PLASMAR

Bases para la planificación sostenible de áreas marinas en la Macaronesia

Zoning proposal for Macaronesia

OFFSHORE WIND ENERGY, AQUACULTURE & SAND EXTRACTION

Andrej Abramic, Alejandro Garcia Mendoza, Natacha Nogueira, Carlos Andrade, Maria Magalhães, Deborah Shinoda, Ricardo Haroun

UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA
ECOAQUA www.ecoaqua.eu
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I. Zoning proposal for Macaronesia

Introduction

This study was delivered by project PLASMAR (MAC/1.1a/030) with the support of the European Union (EU) and co-financed by the European Regional Development Fund and the INTERREG V-A Spain-Portugal MAC 2014–2020 (Madeira-Azores-Canarias). Zoning proposals for introducing new maritime activity or expanding already operational sectors within the Macaronesia, are delivered, as results of the entire project and four years of studies, data collections, monitoring and analyses.

During the last year, exhaustive reviews were done on theoretical Blue Growth documents and sustainability issues, including diverse environmental topics, pressure solutions and impact mitigation, associated with the following maritime sectors: aquaculture, fisheries, maritime transport and offshore wind energy[1]. These studies identified the relevant environmental parameters per each analyzed sector that need to be considered within the Maritime Spatial Planning and Environmental Impact Assessment processes, following the requirements of the Marine Strategy Framework Directive 20008/56/EC (MSFD), more specifically the evaluation of the Good Environmental Status (GES), which is based on 11 quality descriptors and 42 related criteria elements.

To facilitate data collection, it was established a structure of clusters and parameters, called PLASMAR MSP data framework. The different parameters are grouped in five clusters:

1. Data on marine environment structured by GES;
2. Spatial data and information on Marine Protected Areas (MPAs);
3. Coastal Land use- activities on the land in coastal areas;
4. Physical oceanography data;
5. Spatial information on current Maritime Activities.

The same data framework was used to identify and describe which parameters are relevant and how are they related to each one of the analyzed maritime sector. This state of art analysis was done reviewing available technical and scientific reports.

To fill up recognized data gaps, monitoring (and modeling) methods were established and surveys were implemented to acquire data on habitats, non-indigenous species, fish stocks, marine ecosystems, sea floor integrity and marine litter (micro plastics).

Collected data, as information obtained by monitoring campaigns were included in a newly developed Marine Spatial Data Infrastructure, that includes metadata catalogue (discovery service), web (download) services and geoportal (view) services.

Further, a Decision Support System (DSS) tool, called INDIMAR, was developed for facilitating maritime sector zoning. DSS INDIMAR was filled with collected spatial information and data obtained by PLASMAR monitoring campaigns. Using the INDIMAR interface, we defined and introduce in the model relations of each parameter to analyzed maritime sector. The model run by INDIMAR, provided analyses on most suitable location per each analyzed sector, based on environmental sensibility, MPAs locations and conservation targets, oceanographic limiting parameters, land sea interactions, and analysis of potential conflicts with maritime & coastal sectors.

To integrate and superpose cluster analysis, was used “weights” system, that defined significance of each parameter within the framework. Weights profile were calculated with the PLASMAR project experts, external experts and interested maritime stakeholders, using the Analytical Hierarchy Process method. For each profile we used DSS INDIMAR to identify most suitable locations in Macaronesia for potential locations of offshore wind energy, aquaculture and sand extraction activities.

[1] Available on the www.plasmar.eu , products section, 2.1.1. c&d technical reports

In this technical report, the zoning proposal for three analyzed sectors for Azores, Madeira and Canary Islands are presented with detailed maps of suitability for the potential implementation of those activities. These maps are also available through network services (view and download) established within the MSP Spatial Data Infrastructure. Zoning proposal are also available through the thematic geo-viewer, available at:

http://www.geoportal.ulpgc.es/visor2/?json=indimar.json

1 Introducing Offshore Wind Energy in the sea space of Macaronesia

The coastlines and related marine areas of Canary Islands, Madeira and Azores, were analyzed to identify the most suitable locations for potential Offshore Wind Energy (OWE) facilities. This OWE location suitability study was done with DSS INDIMAR, including energy potential analysis; environmental sensibility; restriction related to the marine conservation; land-sea interactions; and potential conflict with current maritime uses. Secondly, we superposed all five analyses, defining significance (weight) per each parameter, applying Analytical Hierarchy Process (a multicriteria decision-making technique) and identifying most suitable areas for OWE facilities in each archipelago included in the European Macaronesian Sea.

Environmental sensibility was already defined and described in the PLASMAR report 2.1.1 c&d "Analysis of the Offshore Wind Industry in Macaronesia under MSFD", Abramic et al. 2018.

Relation of the OWE and parameters included in the marine environment cluster, Marine Protected Areas cluster, oceanography cluster, coastal land use cluster and maritime activities cluster are resumed and documented in this table included in Annex 1.

To include all parameters, clusters in suitability analyses (Oceanography, GES, MPA, Coastal Land use, Maritime uses), and integrate results, it was necessary to determine significance per each parameter. We employed the statistical method Analytical Hierarchy Process (AHP) , applying pairwise comparisons and assigning weights to parameters that are included in analysis.

The parameter weights applying AHP were obtained with the inputs coming from researchers involved in the PLASMAR project. Further, we applied the same methodogical protocol with OWE external experts who are not directly connected with the PLASMAR project. Finally, the method for assigning the weights was again tested with diverse maritime sectors' stakeholders during the MSP process workshop delivered within the parallel MarSP project (http://marsp.eu/).

For the zoning exercise of OWE in the Canaries and in Madeira, we applied PLASMAR project weights profiles. The rest of the profiles is being used for further research and analyses, which will be shortly published.

For Azores we applied external (Azores) experts profile in combination with PLASMAR project profile. The offshore wind energy sector survey was done by one expert within PLASMAR, and additionally, two external experts were consulted individually. The geometric mean was used to integrate all profiles on one that can be applied.

Data collection for Canary Islands covered environmental spatial information (including assessments of the 1st MSFD cycle), MPAs information, oceanographic parameters, coastal land use and current maritime activities.

Data and spatial information availability for Madeira and Azores influenced on the results of the OWE location analyses. The profiles were less restrictive, as data on marine environment were partially available (present but not covering entire analyzed area). Spatial information on operational maritime activities were also partially available. Data on MPAs, oceanographic parameters and coastal land use were properly covered.

Table 1- significance parameters/clusters—defined weights based on pairwise comparison, for three groups: researchers involved in PLASMAR project; external experts; maritime sectors' stakeholders (MarSP workshop)

Cluster	Parameter	Weights		
		PLASMAR	External experts	MSP stakeholders
GES	Biodiversity (Benthic habitats)	11,65	7,97	7,06
	Biodiversity (Mammals)	5,29	3,02	3,17
	Biodiversity (Birds)	16,11	19,08	12,44
	Non-indigenous species	2,33	0,92	1,08
	Population of commercial fish species	10,83	6,97	1,84
	Energy, including underwater noise data	9,63	4,92	3,85
MPA	Natura 2000 Network	7,71	12,9	26,42
Land Use	CORINE	3,17	1,8	8,44
	Distance to the coast	1,56	0,98	1,69
Oceano-graphy	Depth/bathymetry	2,74	3,04	2,99
	Wind	5,73	5,15	20,95
Current Maritime Activities	Aquaculture facilities	1,65	1,66	0,23
	Fishery areas/efforts	7,91	3,57	0,59
	Maritime traffic lanes/intensity maps	5,91	7,71	0,8
	Aggregate extraction (Dredging / Sand extraction)	1,52	0,71	2,39
	Cables	3,65	7,57	2,38
	Military area	1,31	11,19	3,42
	Seaweed cultivation	1,29	0,84	0,27

1.1 Introducing Offshore Wind Energy in the sea space of Canary Islands

The file is available within the MSP Spatial Data Infrastructure (MSP Macaronesian catalogue), developed by PLASMAR. There are enabled three web services and direct download:

Search with the metadata catalogue:

http://www.geoportal.ulpgc.es/geonetwork/srv/spa/catalog.search#/metadata/ES_ECOAQUA_MSPMD_WMS10633-20200901

View network service:

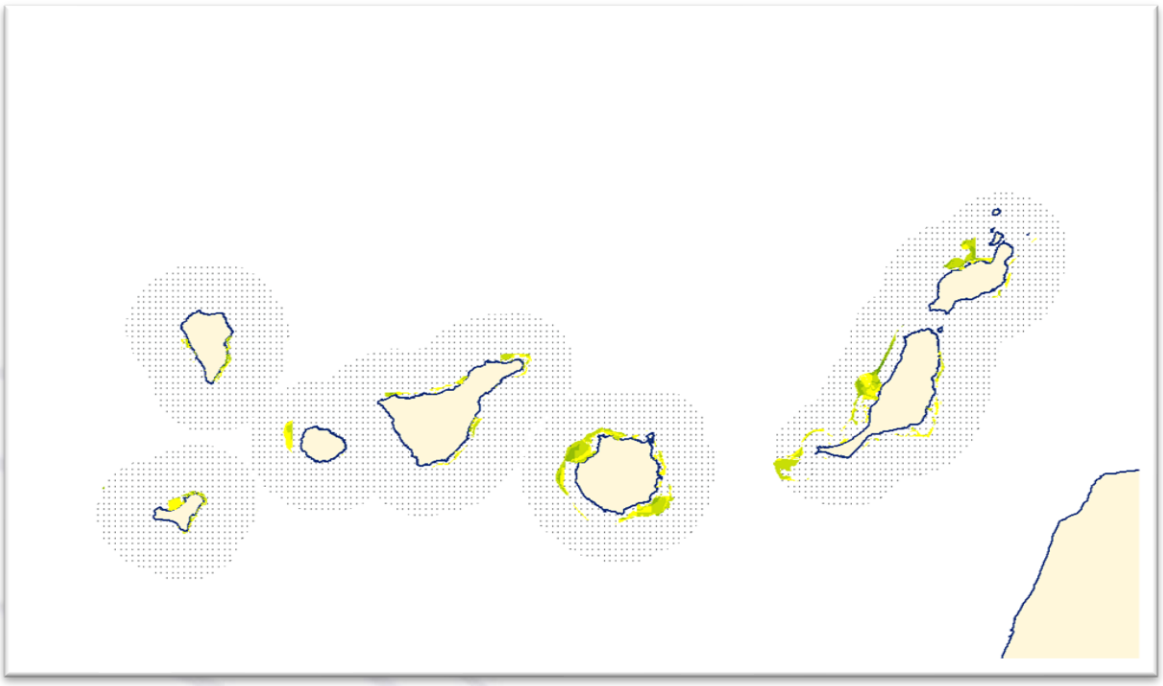
http://www.geoportal.ulpgc.es/geoserver/indimar/wms?request=GetCapabilities

and download service:

http://www.geoportal.ulpgc.es/geoserver/indimar/wfs?request=GetCapabilities.

Direct download:

http://www.geoportal.ulpgc.es/atom/download/ES_ECOAQUA_MSPMD_DATASET_10633.zip



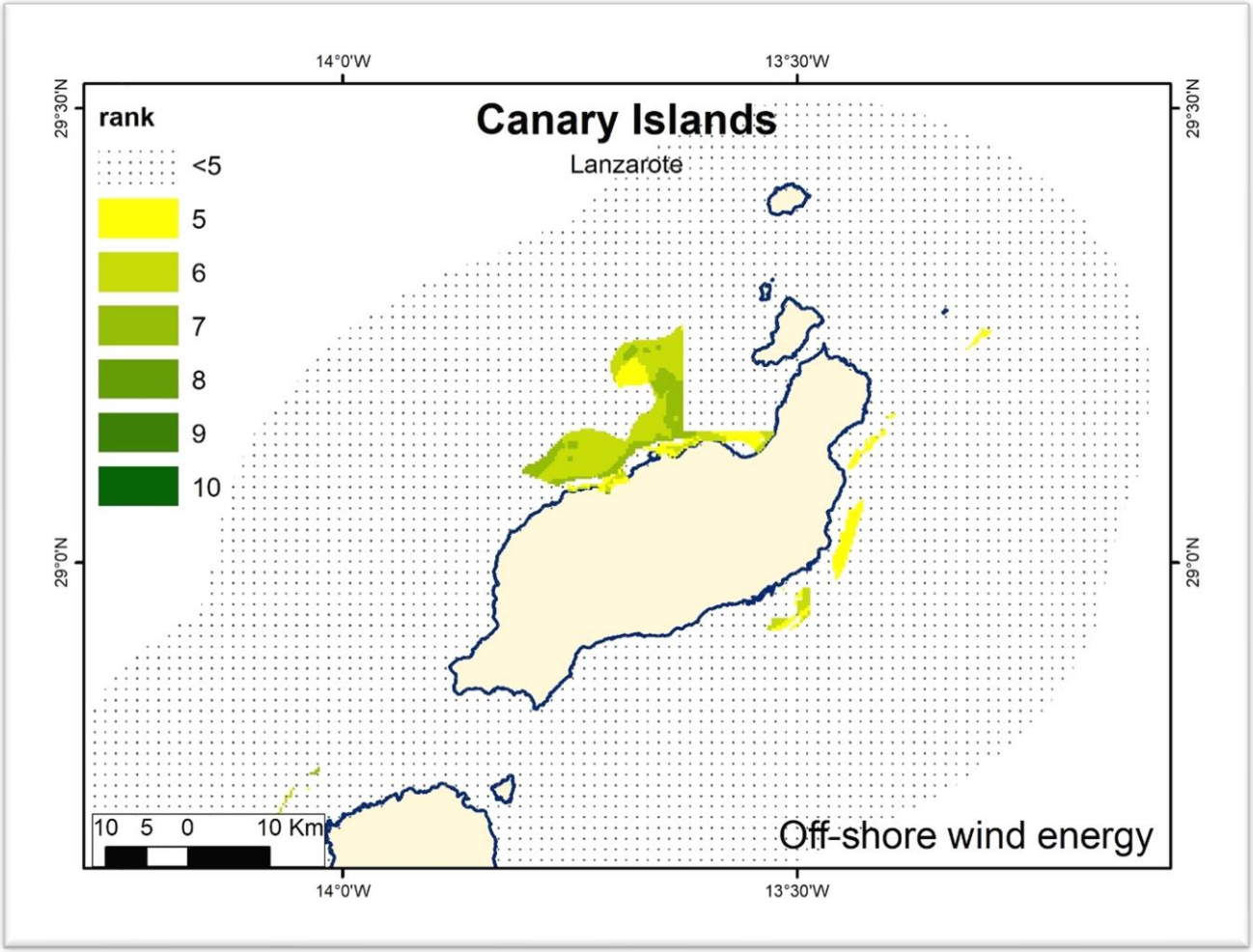


Figure 1- OWE suitability analysis for Canary Islands applying project PLASMAR profile

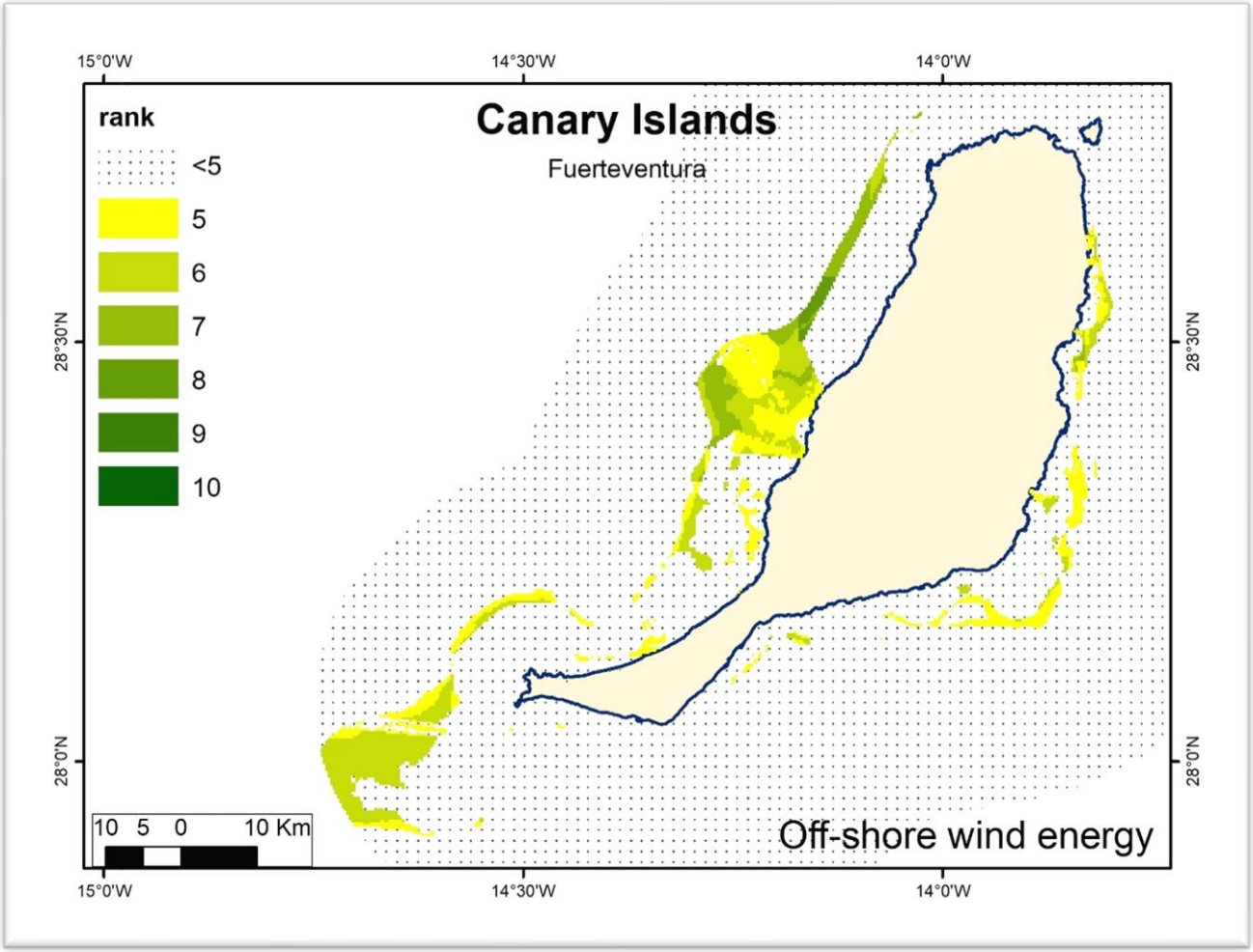


Figure 2 -OWE suitability analysis for Canary Islands applying project PLASMAR profile

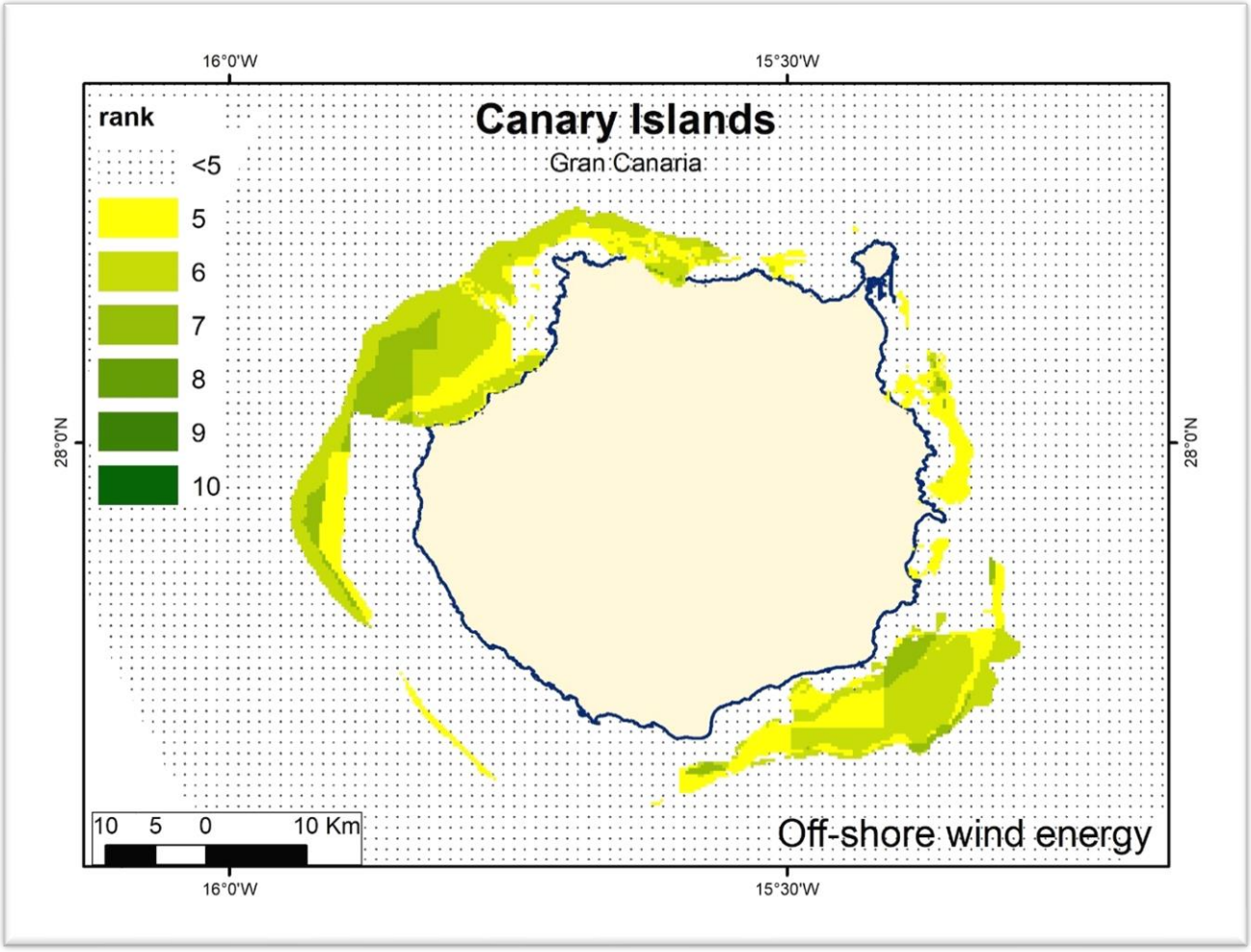


Figure 3 - OWE suitability analysis for Canary Islands applying project PLASMAR profile

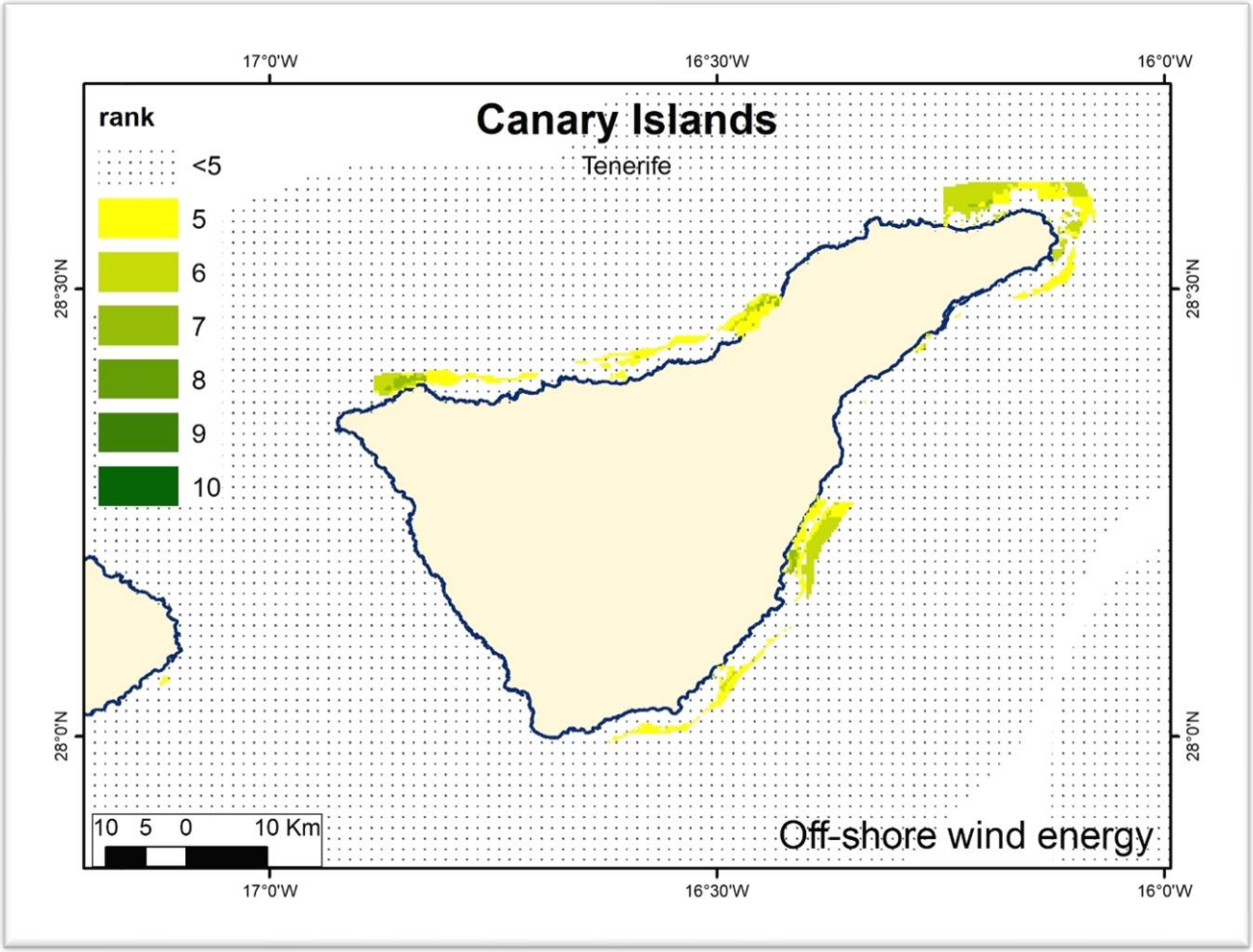


Figure 4 - OWE suitability analysis for Canary Islands applying project PLASMAR profile

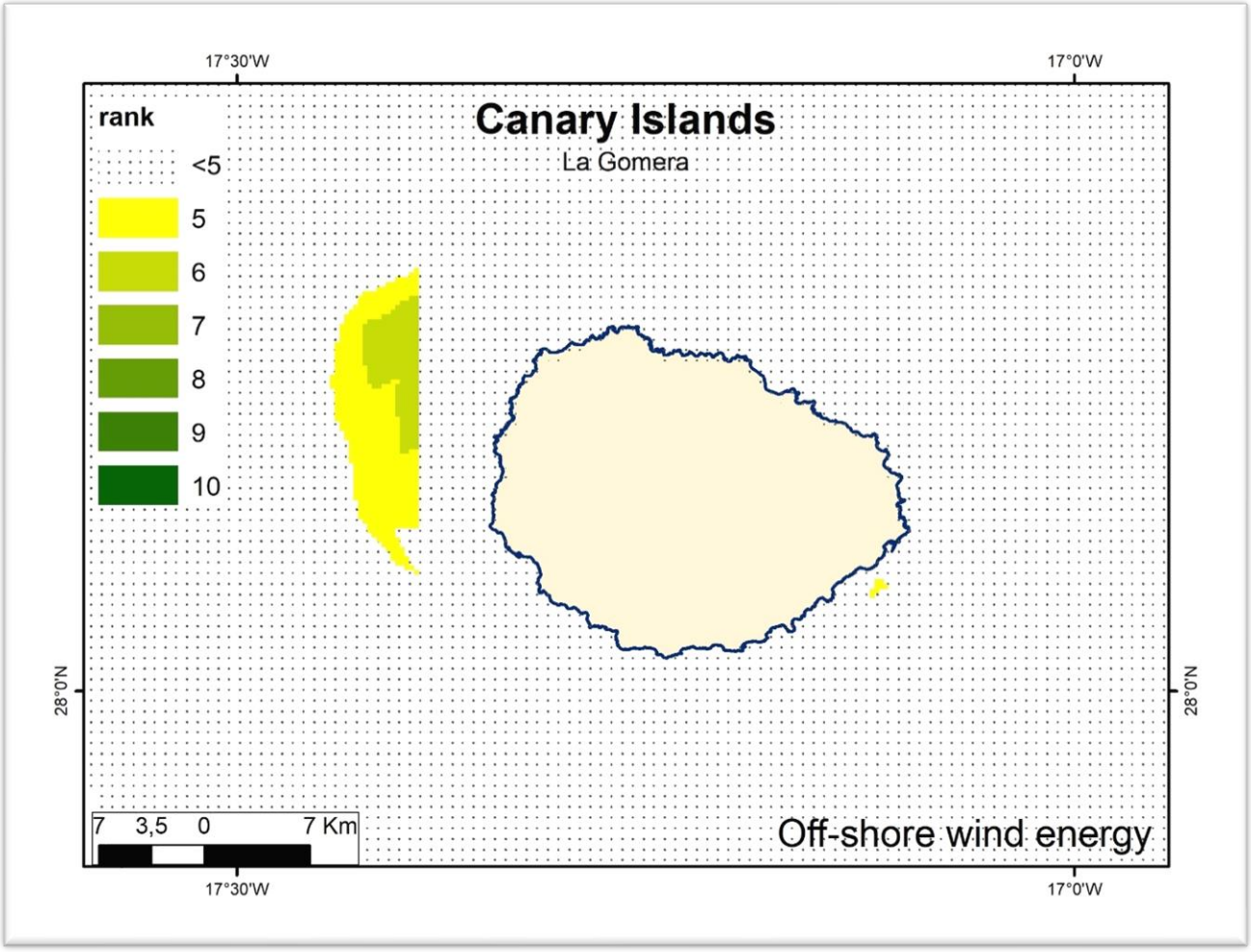


Figure 5 - OWE suitability analysis for Canary Islands applying project PLASMAR profile

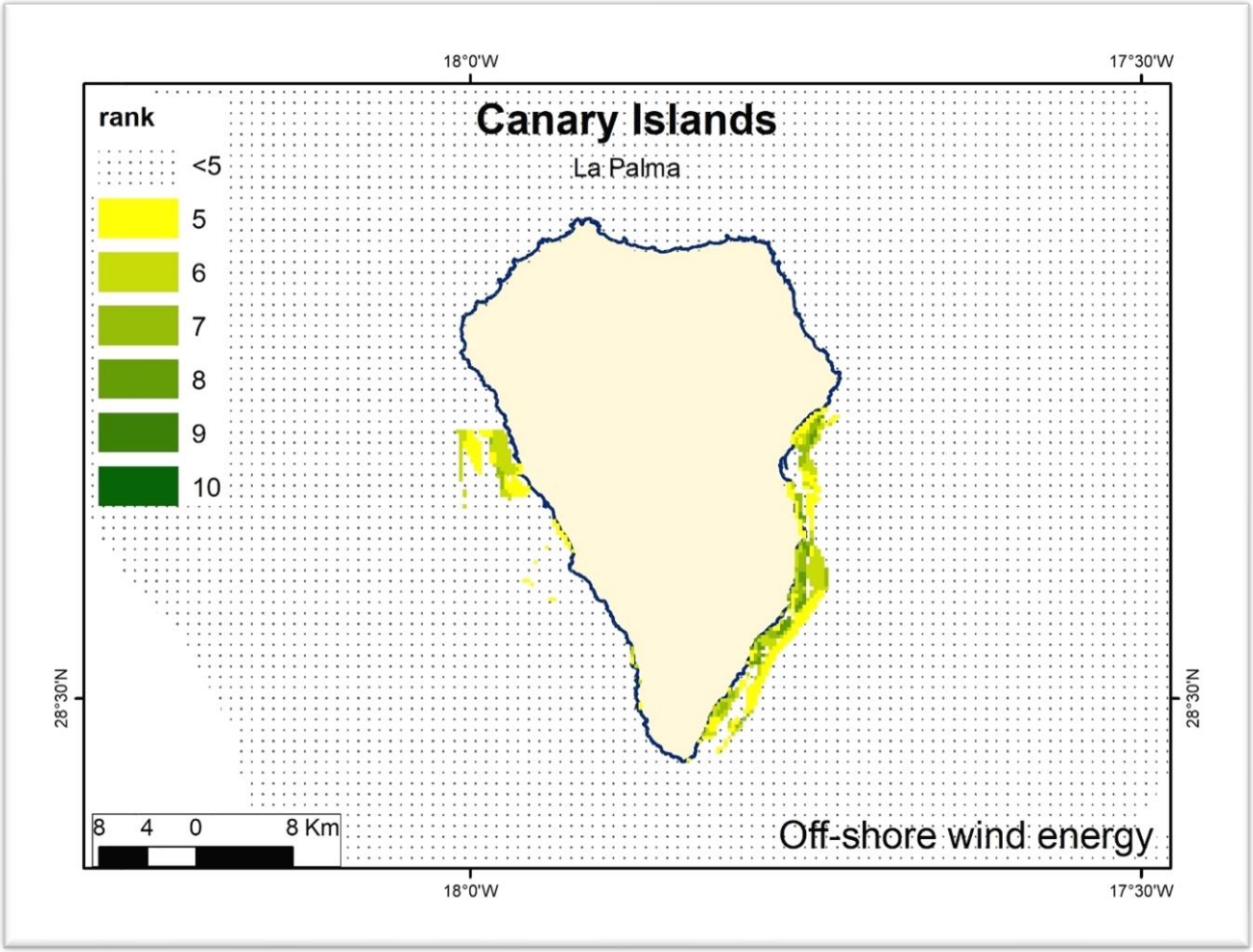


Figure 6 - OWE suitability analysis for Canary Islands applying project PLASMAR profile

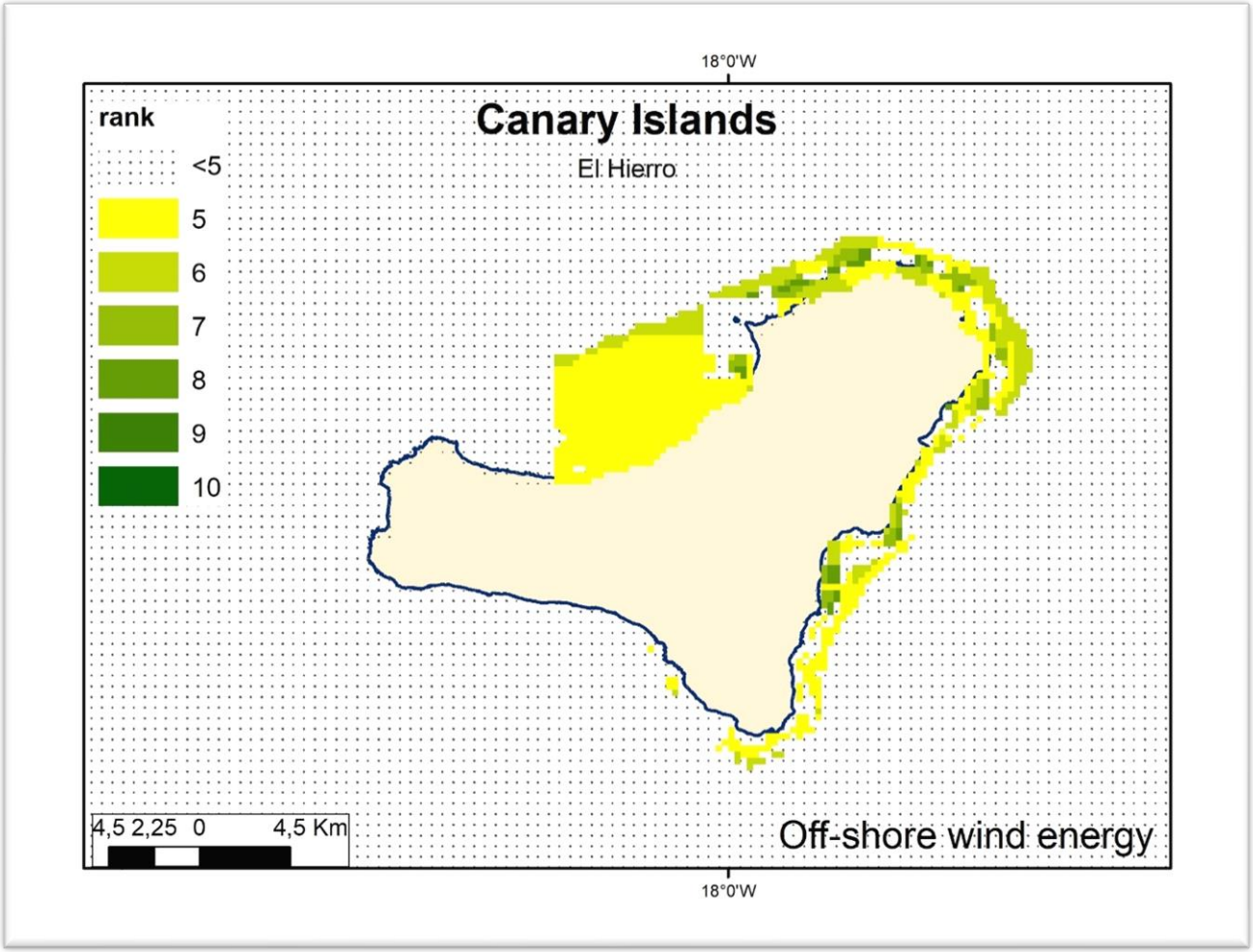


Figure 7 - OWE suitability analysis for Canary Islands applying project PLASMAR profile

1.2 Introducing Offshore Wind Energy in the sea space of Madeira archipelago

The file is available within the MSP Spatial Data Infrastructure (MSP Macaronesian catalogue), developed by PLASMAR. There are enabled three web services and direct download:

Search with the metadata catalogue:

http://www.geoportal.ulpgc.es/geonetwork/srv/spa/catalog.search#/metadata/ES_ECOAQUA_MSPMD_WMS10632-20200901

View network service:

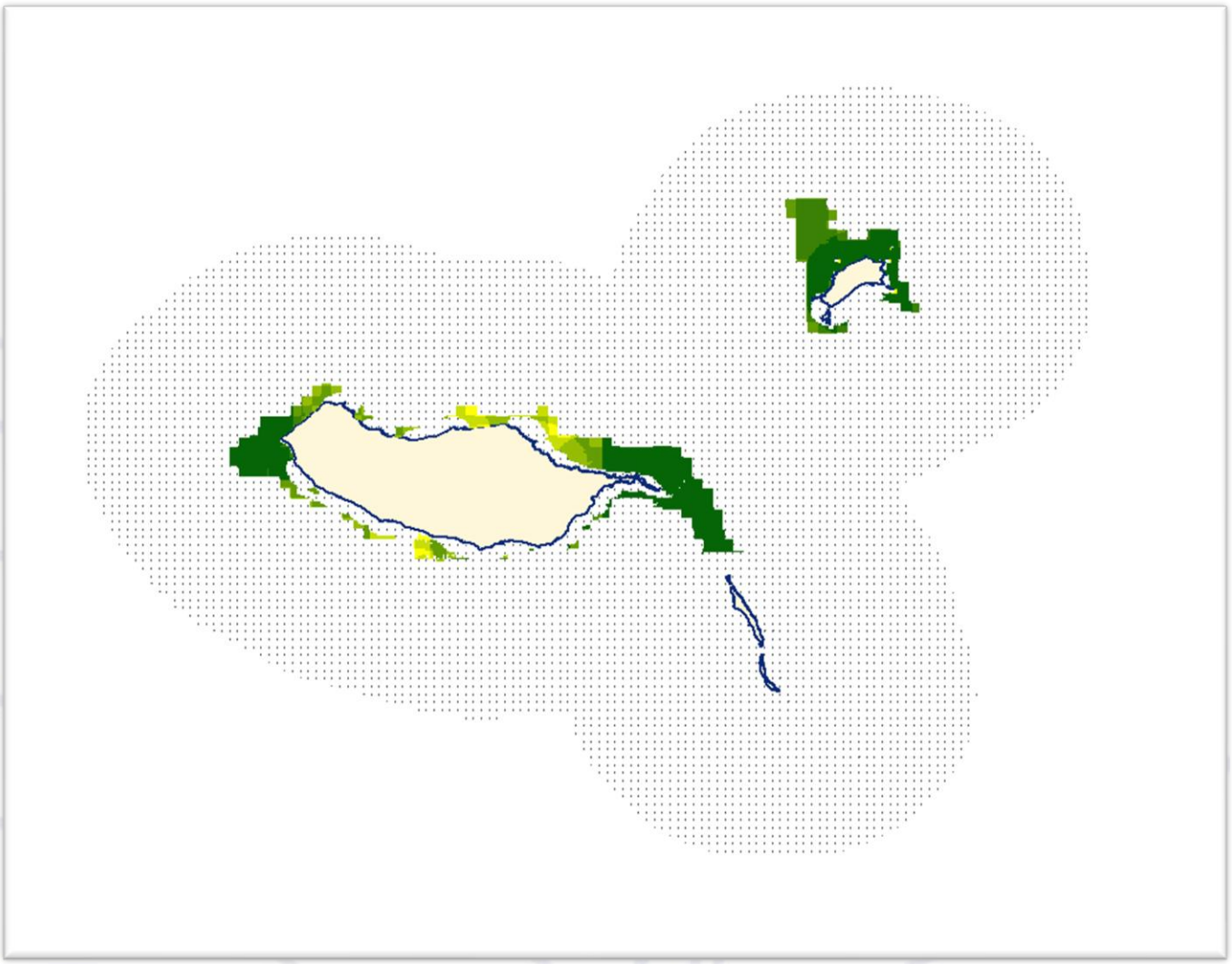
http://www.geoportal.ulpgc.es/geoserver/indimar/wms?request=GetCapabilities

and download service:

http://www.geoportal.ulpgc.es/geoserver/indimar/wfs?request=GetCapabilities.

Direct download:

http://www.geoportal.ulpgc.es/atom/download/ES_ECOAQUA_MSPMD_DATASET_10632.zip



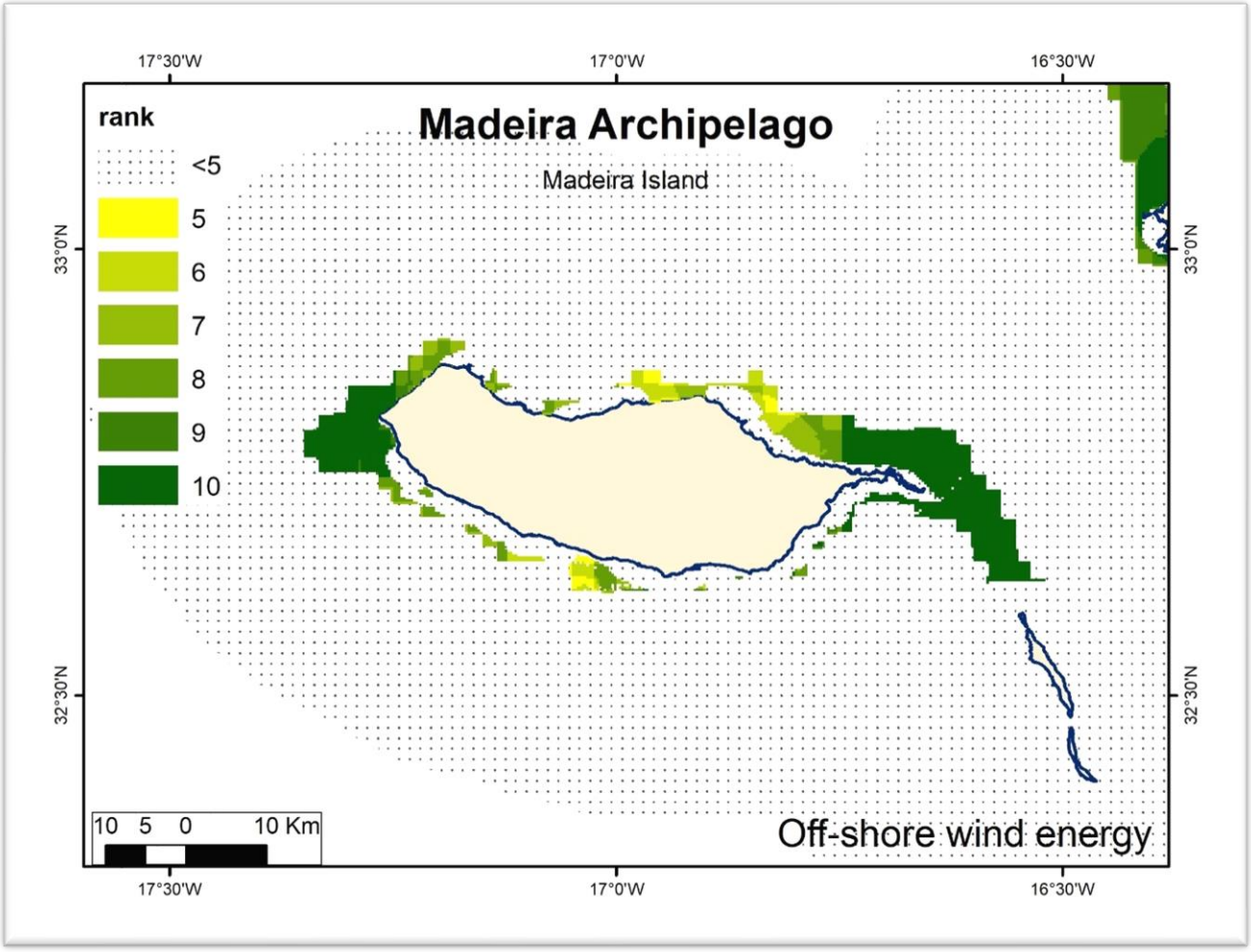


Figure 8 - OWE suitability analysis for Madeira archipelago applying project PLASMAR profile

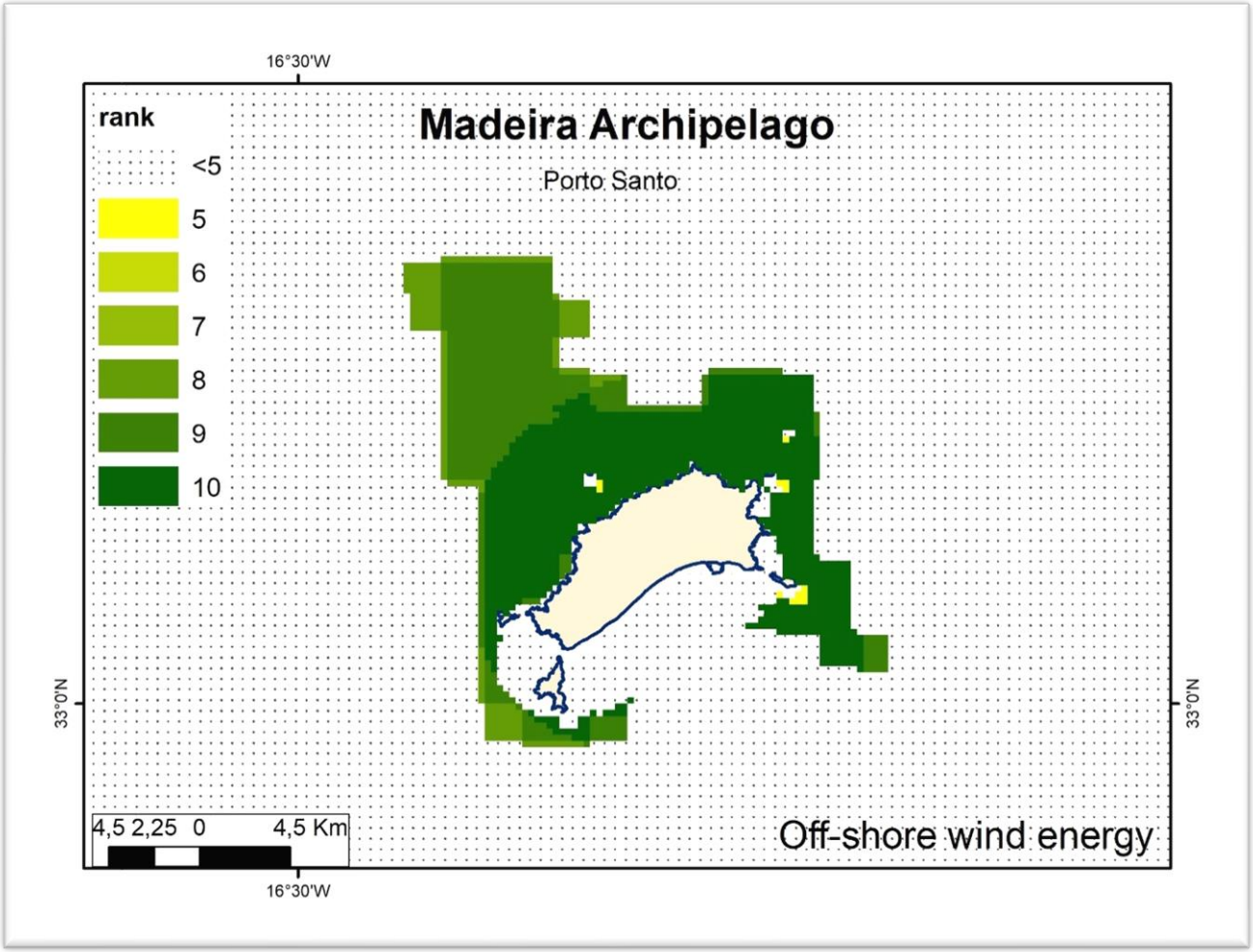


Figure 9 - OWE suitability analysis for Madeira archipelago applying project PLASMAR profile

1.3 Introducing Offshore Wind Energy in the sea space of Azores

The file is available within the MSP Spatial Data Infrastructure (MSP Macaronesian catalogue), developed by PLASMAR. There are enabled three web services and direct download:

Search with the metadata catalogue:

http://www.geoportal.ulpgc.es/geonetwork/srv/spa/catalog.search#/metadata/ES_ECOAQUA_MSPMD_WMS10631-20200901

View network service:

http://www.geoportal.ulpgc.es/geoserver/indimar/wms?request=GetCapabilities

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Direct download:

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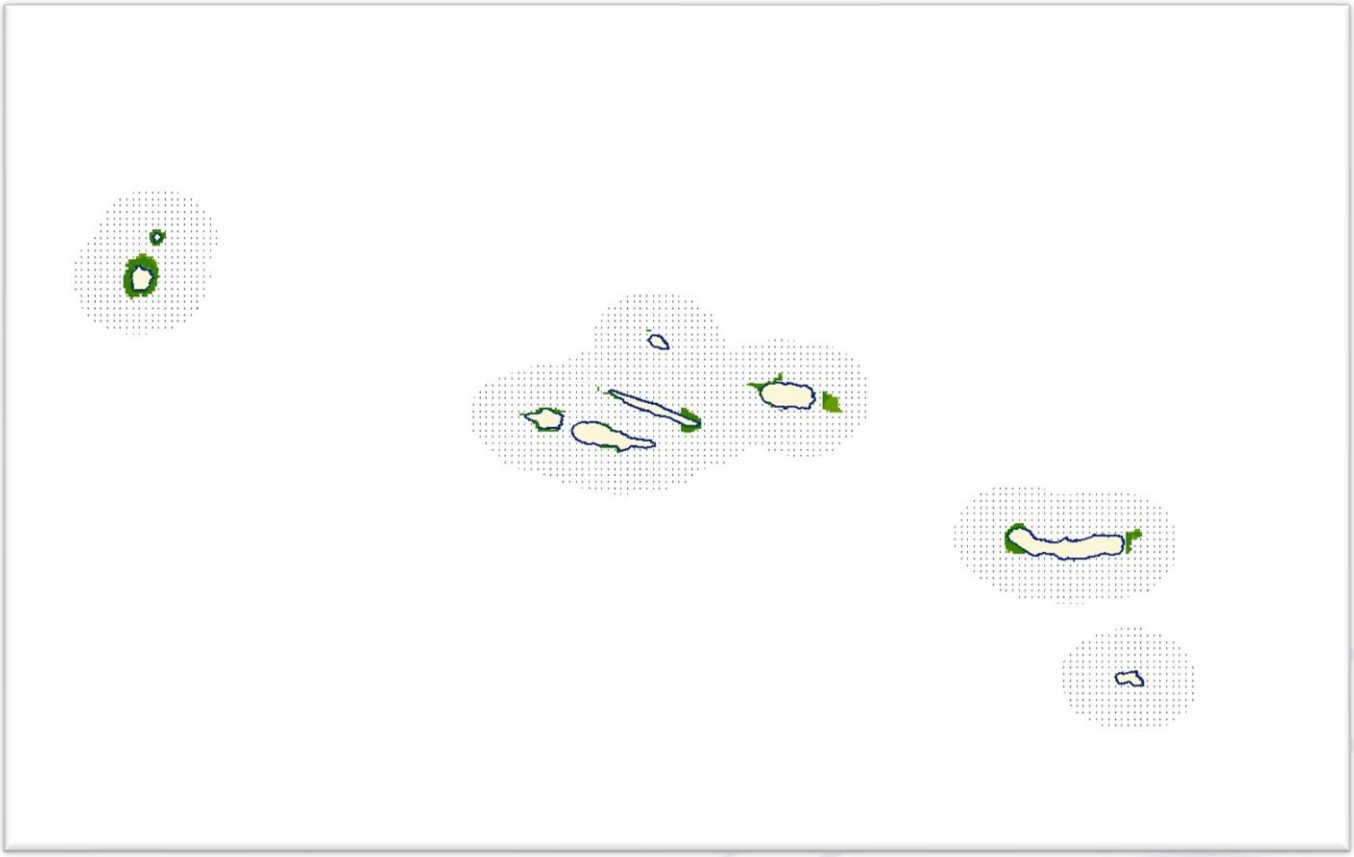


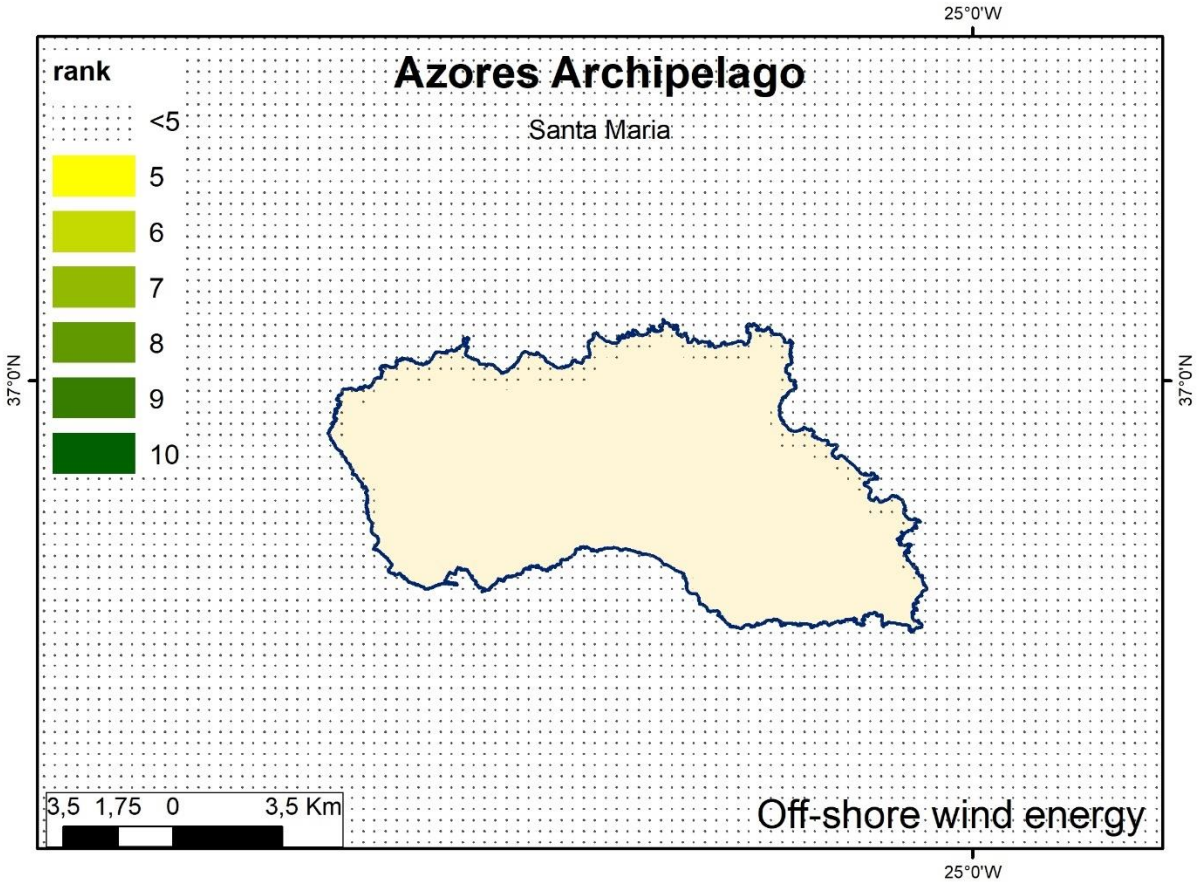


Figure 10 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

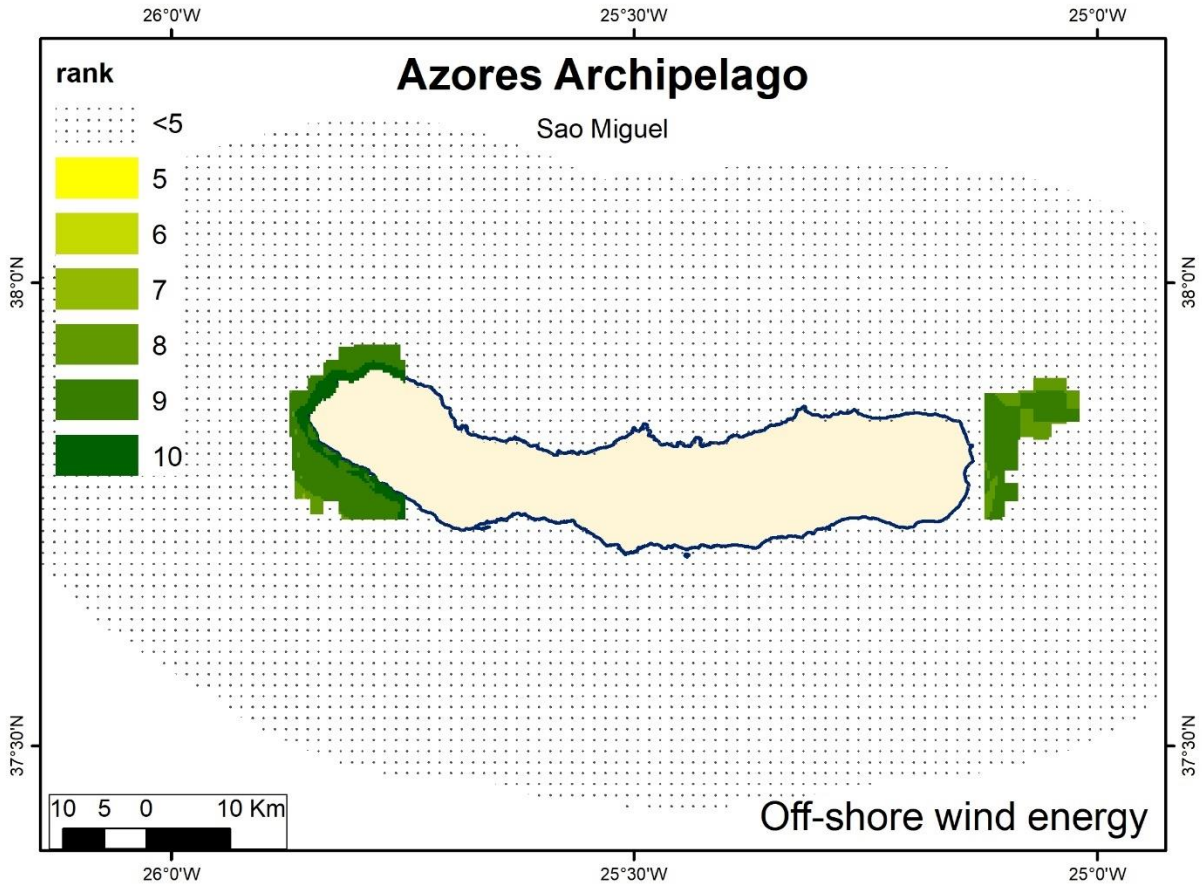


Figure 11- OWE suitability analysis for Azores archipelago applying project PLASMAR profile

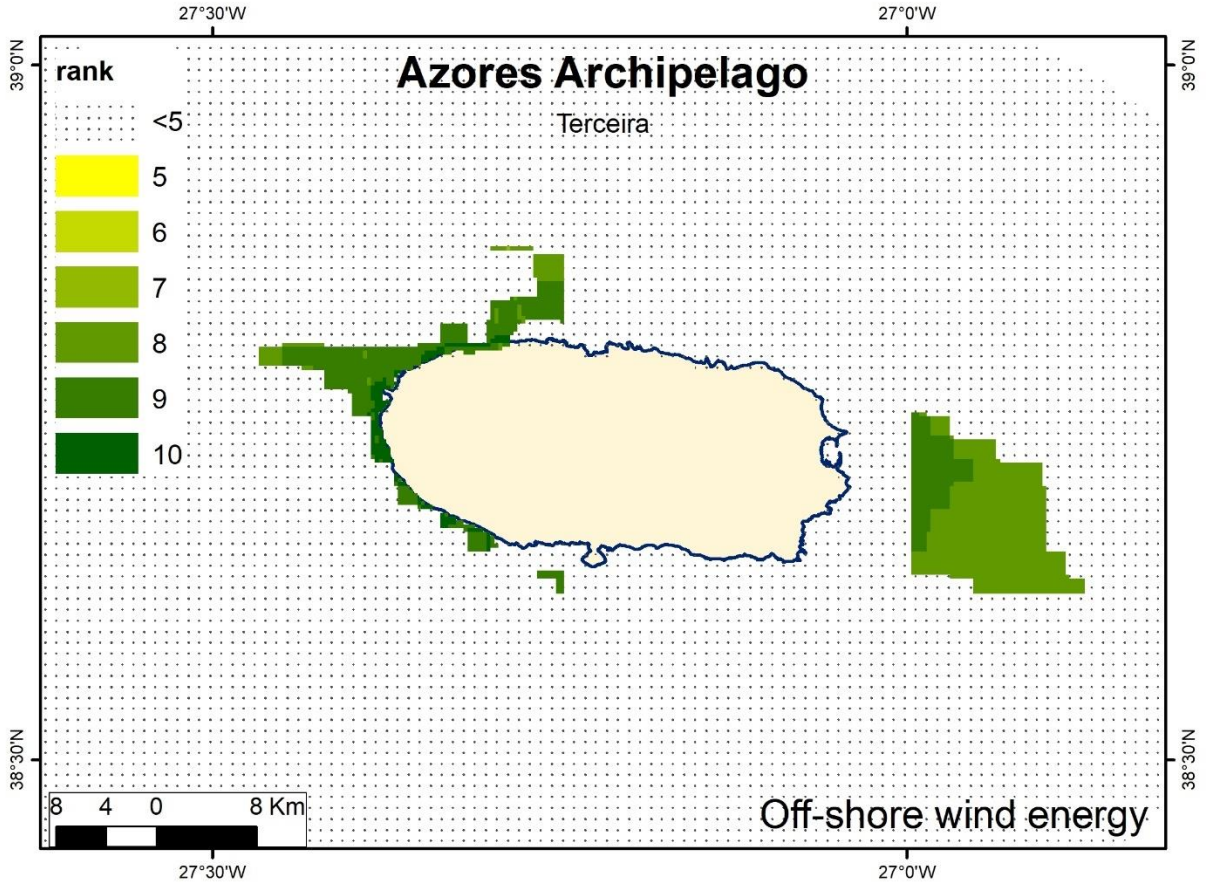


Figure 12 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

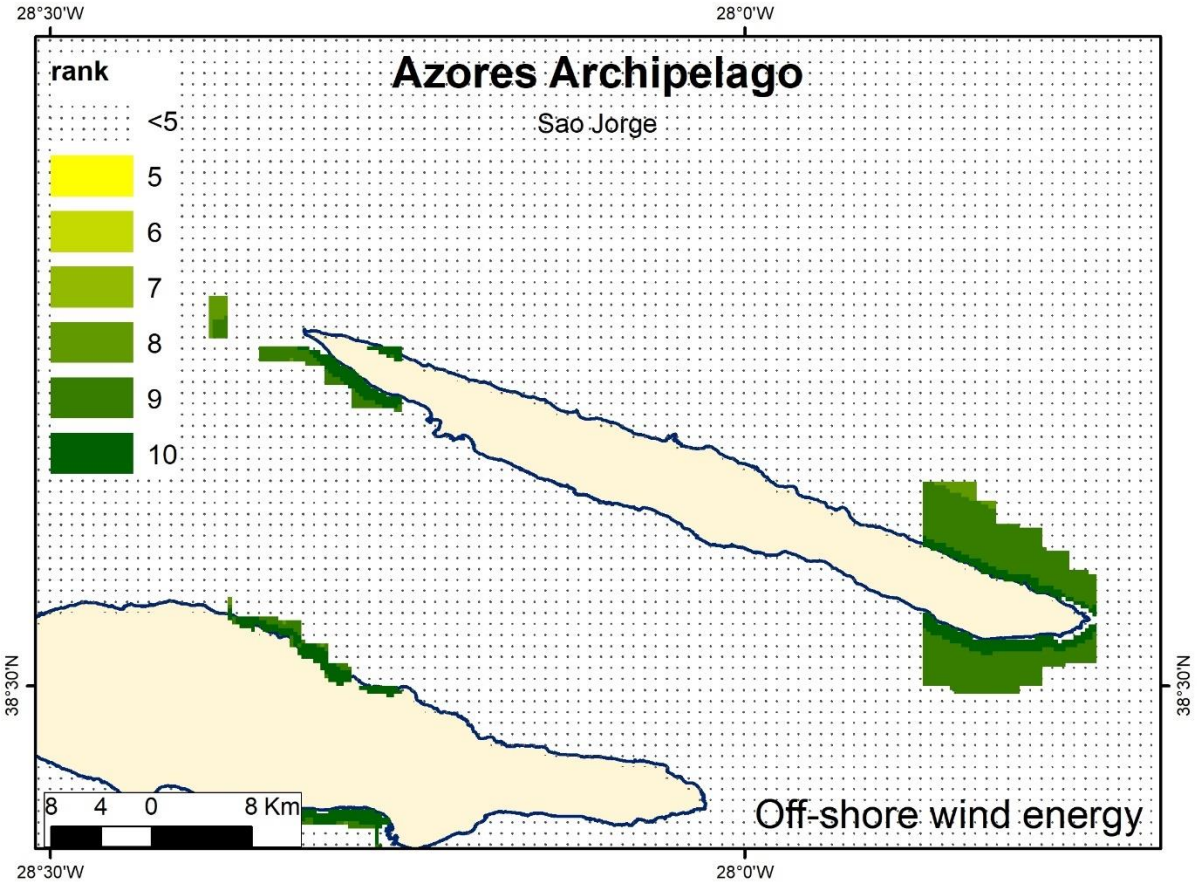


Figure 13 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

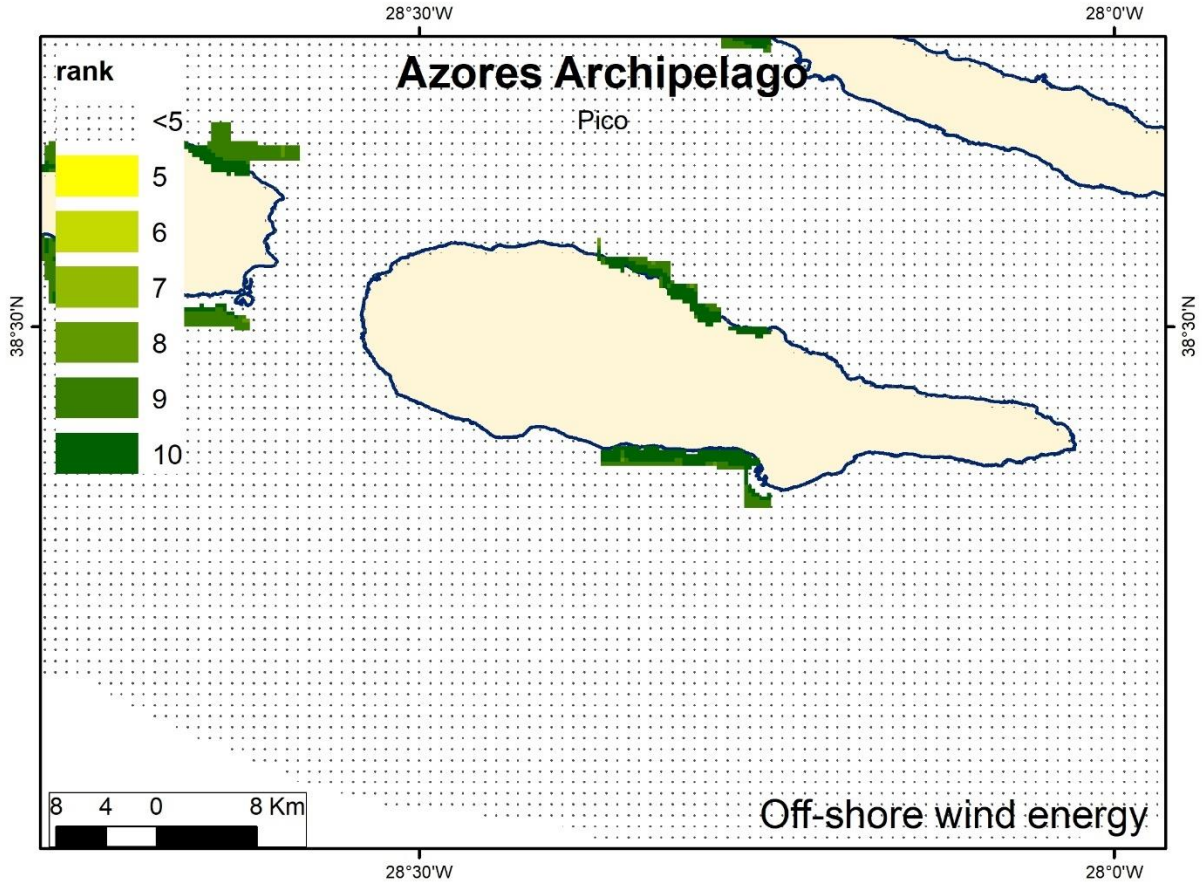


Figure 14 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

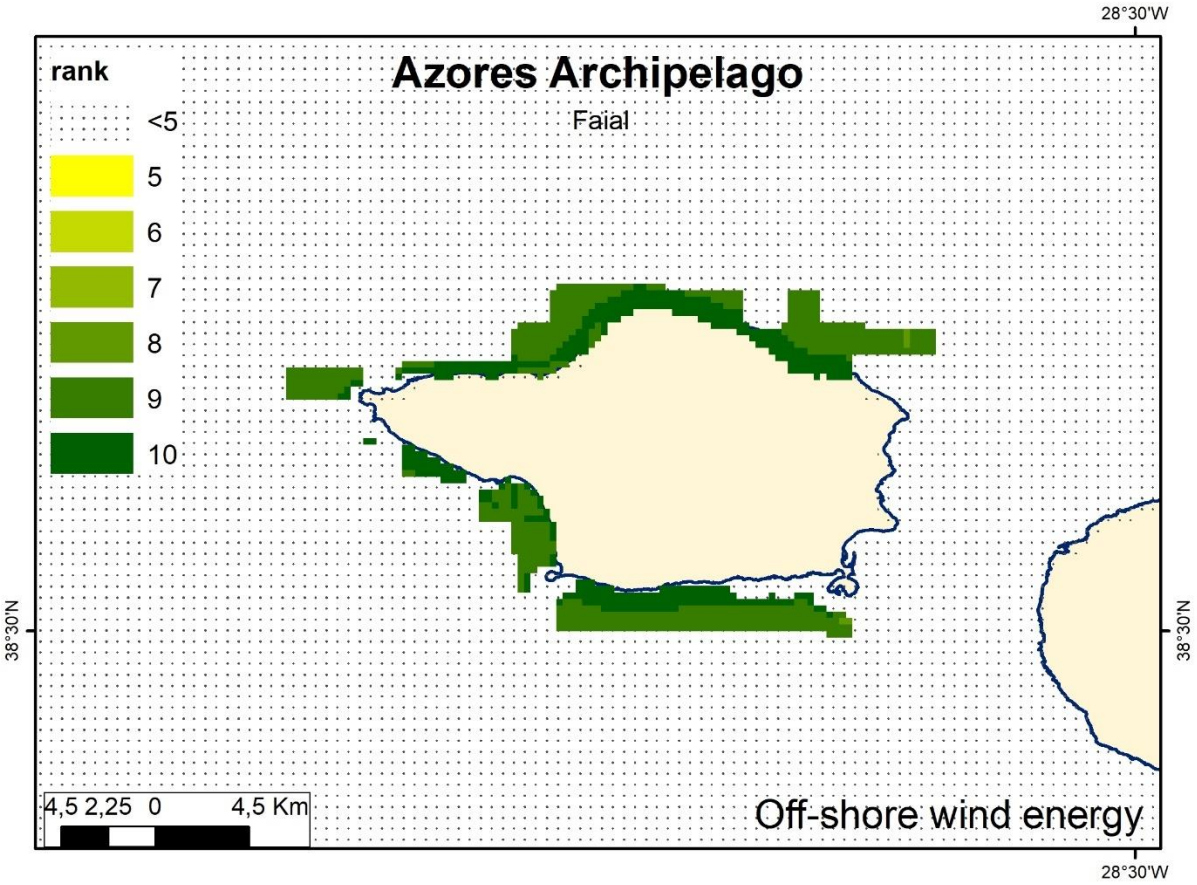


Figure 15 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

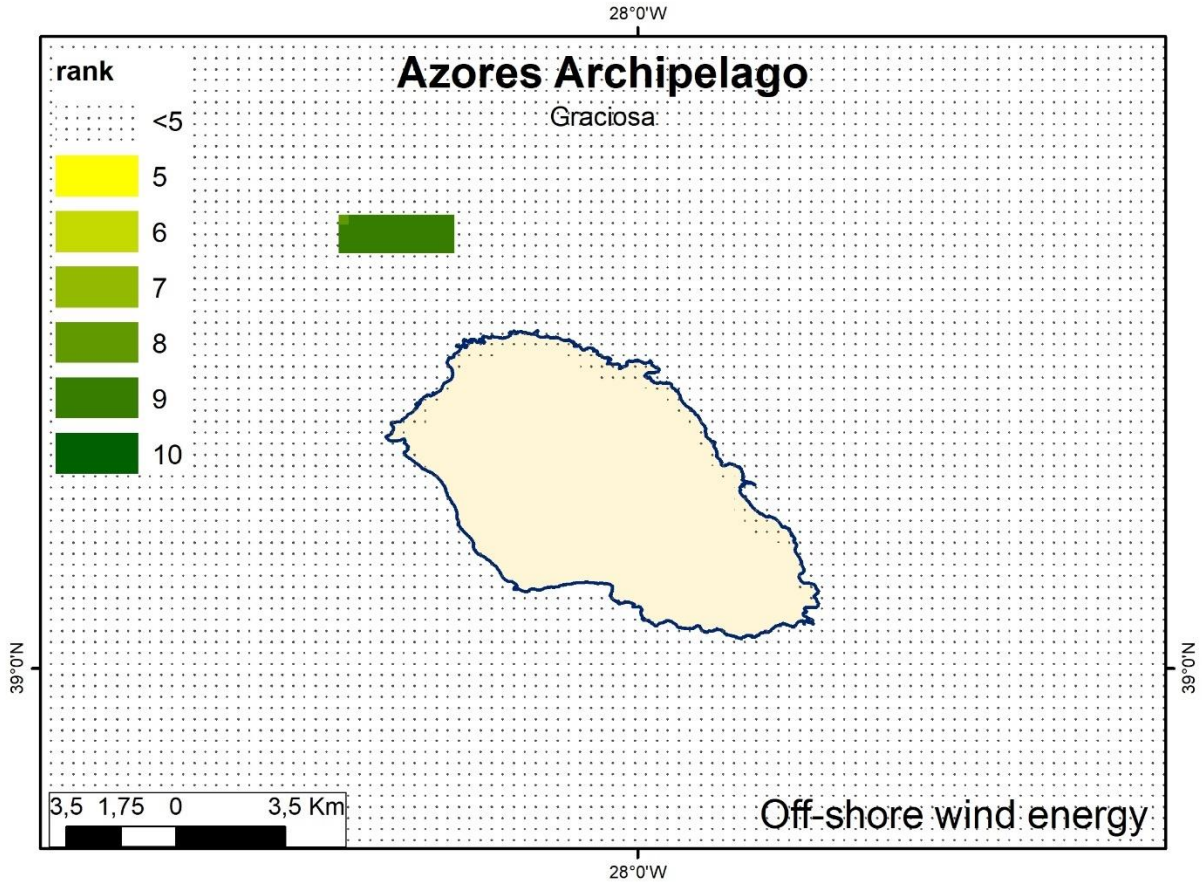


Figure 16 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

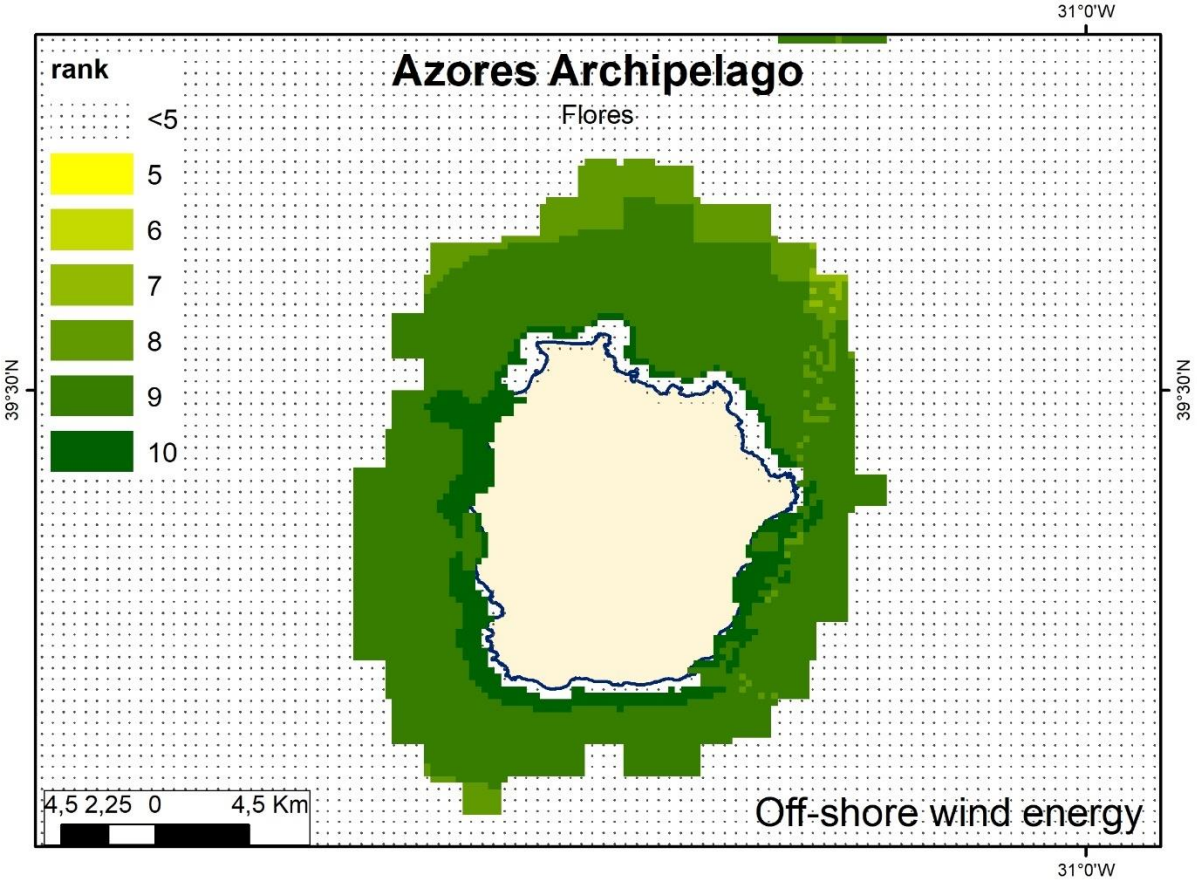


Figure 17 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

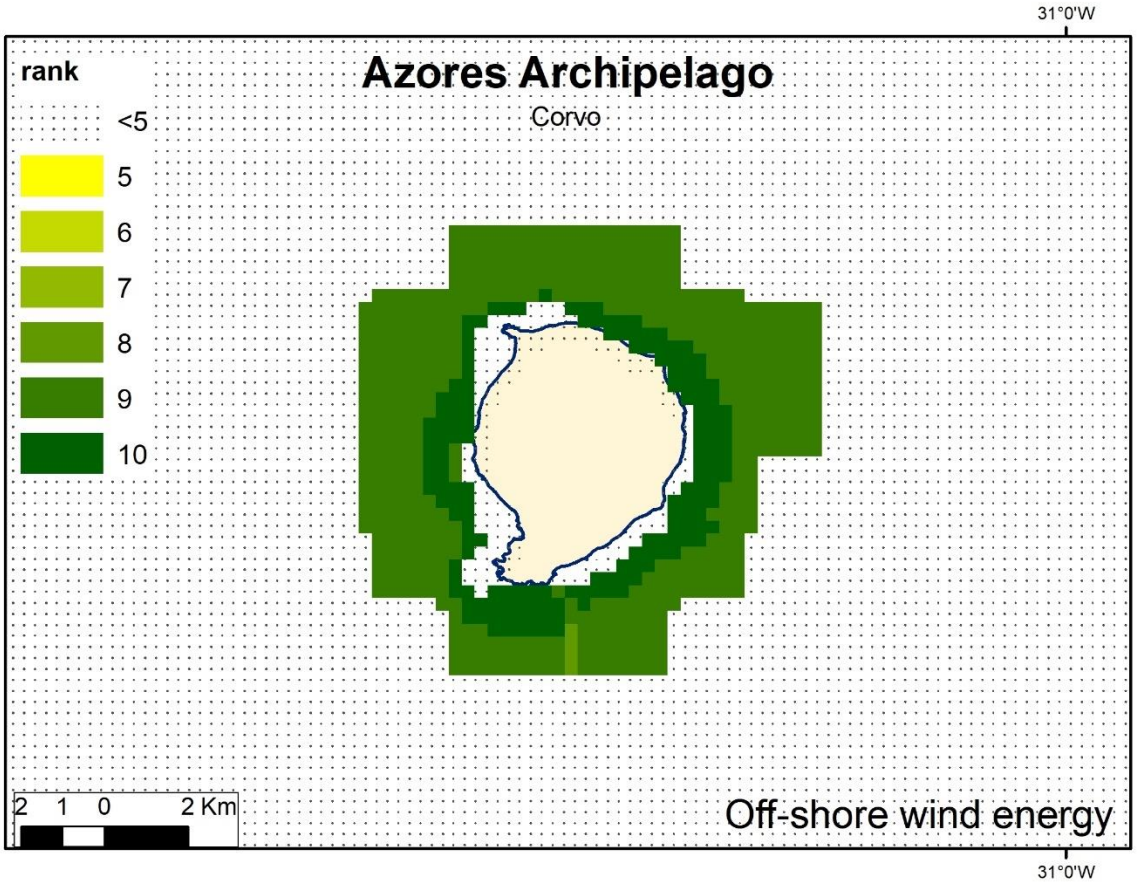


Figure 18 - OWE suitability analysis for Azores archipelago applying project PLASMAR profile

2 Expanding aquaculture in the sea space of Madeira

In this study, we analyzed coastlineS and related marine areas of Madeira archipelago, to identify the most suitable locations for aquaculture facilities. As within the study on OWE, this suitability study was done using Decision Support System INDIMAR. Environmental sensibility is defined by within PLASMAR study described in the reports "Good Environmental Status & Aquaculture", Fernández-Palacios et al. 2018 "Analysis of the Aquaculture Industry in Macaronesia under MSFD", Png-Gonzalez et al. 2018.

Relation of the aquaculture and parameters included in the marine environment cluster, Marine Protected Areas cluster, oceanography cluster, coastal land use cluster and maritime activities cluster are resumed and documented in this table included in the Annex 2.

Unfortunately, due the restricted coverage on marine environmental data & assessments, environmental sensibility analysis was not completed. Analysis on restriction related to the marine conservation; Land-sea interactions; and potential conflict with current maritime uses were finalized. Oceanographic parameters as temperature, currents and waves are limiting factors when comes on aquaculture sites location selection. Oceanographic data (satellite observations) were available, obtained by Copernicus Marine Environment Monitoring Service. Following obtained results and empirical knowledge of the local experts involved in the project, we understand that currents and waves data products (provided with offshore scale), were not appropriate for the coastal aquaculture location analysis. Due that model was not able to restrict areas with high waves regime (mainly Madeira North coast), or to identify areas that have required currents ranges.

We included all relevant parameters covered with available data, defining significance, applying Analytical Hierarchy Process (AHP), calculating weights with aquaculture experts involved in the PLASMAR project. Model run by INDIMAR tool identified areas that are covering all currently selected areas for extension of aquaculture within the Madeira archipelago and included in the current version of Maritime Spatial Plan.

The file is available within the MSP Spatial Data Infrastructure (MSP Macaronesian catalogue), developed by PLASMAR. There are enabled three web services and direct download:

Search with the metadata catalogue:

http://www.geoportal.ulpgc.es/geonetwork/srv/spa/catalog.search#/metadata/ES_ECOAQUA_MSPMD_WMS10631-20200901

View network service:

http://www.geoportal.ulpgc.es/geoserver/indimar/wms?request=GetCapabilities

and download service:

http://www.geoportal.ulpgc.es/geoserver/indimar/wfs?request=GetCapabilities.

Direct download:

http://www.geoportal.ulpgc.es/atom/download/ES_ECOAQUA_MSPMD_DATASET_10630.zip

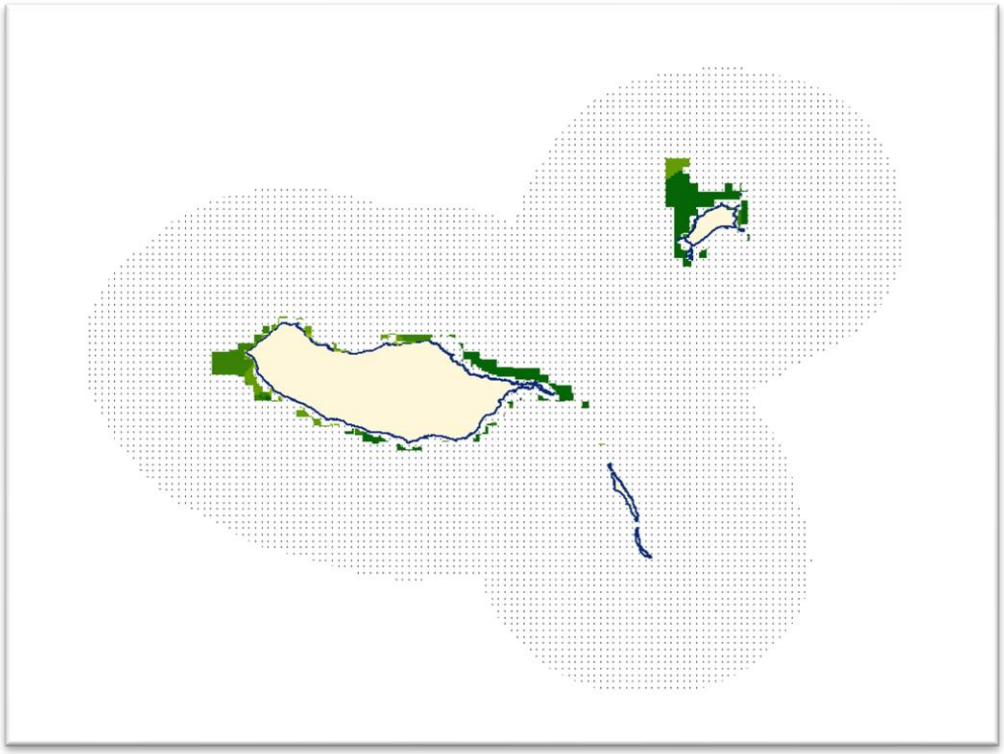


Table 2- Cluster parameters weights, delivered by PLASMAR project aquaculture experts

Cluster	Criteira	Overal weight	AHP		Final weight
Good Environmental Status		**0,193836**			
	Biodiversity (Benthic habitats)	0,356	0,069	0,55	10,63
	Biodiversity (Mammals)	0,142	0,027	0,22	4,23
	Biodiversity (Birds)	0,142	0,028	0,22	4,24
	Non-indigenous species	0,160	0,031	0,25	4,76
	Eutrophication (Dissolved oxygen)	0,061	0,012	0,09	1,81
	Eutrophication (Nutrients)	0,086	0,017	0,13	2,56
	The sea floor integrity	0,028	0,005	0,04	0,83
	Marine litter	0,025526	0,005	0,04	0,76
Maritime Protected Areas		**0,110628**		0,11	**2,13**
Coastal Land Use		**0,059848**			
	CORINE (Urban areas)	0,257	0,015	0,09	1,77
	CORINE (Industrial areas)	0,106	0,006	0,04	0,73
	CORINE (Port areas)	0,045	0,003	0,02	0,31
	CORINE (Agriculture)	0,063	0,004	0,02	0,43
	Distance to the coast	0,351	0,021	0,13	2,43
	Point and lineal coastal presures	0,178	0,011	0,06	1,23
Oceanography		**0,364903**			
	Overal ocean temperature	0,447	0,163	0,82	15,70
	Currents	0,272	0,099	0,50	9,54
	Waves	0,170	0,062	0,31	5,96
	Depth/bathymetry	0,072	0,026	0,13	2,52
	Wind	0,039	0,014	0,07	1,38
Current Maritime Uses		**0,270785**			
	Maritime traffic lanes	0,039	0,011	0,05	1,02
	Aquaculture facilities	0,109	0,030	0,15	2,84
	Submarine outfalls	0,185	0,050	0,25	4,82
	Artificial reefs	0,341	0,092	0,46	8,89
	Seaweed cultivation	0,325	0,088	0,44	8,47

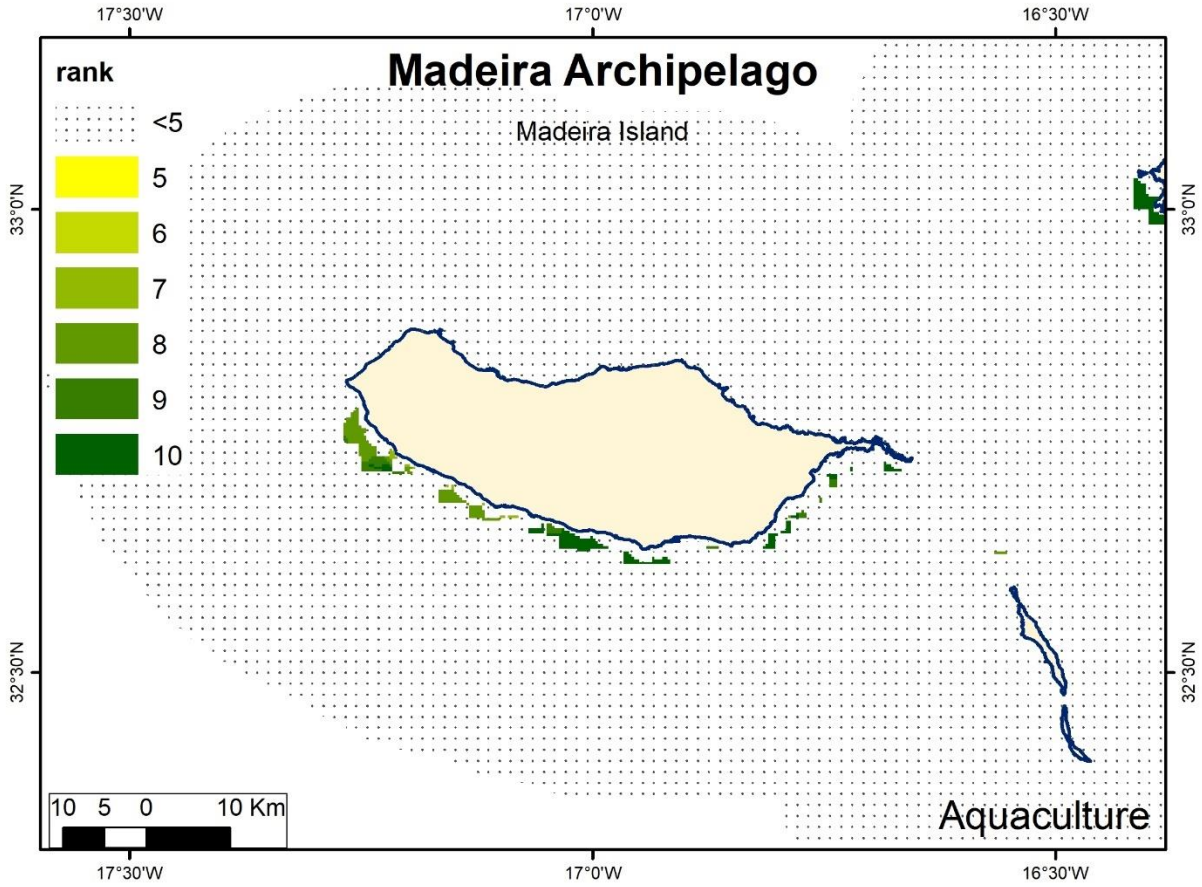


Figure 19 – Aquaculture suitability analysis for Madeira archipelago, applying project PLASMAR profile

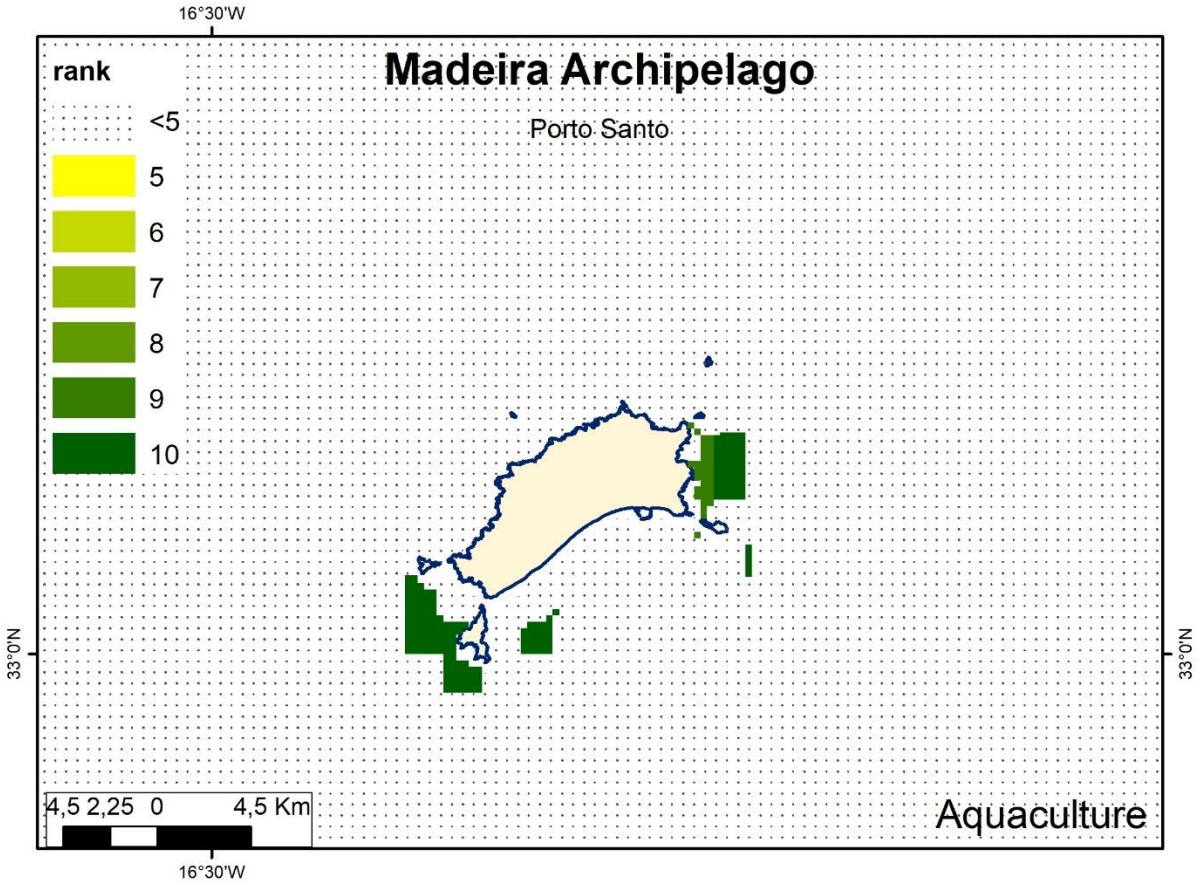


Figure 20 - Aquaculture suitability analysis for Madeira archipelago, applying project PLASMAR profile

3 Introducing and expanding sand extraction in the sea space of Azores

In this study, we analyzed coastline and related marine areas of Azores, to identify the most suitable locations for sand extraction. As within the study on OWE, this suitability study was done using DSS INDIMAR.

Relation of the sand extraction activity and parameters included in the marine environment cluster, Marine Protected Areas cluster, oceanography cluster, coastal land use cluster and maritime activities cluster are documented in this table included in the Annex 3.

Unfortunately, due the restricted coverage on marine environmental data & assessments, environmental sensibility analysis was not completed. Analysis on restriction related to the marine conservation; Land-sea interactions; and potential conflict with current maritime uses were finalized.

In the aggregate extraction sector, the survey was taken within the PLASMAR experts' group, through a consensus-based decision. Furthermore, two external experts (Instituto Hidrográfico / ICES WGEXT and Universidade dos Açores) at the Azores were consulted individually. The geometric mean was taken for each entrance of the comparison matrices. The parameters that present the highest values for this sector were: Marine Protected Areas and CORINE (beaches, dunes and sand). The parameters that presented the lowest values were: Biodiversity (mammals) and energy.

We introduced all relevant parameters and related weights, that were available. ,. Model run by INDIMAR tool identified areas that are appropriate for sand extraction. Nevertheless, results should be taken with precaution, mainly as delivered with significant lack of data on marine environment.

The file is available within the MSP Spatial Data Infrastructure (MSP Macaronesian catalogue), developed by PLASMAR. There are enabled three web services and direct download:

Search with the metadata catalogue:

http://www.geoportal.ulpgc.es/geonetwork/srv/spa/catalog.search#/metadata/ES_ECOAQUA_MSPMD_WMS10634-20200901

View network service:

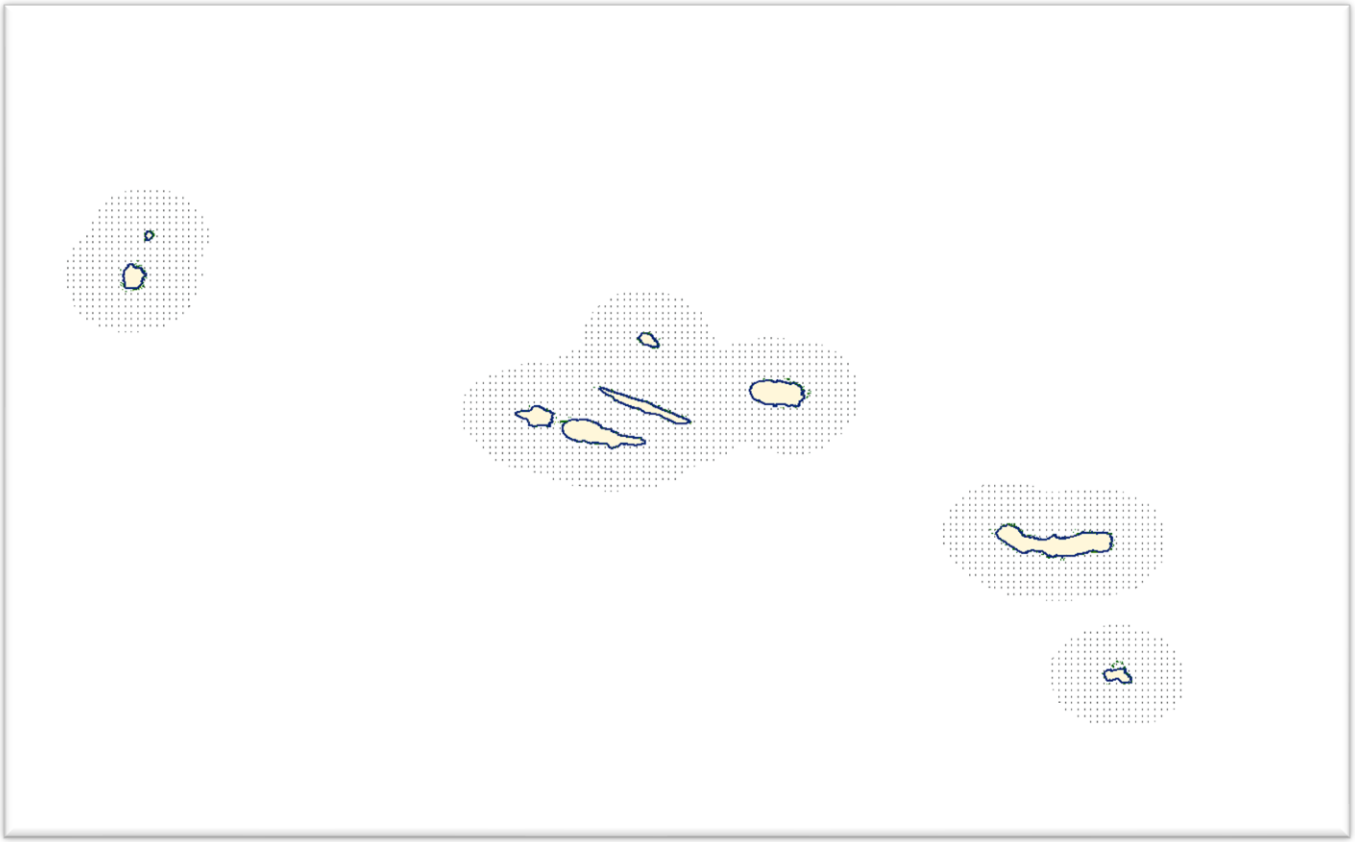
http://www.geoportal.ulpgc.es/geoserver/indimar/wms?request=GetCapabilities

and download service:

http://www.geoportal.ulpgc.es/geoserver/indimar/wfs?request=GetCapabilities.

Direct download:

http://www.geoportal.ulpgc.es/atom/download/ES_ECOAQUA_MSPMD_DATASET_10634.zip



Cluster	Criteira	PLASMAR	EXTERNAL 1	EXTERNAL 2	Final weight
Good Environmental Status					
1	Biodiversity (Benthic Habitats)	7,652249	11,96397	23,32034	14,97
1	Biodiversity (Mammals)	0,774352	7,2265	2,723949	2,59
1	The population of commercial fish species	1,660048	8,129251	5,916462	4,62
1	The sea floor integrity	11,62513	1,707446	6,188571	5,63
1	Permanent alteration of hydrographical conditions	3,945016	31,78874	2,741798	7,92
1	Energy, including underwater noise data	2,153626	3,40834	2,228733	2,66
Maritime Protected Areas		38,07021	8,219503	30,47012	30,10
Coastal Land Use (CORINE: beaches, dune and sand)		22,25836	21,31769	11,47088	21,68
Oceanography (depth/bathymetry)		11,861	6,238563	14,93914	9,84

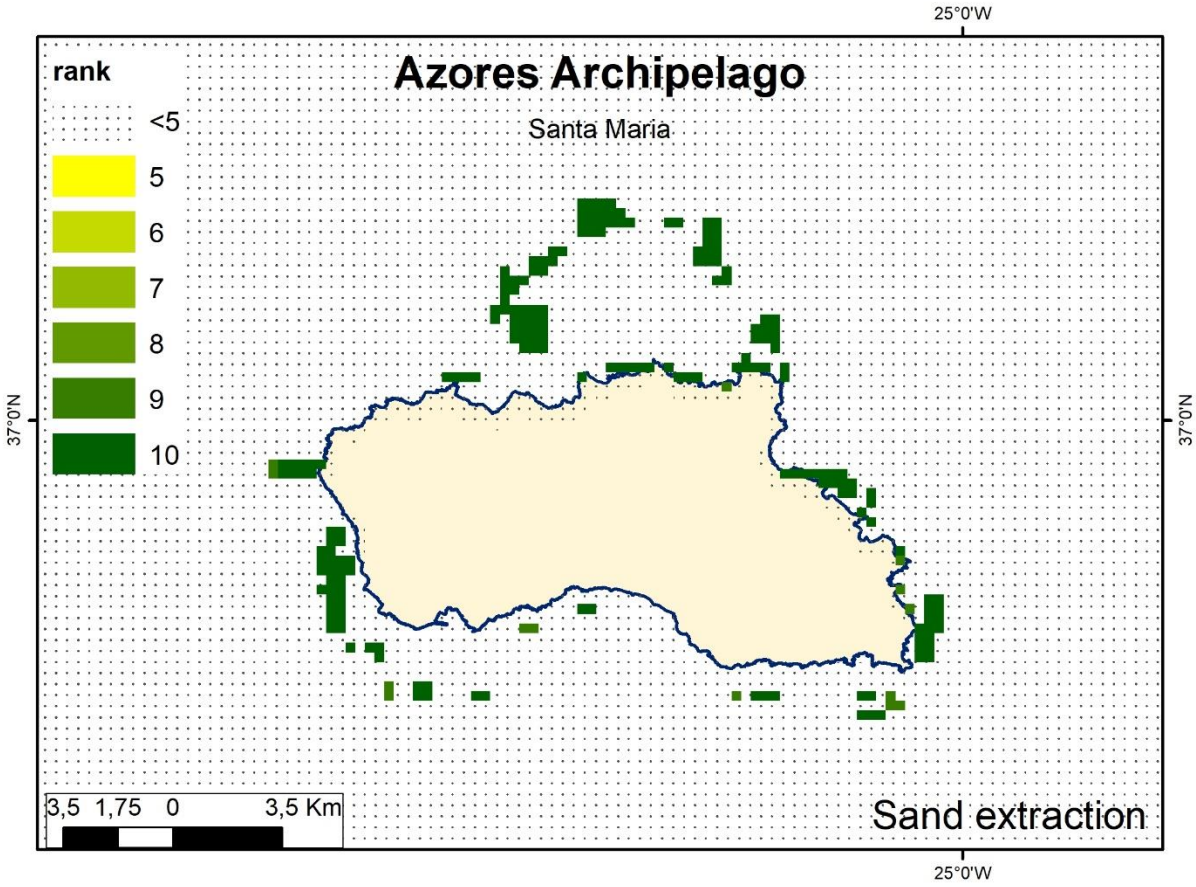


Figure 21 – Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

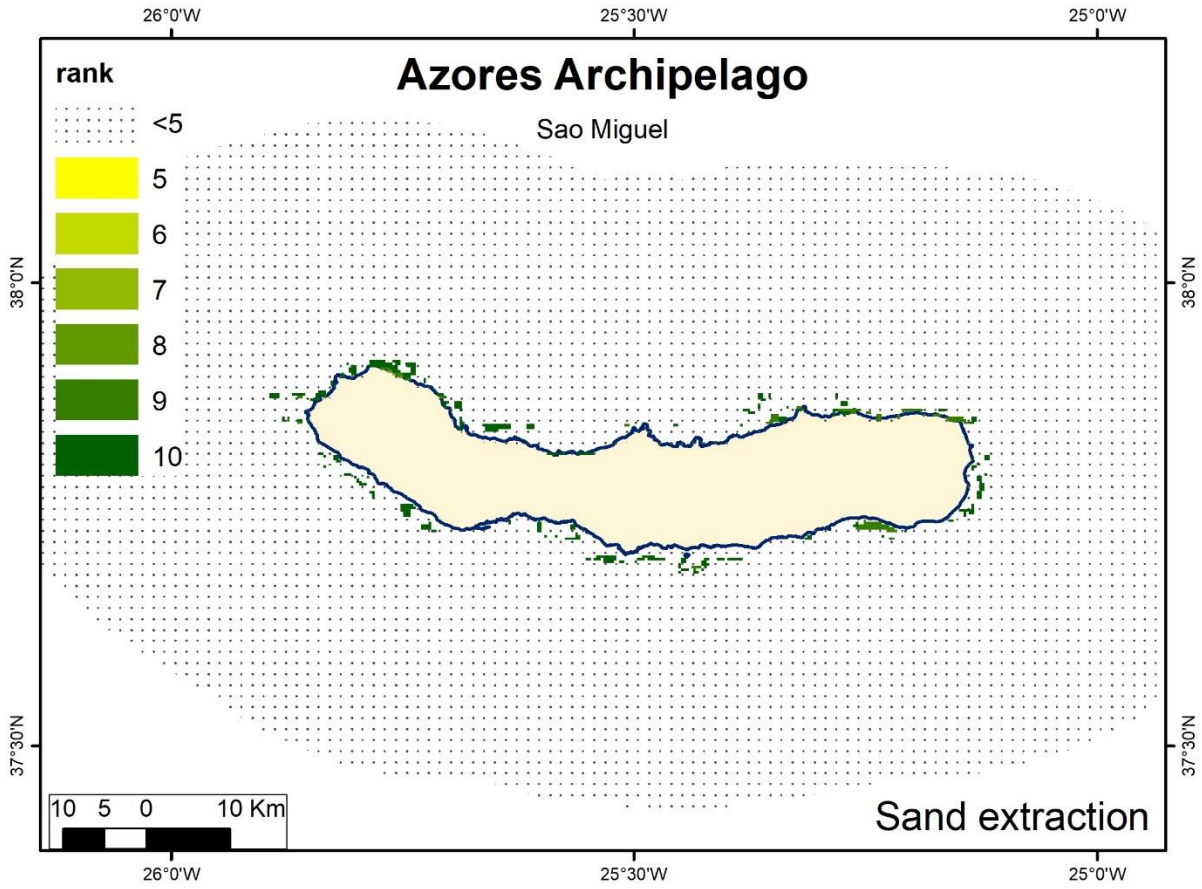


Figure 22 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

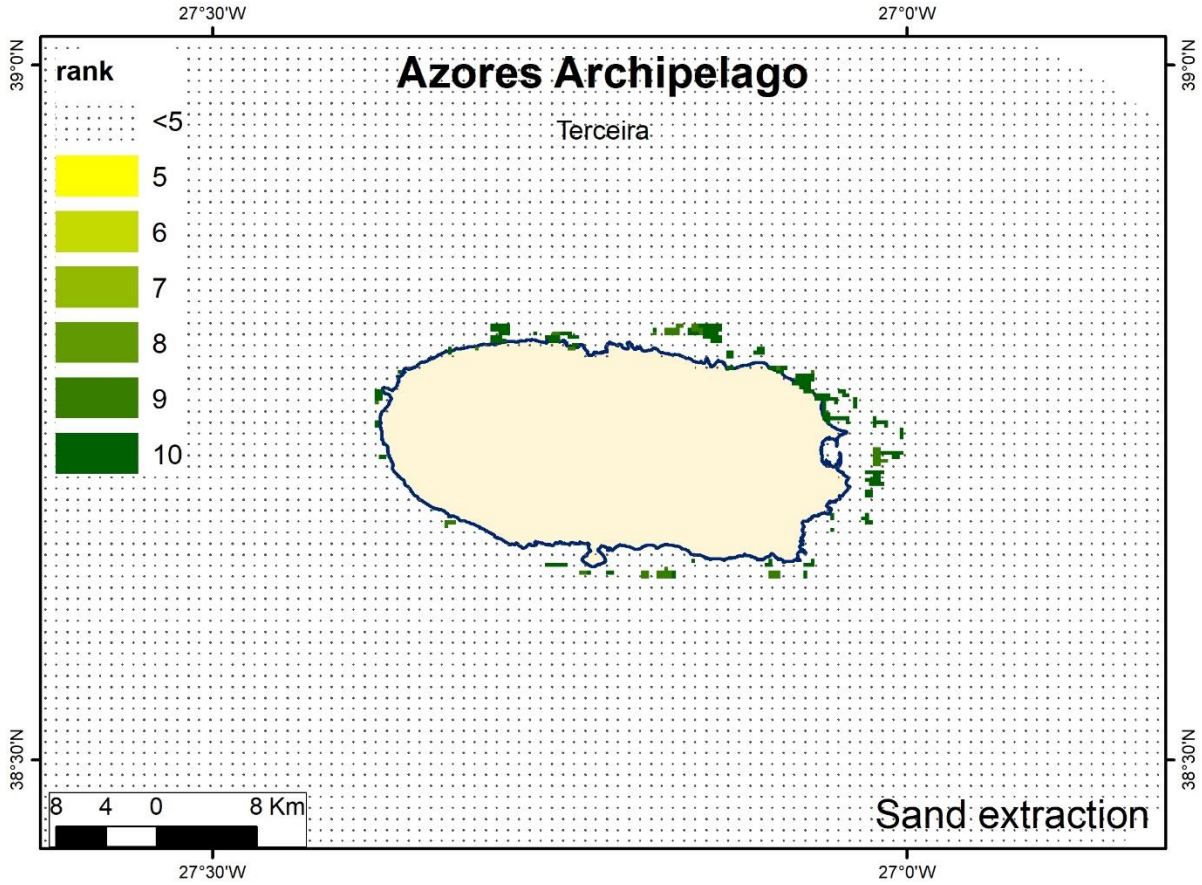


Figure 23 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

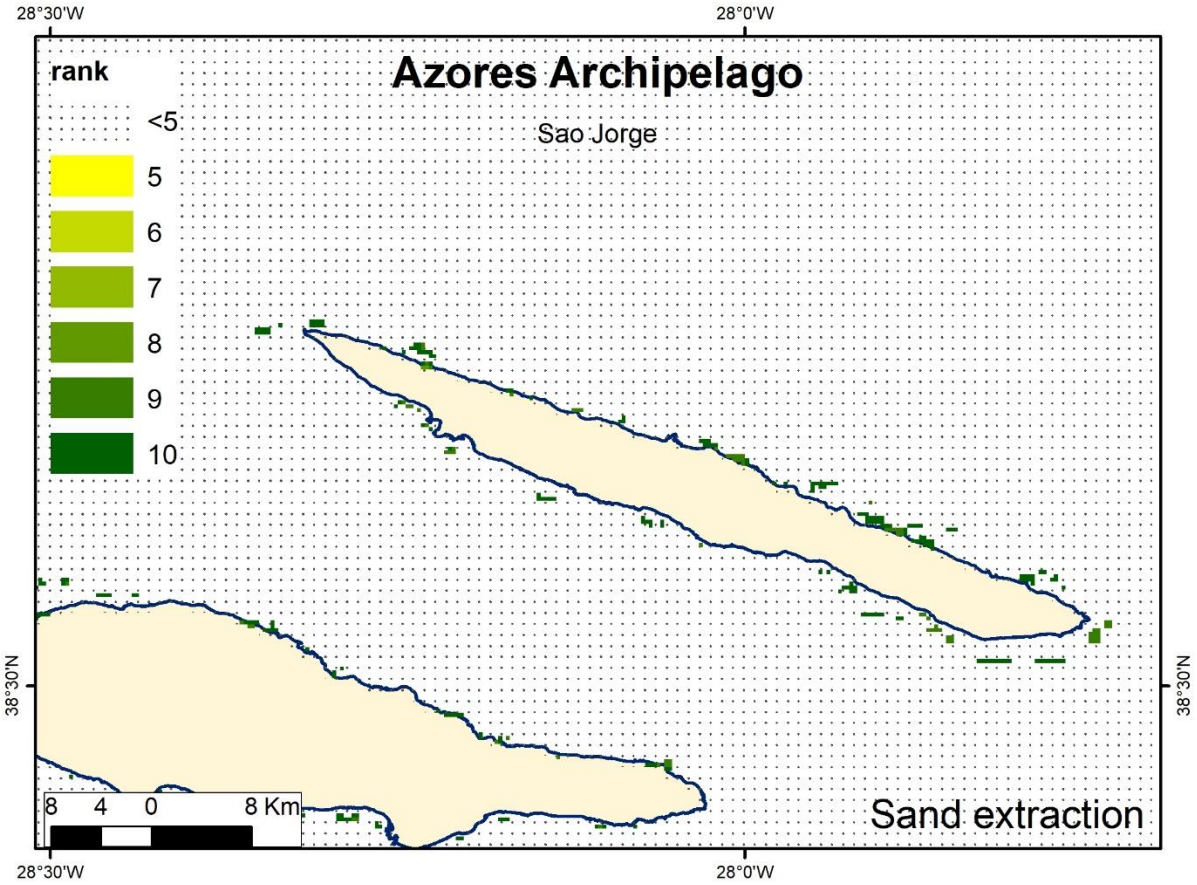


Figure 24 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

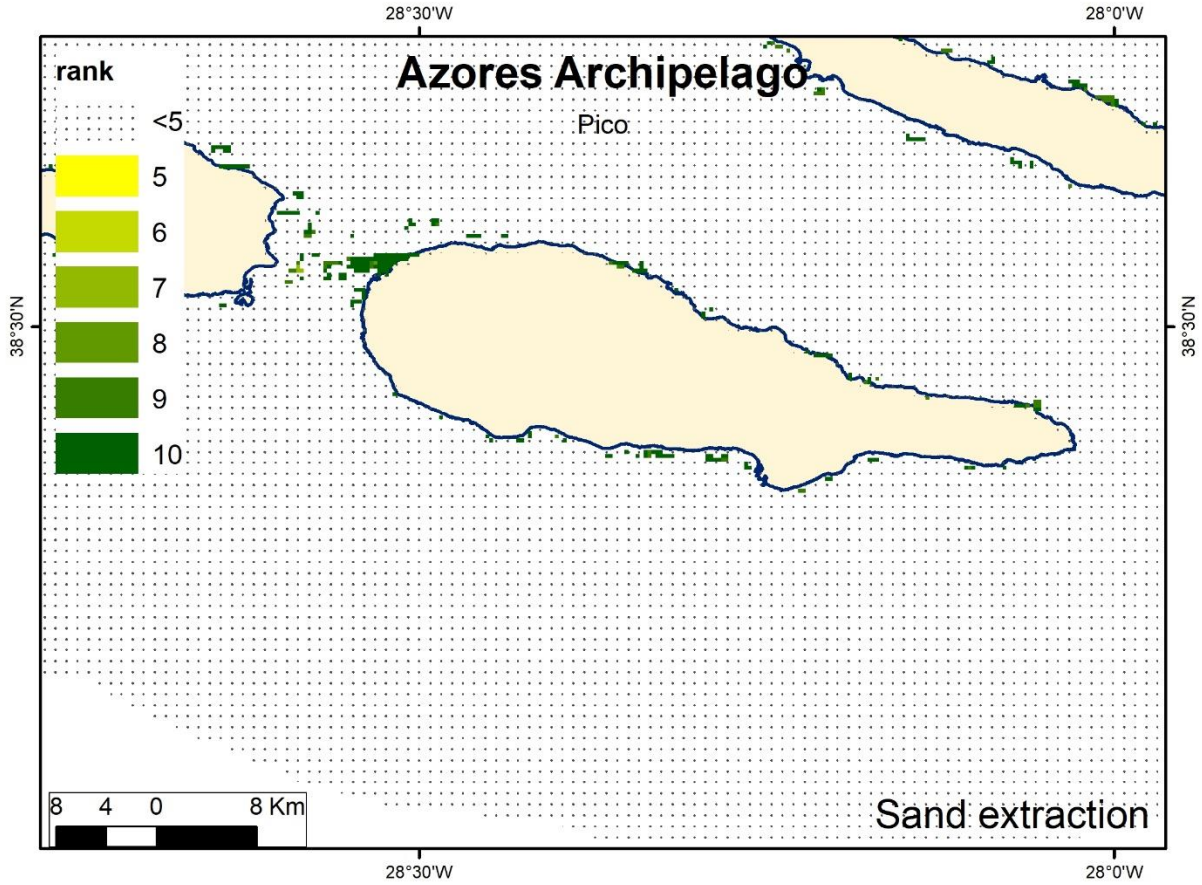


Figure 25 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

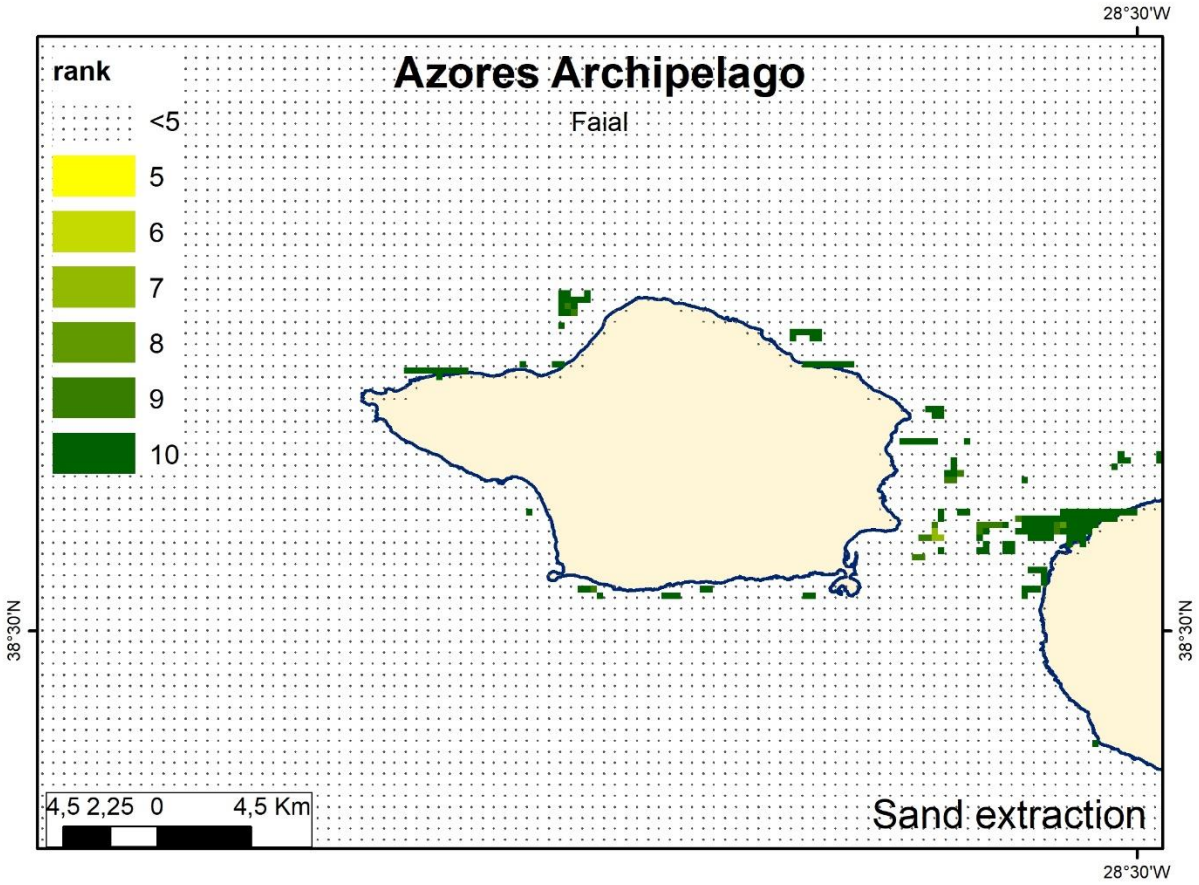


Figure 26 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

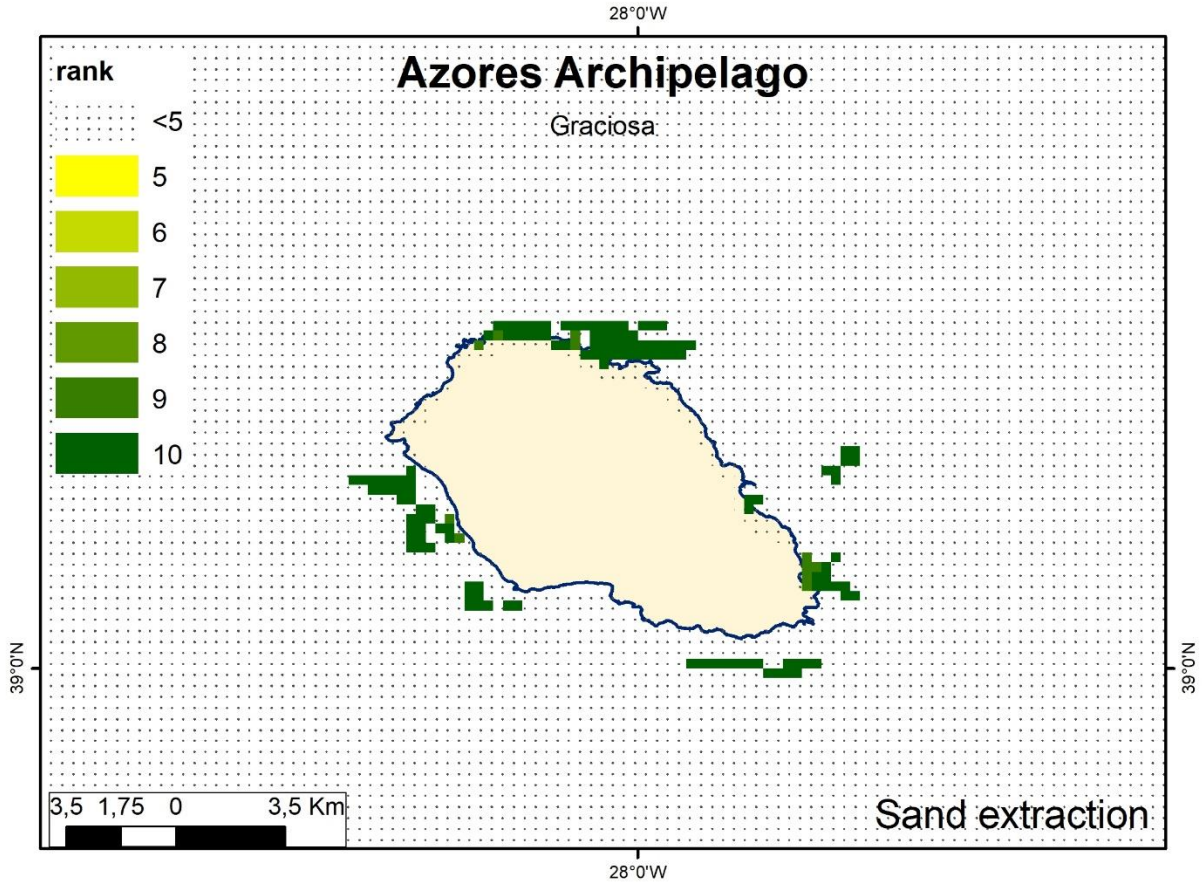


Figure 27 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

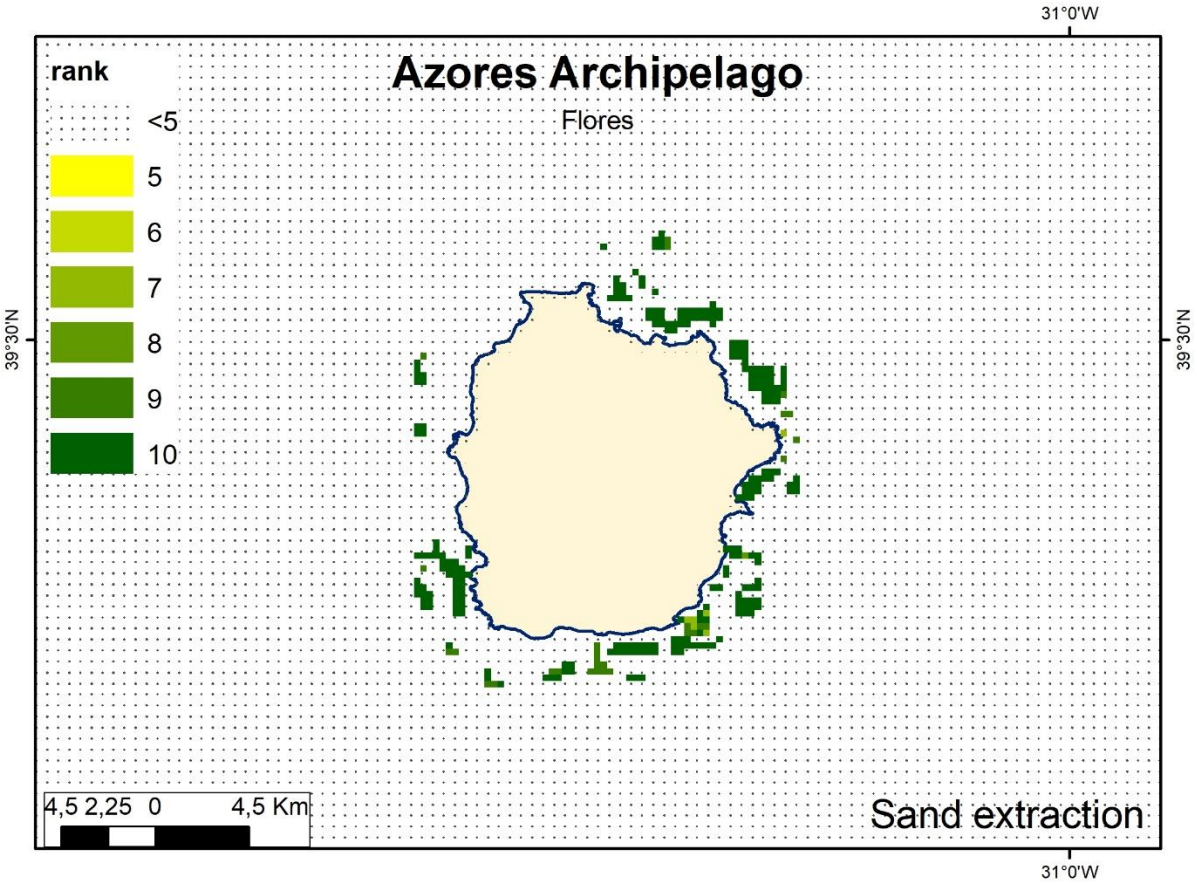


Figure 28 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

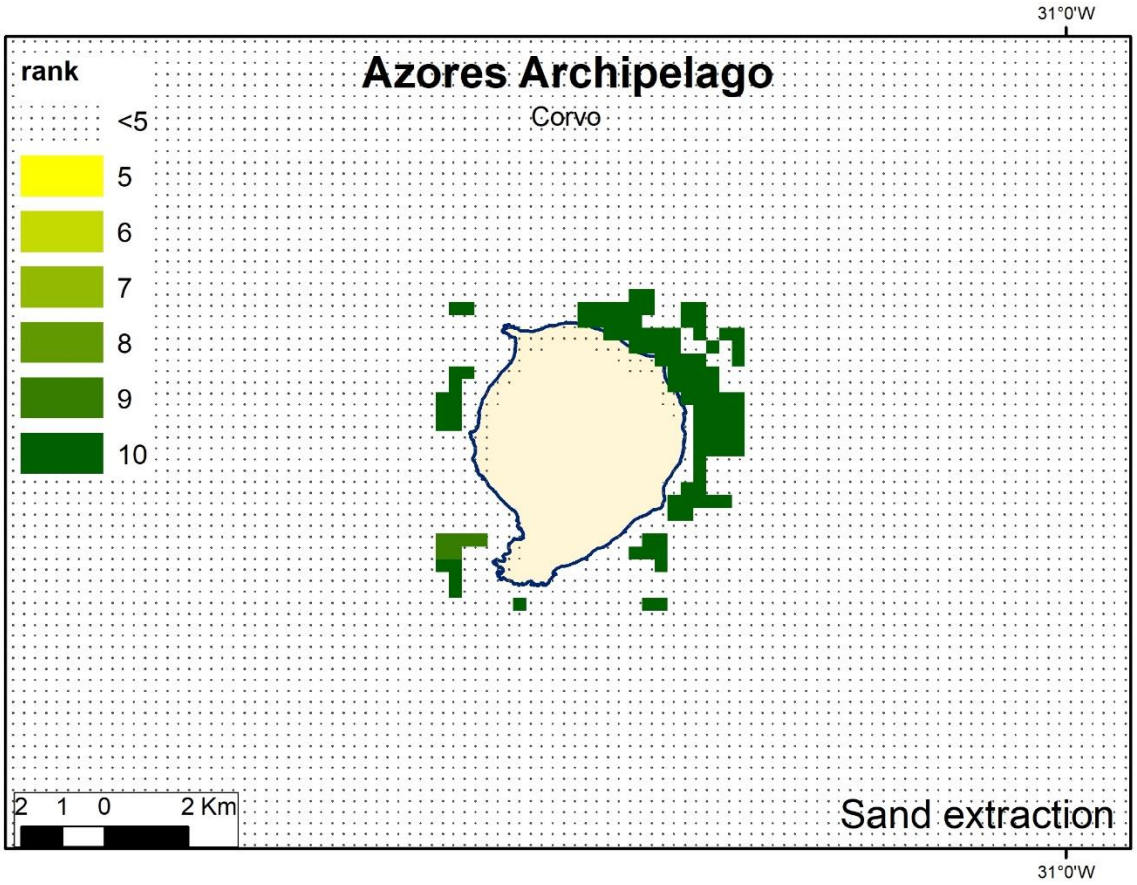


Figure 29 - Sand extraction suitability analysis for Azores archipelago, applying project external expert profile

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