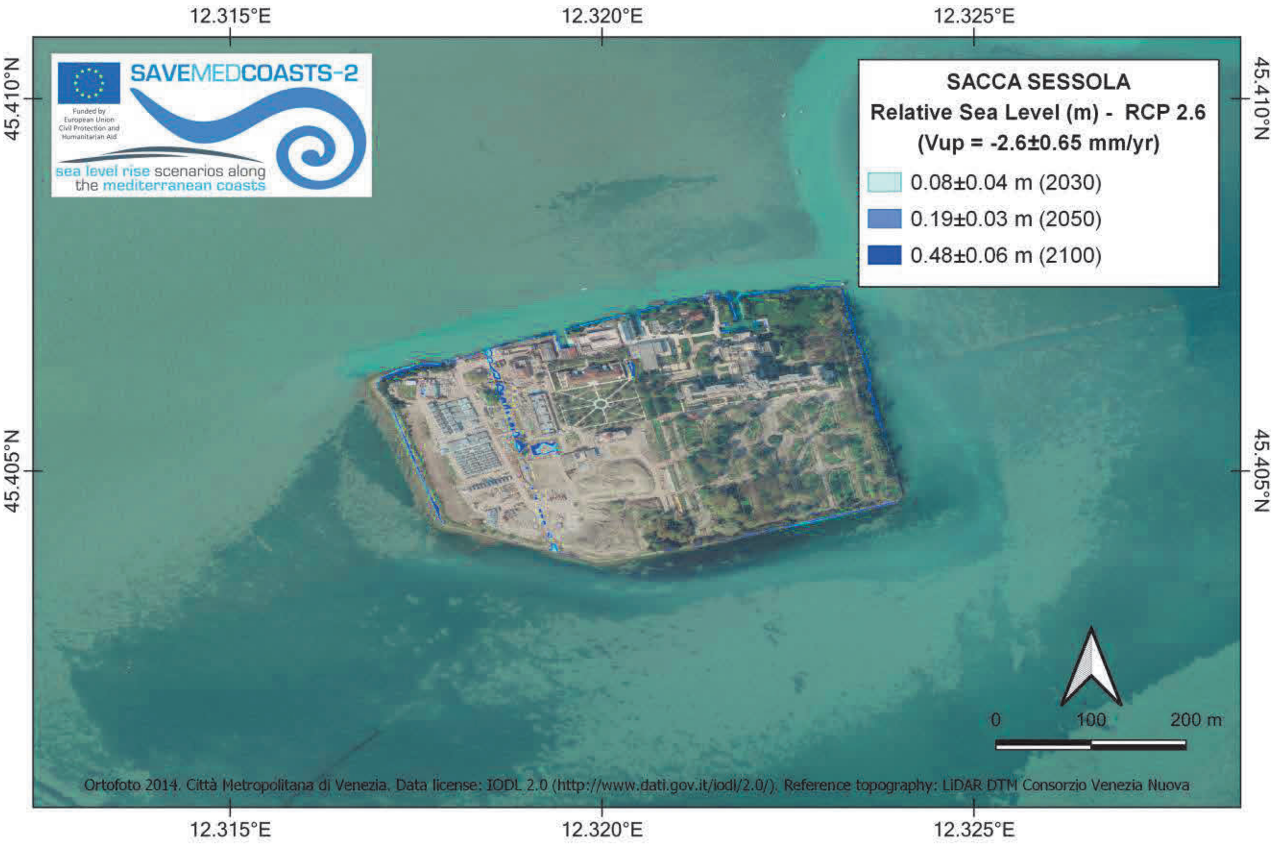

Figure 29 – The Venice lagoon: RCP 2.6 scenario of RSL at Sacca Sessola.

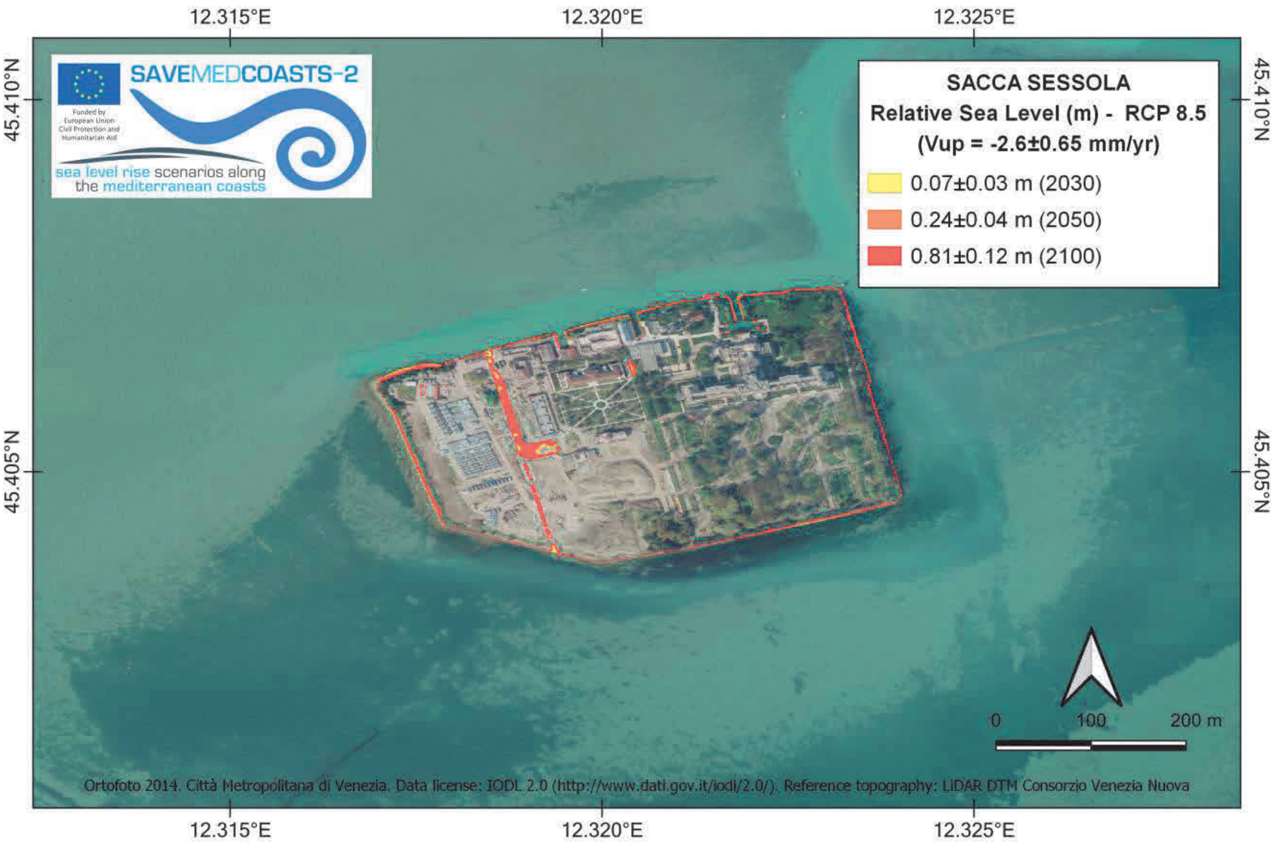

Figure 30 – The Venice lagoon: RCP 8.5 scenario of RSL at Sacca Sessola.

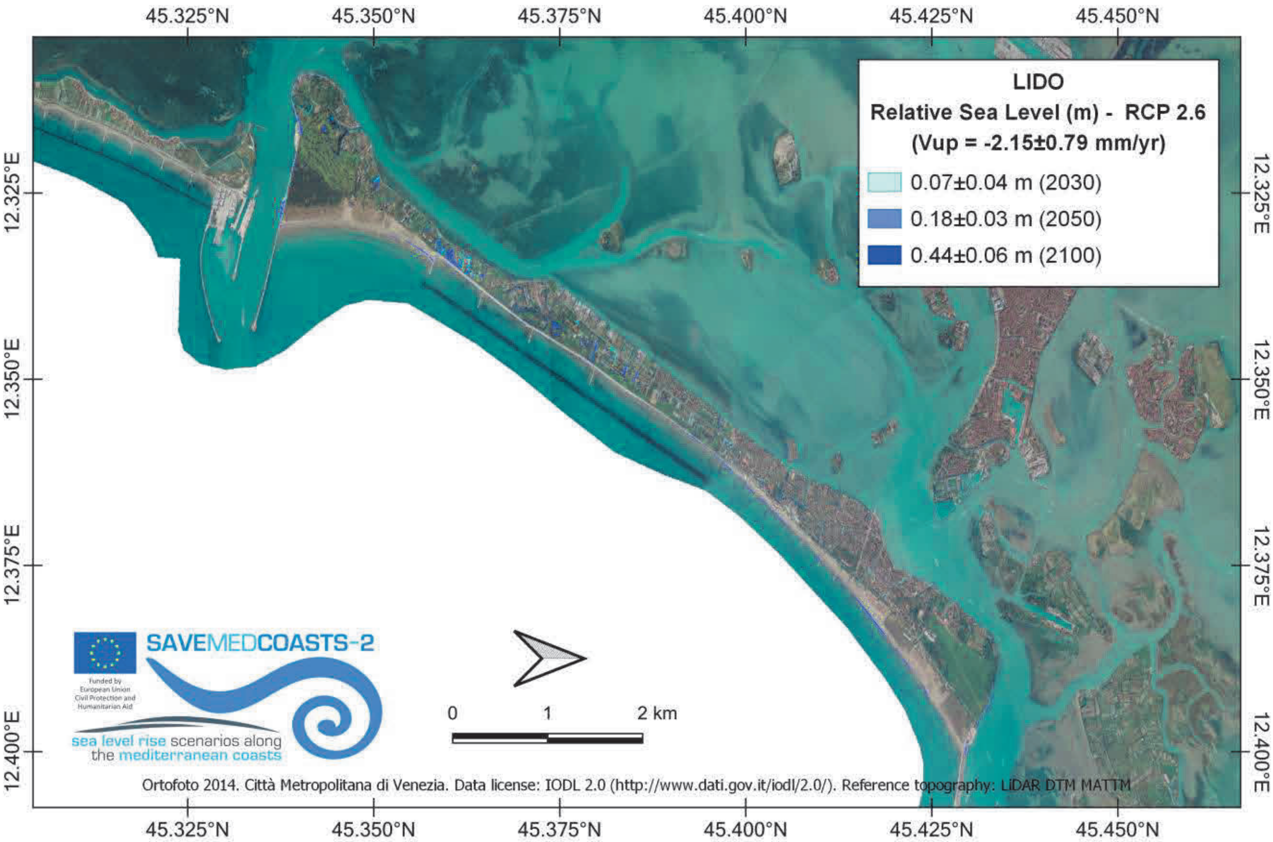

Figure 31 – The Venice lagoon: RCP 2.6 scenario of RSL at Lido.

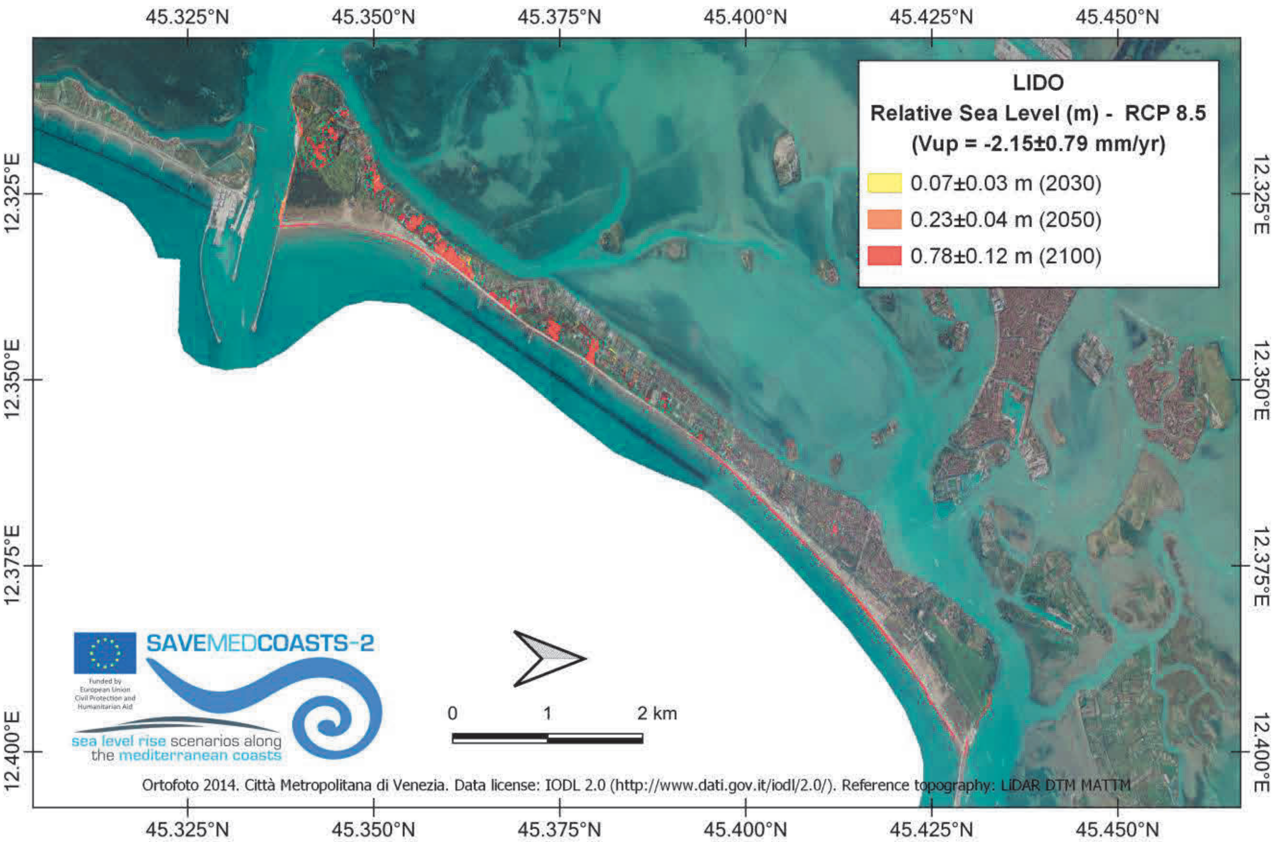

Figure 32 – The Venice lagoon: RCP 8.5 scenario of RSL at Lido.

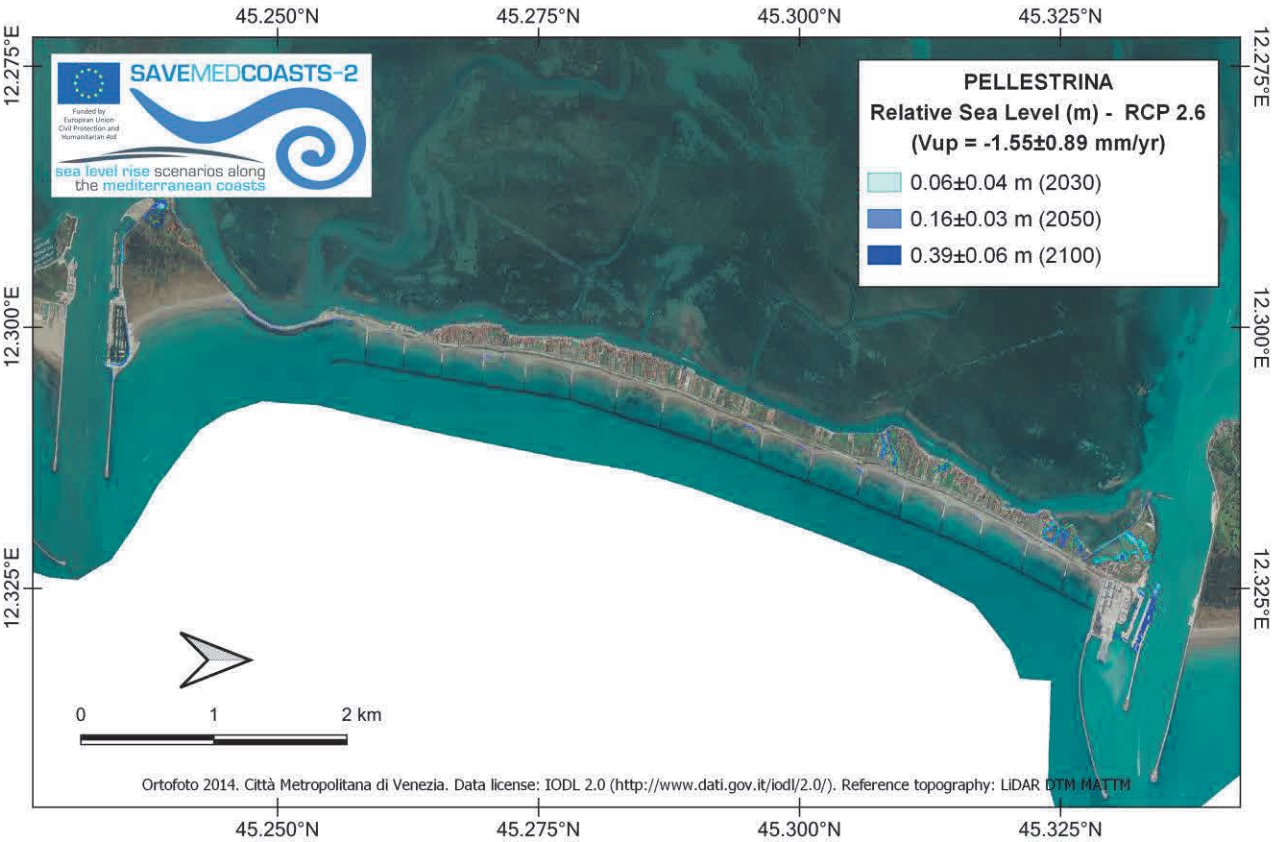

Figure 33 – The Venice lagoon: RCP 2.6 scenario of RSL at Pellestrina.

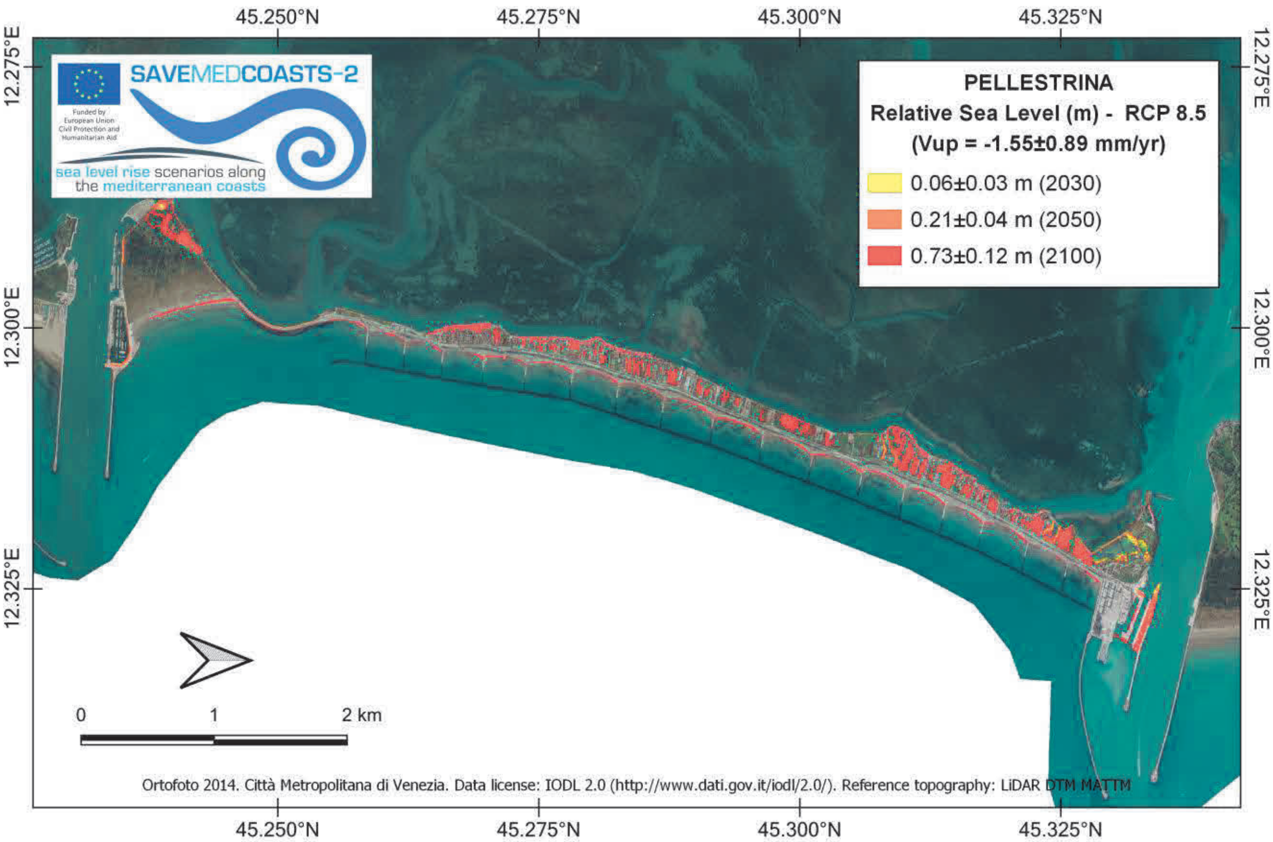

Figure 34 – The Venice lagoon: RCP 8.5 scenario of RSL at Pellestrina.

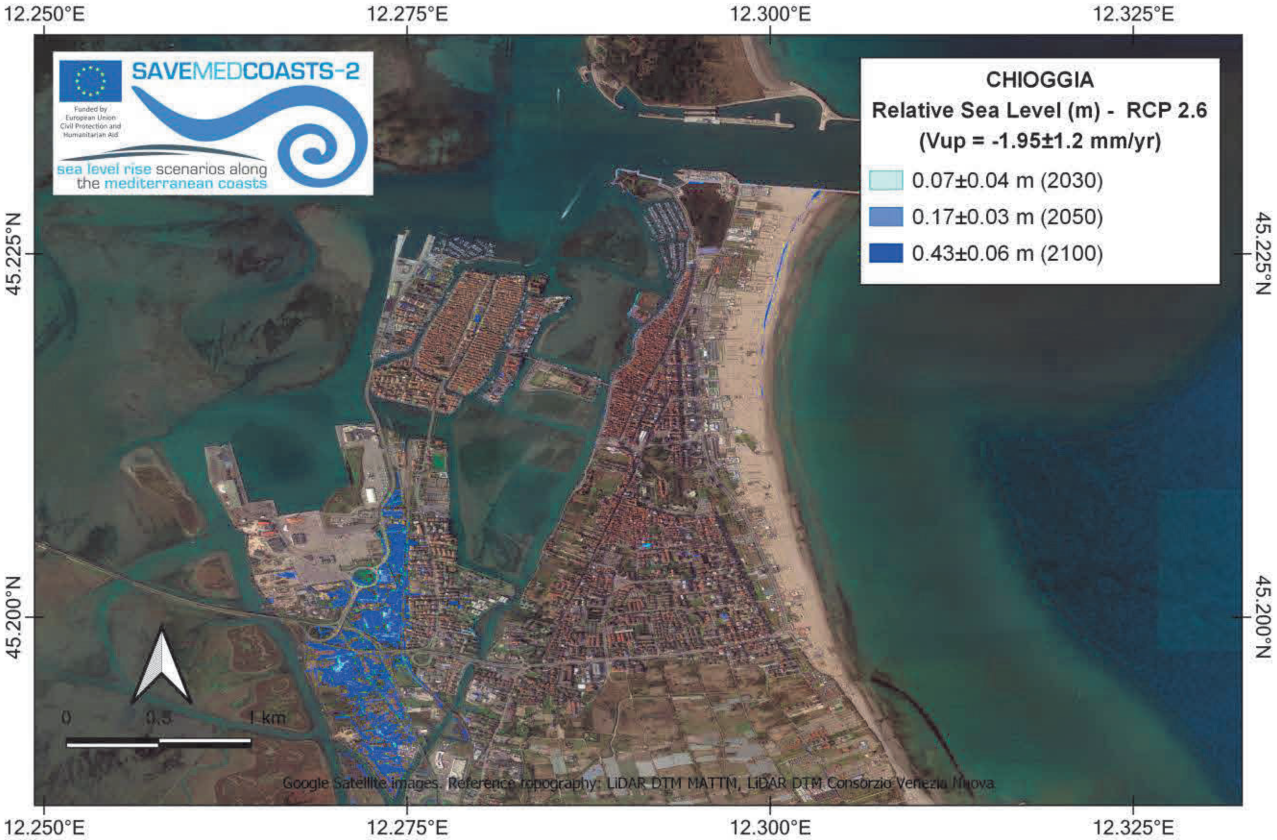

Figure 35 – The Venice lagoon: RCP 2.6 scenario of RSL at Chioggia.

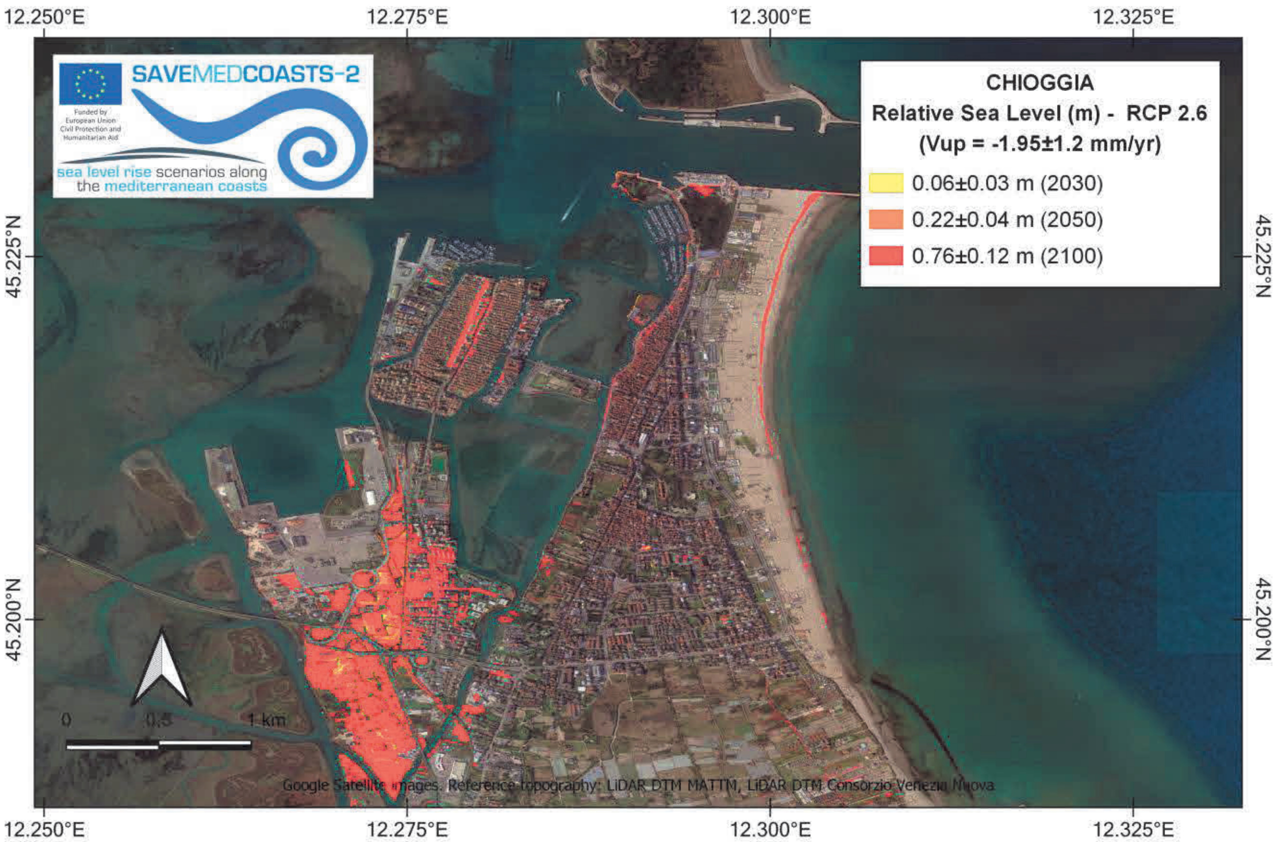

Figure 36 – The Venice lagoon: RCP 8.5 scenario of RSL at Chioggia.

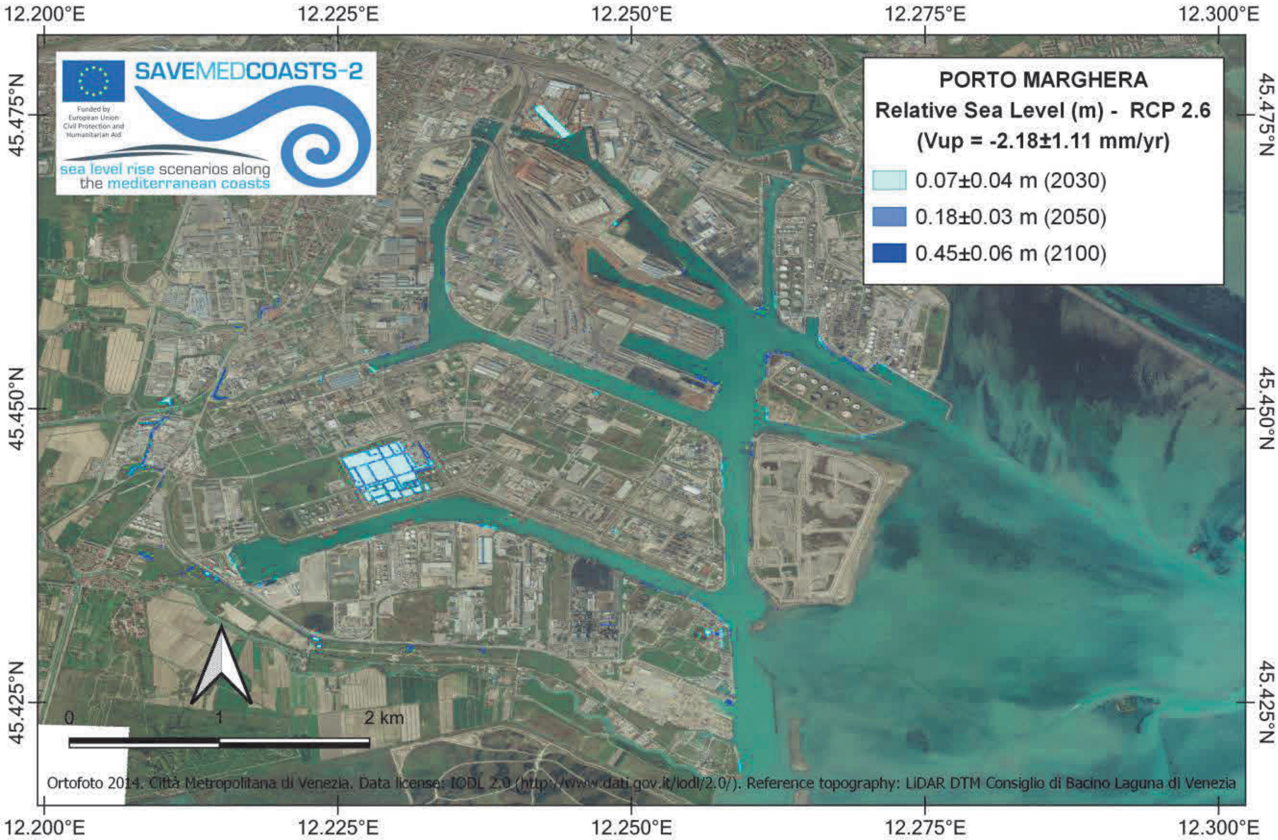

Figure 37 – The Venice lagoon: RCP 2.6 scenario of RSL at Porto Marghera.

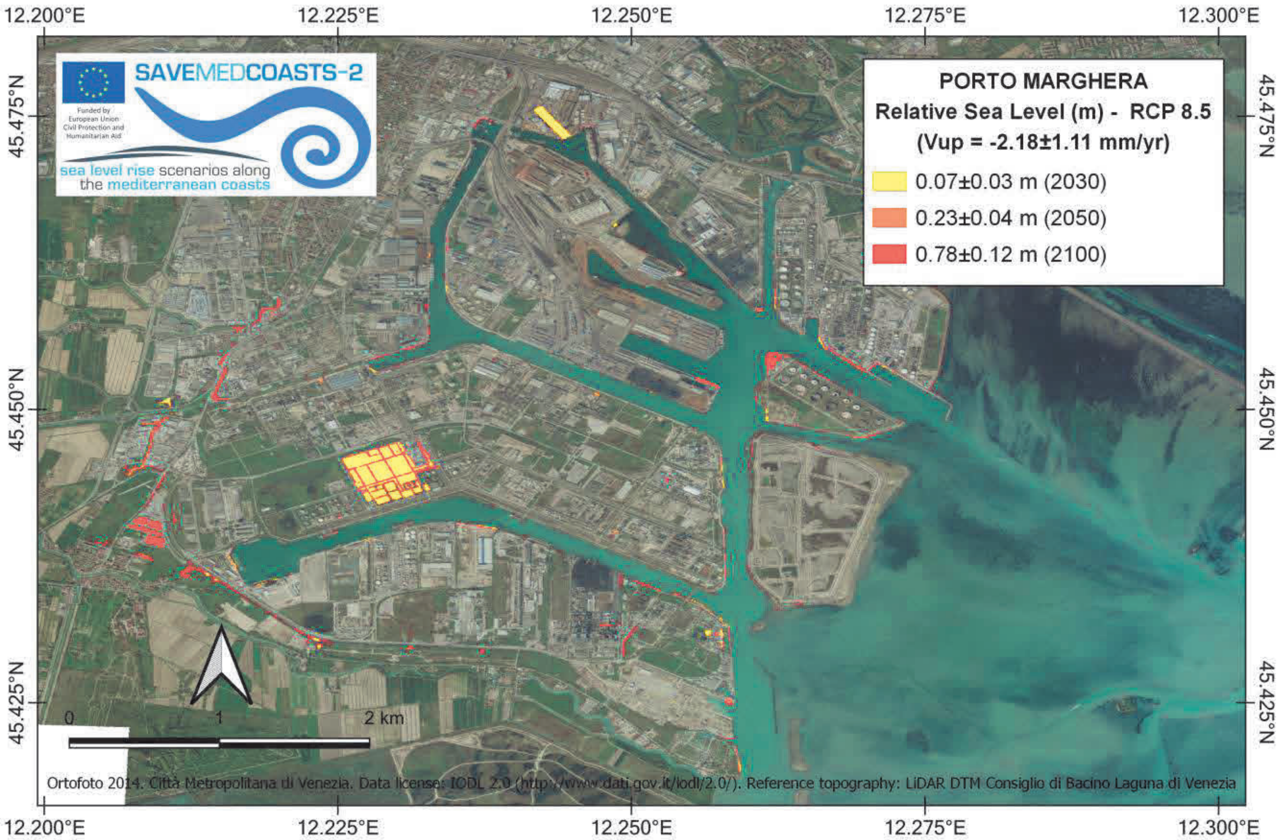

Figure 38 – The Venice lagoon: RCP 8.5 scenario of RSL at Porto Marghera.

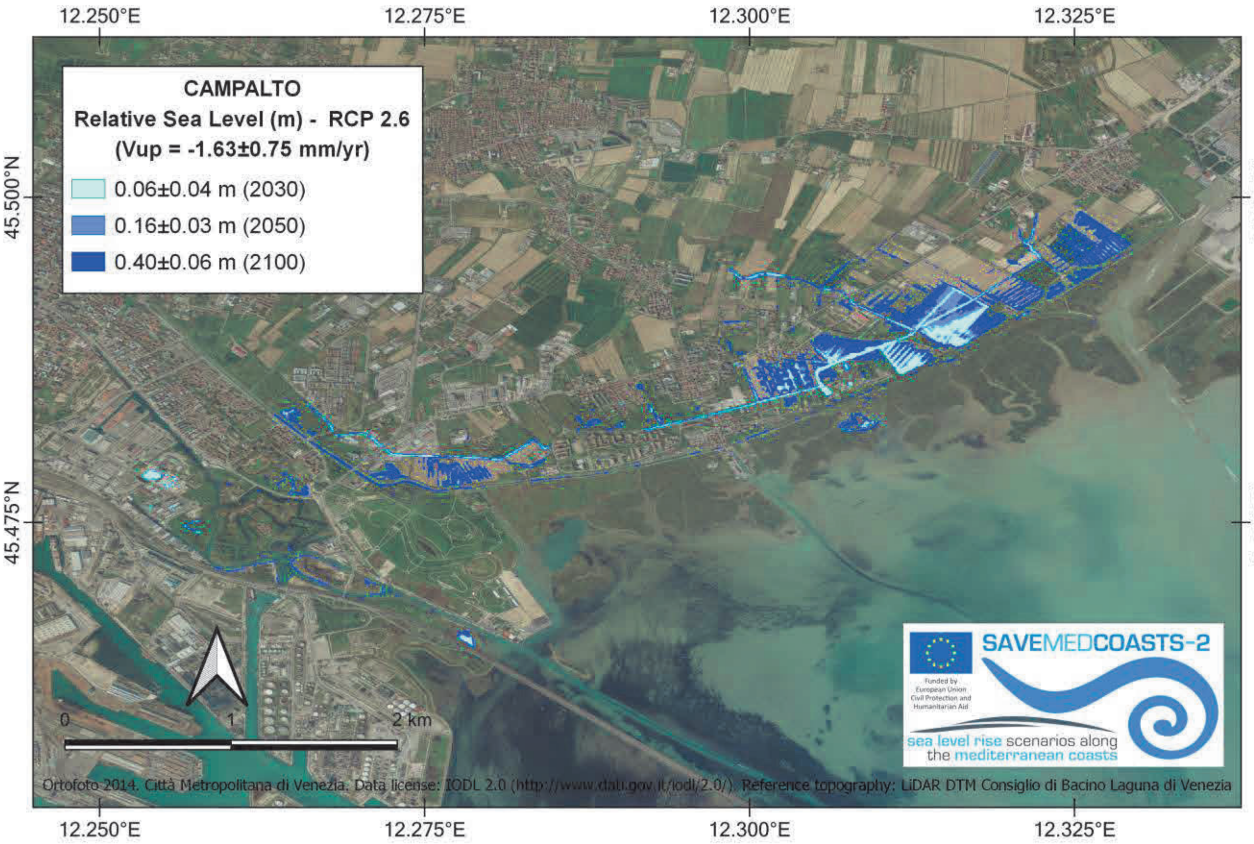

Figure 39 – The Venice lagoon: RCP 2.6 scenario of RSL at Campalto.

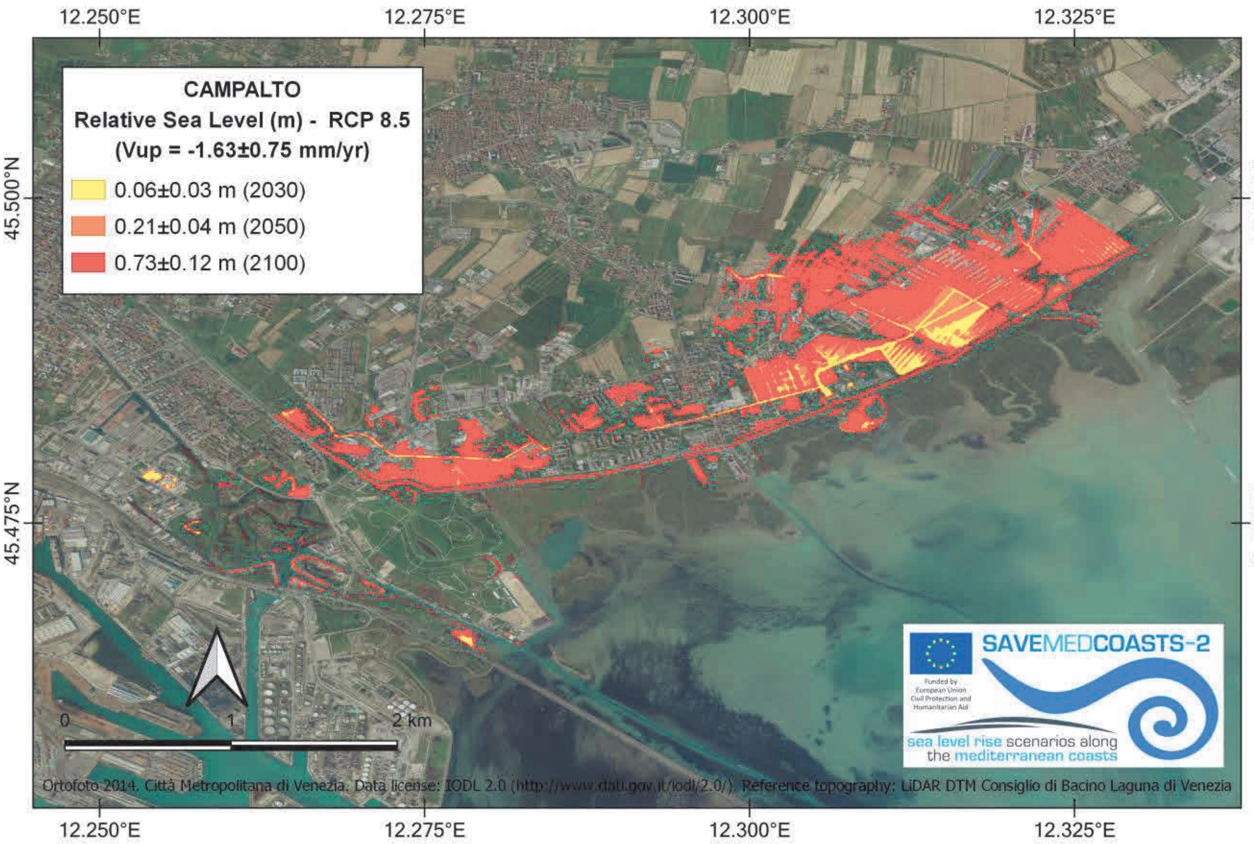

Figure 40 – The Venice lagoon: RCP 8.5 scenario of RSL at Campalto.

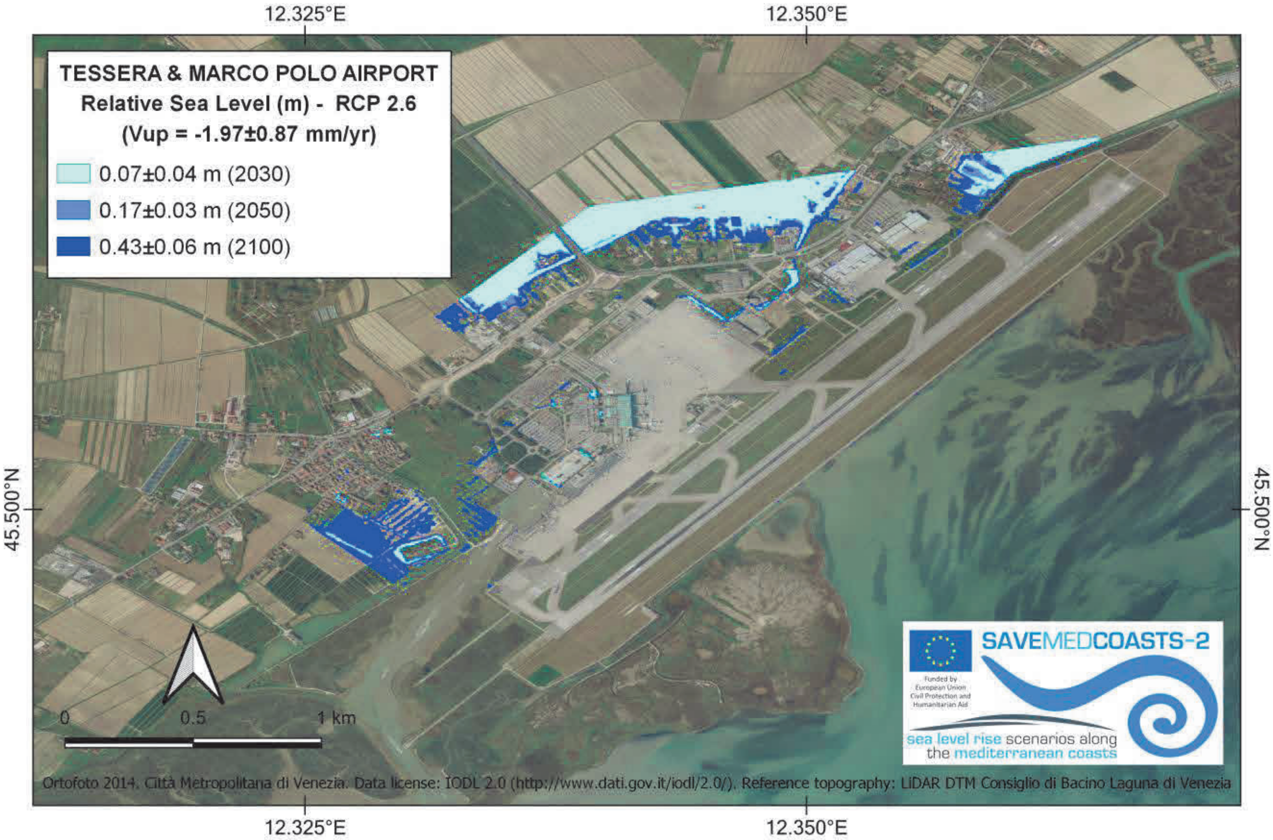

Figure 41 – The Venice lagoon: RCP 2.6 scenario of RSL at Tessera & Marco Polo Airport.

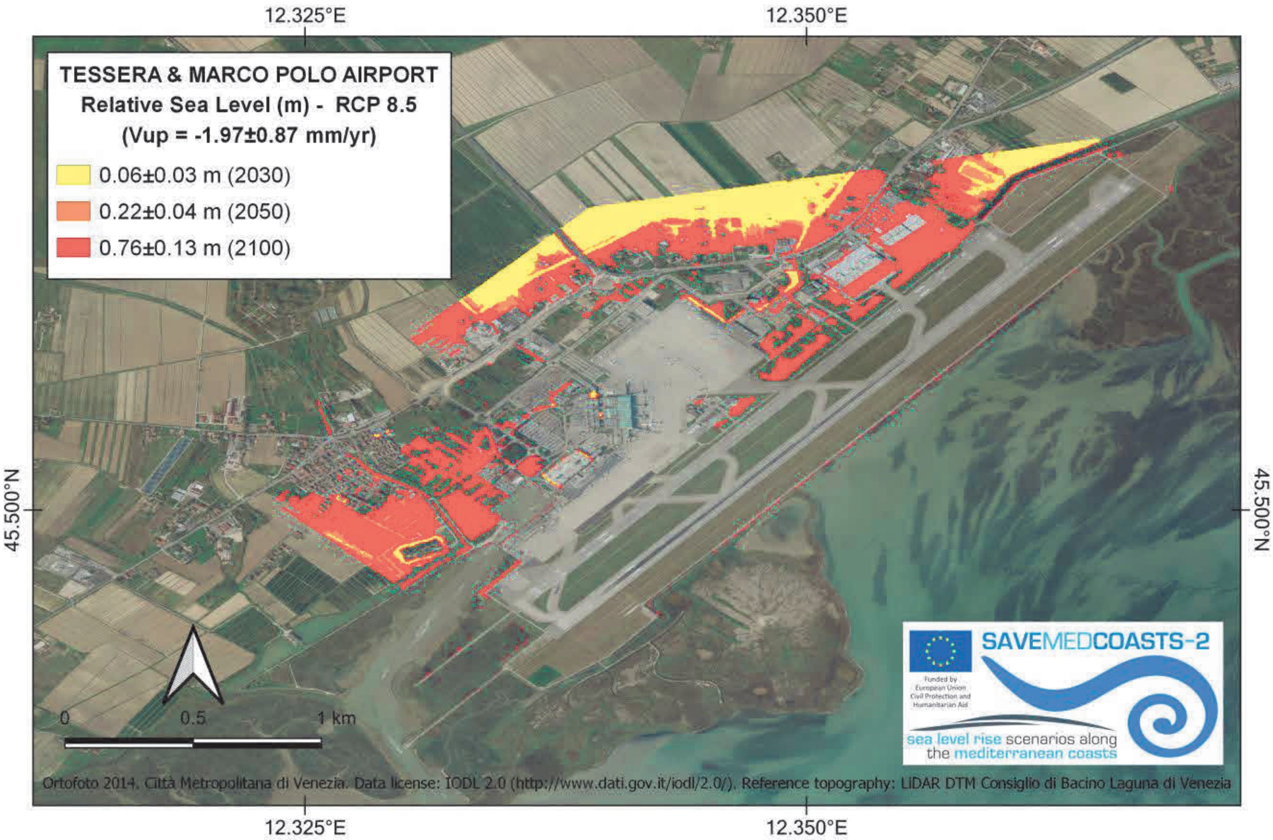

Figure 42 – The Venice lagoon: RCP 8.5 scenario of RSL at Tessera & Marco Polo Airport.

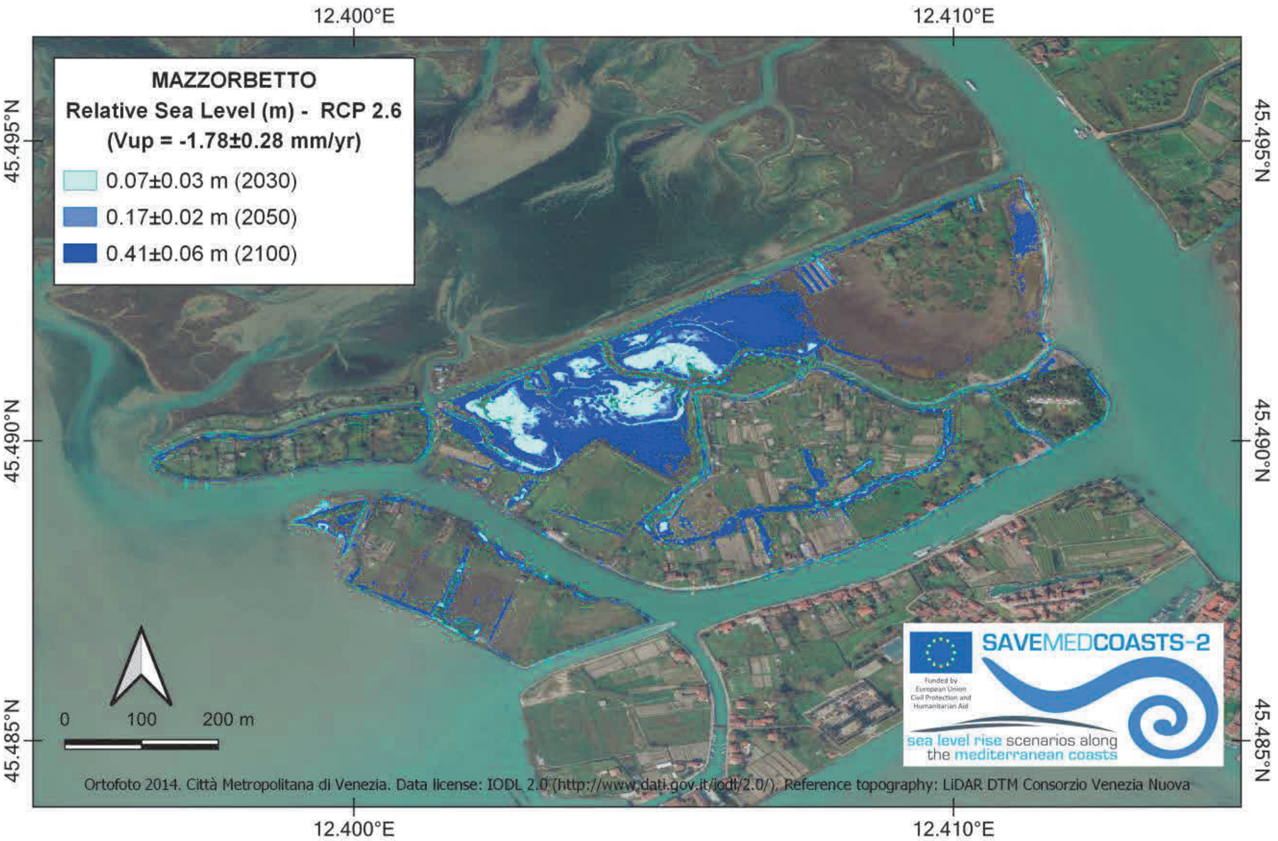

Figure 43 – The Venice lagoon: RCP 2.6 scenario of RSL at Mazzorbetto.

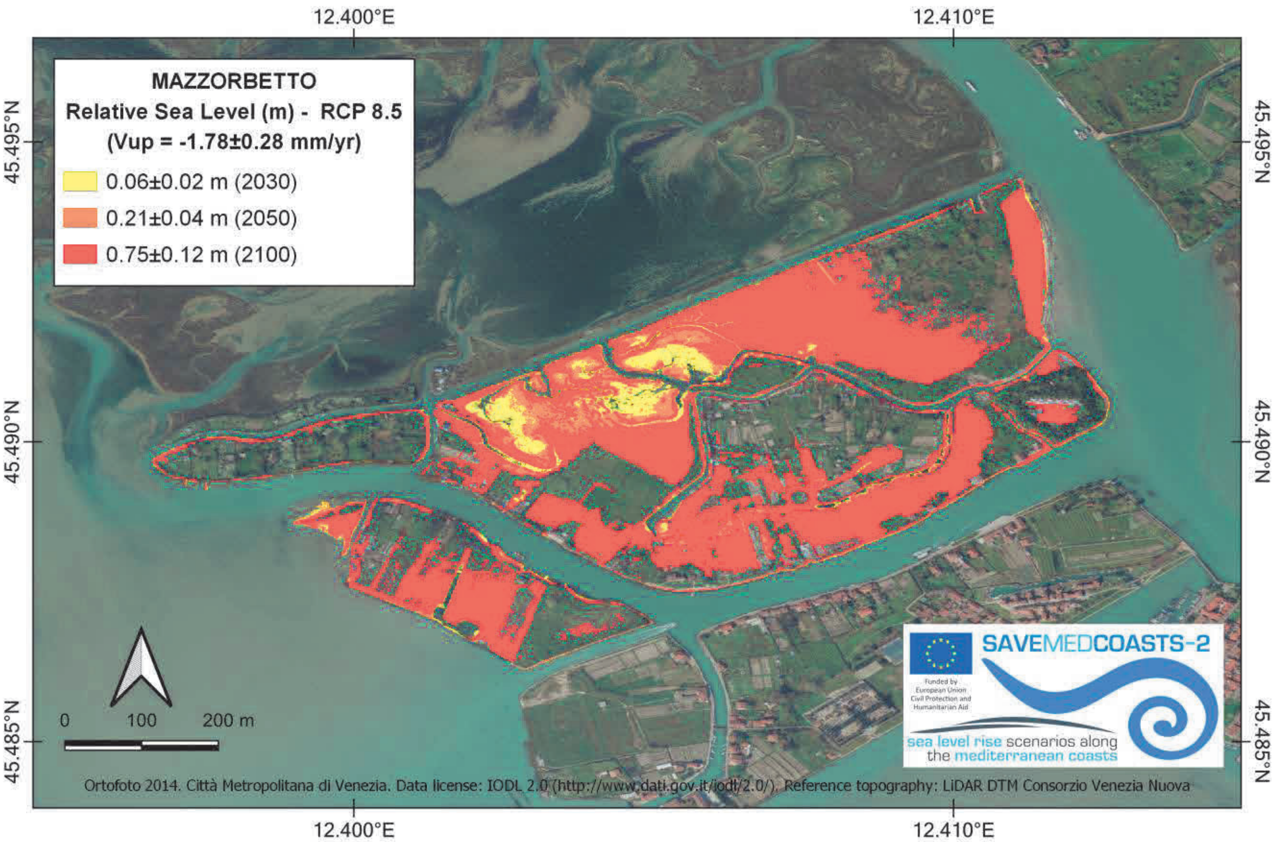

Figure 44 – The Venice lagoon: RCP 8.5 scenario of RSL at Mazzorbetto.

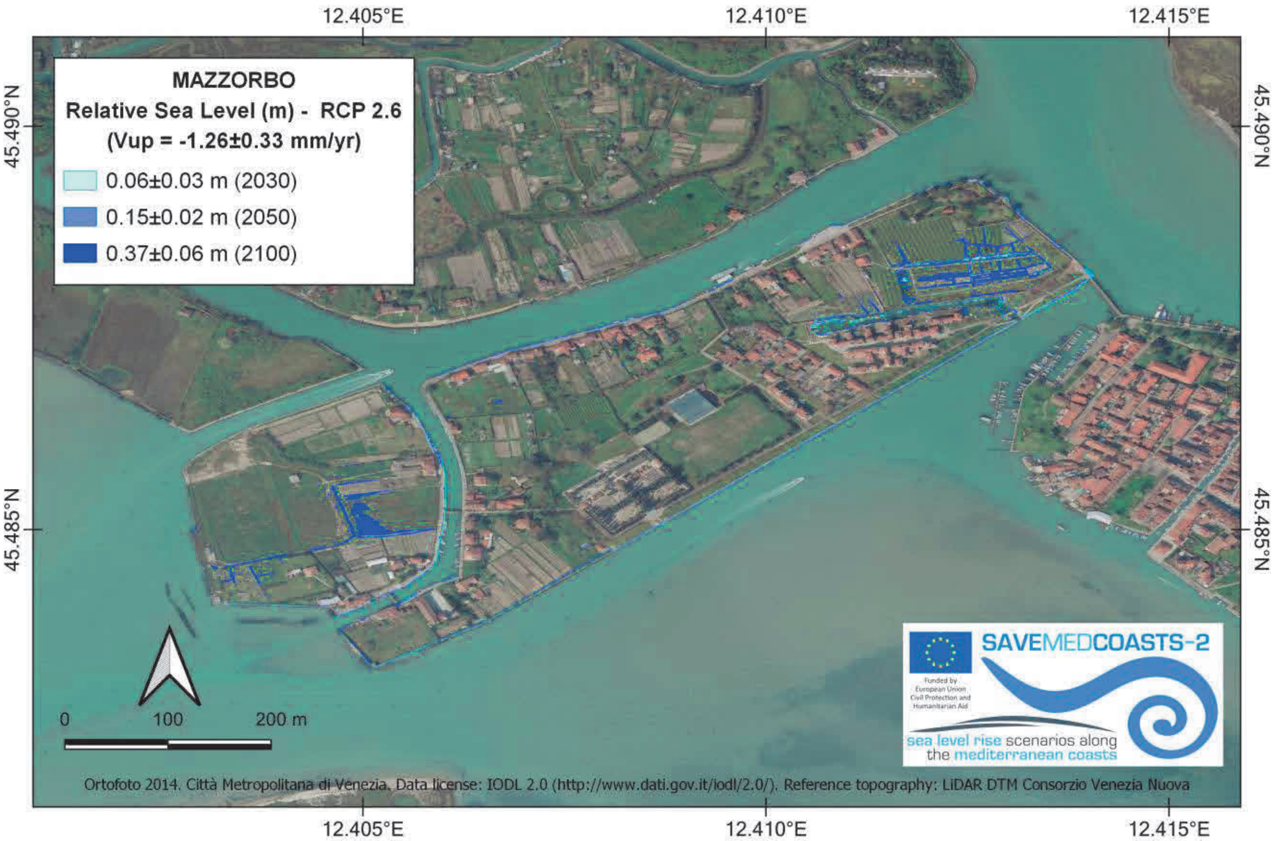

Figure 45 – The Venice lagoon: RCP 2.6 scenario of RSL at Mazzorbo.

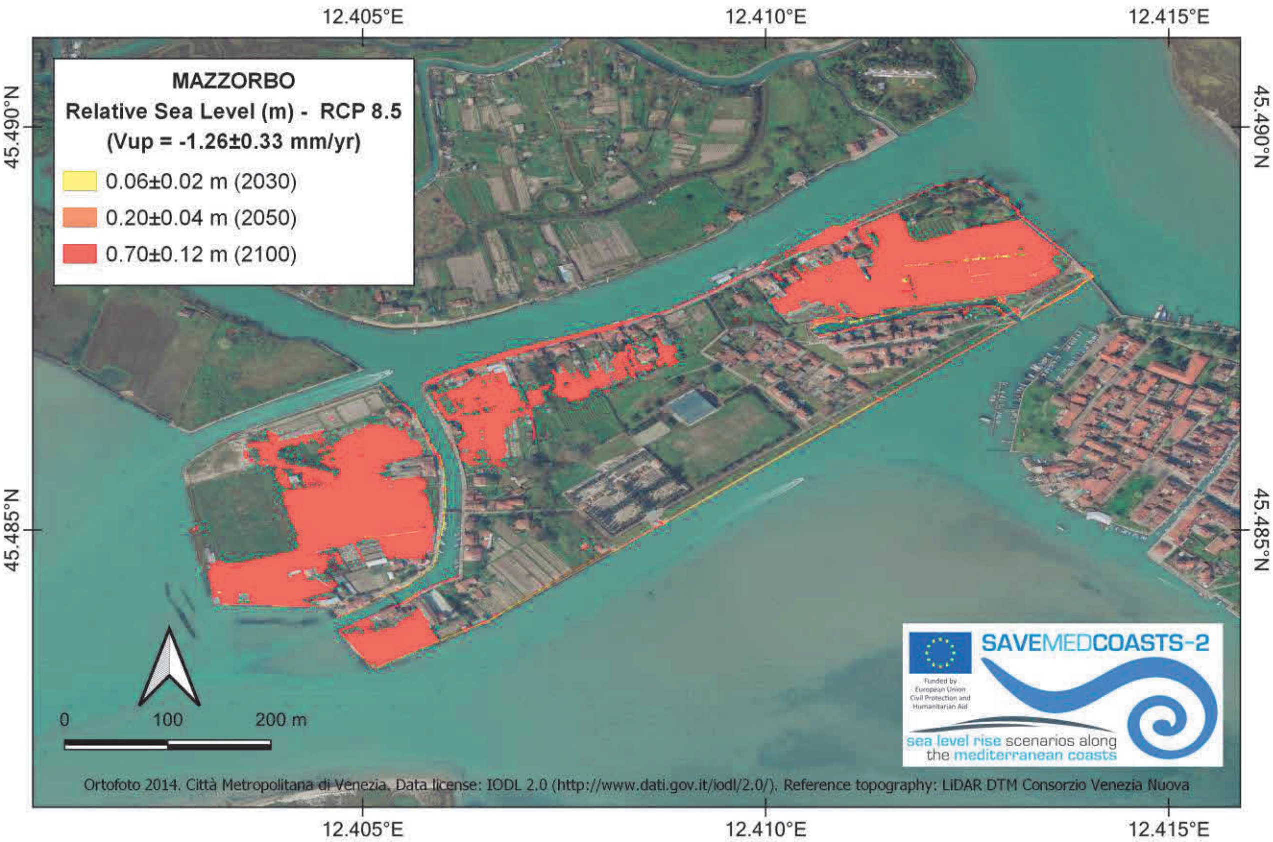

Figure 46 – The Venice lagoon: RCP 8.5 scenario of RSL at Mazzorbo.

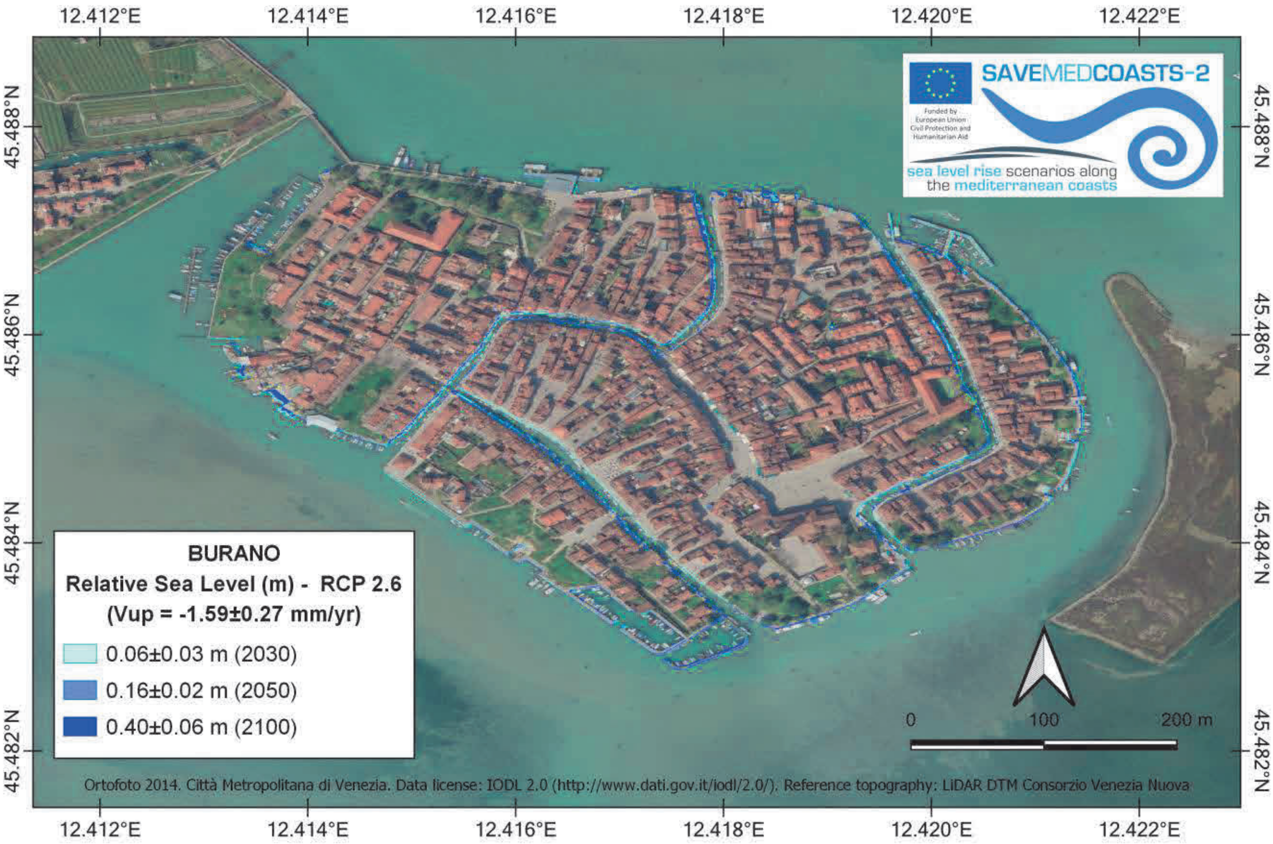

Figure 47 – The Venice lagoon: RCP 2.6 scenario of RSL at Burano.

Figure 48 – The Venice lagoon: RCP 8.5 scenario of RSL at Burano.

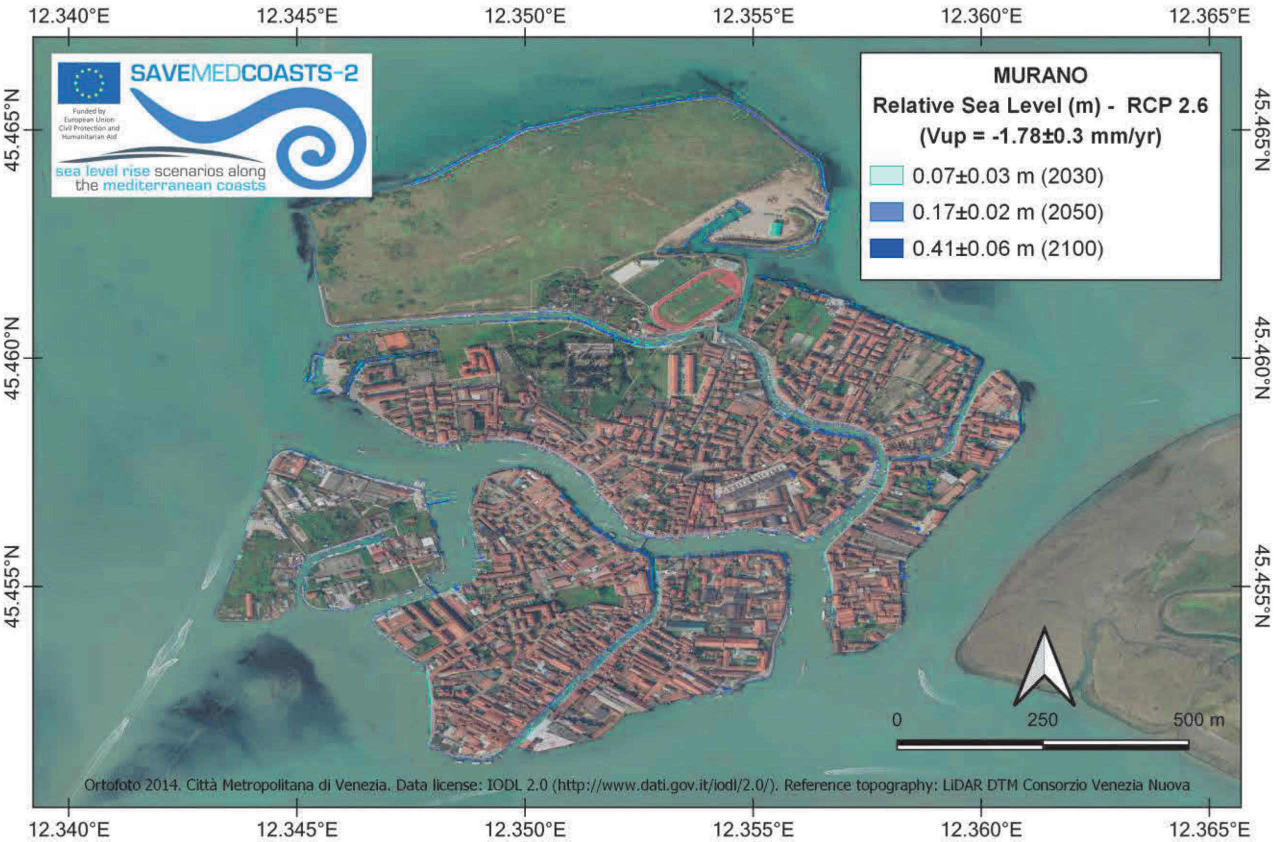

Figure 49 – The Venice lagoon: RCP 2.6 scenario of RSL at Murano.

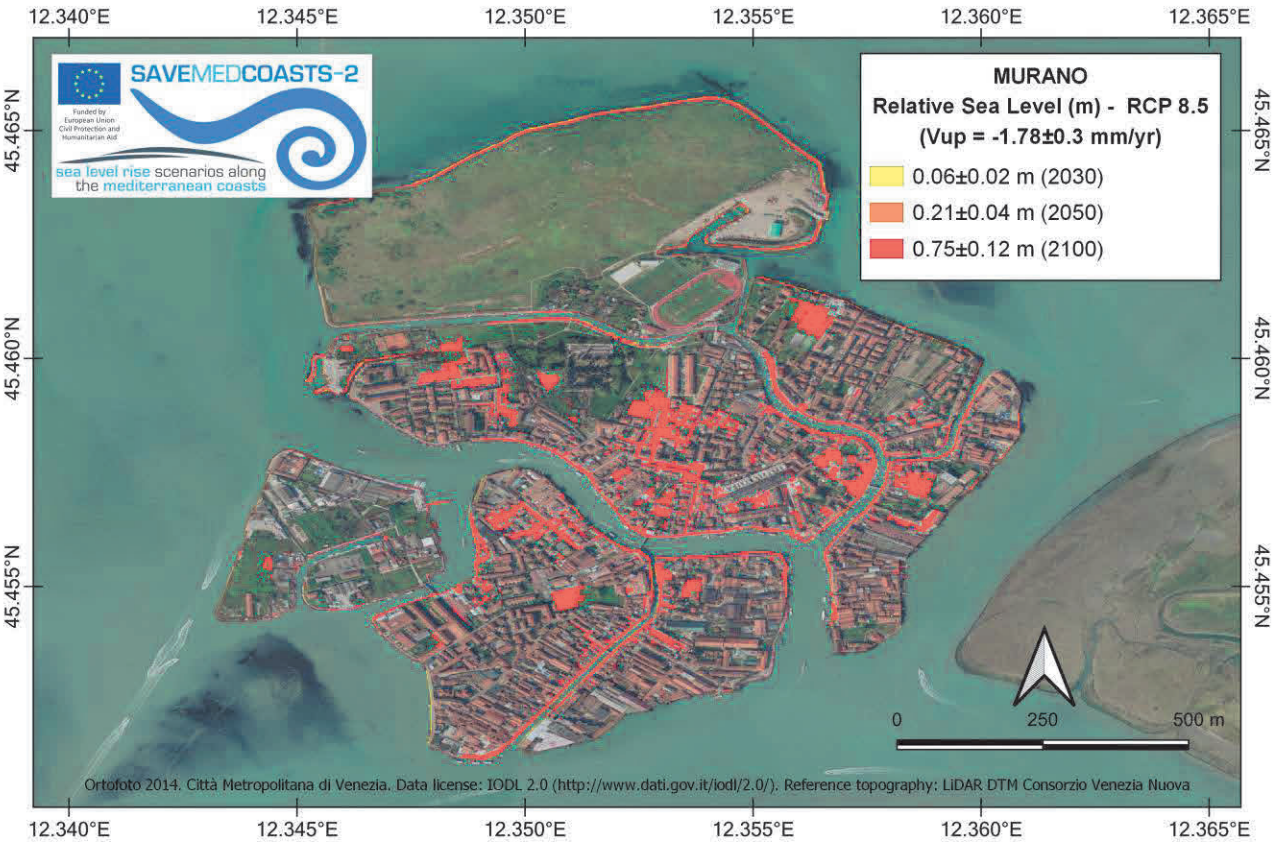

Figure 50 – The Venice lagoon: RCP 8.5 scenario of RSL at Murano.

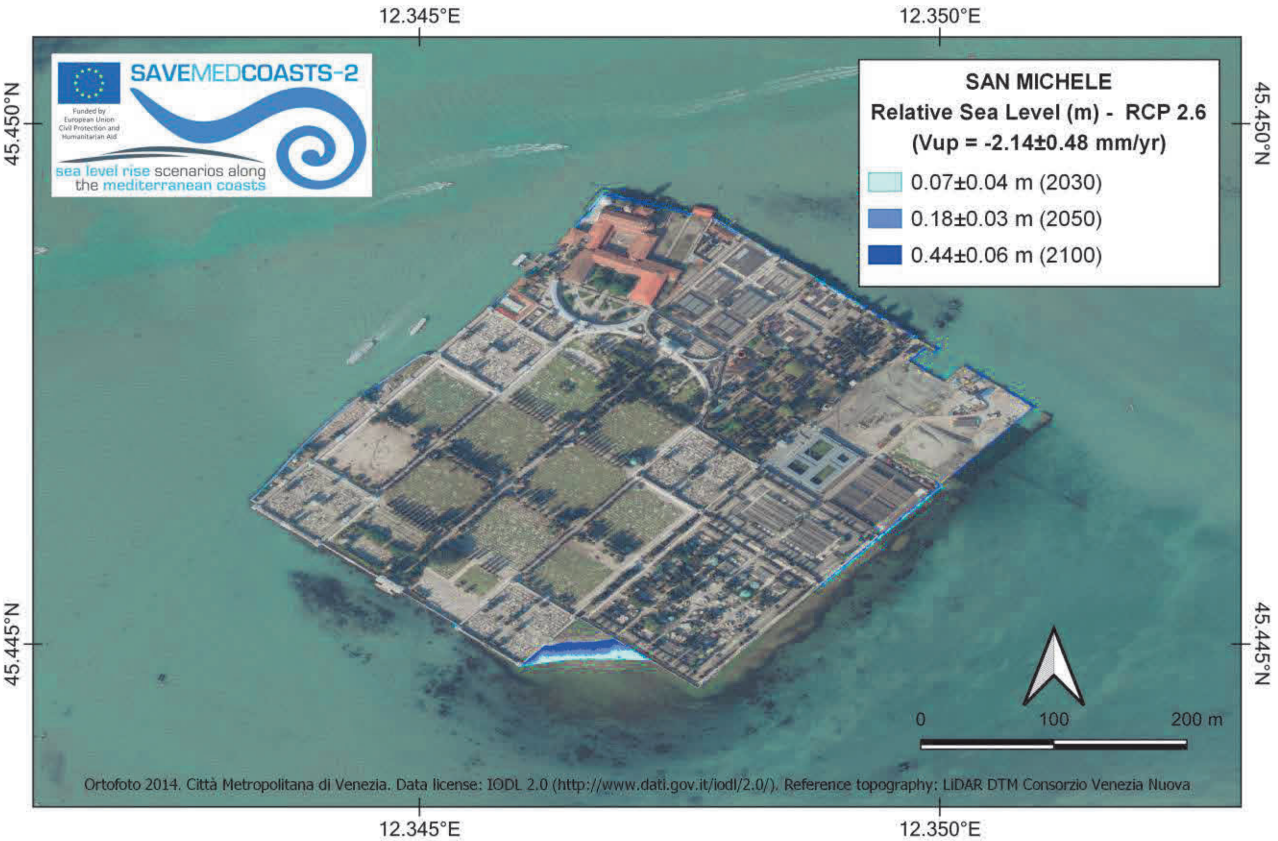

Figure 51 – The Venice lagoon: RCP 2.6 scenario of RSL at San Michele.

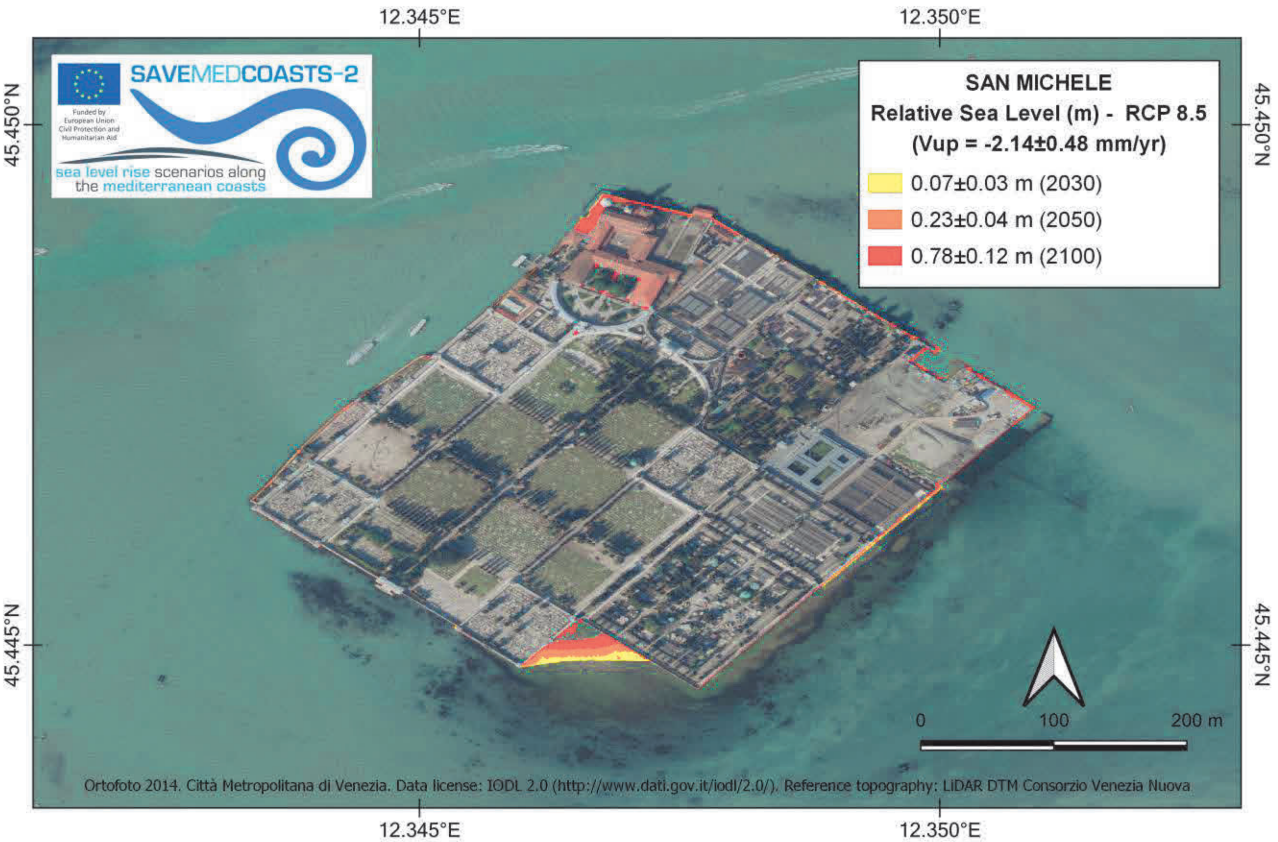

Figure 52 – The Venice lagoon: RCP 8.5 scenario of RSL at San Michele.

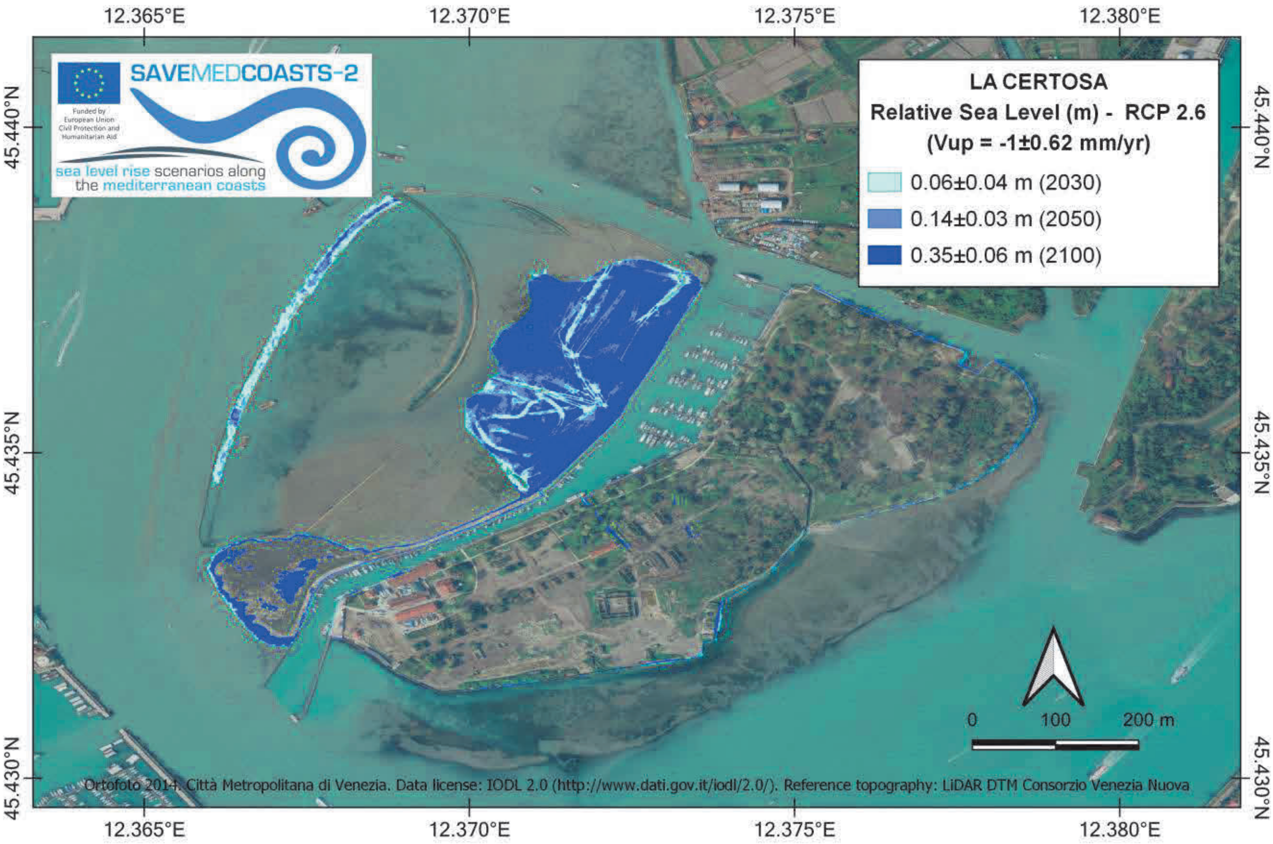

Figure 53 – The Venice lagoon: RCP 2.6 scenario of RSL at La Certosa.

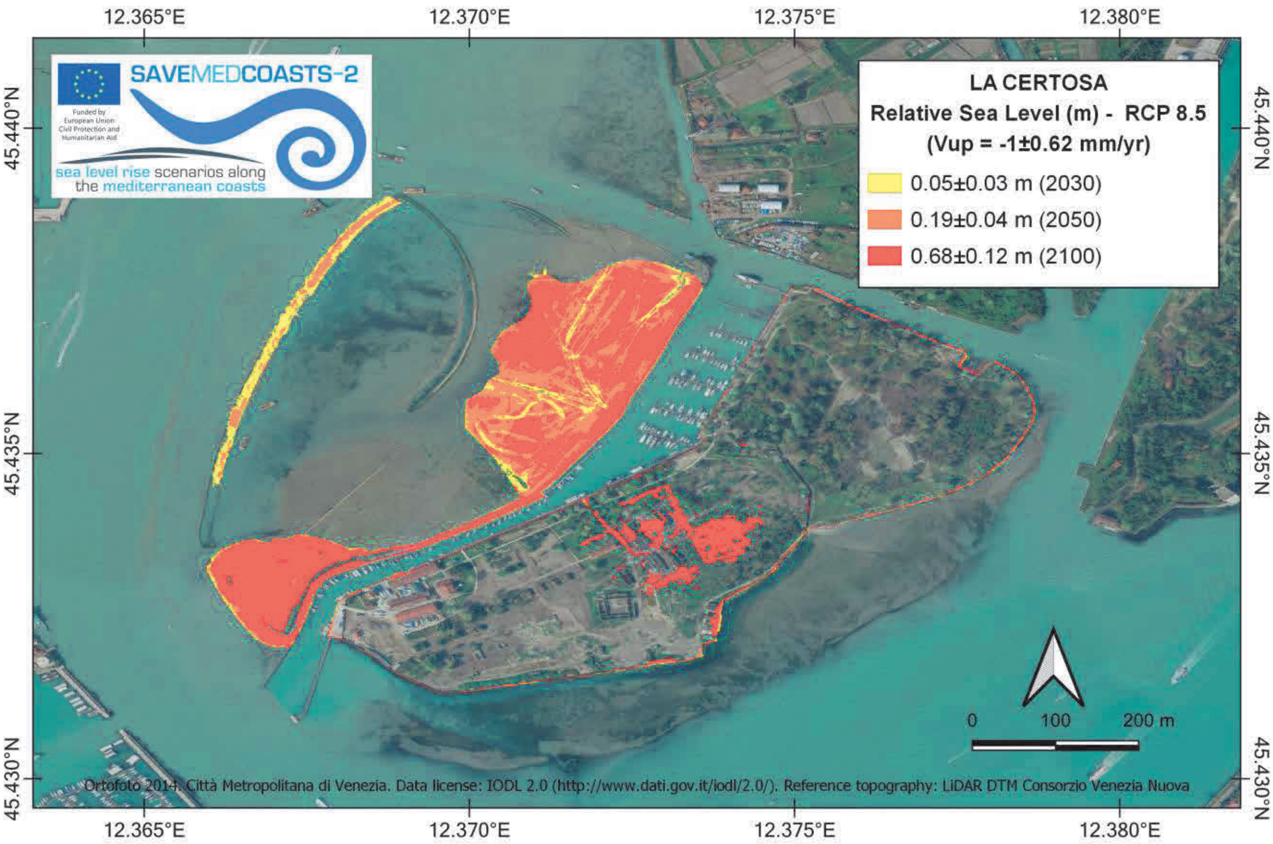

Figure 54 – The Venice lagoon: RCP 8.5 scenario of RSL at La Certosa.

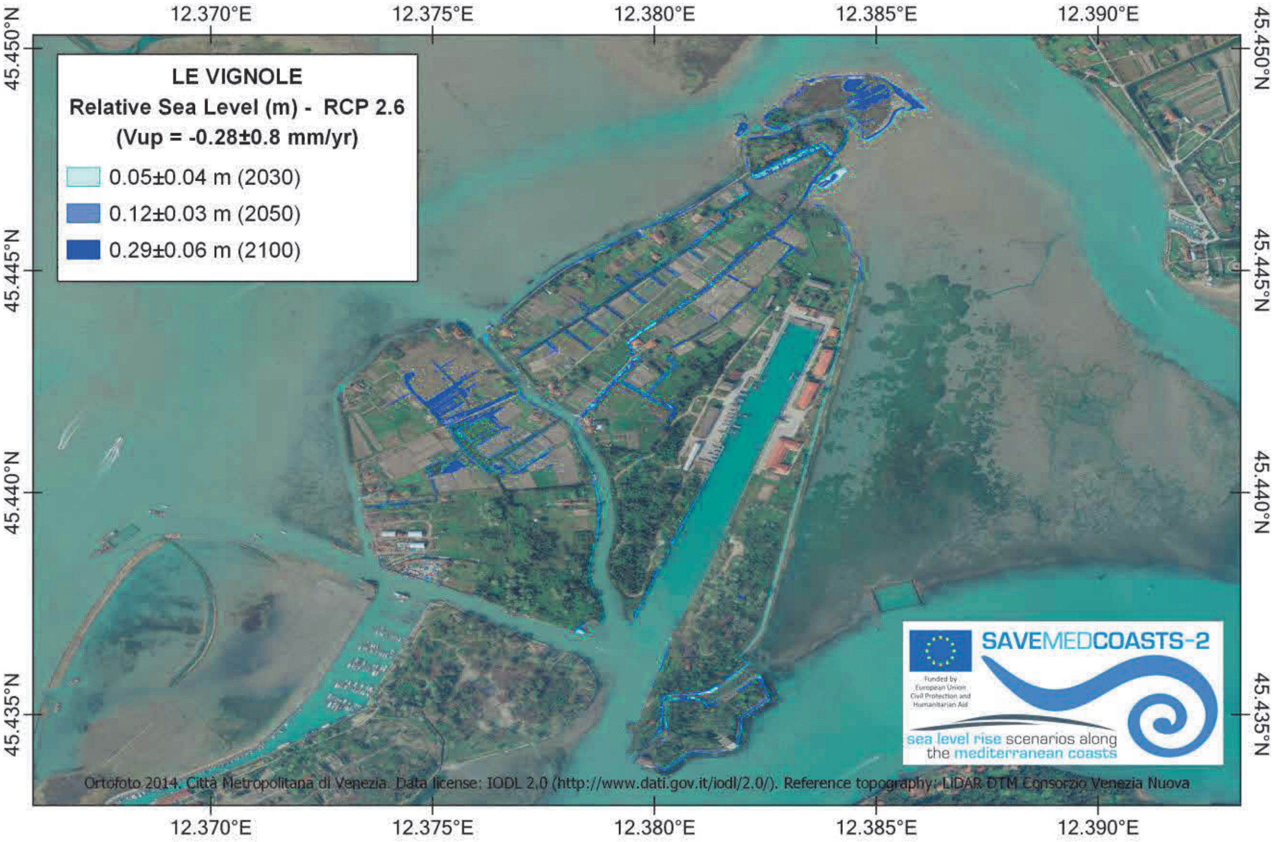

Figure 55 – The Venice lagoon: RCP 2.6 scenario of RSL at Le Vignole.

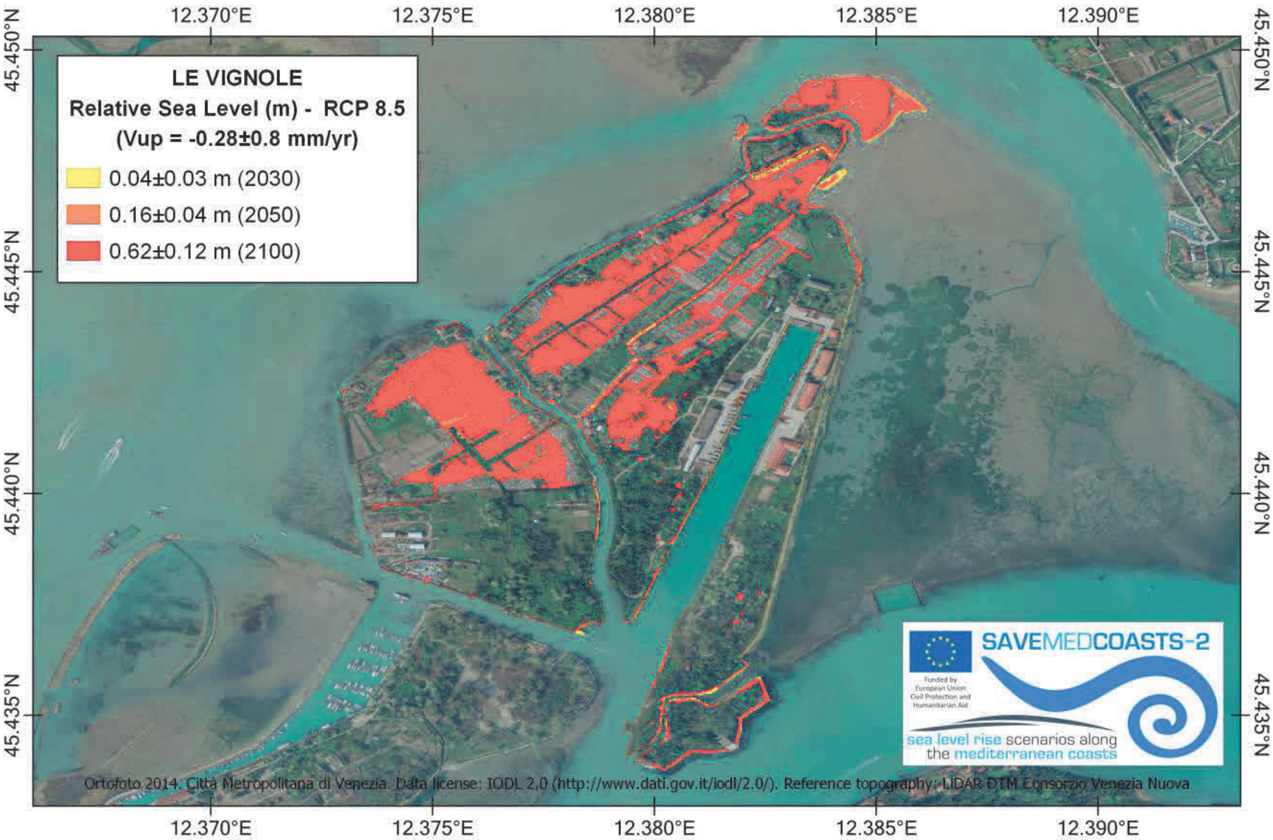

Figure 56 – The Venice lagoon: RCP 8.5 scenario of RSL at Le Vignole.

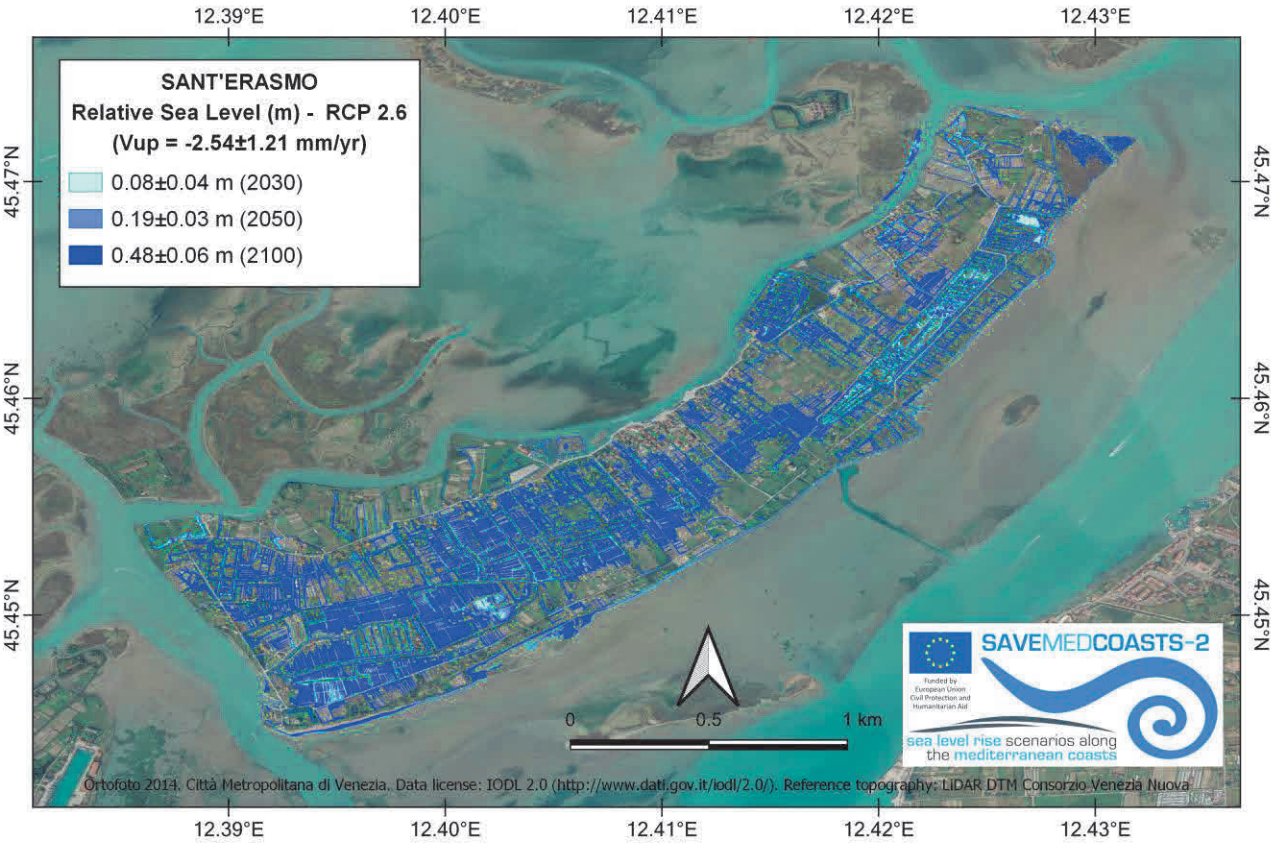

Figure 57 – The Venice lagoon: RCP 2.6 scenario of RSL at Sant'Erasmo.

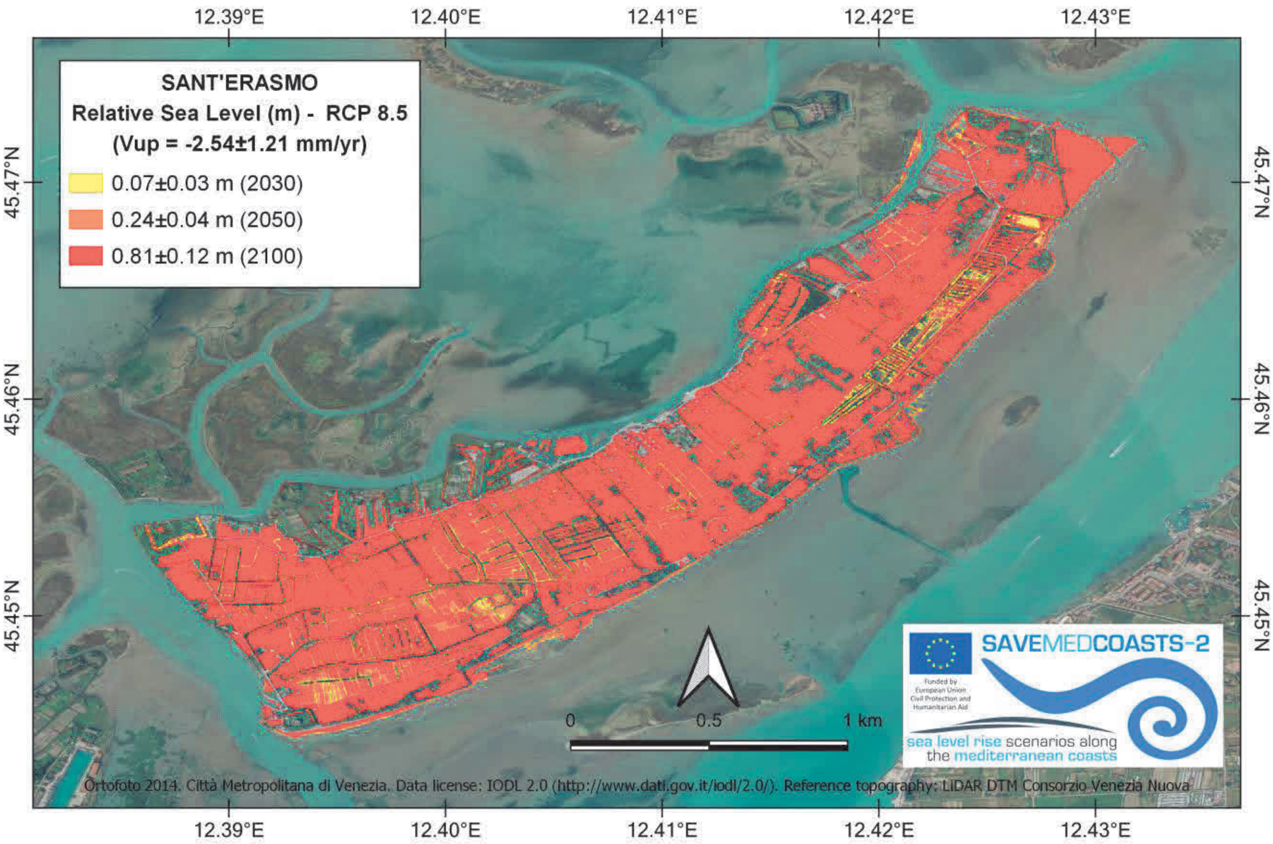

Figure 58 – The Venice lagoon: RCP 8.5 scenario of RSL at Sant'Erasmo.

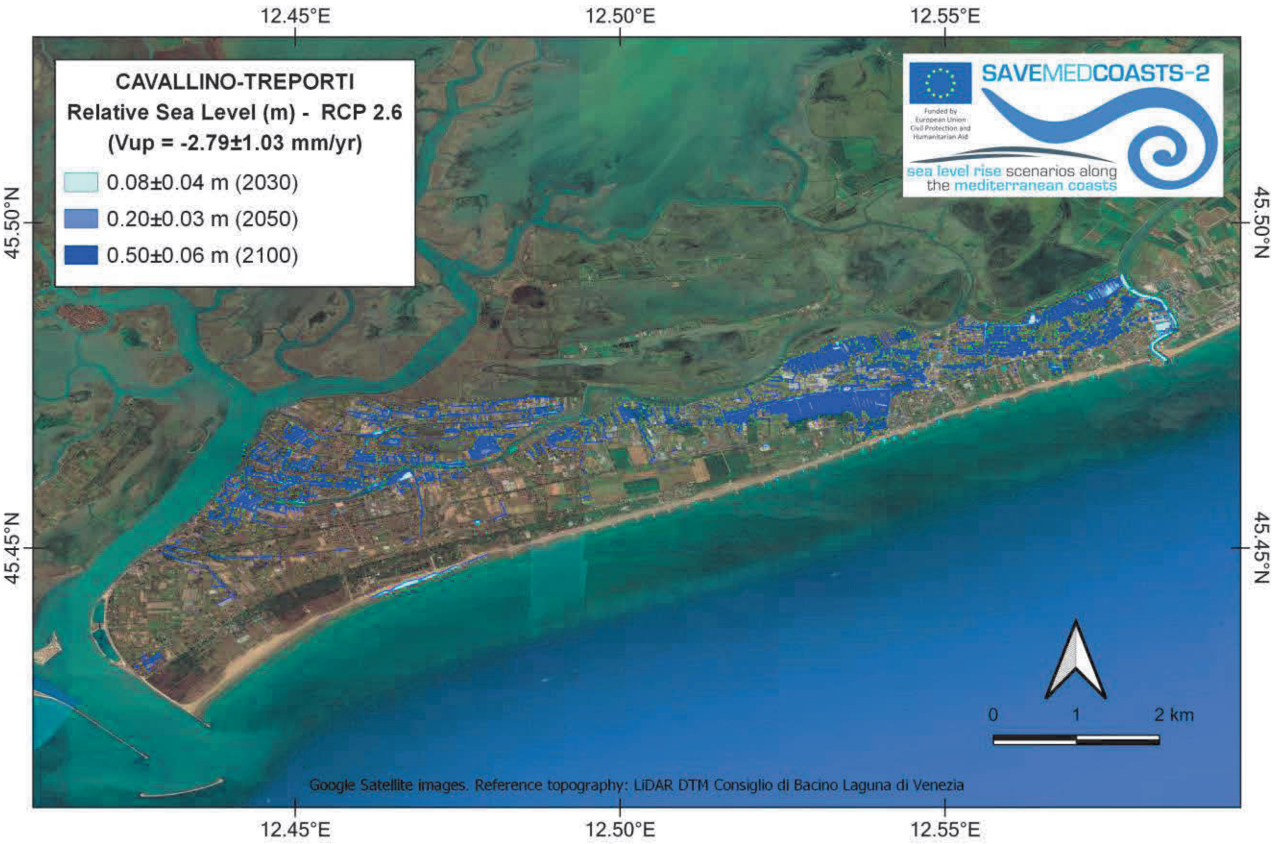

Figure 59 – The Venice lagoon: RCP 2.6 scenario of RSL at Cavallino-Treporti.

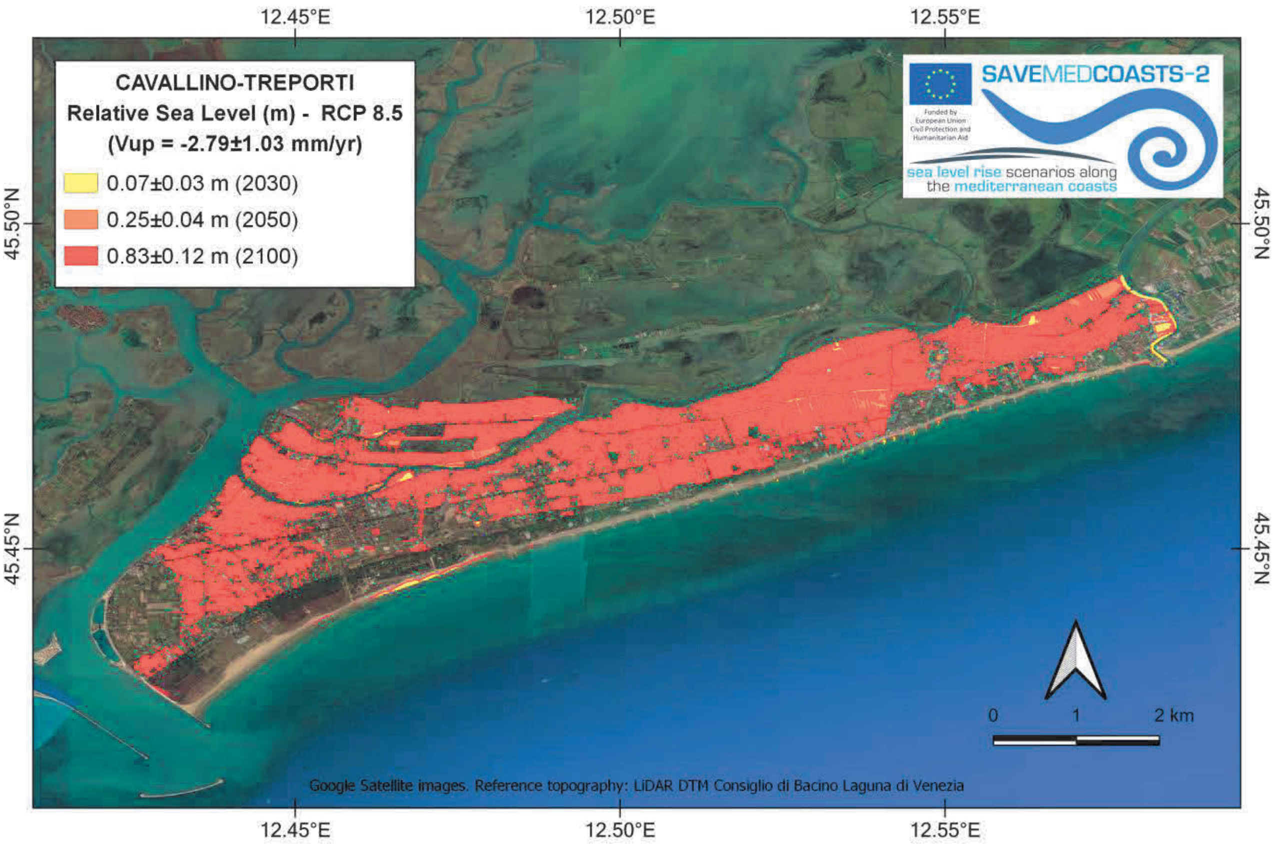

Figure 60 – The Venice lagoon: RCP 8.5 scenario of RSL at Cavallino-Treporti.

4.3 The Venice lagoon (Italy)

The six transects considered in the storm surges modelling for the Venice lagoon (Figure 120) are relative only to a portion of the extra-lagoon coast (Lido and Cavallino-Treporti). The graphical outputs of the one-dimensional model of storm surges for each combination of boundary conditions and each time horizon considered are reported respectively: Figures 121-124 (transect 1), Figures 125-128 (transect 2), Figures 129-132 (transect 3), Figures 133-136 (transect 4), Figures 137-140 (transect 5) and, finally, Figures 141-144 (transect 6). The output values of the storm surge models and the combined flooding scenarios of RSLR and storm surges for 2021, 2030, 2050 and 2100 are reported in Table 11. Finally, the maps of flooding scenarios for each combination of boundary conditions and each time horizon considered are represented in Figures 145-148 (Lido) and in Figures 149-152 (Cavallino-Treporti).

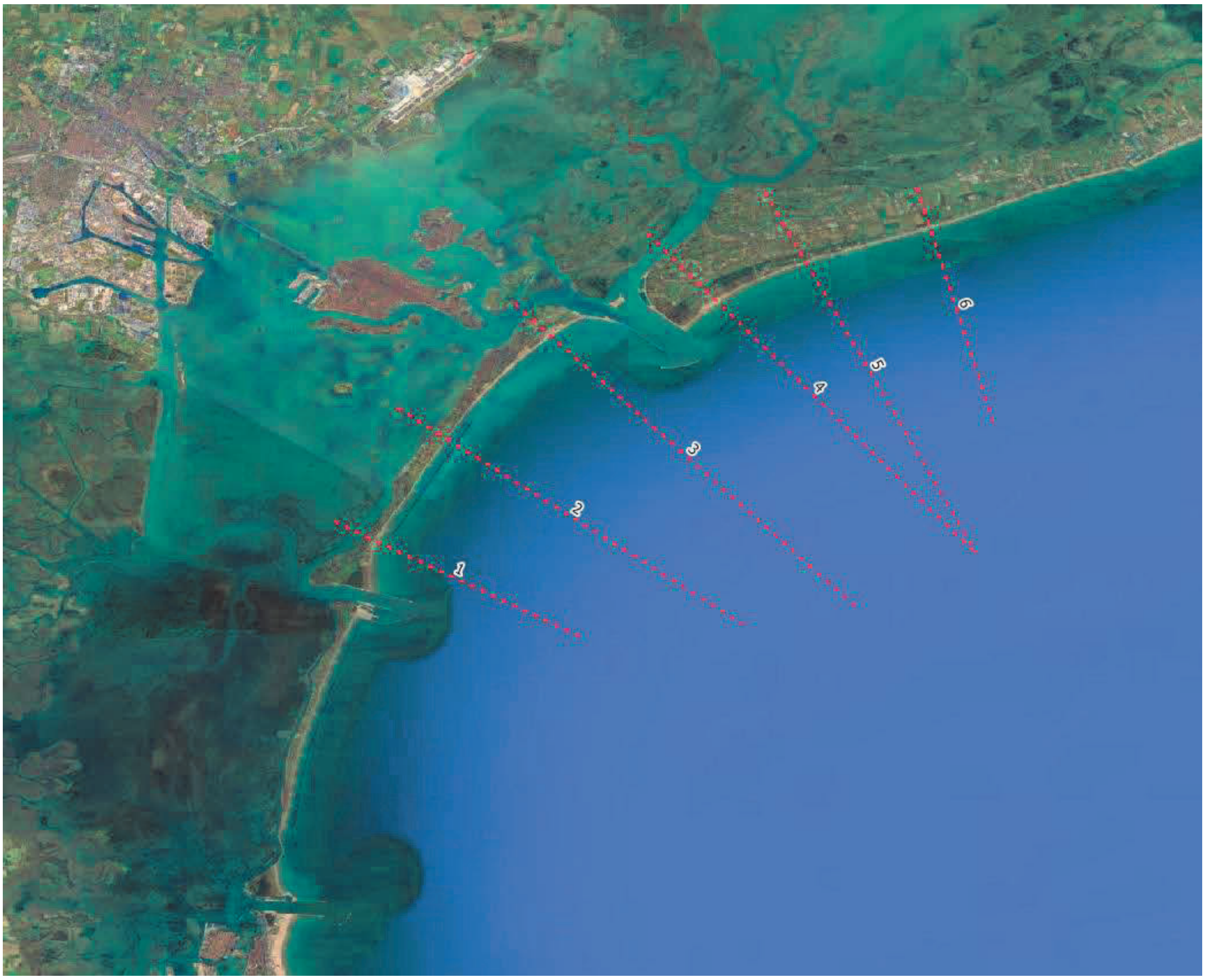

Figure 120 – The Venice lagoon. The red dotted lines show the transects considered in the storm surges modelling.

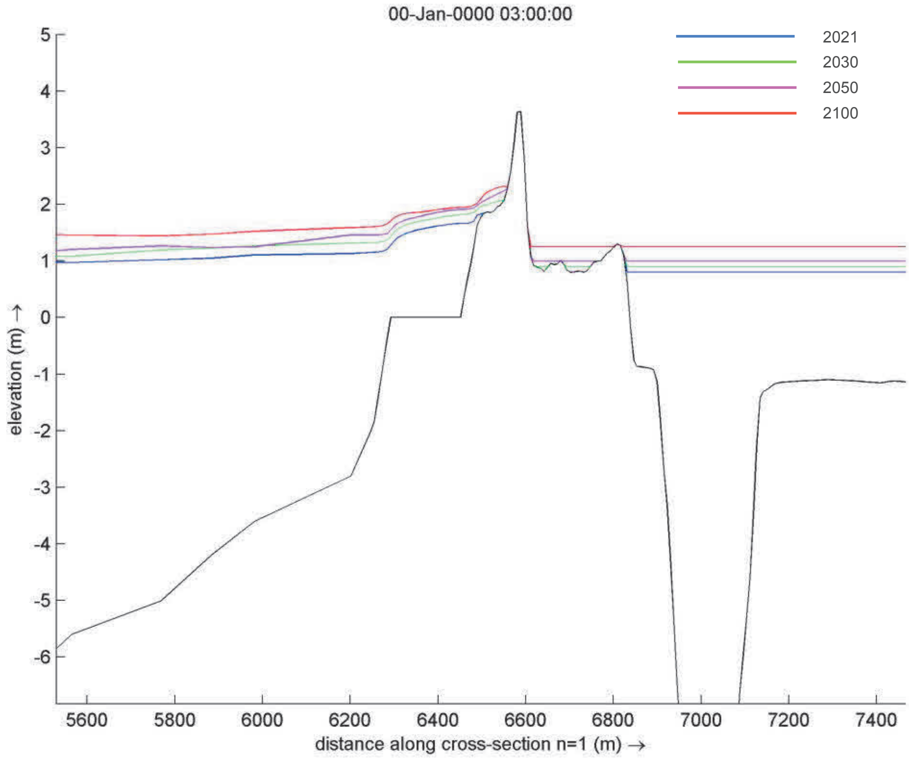

Figure 121 – The Venice lagoon: transect 1 output for RCP 2.6 and storm surge RT = 1 yr

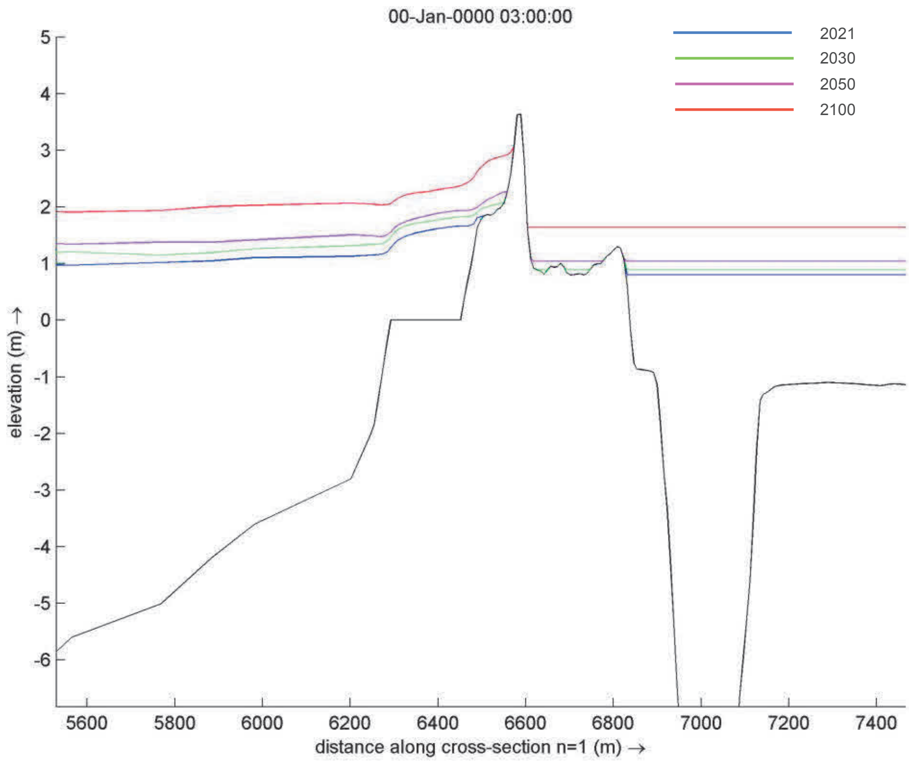

Figure 122 – The Venice lagoon: transect 1 output for RCP 8.5 and storm surge RT = 1 yr

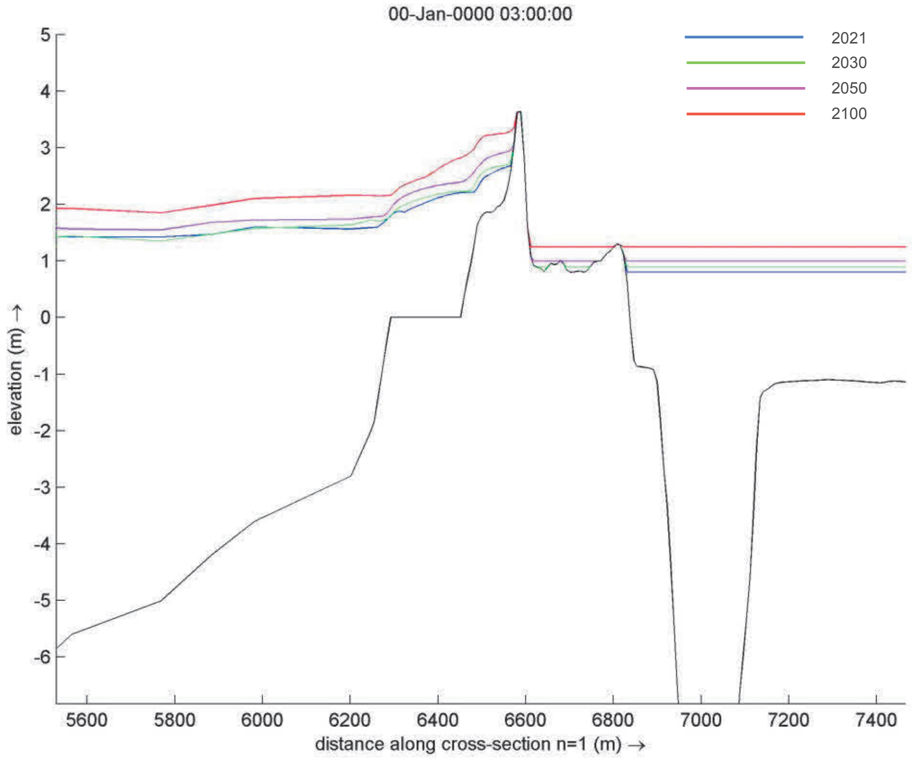

Figure 123 – The Venice lagoon: transect 1 output for RCP 2.6 and storm surge RT = 100 yr

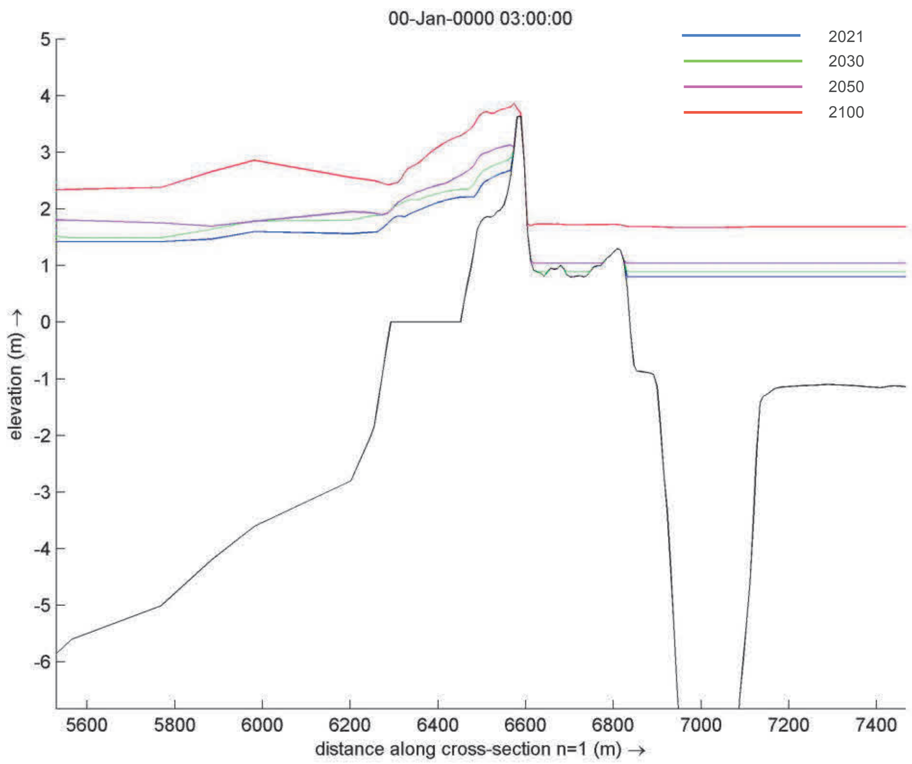

Figure 124 – The Venice lagoon: transect 1 output for RCP 8.5 and storm surge RT = 100 yr

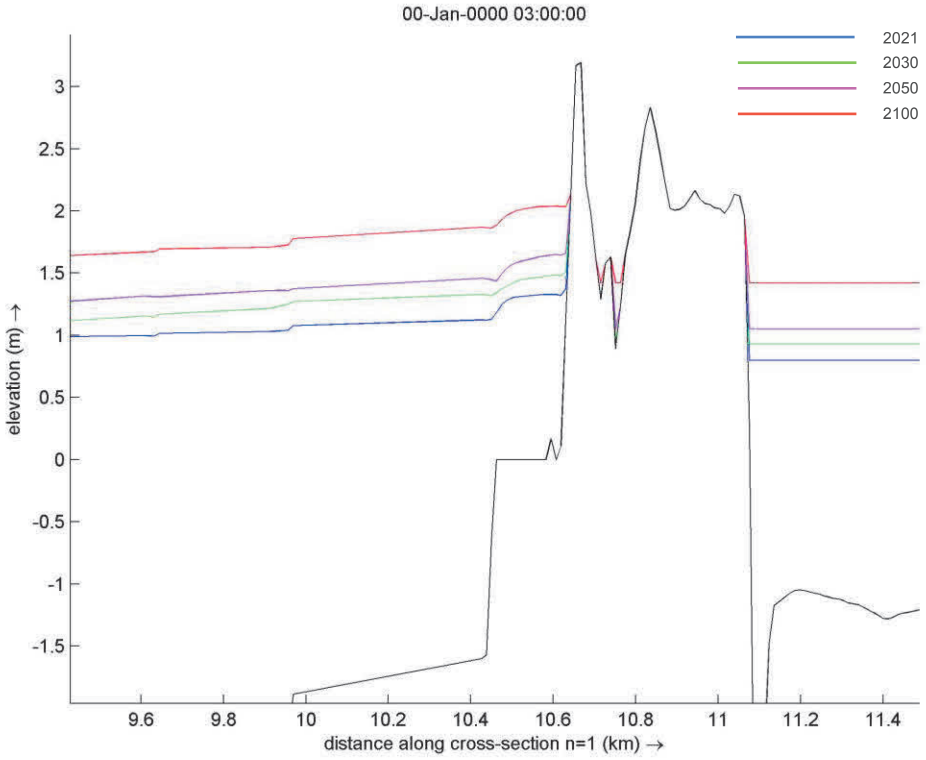

Figure 125 – The Venice lagoon: transect 2 output for RCP 2.6 and storm surge RT = 1 yr

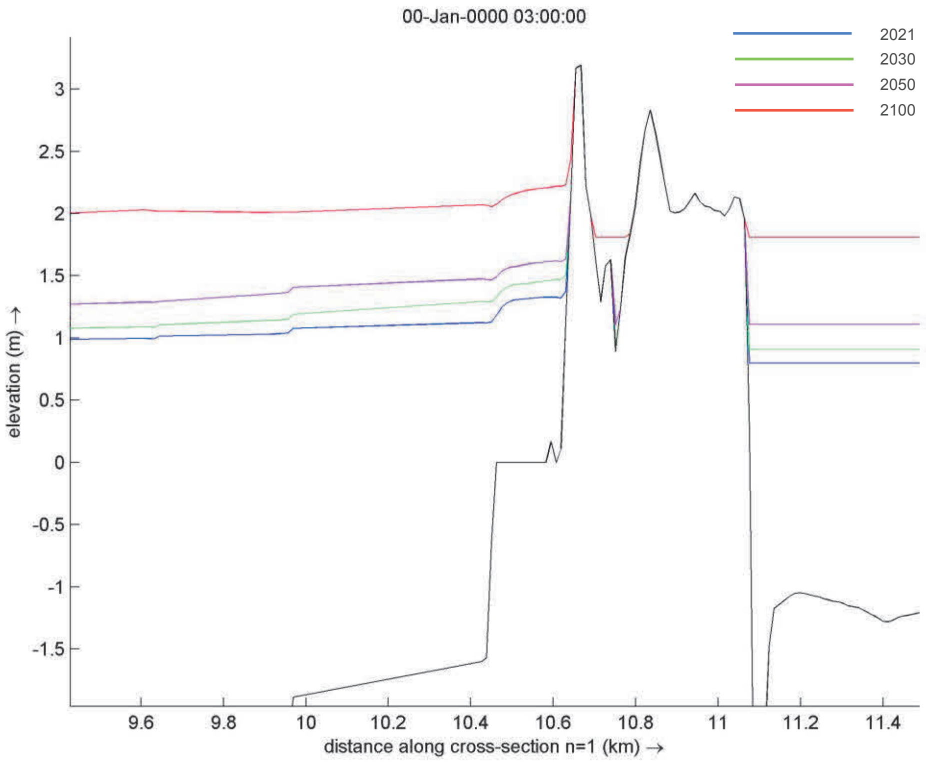

Figure 126 – The Venice lagoon: transect 2 output for RCP 8.5 and storm surge RT = 1 yr

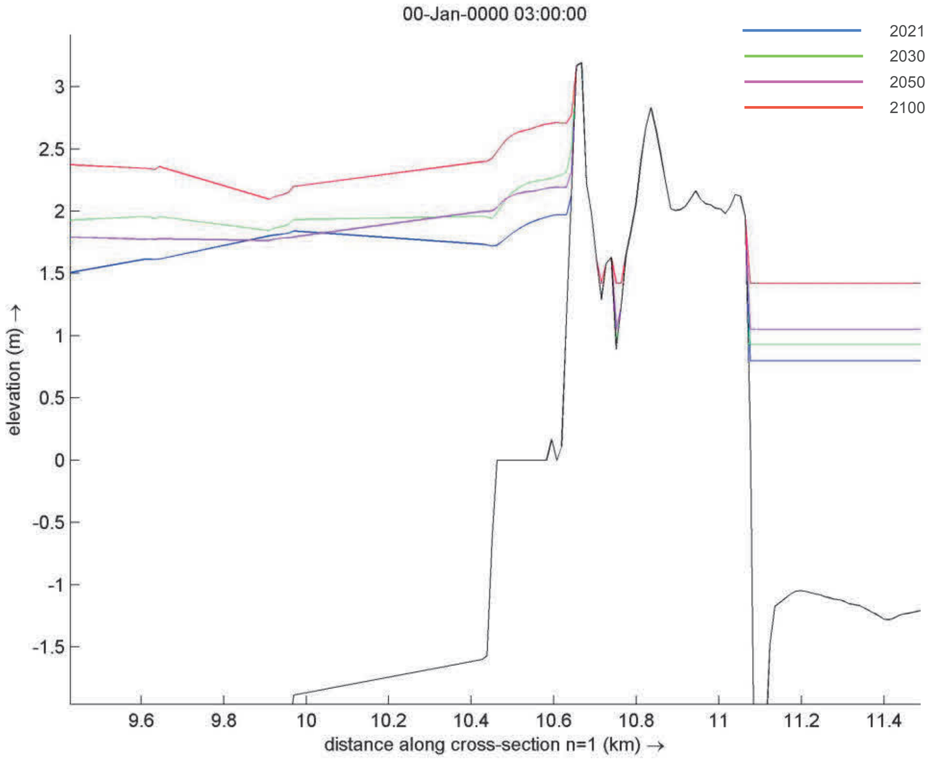

Figure 127 – The Venice lagoon: transect 2 output for RCP 2.6 and storm surge RT = 100 yr

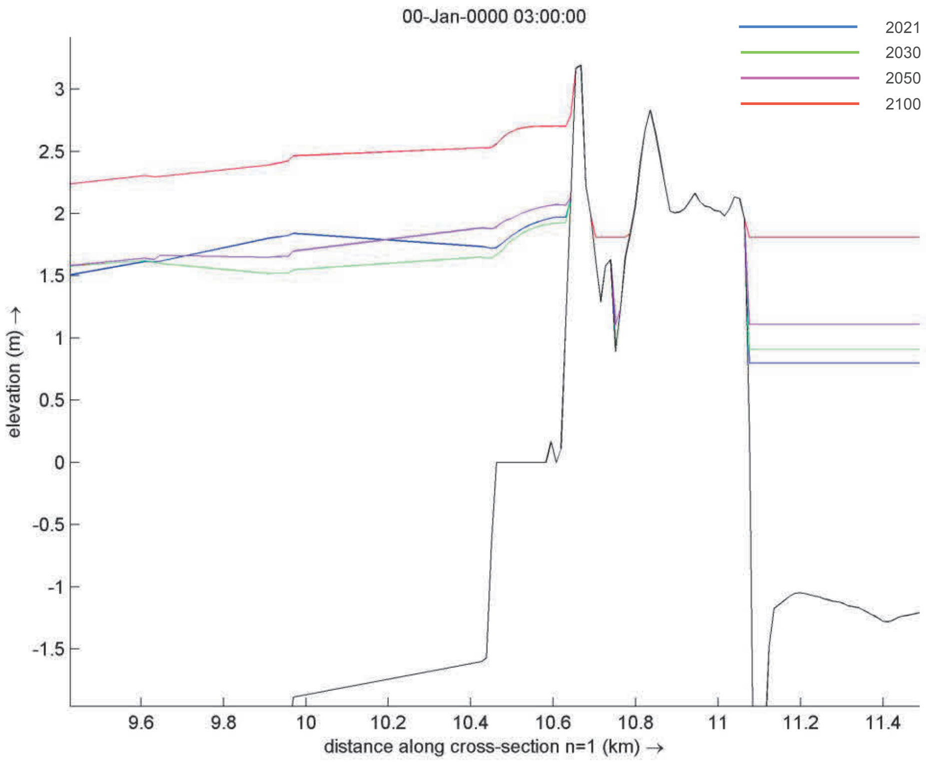

Figure 128 – The Venice lagoon: transect 2 output for RCP 8.5 and storm surge RT = 100 yr

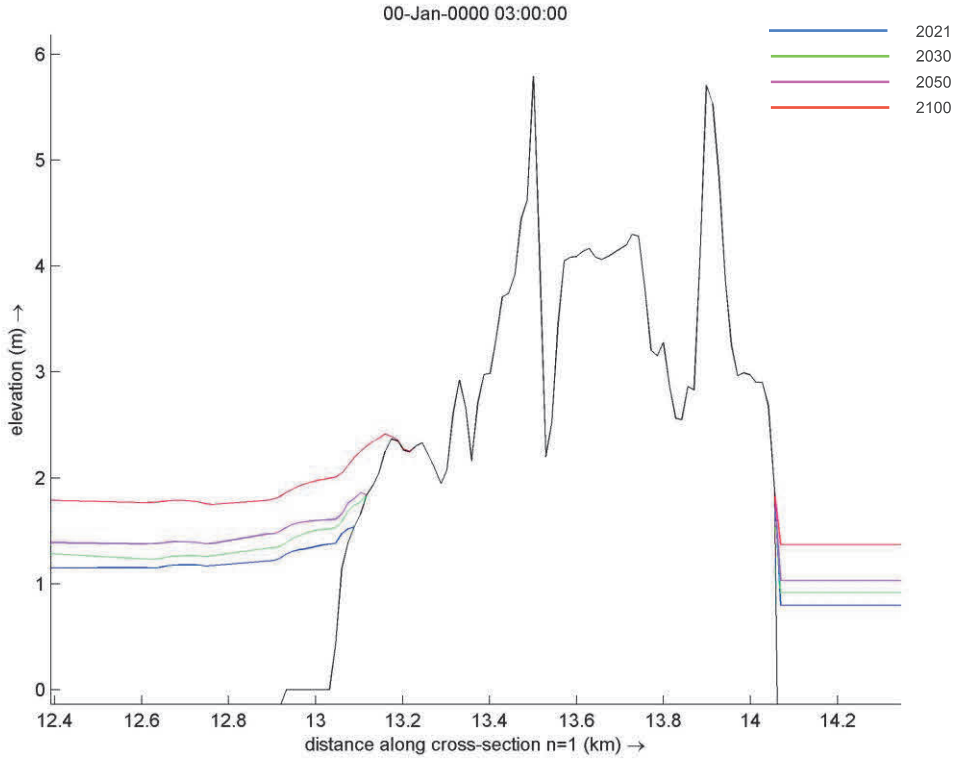

Figure 129 – The Venice lagoon: transect 3 output for RCP 2.6 and storm surge RT = 1 yr

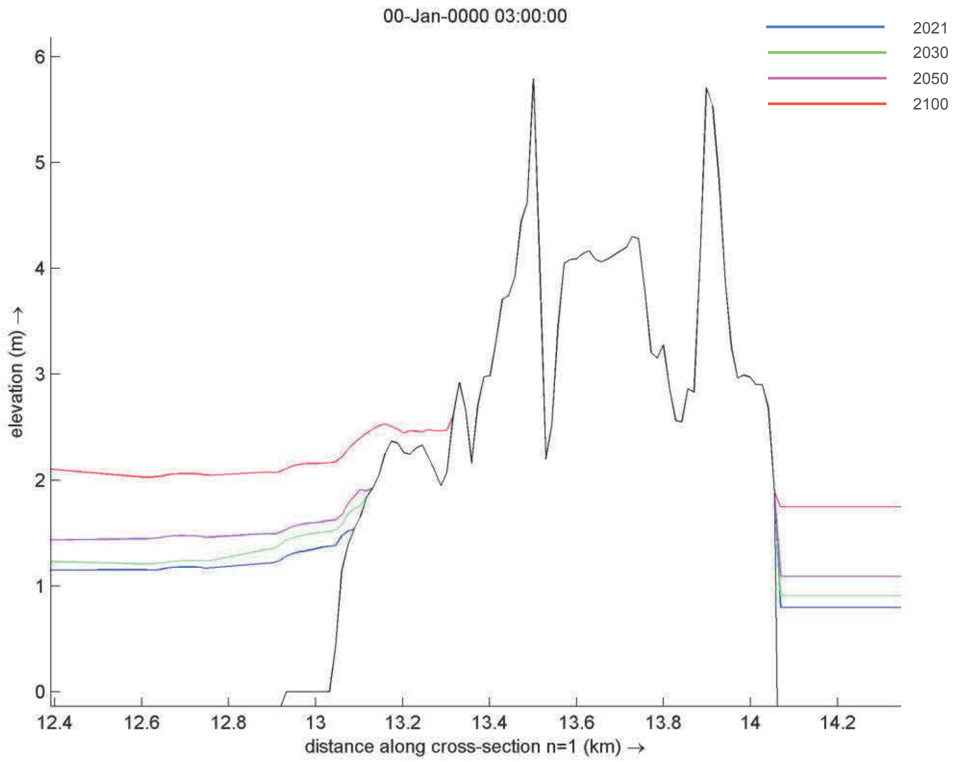

Figure 130 – The Venice lagoon: transect 3 output for RCP 8.5 and storm surge RT = 1 yr

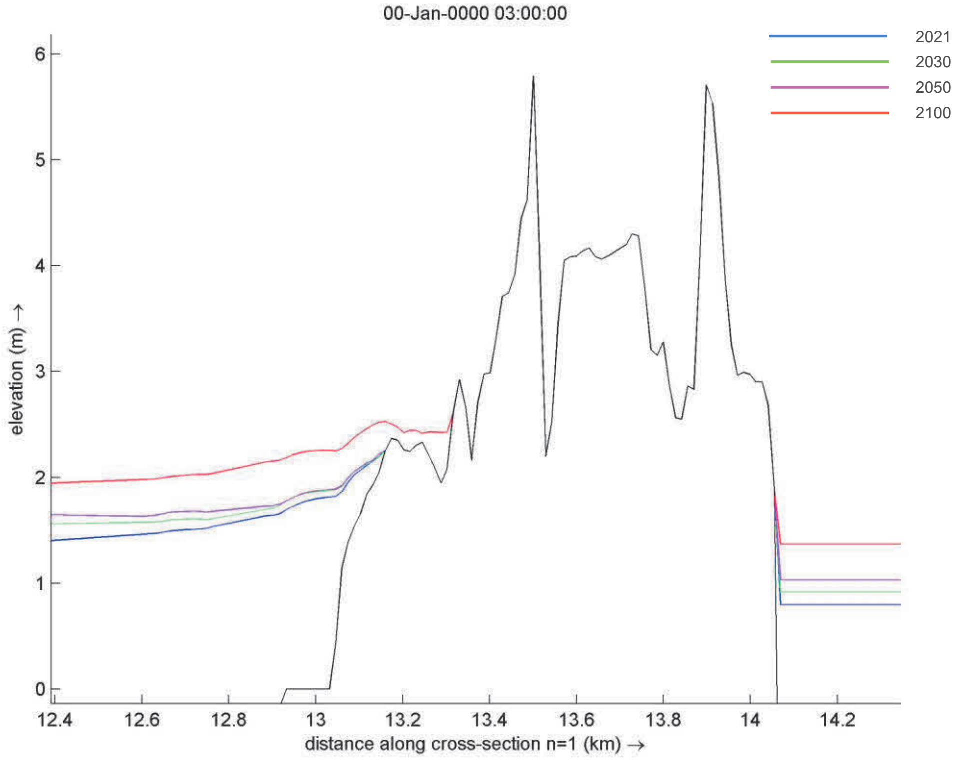

Figure 131 – The Venice lagoon: transect 3 output for RCP 2.6 and storm surge RT = 100 yr

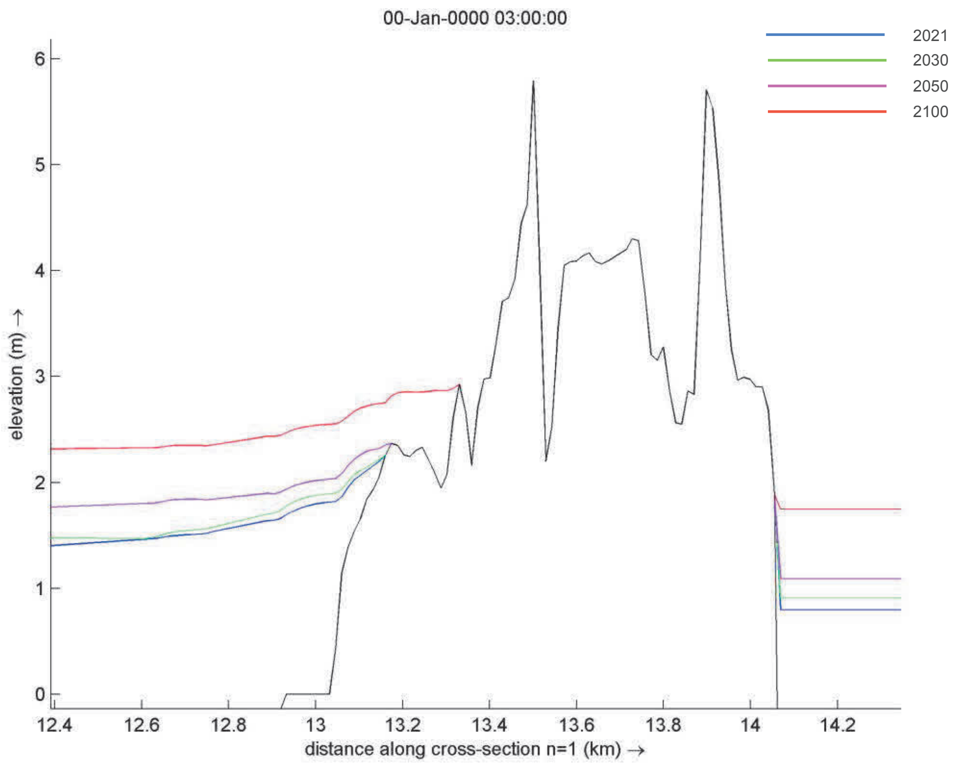

Figure 132 – The Venice lagoon: transect 3 output for RCP 8.5 and storm surge RT = 100 yr

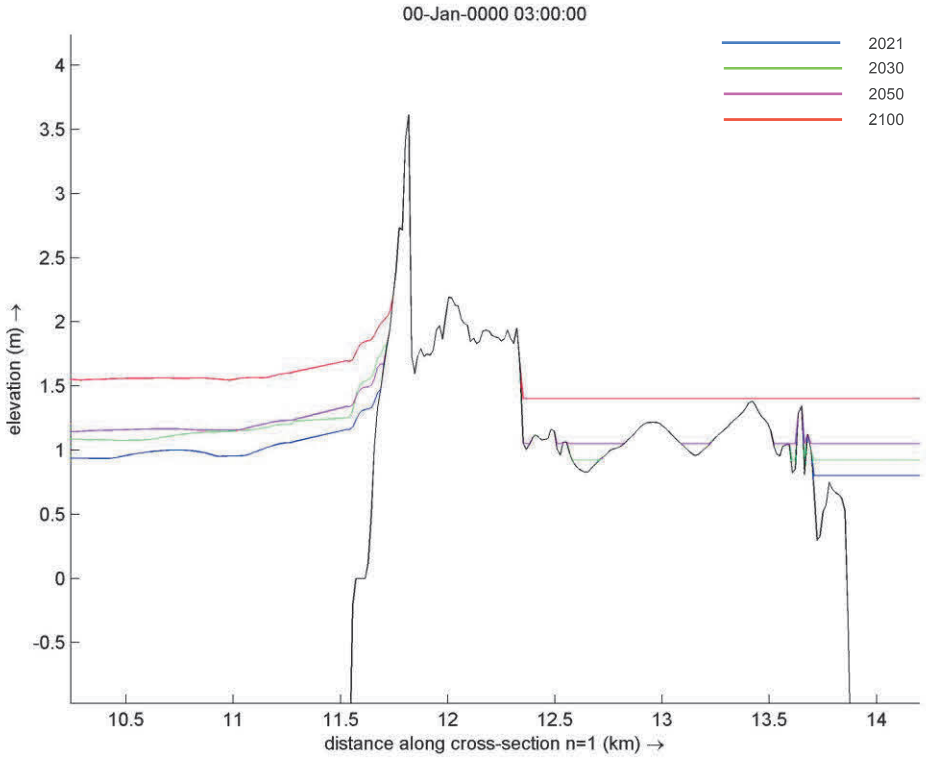

Figure 133 – The Venice lagoon: transect 4 output for RCP 2.6 and storm surge RT = 1 yr

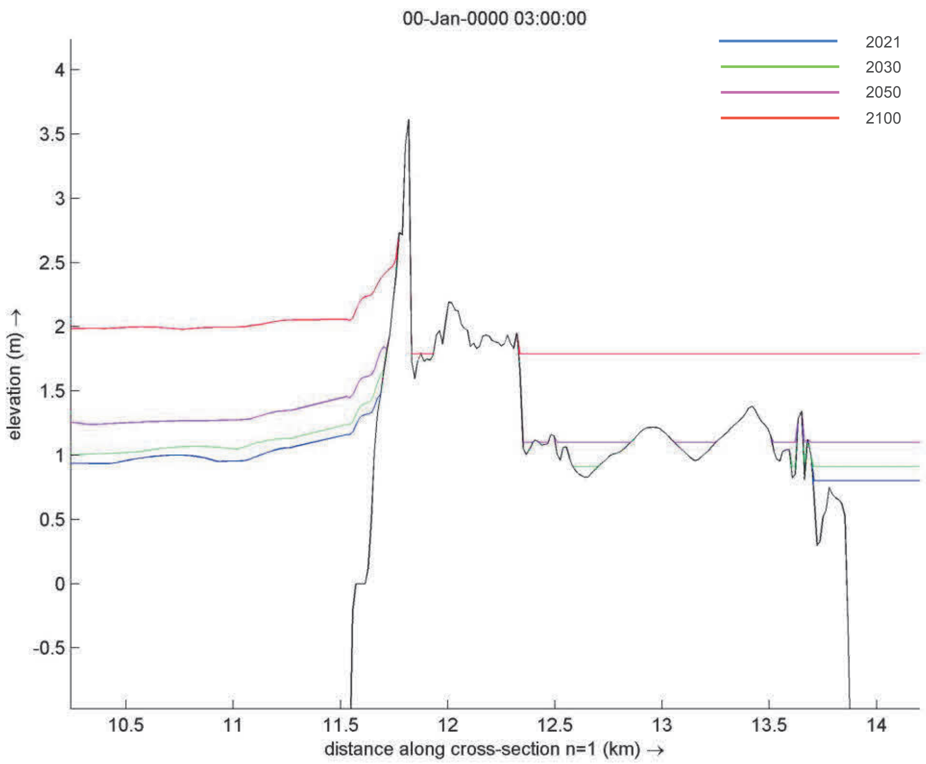

Figure 134 – The Venice lagoon: transect 4 output for RCP 8.5 and storm surge RT = 1 yr

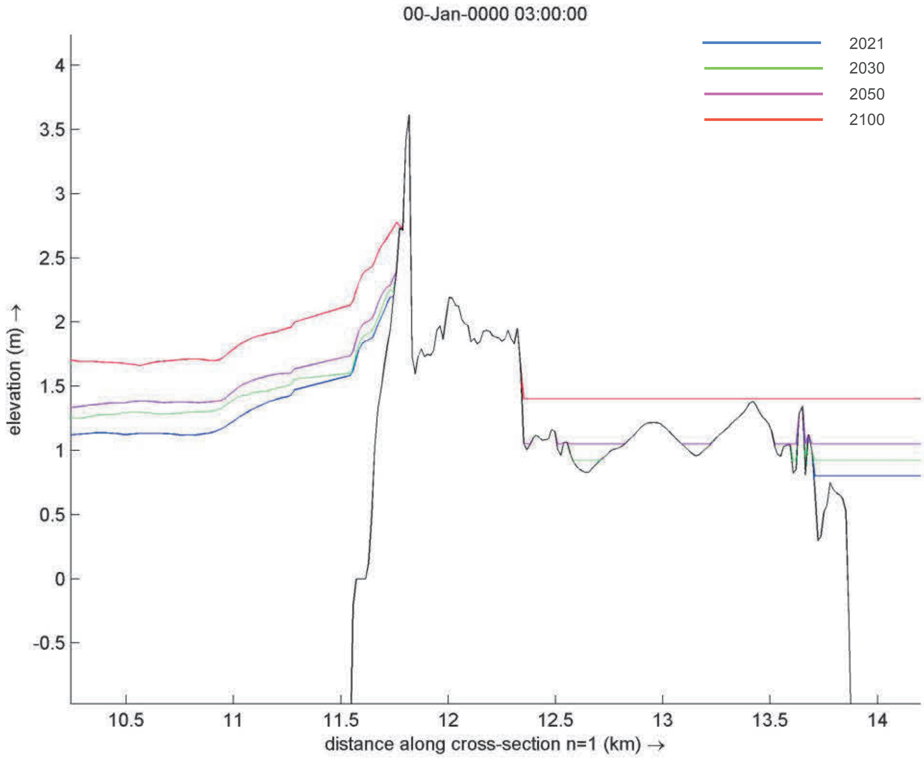

Figure 135 – The Venice lagoon: transect 4 output for RCP 2.6 and storm surge RT = 100 yr

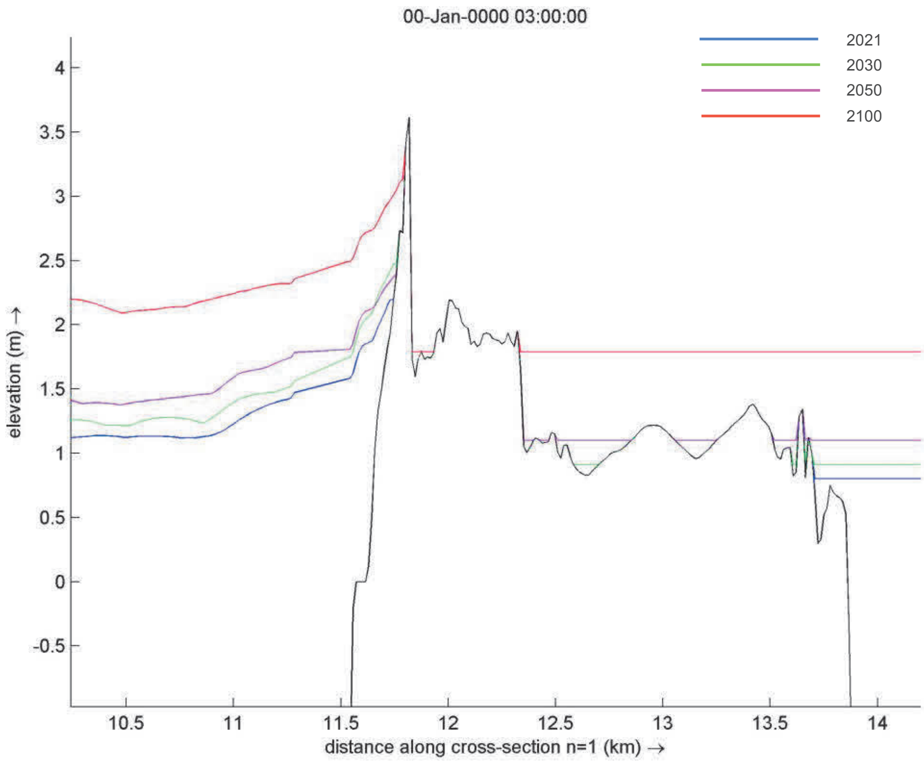

Figure 136 – The Venice lagoon: transect 4 output for RCP 8.5 and storm surge RT = 100 yr

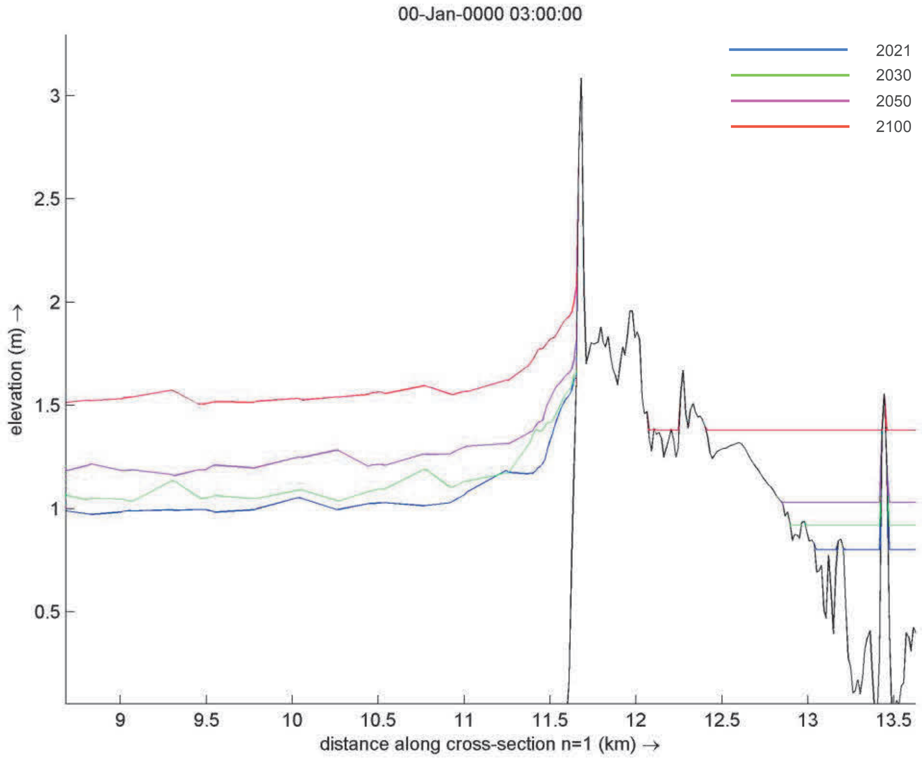

Figure 137 – The Venice lagoon: transect 5 output for RCP 2.6 and storm surge RT = 1 yr

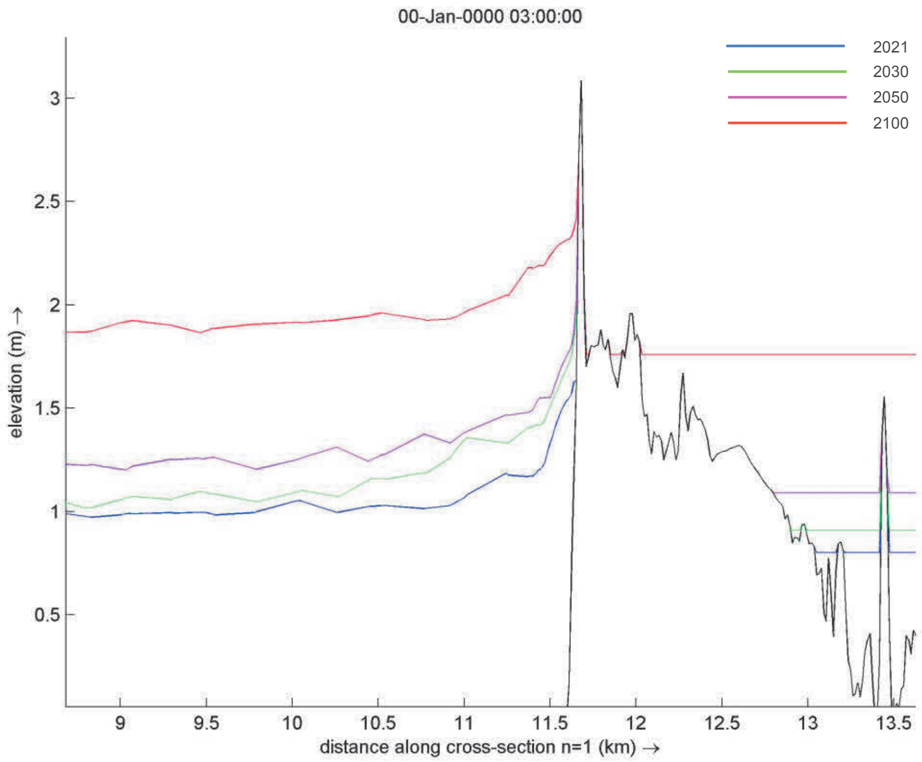

Figure 138 – The Venice lagoon: transect 5 output for RCP 8.5 and storm surge RT = 1 yr

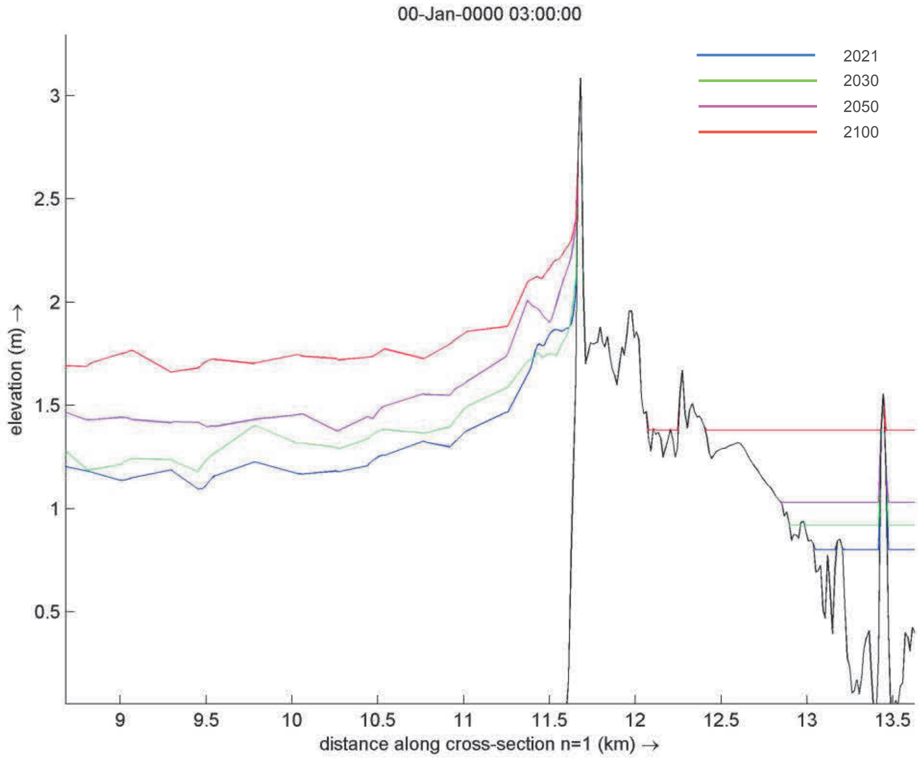

Figure 139 – The Venice lagoon: transect 5 output for RCP 2.6 and storm surge RT = 100 yr

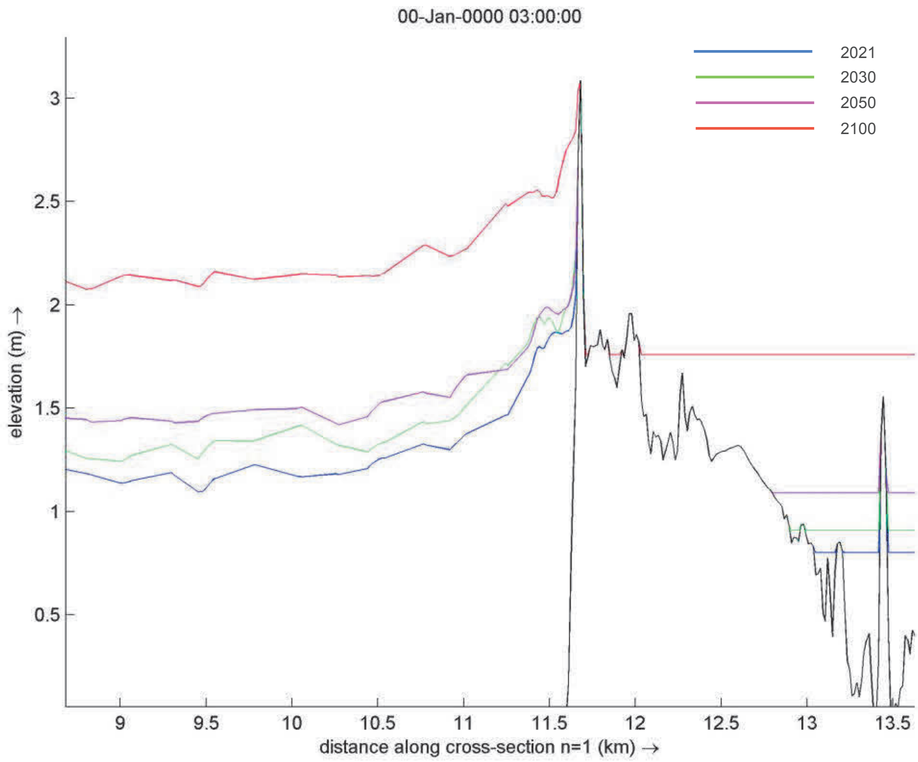

Figure 140 – The Venice lagoon: transect 5 output for RCP 8.5 and storm surge RT = 100 yr

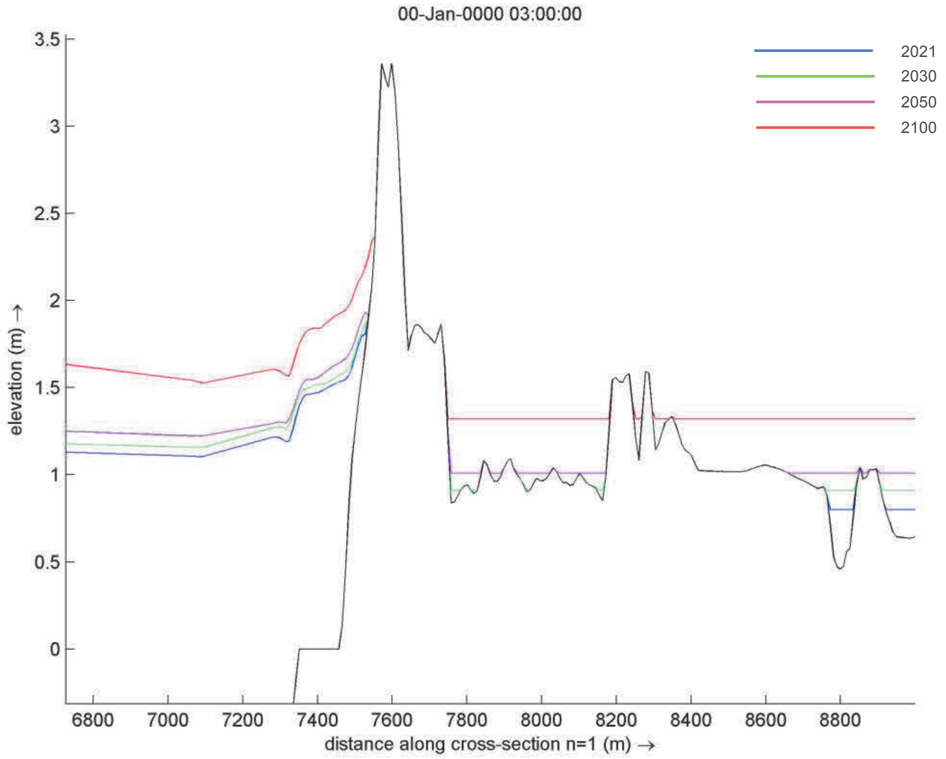

Figure 141 – The Venice lagoon: transect 6 output for RCP 2.6 and storm surge RT = 1 yr

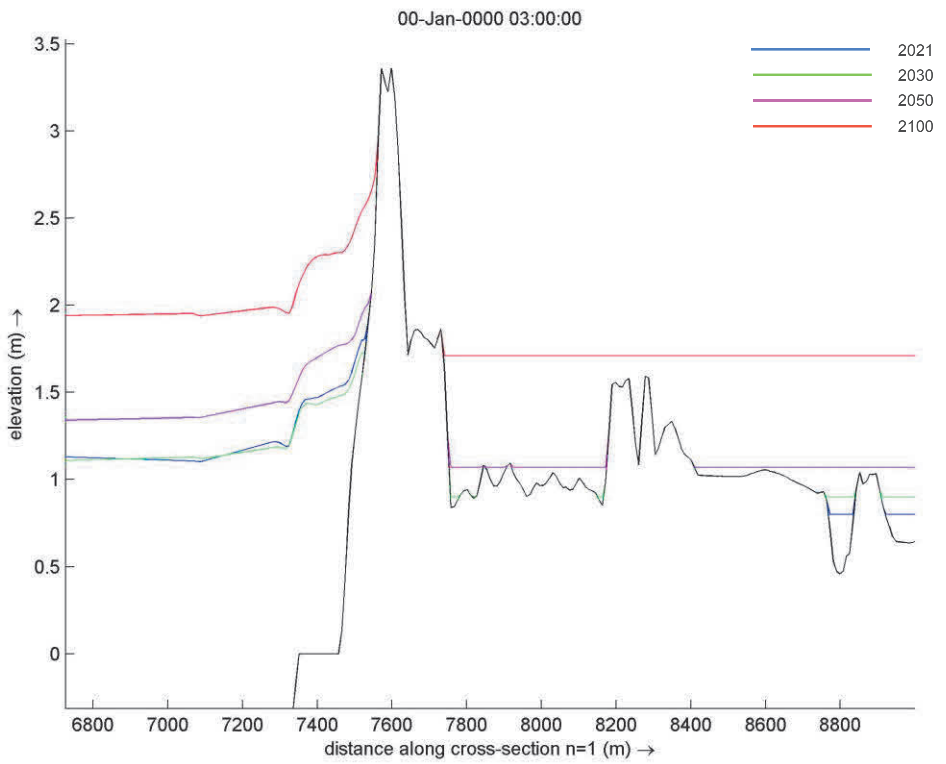

Figure 142 – The Venice lagoon: transect 6 output for RCP 8.5 and storm surge RT = 1 yr

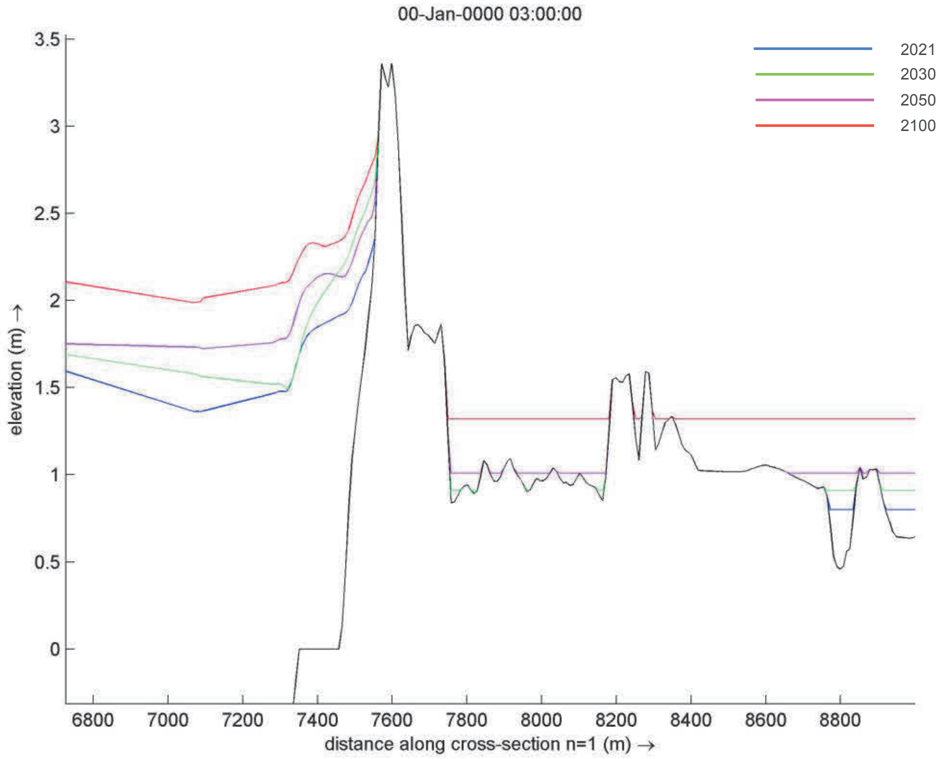

Figure 143 – The Venice lagoon: transect 6 output for RCP 2.6 and storm surge RT = 100 yr

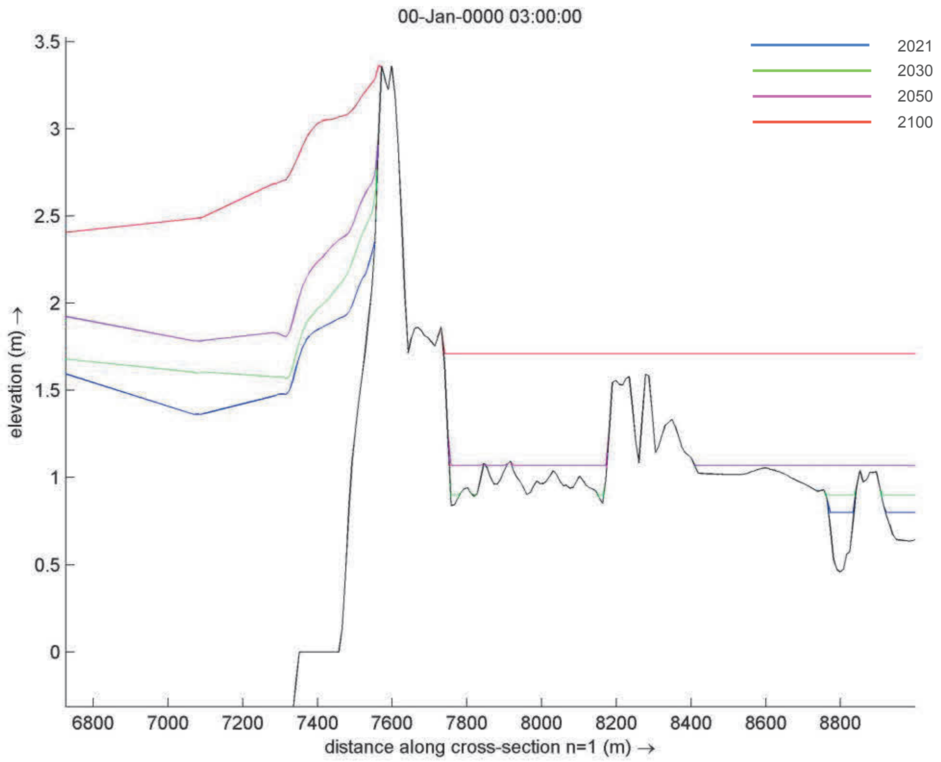

Figure 144 – The Venice lagoon: transect 6 output for RCP 8.5 and storm surge RT = 100 yr

Table 11 – The Venice lagoon. Storm surge scenarios at 2021, 2030, 2050 and 2100

			2021		2030				2050				2100			
					RCP 2.6		RCP 8.5		RCP 2.6		RCP 8.5		RCP 2.6		RCP 8.5	
		RT (yr)	**1**	**100**	**1**	**100**	**1**	**100**	**1**	**100**	**1**	**100**	**1**	**100**	**1**	**100**
		HS (m)	4.5	6.5	4.5	6.5	4.5	6.5	4.5	6.5	4.5	6.5	4.5	6.5	4.5	6.5
		fp (Hz)	0.1105	0.092	0.1105	0.092	0.1105	0.092	0.1105	0.092	0.1105	0.092	0.1105	0.092	0.1105	0.092
transects	**1**	**z0 (m)**	0.8	0.8	0.9	0.9	0.89	0.89	0.99	0.99	1.04	1.04	1.25	1.25	1.64	1.64
		Rmax (m)	1.84	3.06	2.07	3.06	2.07	3.06	2.27	3.06	2.27	3.63	2.56	3.63	3.06	3.86
		overtop (m)														1.73
	2	**z0 (m)**	0.8	0.8	0.93	0.93	0.91	0.91	1.05	1.05	1.11	1.11	1.42	1.42	1.81	1.81
		Rmax (m)	2.13	2.13	2.13	3.17	2.13	2.13	2.13	3.17	2.13	2.13	2.13	3.17	3.17	3.17
		overtop (m)														
	3	**z0 (m)**	0.8	0.8	0.92	0.92	0.91	0.91	1.03	1.03	1.09	1.09	1.37	1.37	1.75	1.75
		Rmax (m)	1.54	2.23	1.83	2.23	1.83	2.25	1.93	2.23	1.93	2.36	2.4	2.6	2.53	2.92
		overtop (m)														
	4	**z0 (m)**	0.8	0.8	0.92	0.92	0.91	0.91	1.05	1.05	1.1	1.1	1.4	1.4	1.79	1.79
		Rmax (m)	1.47	2.19	1.81	2.39	1.65	2.73	1.81	2.39	1.94	2.73	2.19	2.78	2.73	3.41
		overtop (m)														
	5	**z0 (m)**	0.8	0.8	0.92	0.92	0.91	0.91	1.03	1.03	1.09	1.09	1.38	1.38	1.76	1.76
		Rmax (m)	1.63	2.71	1.65	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	3.08
		overtop (m)														
	6	**z0 (m)**	0.8	0.8	0.91	0.91	0.9	0.9	1.01	1.01	1.07	1.07	1.32	1.32	1.71	1.71
		Rmax (m)	1.9	2.36	1.9	2.94	1.72	2.94	2.08	2.94	2.07	2.94	2.56	2.94	2.94	3.36
		overtop (m)														
		MSEL (m)	**0.8**	**0.8**	**0.93**	**0.93**	**0.91**	**0.91**	**1.05**	**1.05**	**1.11**	**1.11**	**1.42**	**1.42**	**1.81**	**1.81**

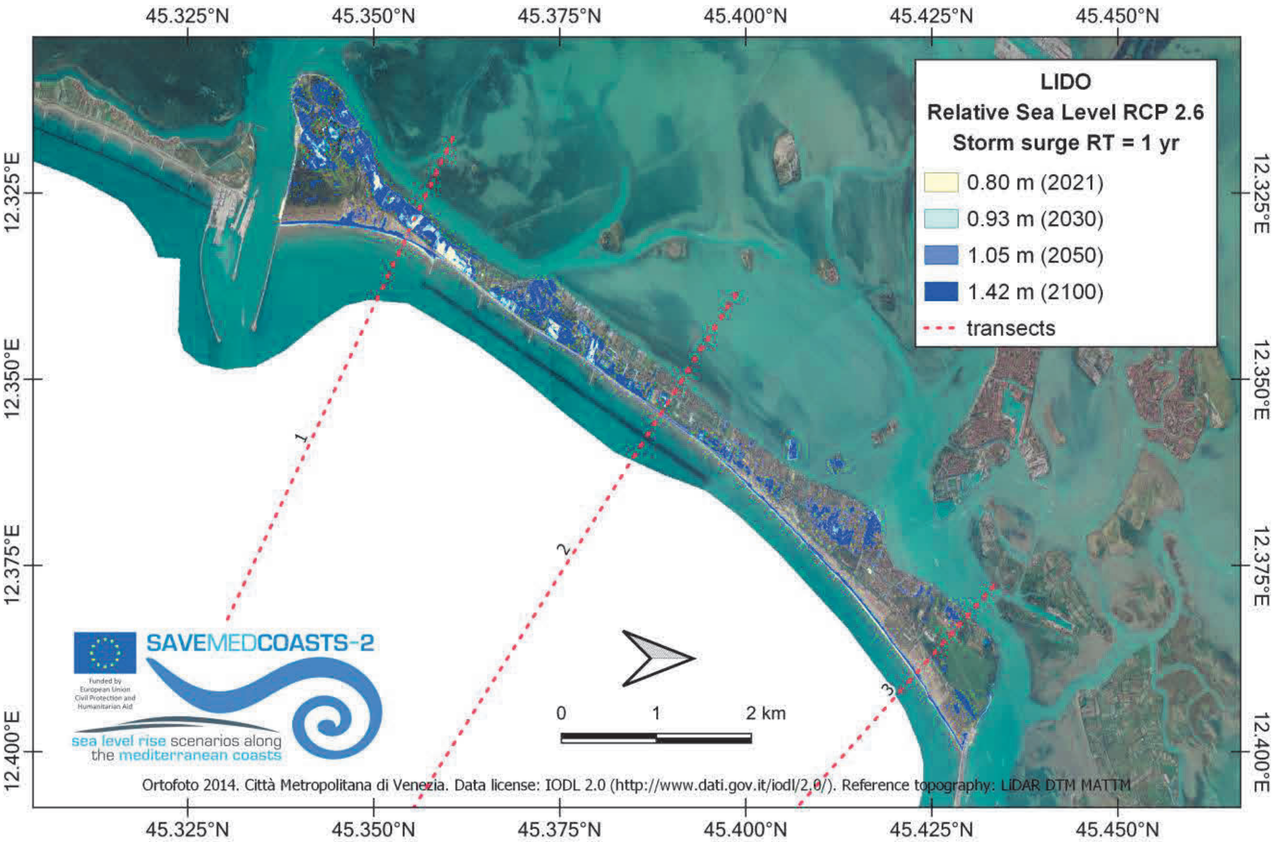

Figure 145 – The Venice lagoon: flooding scenario for RCP 2.6 and storm surge RT = 1 yr at Lido

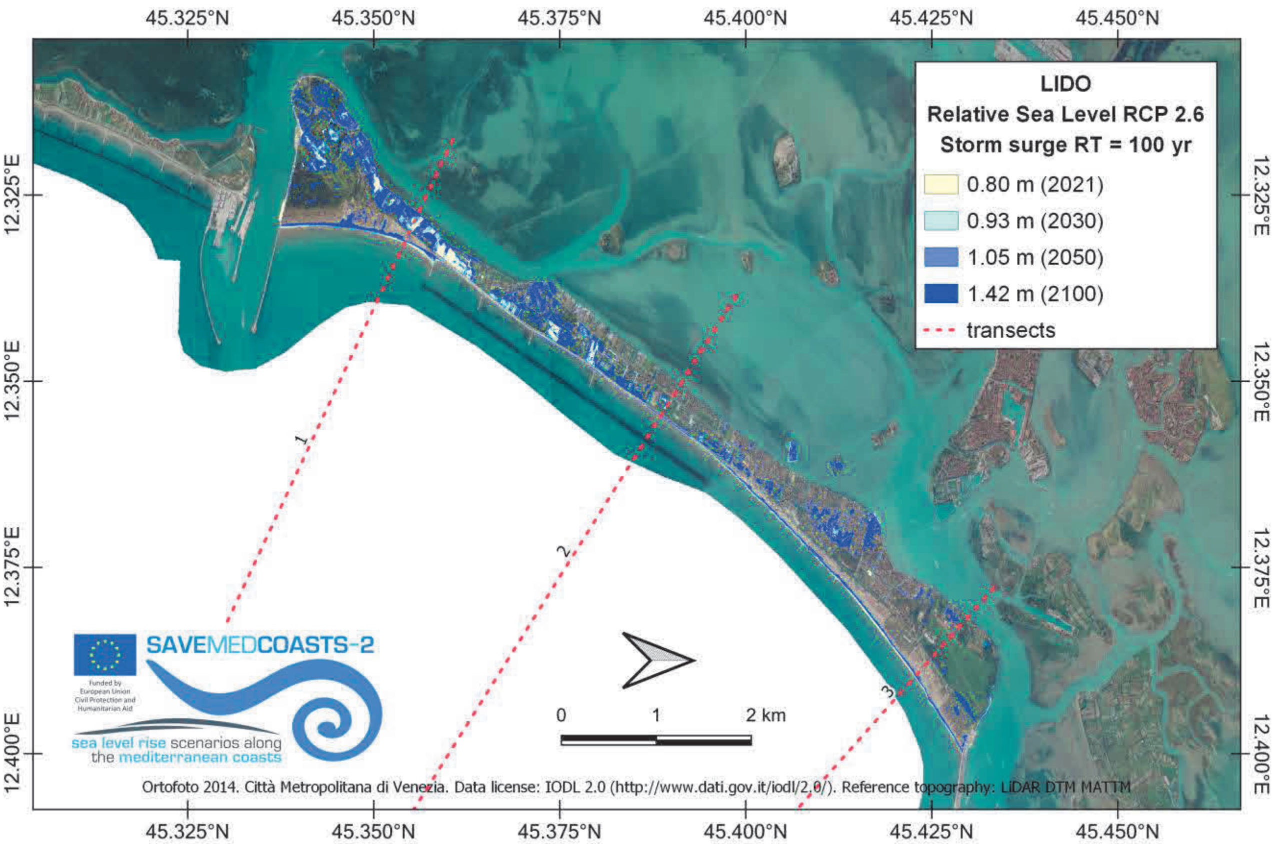

Figure 146 – The Venice lagoon: flooding scenario for RCP 2.6 and storm surge RT = 100 yr at Lido

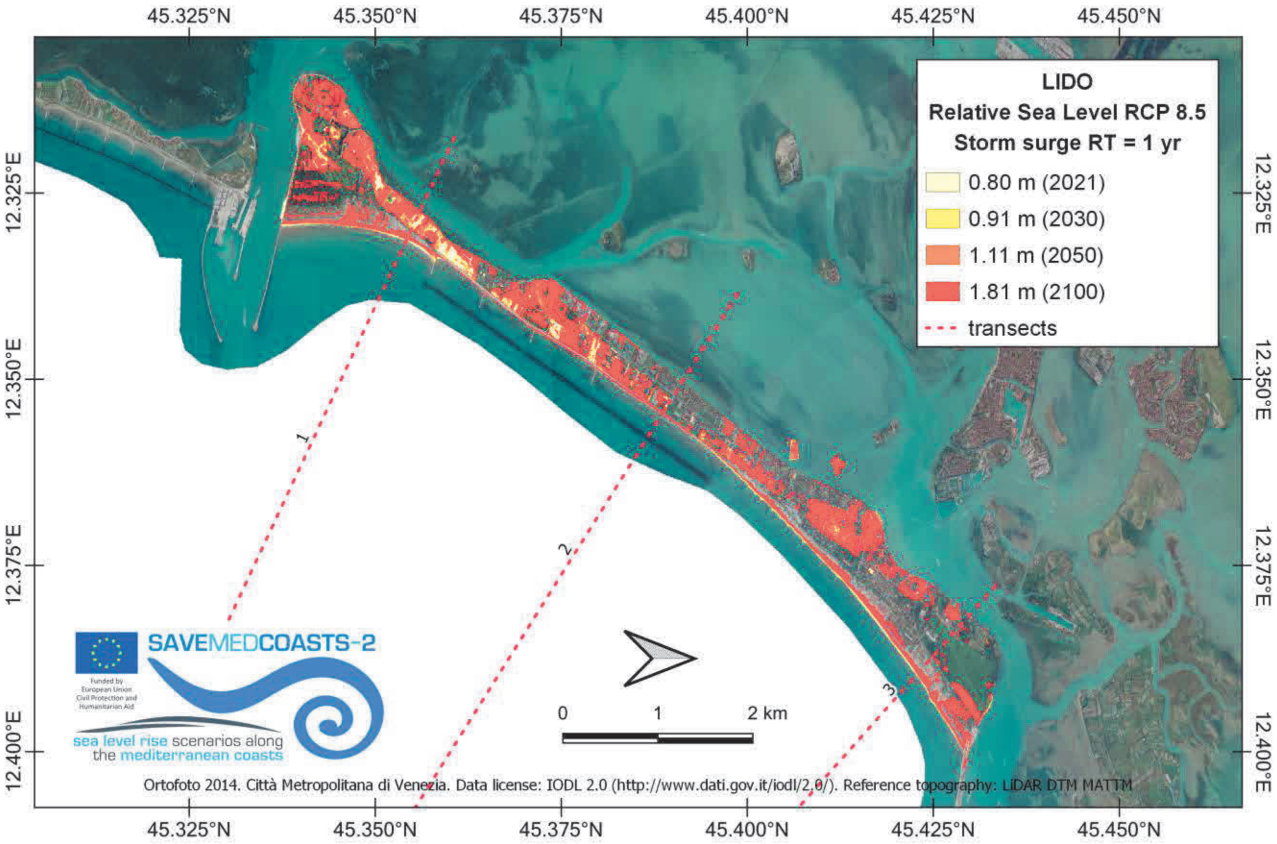

Figure 147 – The Venice lagoon: flooding scenario for RCP 8.5 and storm surge RT = 1 yr at Lido

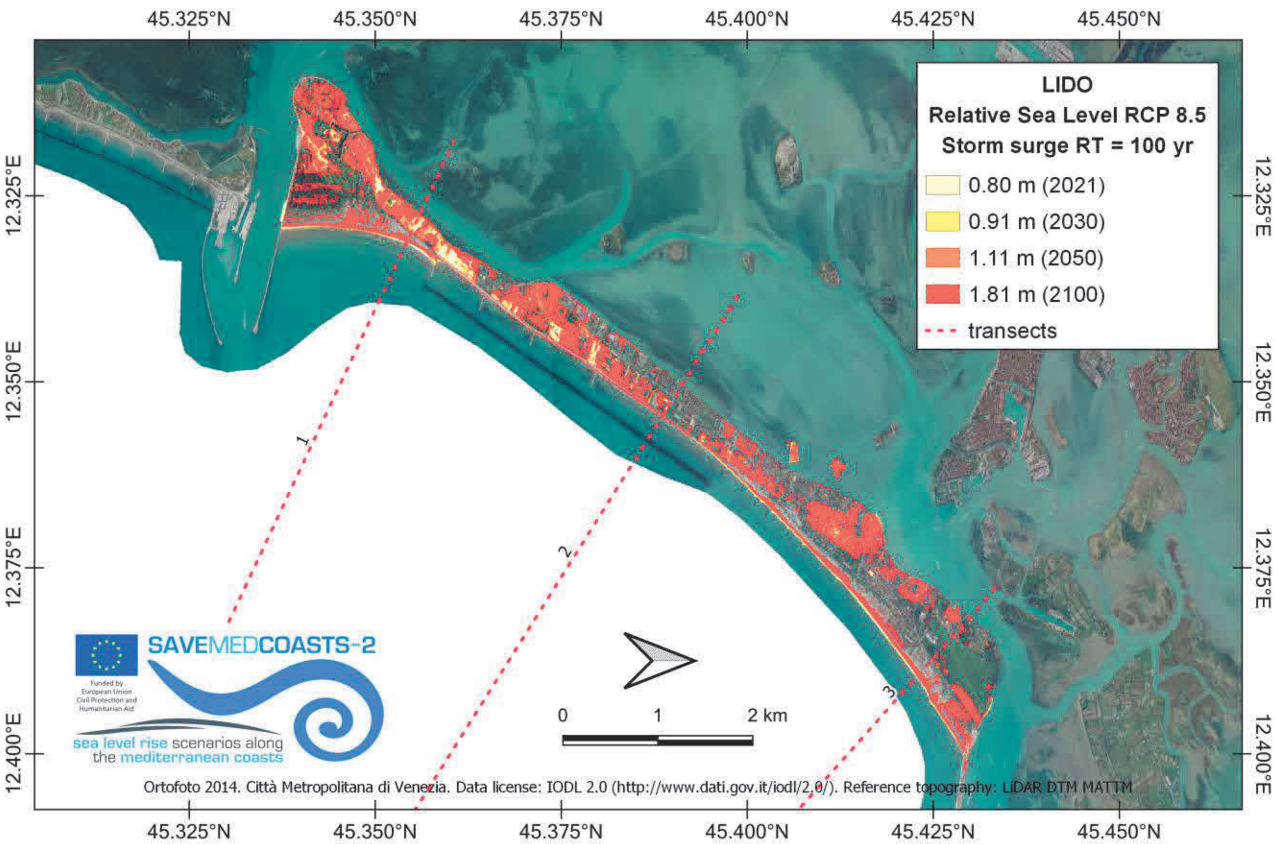

Figure 148 – The Venice lagoon: flooding scenario for RCP 8.5 and storm surge RT = 100 yr at Lido

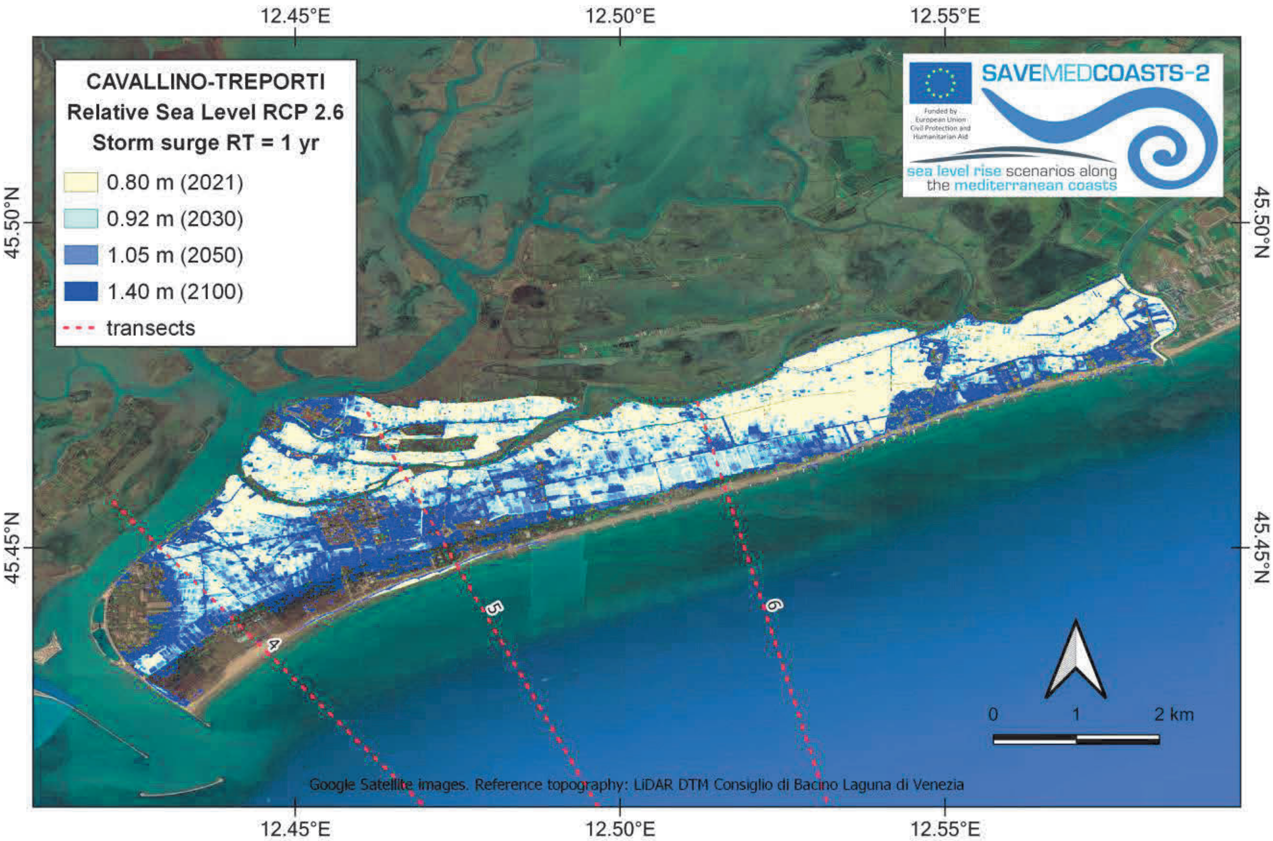

Figure 149 – The Venice lagoon: flooding scenario for RCP 2.6 and storm surge RT = 1 yr at Cavallino-Treporti

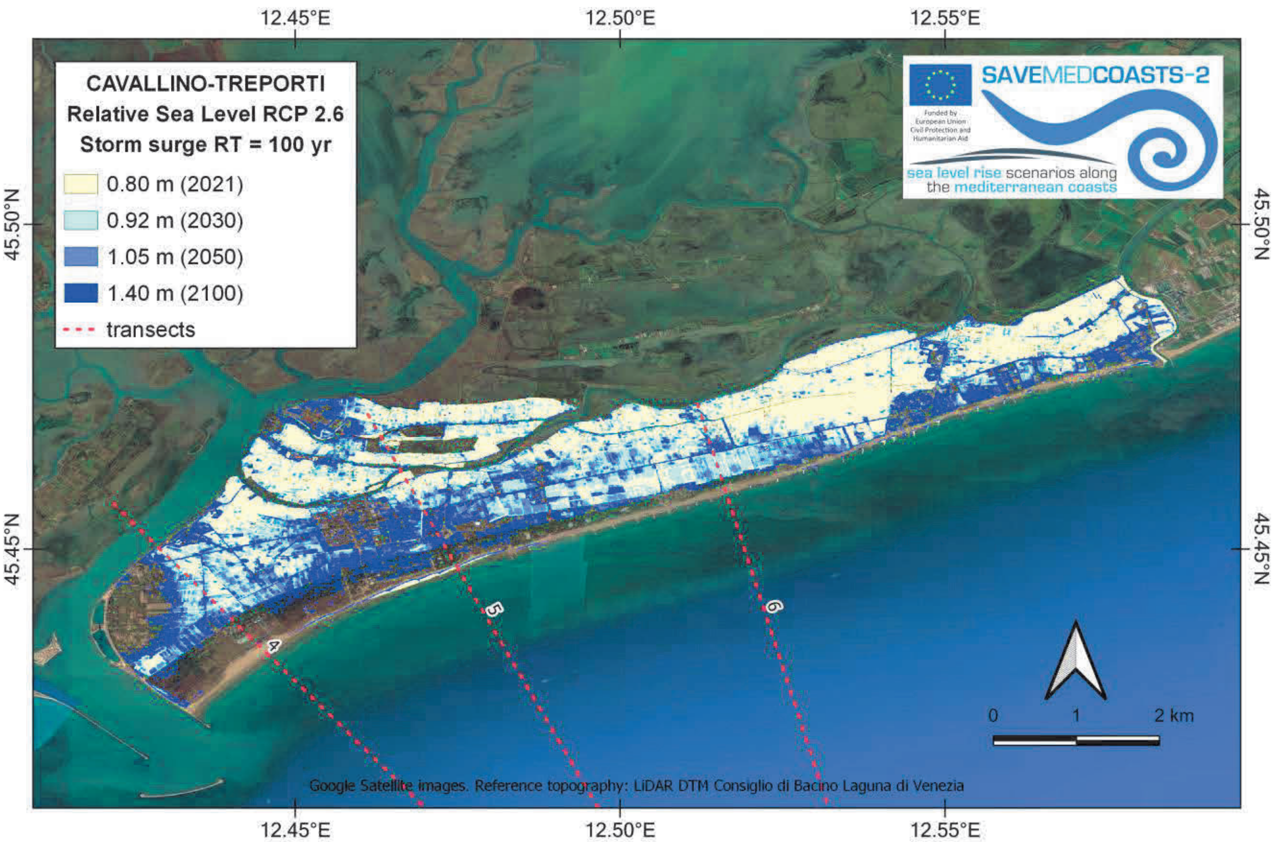

Figure 150 – The Venice lagoon: flooding scenario for RCP 2.6 and storm surge RT = 100 yr at Cavallino-Treporti

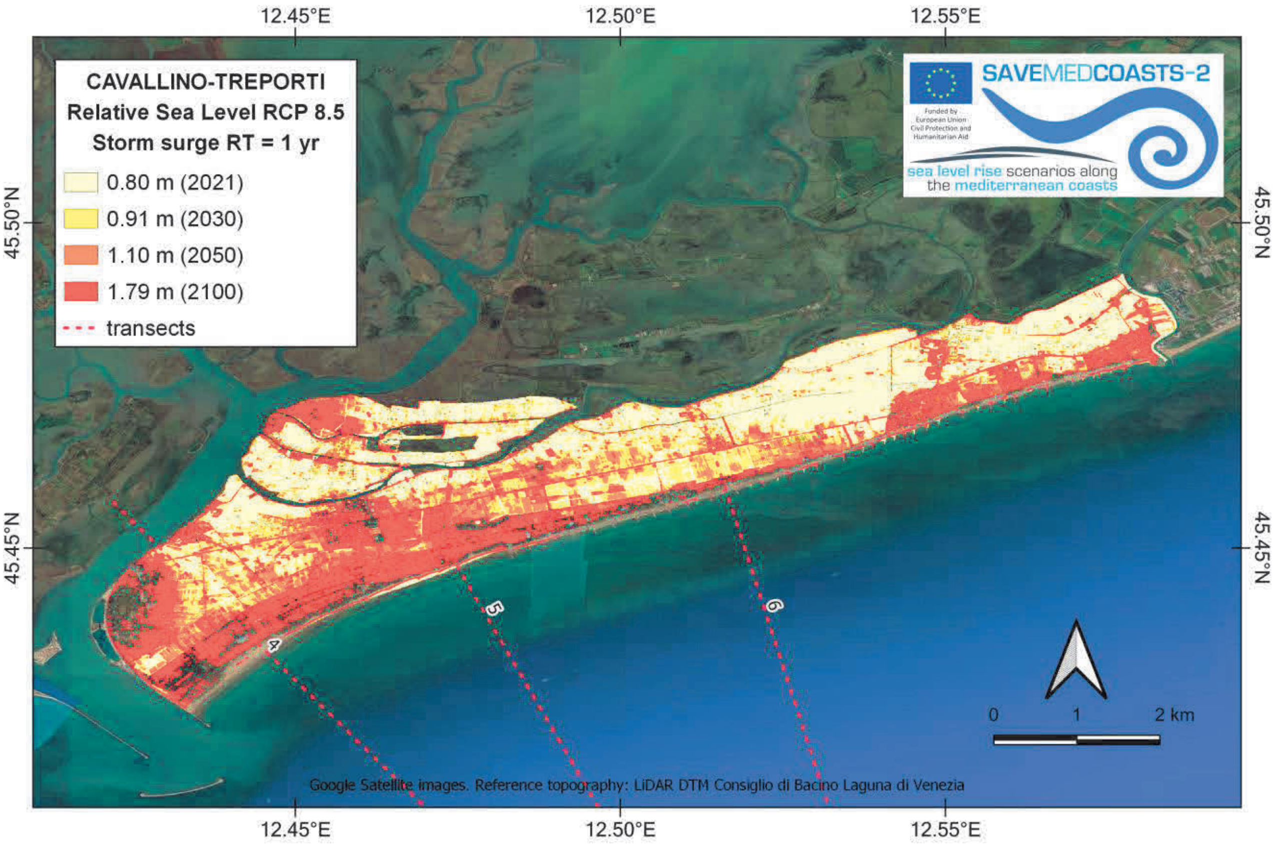

Figure 151 – The Venice lagoon: flooding scenario for RCP 8.5 and storm surge RT = 1 yr at Cavallino-Treporti

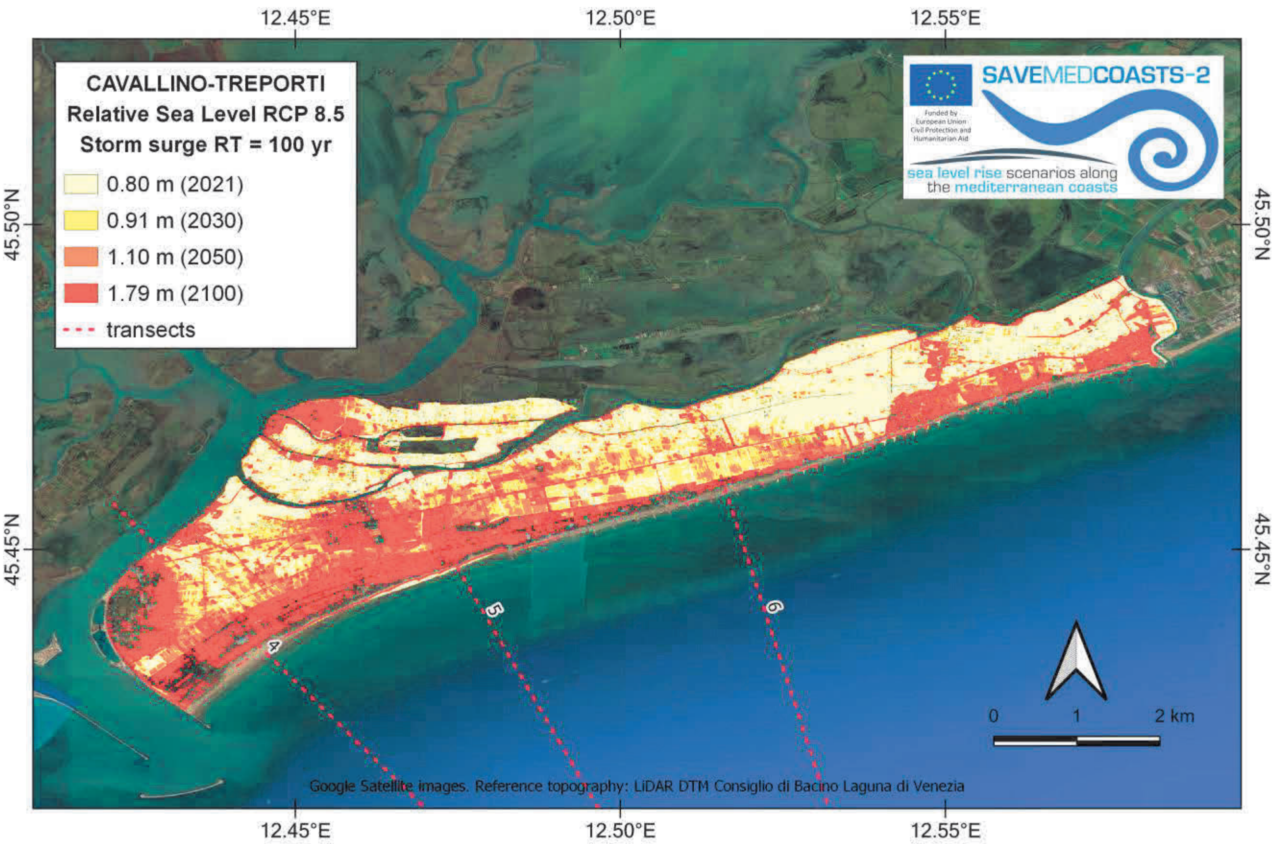

Figure 152 – The Venice lagoon: flooding scenario for RCP 8.5 and storm surge RT = 100 yr at Cavallino-Treporti

4.6 Alexandria (Egypt)

At the moment it is not possible to map the potential flooding areas due to storm surges at Alexandria of Egypt because of the low vertical accuracy (10 m) of the best freely available digital terrain model (SRTM/NASADEM).

5. Conclusions

In the first part of this report, we mapped the potential extent of the coastal flooding for the Ebro delta (Spain), Rhone delta (France), Venice lagoon (Italy), Metaponto plain (Italy) and Chalastra plain (Greece), as a result of the projected RSLR up to 2100 epoch. The permanent land flooding caused by the RSLR were evaluated for two climate change scenarios, namely RCP 2.6 and RCP 8.5, and further combined with the storm surges events in ordinary (RT = 1 yr) or extreme (RT = 100 yr) conditions, as described in the second half of the report.

The analysis reported in this document is among the first detailed study on RSLR impacts in specific Mediterranean areas, based on the integration of InSAR and GNSS data and climatic projections of the SROCC Report (IPCC, 2019), and considers the contribution of land subsidence due to natural (tectonic and eustatic components) and anthropogenic (fluid withdrawal and other contributions) for the reported scenarios.

6. Acknowledgements

The SAVEMEDCOASTS-2 project would like to thank Giovanni Martino (University of Basilicata, Italy) for the scientific discussion and his contribution in the storm surges modelling and Antonio Vecchio (Lesia Observatory, France) for his contribution in RSLR projections.