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ENERGY BRIDGE

REPORT

CONNECT FOR GROWTH (C4G)

ALBANIA OFFSHORE WIND SITING STUDY

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ACRONYMS AND ABBREVIATIONS

<	Less Than
>	More Than
ACER	Agency for the Cooperation of Energy Regulators
AIMS	Albania, Italy, Montenegro, and Serbia
ALPEX	Albanian Power Exchange
C4G	Connect for Growth
EEZ	Exclusive Economic Zone
EU	European Union
GIS	Geographic Information System
IBA	Important Bird Area
IMMA	Important Marine Mammal Area
KM	Kilometer
M	Meter
M/S	Meters per Second
MIE	Ministry of Infrastructure and Energy
MCA	Multicriteria Analysis
MPA	Marine-Protected Areas
NM	Nautical Mile
OWP	Offshore Wind Project
USAID	United States Agency for International Development
WDPA	World Database of Protected Areas

1 EXECUTIVE SUMMARY

The Albanian Ministry of Infrastructure and Energy (MIE) requested support from the United States Agency for International Development (USAID) for offshore wind power development, to understand the areas of Albanian sea waters best suited to offshore wind development via conducting an offshore wind power suitability study.

USAID fulfilled this request through Connect for Growth (C4G), a project aimed at strengthening energy security and resilience in USAID's partner countries in the Europe and Eurasia region as part of the U.S.–Europe Energy Bridge project. C4G provides technical guidance, recommendations, and support for energy market development; regional integration and reforms; diversified and efficient resource utilization and planning; and resilient energy systems, to advance USAID's goal of increasing connectivity and cooperation in the energy sector between partner countries and the EU. C4G aims to respond quickly and effectively to emerging issues and technical needs in partner countries that impact the regional energy sector and critical infrastructure.

C4G developed this study, drawing upon existing public databases, to identify potentially suitable areas to develop offshore wind projects (OWPs) off the coast of Albania.

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The goal of the methodology is to support the decision-making process for preliminary identification of the most suitable areas for the development of OWPs, considering technical feasibility, environmental impact, and social acceptability.

Methodology

C4G's methodology supports the decision-making process for preliminary identification of the most suitable areas for the development of OWPs, considering technical feasibility, environmental impact, and social acceptability. The site identification methodology consisted of:

- Creating a Geographic Information System (GIS) database to collect and manage geospatial data describing the physical, technical, environmental, and social features that characterize the study area.
- Combining the multilayer GIS database with a multicriteria analysis (MCA).

The criteria to determine the suitability of areas for OWPs reflect the criteria adopted in the most authoritative information sources available (see the Bibliography section) at the date of publication, regarding both (1) constraints (or "no-go areas") that exclude OWPs, and (2) indicators to characterize the suitability of an area for the sustainable development of an OWP.

The indicators influencing the suitability of an offshore area include technical (including cost impacts), environmental, and social factors. The main indicators used in this study are shown in Table 1, below.

TABLE 1. INDICATORS

CATEGORY	SPECIFICATIONS	OBJECTIVE
Technical	Wind speed at 100-meter (m) hub height	Maximize
Technical	Sea depth (> 30 m)	Minimize
Technical / Social	Distance from shoreline (> 10 kilometers [km])	Maximize for distance < 30 km; Minimize for distance > 30 km
Environmental	Distance from marine protected areas (MPAs), Important Bird Areas (IBAs), and Important Marine Mammal Areas (IMMAs) (> 5 km)	Maximize up to 20 km
Technical	Distance from high-voltage electricity grid	Minimize
Technical	Distance from local ports	Minimize
Social	High-density ship routes	Minimize interference

The study team assigned each indicator a rating (up to 100) and applied a final weighting factor to calculate the level of suitability. All details are reported in 6.2 Evaluation Phase of this study.

Although the methodology adopted the outcomes of some of the most recent scientific literature, preselection criteria, indicators, evaluation criteria and site selection ranking were customized based on the specific characteristics of the study area, allowing for a country-specific suitability index.

The criteria were then weighted based on their relative importance, and according to information received during a consultation process with stakeholders (which included meetings with Albanian Ministry of Infrastructure and Energy, the Albanian Power Corporation KESH and the Albanian Transmission System Operator OST), such as the importance of preserving the environment and tourist vocation of coastal areas and considering the configuration of the power transmission network.

The main output of the study is a map showing the suitable areas and their level of suitability. The study also includes the suitability map and complete set of exclusion criteria and no-go areas as GIS files. This information is available for a more in-depth analysis to locate the most reliable areas for siting an OWP, such that the site will ideally meet and trade off the goals of sustainability with construction and operation, according to the scale and consistency of available data sources.

Applications and limitations

This study can enable a more confident and efficient decision-making process for further stages of OWP development, by providing a first reference point to authorities, developers, and stakeholders.

This study provides neither a feasibility assessment nor an impact assessment of any specific wind farm project. Further evaluation is required to inform the suitability of these areas. Since OWP technology is constantly evolving, this study makes assumptions regarding the future technical feasibility of floating offshore technology that developers should duly verify to inform the design of specific offshore wind farms.

Due to its country-specific nature, the suitability index should not be compared with suitability values obtained in other parts of the world.

This study does not include a complete assessment of all possible conditions or circumstances that may exist at the sites. Examples of unevaluated criteria include bird migration corridors, oil and gas offshore structures and leases, marine archaeological sites and shipwrecks, military zones, and aquaculture. More information is in section 8 Study Limitations.

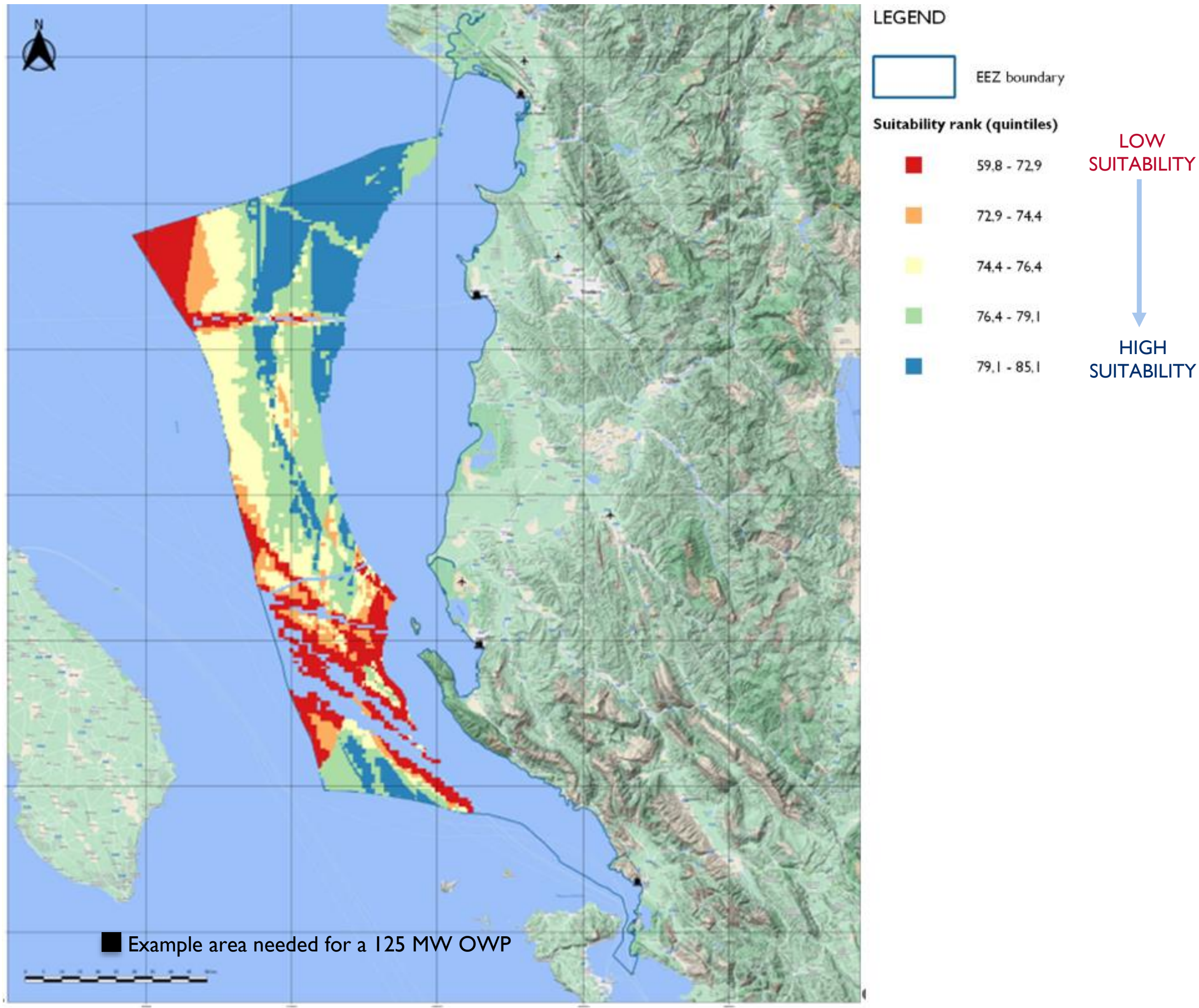
Findings

Figure 1, below, shows the Albanian OWP suitable areas. The highest suitability rankings are shown in blue color (top quintile), with an overall area of 1,480 km^2. Most of the suitable areas would require floating foundations for OWPs, as the water depth is greater than 60 m.

The windiest areas are located in the southern portion of the map (about 30-40 km off the Karaburun Peninsula), mainly in very deep seas (900-1,000 m), where only floating offshore technology will be feasible in the future. The ultimate suitability of these areas will have to be evaluated considering the development of offshore floating technology. Shallower areas (from 50 to 250 m sea depth), preferable for currently available bottom-fixed and floating technologies, are located on the northern portion of the map, where the average wind speed is approximately 6.5-6.7 m/s, the lower limit of suitability.

Considering, as a first approximation, a 5 MW/km^2 power density for OWP in European regions, the availability of suitable areas seems not to be a constraint to the development of OWP. Final OWP area needs will be better identified in future studies, for which the Government of Albania might set targets for OWP that will lay out more clearly the timing, technology and capacity pertaining to this power generation source.

FIGURE 1. SUITABILITY MAP (QUINTILES) FOR OWPS



2 OBJECTIVE OF THE STUDY

The objective of this study is to support the identification of suitable areas for OWP development in the Republic of Albania (Albania), considering the following three factors:

TECHNICAL FEASIBILITY AND COSTS

ENVIRONMENTAL IMPACT

SOCIAL ACCEPTABILITY

The site selection methodology consisted of combining geospatial data organized in a multilayer GIS database with a multicriteria analysis.

The basis of this study is the development of verifiable criteria that reflect the goals and priorities for ranking OWP sites at a national level.

The key goals of the study are to prioritize potential OWP development areas that:

- Maximize wind energy production (e.g., identify areas with adequate average wind speed)
- Exclude areas with potential use conflicts, such as areas close to coastlines, priority ship routes, and offshore structures, to ease the process of obtaining social consent and licenses to operate
- Minimize construction and operational costs by identifying the most suitable areas, closer to ports and existing electrical transmission networks
- Respect a wide range of existing protection measures (e.g., ensure that OWPs are far away from areas of natural and environmental interest, such as protected international/national areas, MPAs, IBAs, and IMMAs).

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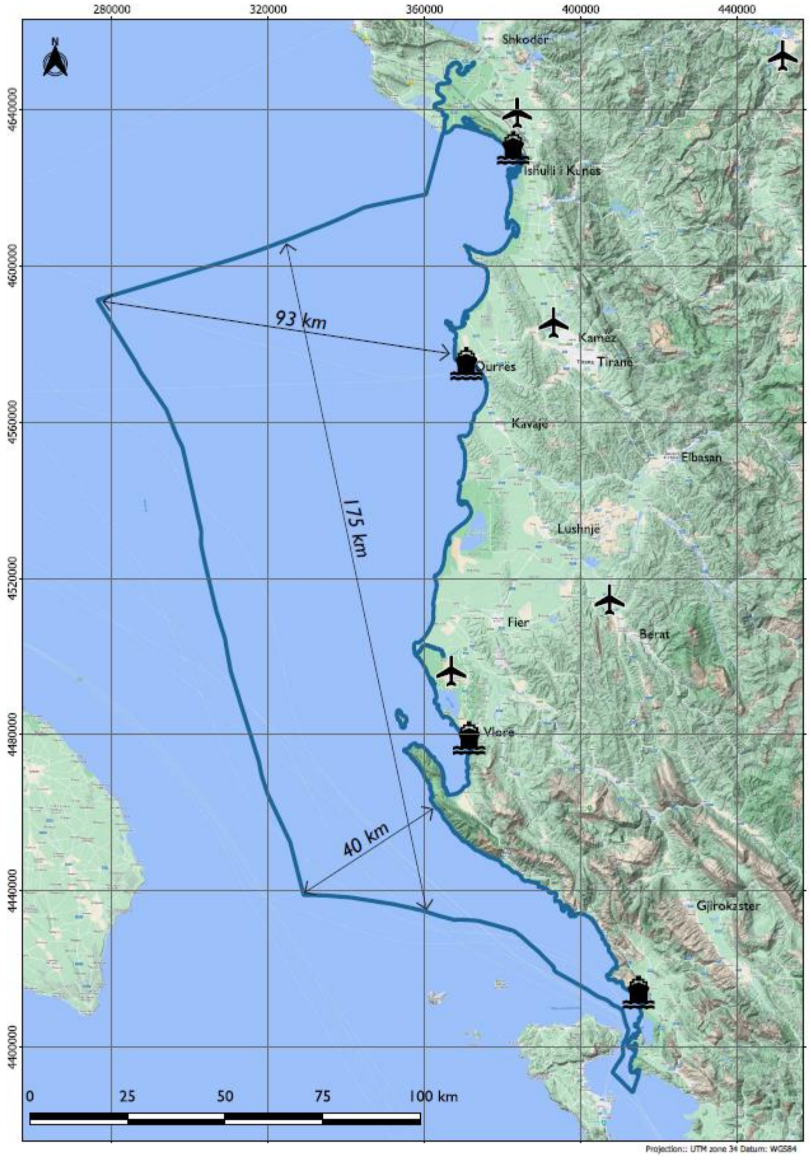
3 STUDY AREA

The suitability assessment was carried out within the area between the coastline and outer boundary limit of the exclusive economic zone (EEZ: maximum 200 nautical miles [nm] from the coastline) of Albania.

The boundary of the EEZ has been defined using the following guidelines: Flanders Marine Institute (2019); Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200nm), version 11; and Albania EEZ (http://www.marineregions.org/eezdetails.php?mrgid=5670).

The study area includes a portion of the sea with a maximum distance from the shore of about 90 km to the north and about 40 km to the south. The average longitudinal distance across the sea is about 175 km. The map in Figure 2 includes the main ports and airports in the region.

FIGURE 2. MAP OF THE STUDY AREA



4 EXCLUSION CRITERIA

The evaluation of suitability considered the following exclusion criteria.

TABLE 2. EXCLUSION CRITERIA

CATEGORY	CRITERIA
Environmental	**Birds** Minimize proximity to bird areas
	Coastal environment Minimize proximity to the coast and shallow water areas
	Protected Areas Minimize proximity to protected areas
	Marine mammals Minimize proximity to protected areas
Social	**Tourist areas and beaches** Avoid visibility from tourist areas
	Historic resource Minimize proximity to historic resources areas
	Competing use of the sea and coastline Minimize conflicts for the use of the sea
Technical	**Airports** Minimize proximity to airports
	Offshore structures Avoid interference with existing offshore structures
	Sea routes Avoid interference with major sea routes
	High-voltage transmission network Minimize distance from high-voltage electrical grid
	Ports Minimize distance from major ports
	Sea depth Prefer installation in areas that are not excessively deep
	Wind speed Prefer areas characterized by optimal average wind speed

5 DATA SOURCES

The desk study is based on information from existing accessible global and local datasets.

In June 2022, the study team accessed data for this study from public and private sources. Table 3, below, catalogs all data sources that the team collected and organized into a new geo-database. The team preprocessed and re-projected the data with a GIS tool, using precise global location (i.e., a common geodetic reference system WGS84 UTM 34N) and reducing the map to the national border (EEZ).

TABLE 3. DATA SOURCES

EEZ Boundaries	Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11.
Wind speed	Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP).
Water depth	GEBCO - General Bathymetric Chart of the Ocean GEBCO Compilation Group (2020) GEBCO 2020 Grid (doi:10.5285/a29c5465-b138-234d-e053-6c86abc040b9).
Environmental protected areas	WDPA – World Database of Protected Areas, EEA -European Environmental Agency IUCN and UNEP-WCMC (year), The World Database on Protected Areas (WDPA) [On-line], Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net.
Important Bird Areas	BirdLife International (2022) Country profile: Albania. Available from http://www.birdlife.org/datazone/country/albania. Accessed: 2022-06-13
Important Marine Mammal Areas	Global Dataset of Important Marine Mammal Areas (IUCN-IMMA). IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force. Accessible via the IMMA e-Atlas https://www.marinemammalhabitat.org/imma-eatlas/
Airport, cities, port	Openstreet map /Geofabrik; ASIG Geoportal
Seismic hazards	The European Fault-Source Model 2020 (EFSM20), available in the efehr.org website [Swiss Seismological Service (SED) at ETH Zurich, in collaboration with GEM (Global Earthquake Model Foundation) and EPOS (European Plate Observing System)], ref. Danciu L., Nandan S., Reyes C., Basili R., Weatherill G., Beauval C., Rovida A., Vilanova S., Sesetyan K., Bard P-Y., Cotton F., Wiemer S., Giardini D. (2021)
Vessel route density	EMODnet Human Activities project, www.emodnet-humanactivities.eu, funded by the European Commission Directorate General for Maritime Affairs and Fisheries. The route density maps are produced and provided to EMODnet by the European Maritime Safety Agency (EMSA)
High-voltage substation and grid	ASIG Geoportal

6 SELECTION PROCESS

Following other recent OWP macro-siting studies (listed in the Bibliography section), the study team conducted the process of selecting suitable sites in two steps:

1. Preselection of suitable sites based on preliminary indicators
2. Evaluation of pre-selected sites with multicriteria analysis.

Preselection criteria, indicators, evaluation criteria and site selection ranking were customized based on the specific characteristics of the study area, allowing for a country-specific suitability index. This enhances the index definition in the study area and brings out the differences between different areas.

6.1 CRITERIA FOR PRESELECTION OF SUITABLE SITES

The specific considerations and constraints for appropriate sites were determined according to the most recent scientific literature available (see the Bibliography section). A systematic review of the scientific literature on siting offshore wind projects using the most recent studies from leading countries in northern and southern Europe was conducted. A less-recent study [8] is relevant because it contains an interesting methodology that can be applied in the present work. A recent study by the U.S. National Renewable Energy Laboratory, specifically dedicated to the evaluation of future cost trends for the construction of floating offshore wind farms, was also reviewed.

6.1.1 PRESELECTION CRITERIA

The preliminary conditions for the siting of an offshore wind power plant are as follows:

- Availability of wind resource
- Technical feasibility.

In addition, the siting process must exclude buffer zones for "no-go areas," such as existing infrastructure, legally restricted areas, main shipping routes, etc.

In accordance with the literature review, the following preselection criteria and buffer zones (also known as "excluded areas") were adopted: wind speed, bathymetry, and excluded areas.

6.1.1.1 WIND SPEED

Wind speed directly affects energy production per installed MW and consequently the financial efficiency of any offshore wind project.

Areas with annual average wind speed > 6.5 meters per second (m/s) at 100 m hub height were considered. A limit of 6 m/s (often considered at 10 m instead of at 100 m hub height) is commonly considered the minimum to achieve a cost-competitive investment [1,2]. Note that:

- The World Bank Report "*Going Global: Expanding Offshore Wind to Emerging Markets*" cites a minimum of 7 m/s at 100 m hub height [7]
- Most offshore wind power plants in Europe are in areas with annual average wind speed of 8-9 m/s [1]
- In Asian countries where wind potential is generally lower, wind speed limits are also lower (4 m/s or less).

Local mean wind speed was considered also in the evaluation phase of selected sites to maximize power production.

Georeferenced data source: Global Wind Atlas.

6.1.1.2 BATHYMETRY

Water depth significantly affects the feasibility and cost of construction, both for fixed and floating wind turbines (also known as "anchoring").

This study also adopts the following preselection criteria, which are frequently adopted in relevant scientific literature:

- Minimum water depth: 30 m (protection of natural values of shallow waters)
- Maximum water depth for bottom-fixed foundations: 60 m
- Maximum water depth for floating foundations: 1,200 m.

The source for these georeferenced data is General Bathymetric Chart of the Oceans (GEBCO).

6.1.1.3 EXCLUDED AREAS

In the preselection phase, the following buffer zones were considered as no-go areas for offshore wind energy development.

Criteria marked with [E] were also considered in the evaluation phase as criteria to maximize or minimize.

- Minimum distance from shoreline: A minimum distance of 10 km from the shore is considered to reduce visibility and the potential impact on both coastline activities and the coastline environment during construction and operation. Note that other studies propose a significantly larger exclusion zone based on the distance from the shore due to visibility issues (typically 20-22 km). The potential impacts on the landscape (and consequently on the social acceptability and attractiveness of coastal touristic areas) was considered in this study by attributing a major penalty in the rankings of areas located less than 30 km from the coast in the evaluation process. [E]

- Airports: A buffer zone of 5 km around airports in no-go areas (i.e., the buffer zones are inside the excluded zone of 10 km from the coast).

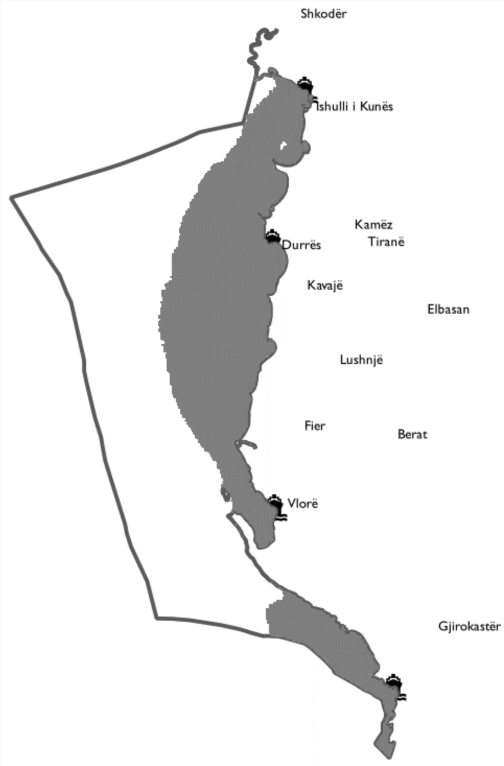
- Environmental protection areas: Based on the World Database of Protected Areas (WDPA), this study considered an exclusion zone of 5 km around environmental protection areas (i.e., that the 5 km excluded zones, which include MPAs, remain inside the excluded range of 10 km from the coast). This study also considered distance from environmental protection areas in the evaluation phase. [E]

- Important Bird Areas (IBAs): This study considered an exclusion zone of 5 km around IBAs. Also, in this case, the exclusion zone remains inside the excluded range of 10 km from the coast. The study's evaluation phase also considered the distance from IBAs. [E]

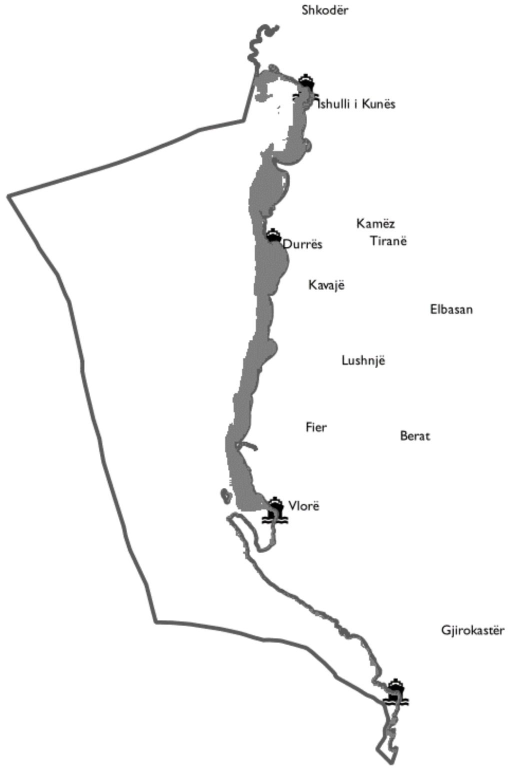
- Bird migration corridors: This study does not evaluate these areas due to a lack of detailed information. The exclusion of coastal areas extending 10 km from the shore prevents significant interference with migration corridors that follow coastlines. Detailed studies shall be executed during a micro-siting, particularly in the case of projects located in the Otranto Channel and within a distance of about 5 km around the Capo d'Otranto - Cape of Gjuhëz (on the Karaburun Peninsula) connection line, a potentially important migration corridor for birds of prey.

- Important Marine Mammal Areas (IMMAs): The study considered an exclusion zone of 5 km around IMMAs. The study also considered the distance from IMMAs in the evaluation phase. [E]
- High seismic-hazard zones: The study considered a 3 km buffer zone around earthquake fault lines as an exclusion zone.
- High-density shipping routes: High-density shipping routes (defined as areas with more than an average of 350 vessel routes per month per square kilometer) were excluded to avoid posing risks to shipping navigation, as well as to avoid potential environmental risks caused by collision of cargo and tank ships with offshore structures. The study also considered shipping route density in the evaluation phase. [E]
- Oil and gas offshore structures: The study did not consider these structures due to a lack of detailed information. Interference with these structures should be properly investigated during micro-siting for specific OWPs.
- Existing or planned leases for offshore oil and gas: The study did not consider these elements. Interference with these structures should be properly investigated during micro-siting for specific OWPs.
- Pipeline and underwater cables: The study considered a buffer zone of 0.5 km on each side of subsea pipelines as an excluded area. Due to the lack of detailed information on the route of other subsea pipelines and cables, the study only considered the Trans Adriatic Pipeline (TAP). The study mapped schematic routes of the main telecom cables for reference only.
- Existing offshore wind farm (1 km buffer): The study did not consider this possibility, as there are no reported offshore wind farms in the study area.
- Marine archaeological sites and shipwrecks (1 km buffer): The study did not consider these historical sites due to a lack of detailed information.
- Military zones (0 m): The study did not consider these areas due to a lack of detailed information.
- Resulting areas < 10 km^2 will be excluded from potentially suitable areas.
- The study evaluated but did not directly exclude the following potentially restricted sea areas, considering that it may be better to evaluate optimal distances or shared uses in micro-siting and during the authorization procedures.
    - Fishing zones: The study evaluated and mapped fishing zones through fishing vessel route density (see 6.2 Evaluation Phase).
- Aquaculture: The study did not consider this topic due to a lack of detailed information.

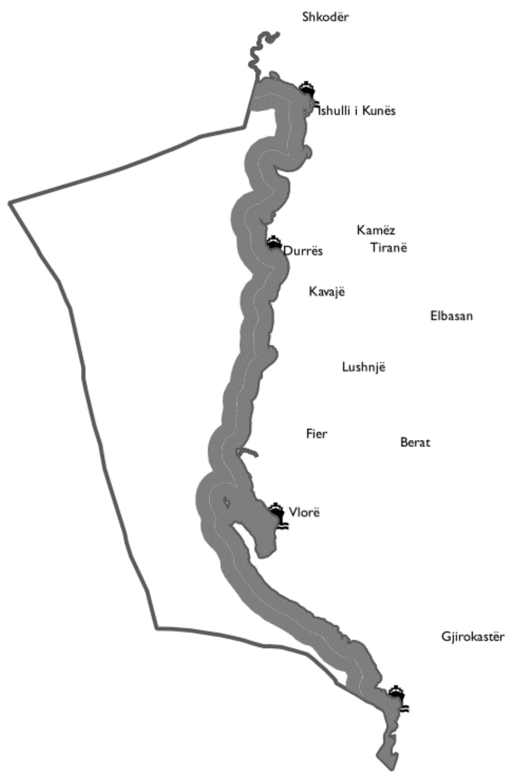
FIGURE 3. EXCLUDED AREAS – PART ONE



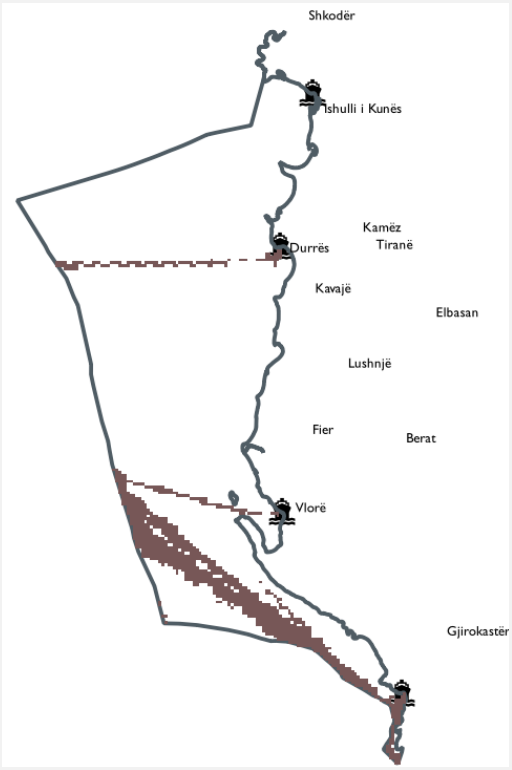
Wind 100 m hub height (annual mean) < 6.5 m/s



Sea depth < 30 m

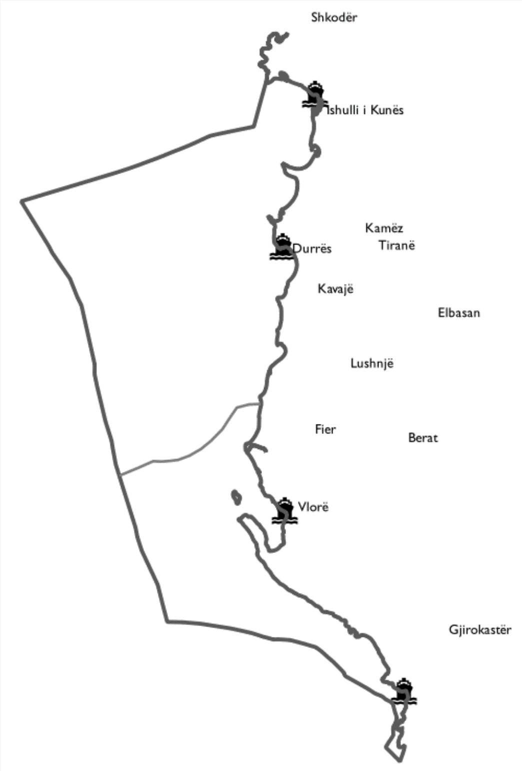


Shoreline distance < 10 km

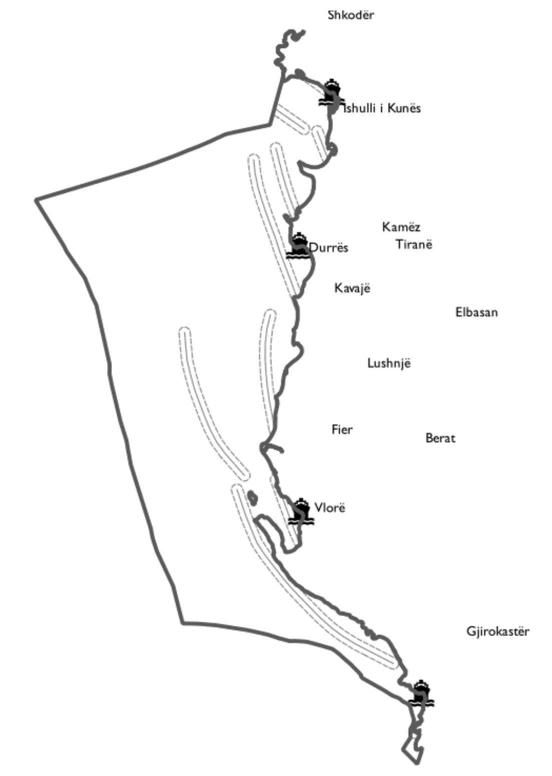


Vessel routes density> 350 routes/month/km^2

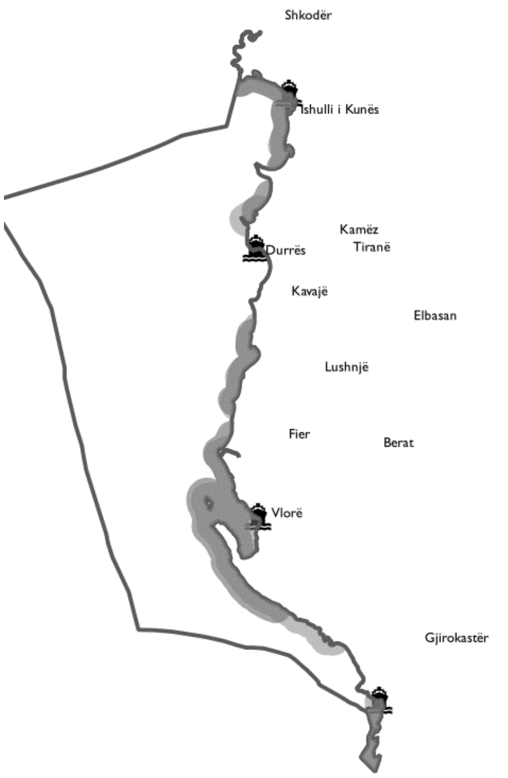
FIGURE 4. EXCLUDED AREAS – PART TWO



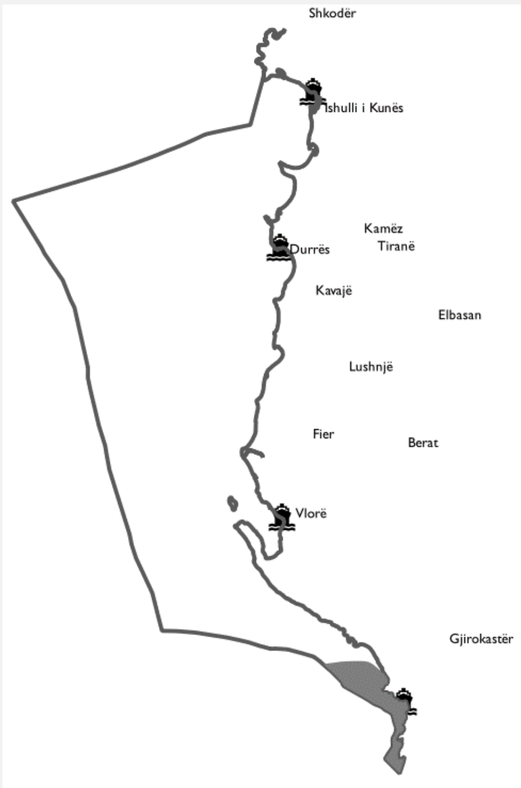
TAP 500 m buffer on both sides



Seismic faults buffer 2 km



Natural protected areas/IBAs buffer 5 km



IMMAs buffer 5 km

6.2 EVALUATION PHASE

6.2.1 INDICATORS

The study considered the following indicators in the evaluation phase:

TABLE 4. INDICATORS

CATEGORY	SPECIFICATIONS	OBJECTIVE
Technical	Wind speed at 100-meter (m) hub height	Maximize
Technical	Sea depth (> 30 m)	Minimize
Technical / Social	Distance from shoreline (> 10 km)	Maximize for distance < 30 km; Minimize for distance > 30 km
Environmental	Distance from MPAs, IBAs, and IMMAs (> 5 km)	Maximize up to 20 km
Technical	Distance from high-voltage electricity grid	Minimize
Technical	Distance from local ports	Minimize
Social	High-density ship routes	Minimize interference

6.2.2 EVALUATION CRITERIA

The study adopted a scoring methodology borrowed from the Orecca 2011 report [8], which the study team adapted and modified to consider technological evolution (especially for offshore floating technology), the geographical limitations of the study area, and feedback from stakeholders. This enhances the index definition in the study area and brings out differences between areas in the study region, allowing for a country-specific suitability index. Due to its country-specific nature, the suitability index is not directly comparable to suitability values obtained in other parts of the world. The study applied the evaluation process to potentially suitable areas (see Figure 6 or Appendix C) after excluding no-go areas (See Figure 5 or Appendix B).

Each indicator has a defined suitability criterion standardized between 100 (maximum suitability) and a minimum score, set for each parameter, that follows expert judgment based on cited literature and the specific characteristics of the country. Since the study excluded unsuitable areas before the evaluation phase, the minimum scores are always greater than 0 and all assessed areas are potentially suitable. The team evaluated parameters with a GIS tool by calculating the score for each parameter on a grid of 0.5 x 0.5 km^2, internal to the potentially suitable area; each node of the grid, therefore, represents an area of 0.25 km^2. To assign a single overall score to each node of the grid, the team multiplied the suitability score for each parameter by a weighting factor and summed the parameters to give the final ranking of the site. Finally, the study divides potentially suitable area into quintiles to classify the study area into five suitability classes, from very low to very high.

6.2.3 SITE SELECTION RANKING

6.2.3.1 WIND SPEED

Wind speed directly affects the power output and, therefore, the economic feasibility of wind power plants. The average annual wind speed at 100 m hub height in the potentially suitable area varies from 6.5 to approximately (~) 8.0 m/s. A score of 100 is assigned to 8 m/s. Considering that the energy content of the wind varies with the cube of the wind speed, a decreasing score is assigned following a cube power law for the remaining wind speed categories, which were set at an interval of 0.5 m/s.

TABLE 5. WIND SPEED

ORDER OF PREFERENCE	WIND SPEED AT 100 M HUB HEIGHT	SITE SELECTION RANKING
1	> 8	100
2	7.5 – 8	83
3	7 – 7.5	68
4	6.5 – 7	55

6.2.3.2 SEA DEPTH

Sea depth in the potentially suitable area varies from 30 to ~1,200 m. An increase in depth directly affects the cost of construction for each turbine (foundation and mooring). A score of 100 is assigned to the 30-60 m range (allowing for a bottom-fixed foundation). Subsequently, a decreasing score is assigned at increasing depth range (assuming a floating foundation). The relatively low reduction of the score with increasing depth is because the available scientific literature assigns great development potential to floating offshore wind technology (using a semi-submersible foundation); therefore, a steep reduction of the cost and the technical difficulty of anchoring at depths up to 1250 m is expected over the next 10 years [2].

TABLE 6. SEA DEPTH

ORDER OF PREFERENCE	WATER DEPTH RANGE	TYPICAL WIND TURBINE STRUCTURE	SITE SELECTION RANKING
1	30 – 60 m	Bottom-fixed	100
2	60 – 200 m	Floating	80
3	200 – 500 m	Floating	70
5	500 – 750 m	Floating	60
6	750 – 1000 m	Floating	50
7	1000 – 1250 m	Floating	40

6.2.3.3 DISTANCE FROM SHORE

Distance from the coastline in the potentially suitable areas ranges from 10 to ~100 km. A score of 100 is assigned to the 30-40 km range. According to best international practice, this range is the optimal distance from shore because it avoids creating a significant visual impact from the coast even for larger turbines,while remaining at an acceptable distance for construction, operation, and electrical connection. A significantly lower score is assigned to lower distances from shore, 30-20 km and 20-10 km, to account for significantly increased visual impact, reduced social acceptability, potentially increased conflicts in the uses of the area (e.g., fishing, aquaculture, tourism, and recreational activities). A less steeply decreasing score is applied to increasing distances from shore, considering that all the distances remain in a range of good economic and technical feasibility.

TABLE 7. DISTANCE FROM SHORE

ORDER OF PREFERENCE	DISTANCE FROM SHORE	SITE SELECTION RANKING
1	30 – 40 km	100
2	40 – 60 km	90
3	60 – 80 km	80
4	80 – 100 km	70
5	20 – 30 km	60
6	10 – 20 km	40

6.2.3.4 DISTANCE FROM PORTS

The radial distance from ports in the potentially suitable area varies in the range of 10-115 km. The distance from ports affects operation and maintenance costs, as well as safety issues. According to best international practice, a distance < 40 km is considered optimal and given a score of 100; the score decreases linearly until the distance is > 100 km, which receives a score of 60.

TABLE 8. DISTANCE FROM PORTS

ORDER OF PREFERENCE	DISTANCE FROM PORT	SITE SELECTION RANKING
1	< 40 km	100
2	40 – 60 km	90
3	60 – 80 km	80
4	80 – 100 km	70
5	>100 km	60

6.2.3.5 DISTANCE FROM HIGH-VOLTAGE GRID

The radial distance from high-voltage transmission lines in the potentially suitable area varies between 10 and ~100 km. The distance from the high-voltage grid affects the connection cost and the electrical losses. Distances < 40 km have been assigned a score of 100, with the score linearly decreasing to 40 at distances > 80-100 km. The evaluation does not consider the residual capacity of the existing transmission lines and the voltage in relation to the power of the wind farm.

TABLE 9. DISTANCE FROM HIGH-VOLTAGE GRID

ORDER OF PREFERENCE	DISTANCE FROM HIGH VOLTAGE ELECTRICITY GRID	SITE SELECTION RANKING
1	< 40 km	100
2	40 – 60 km	80
3	60 – 80 km	60
4	80 – 100 km	40

6.2.3.6 SHIPPING AND NAVIGATION

The vessel route density in the potentially suitable area varies from 0 to ~ 350 routes/month/km^2 (annual mean for all vessels). Interference with high-route densities affects safety and planning complexity. The range of route density has been categorized in 4 classes as follows: route densities < 70 have been assigned a score of 100, which decreases to 40 for a density range of 210-350 routes/month/km^2.

TABLE 10. SHIPPING AND NAVIGATION

ORDER OF PREFERENCE	SHIPPING ROUTE DENSITY (ROUTES/MONTH PER KM^2)	SITE SELECTION RANKING
1	Lower (< 70)	100
2	Medium (70-140)	80
3	High (140-210)	60
4	Very high (210-350)	40

6.2.3.7 IBAS, IMMAS, AND MPAS

The optimal distance from IBAs, IMMAs, and MPAs is considered to be > 20 km, considering disturbance during construction and operation and potential interference with bird migration. Minor distances are assigned linear decreasing scores down to 70 at a distance of 5-10 km (distances < 5 km are considered to be in the excluded areas). The attributed score considered the minimum distance from each type of protected area.

TABLE 11. IBAS, IMMAS, AND MPAS

ORDER OF PREFERENCE	MINIMUM DISTANCE FROM IBAS, IMMAS, MPAS	SITE SELECTION RANKING
1	> 20 km	100
2	15 – 20 km	90
3	10 – 15 km	80
4	5 – 10 km	70

6.2.4 PARAMETER WEIGHTING

The following table illustrates the weighting factors assigned to each parameter. The weighting factors were defined based on their relative importance, and according to information received during a consultation process with stakeholders. The suitability ranking of each site is obtained by the sum of each parameter multiplied by the relative weighting factor.

TABLE 12. PARAMETER WEIGHTING

PARAMETER	WEIGHTING FACTOR	COMMENTS
Wind Speed	0.3	Wind speed is the main parameter influencing the viability of a wind power project; therefore, it is given the highest weighting.
Water depth	0.2	Water depth significatively affects technical feasibility and costs.
Location (Includes the average of distance to shore, distance to port, and distance to grid)	0.2	Distance from shore and available infrastructure affect costs of installation and operation as well as social acceptability.
Ship route density	0.1	Shared use of the sea may be negotiable.
Environmental	0.2	Minimizing environmental impact is a key aspect in project assessment.
Total	1	

The following table shows an example of calculation for the suitability score for a 0.5 x 0.5 km^2 suitable area node (non-excluded in the previous step of the process).

TABLE 13. EXAMPLE SUITABILITY SCORE CALCULATION

PARAMETER	VALUE	SITE SELECTION RANKING (A)	WEIGHTING FACTOR (B)	RESULT (C=A*B)
Wind speed (m/s)	7.2	68	0.3	20.4
Water depth (m)	80	80	0.2	16.0
Location (Distance to shore, distance to port, and distance to grid, km)	15	87 (average of 60,100,100)	0.2	17.4
Ship route density (Routes/month/km^2)	150	60	0.1	6.0
Environmental (Minimum distance from IBAS, IMMAS, MPAS in km)	18	90	0.2	18.0
Suitability score				**77.8**

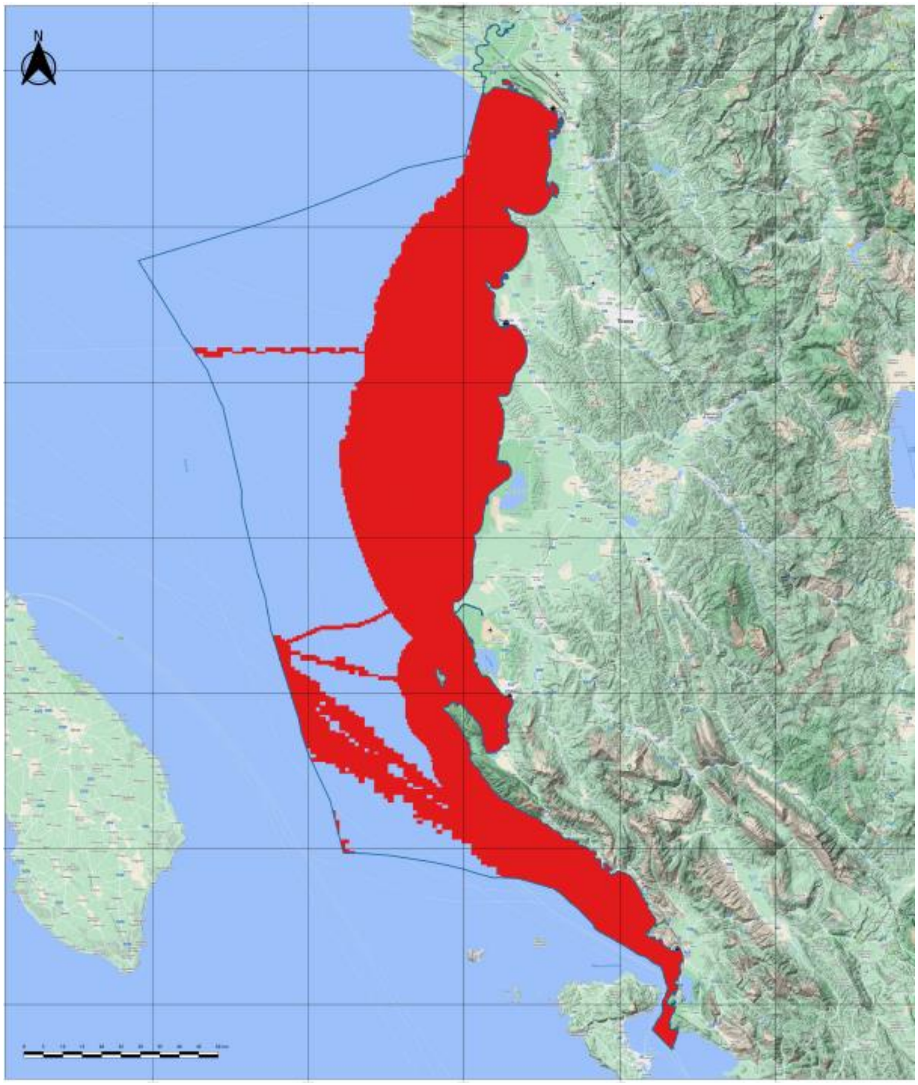
7 SUITABILITY MAPPING

The exclusion criteria were combined in different layers of a GIS tool to create a map of excluded areas. A map of potentially suitable areas was obtained by subtracting the excluded areas from the study area.

7.1 MAP OF EXCLUDED AREAS

Figure 5 (see also Appendix B) shows the map of excluded areas resulting from the overlap of all the exclusion criteria. To the north, a large, excluded area results from the application of a wind speed limit of 6.5 m/s overlapping the other no-go areas. To the south, areas are excluded due to the presence of high-density ship routes. Along the coastline, low wind areas partially overlap the criterion of minimum distance from the coast.

FIGURE 5. MAP OF EXCLUDED AREAS

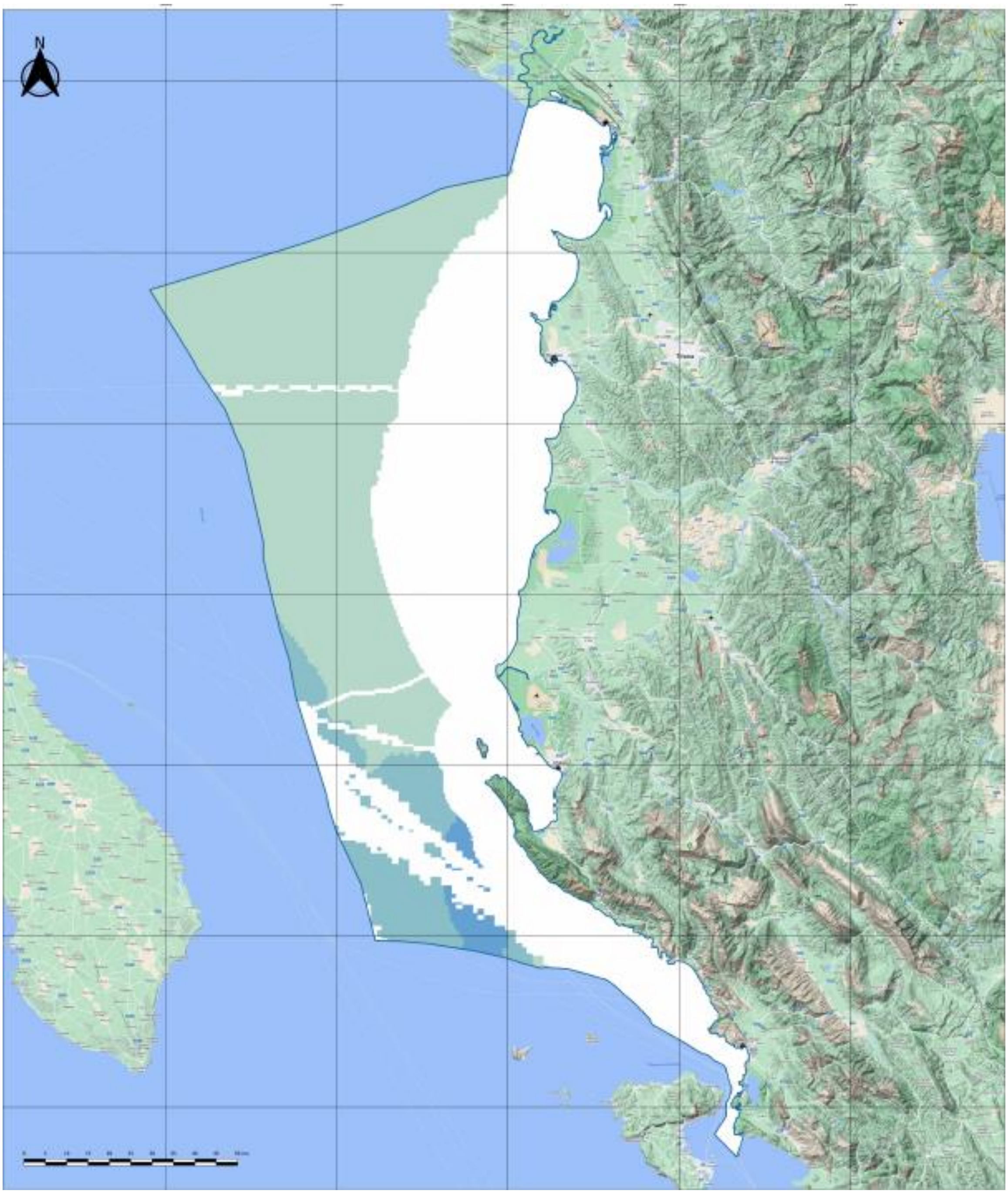


NOTE: RED COLORING INDICATES EXCLUDED AREAS.

7.2 MAP OF POTENTIALLY SUITABLE AREAS

Figure 6 (see also Appendix C) shows the potentially suitable areas resulting from the application of the preselection phase. The map shows the average wind speed in the resulting areas. Note that the higher wind-speed areas occur in the southern portion of the map.

FIGURE 6. MAP OF POTENTIALLY SUITABLE AREAS

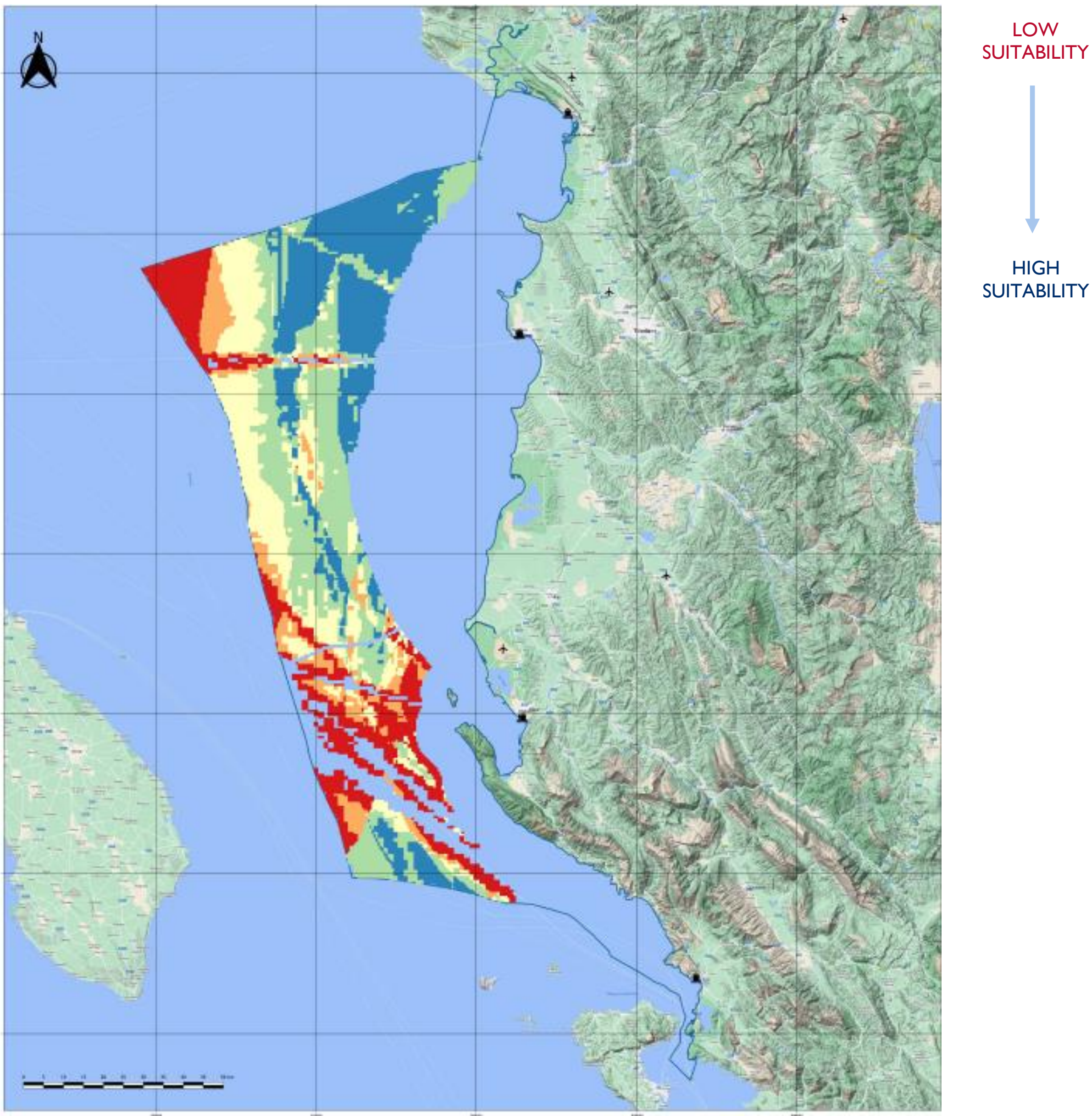


NOTE: LIGHTER TONES (GREEN) INDICATE LOWER WIND SPEEDS AND DARKER TONES (BLUE) INDICATE HIGHER WIND SPEEDS.

7.3 MAP OF SUITABLE SITES

Figure 7 (see also Appendix D) shows the suitability of offshore wind areas. Using the described ranking and weighting criteria, the map shows the suitability subdivided in quintiles from very low (red) to very high (blue).

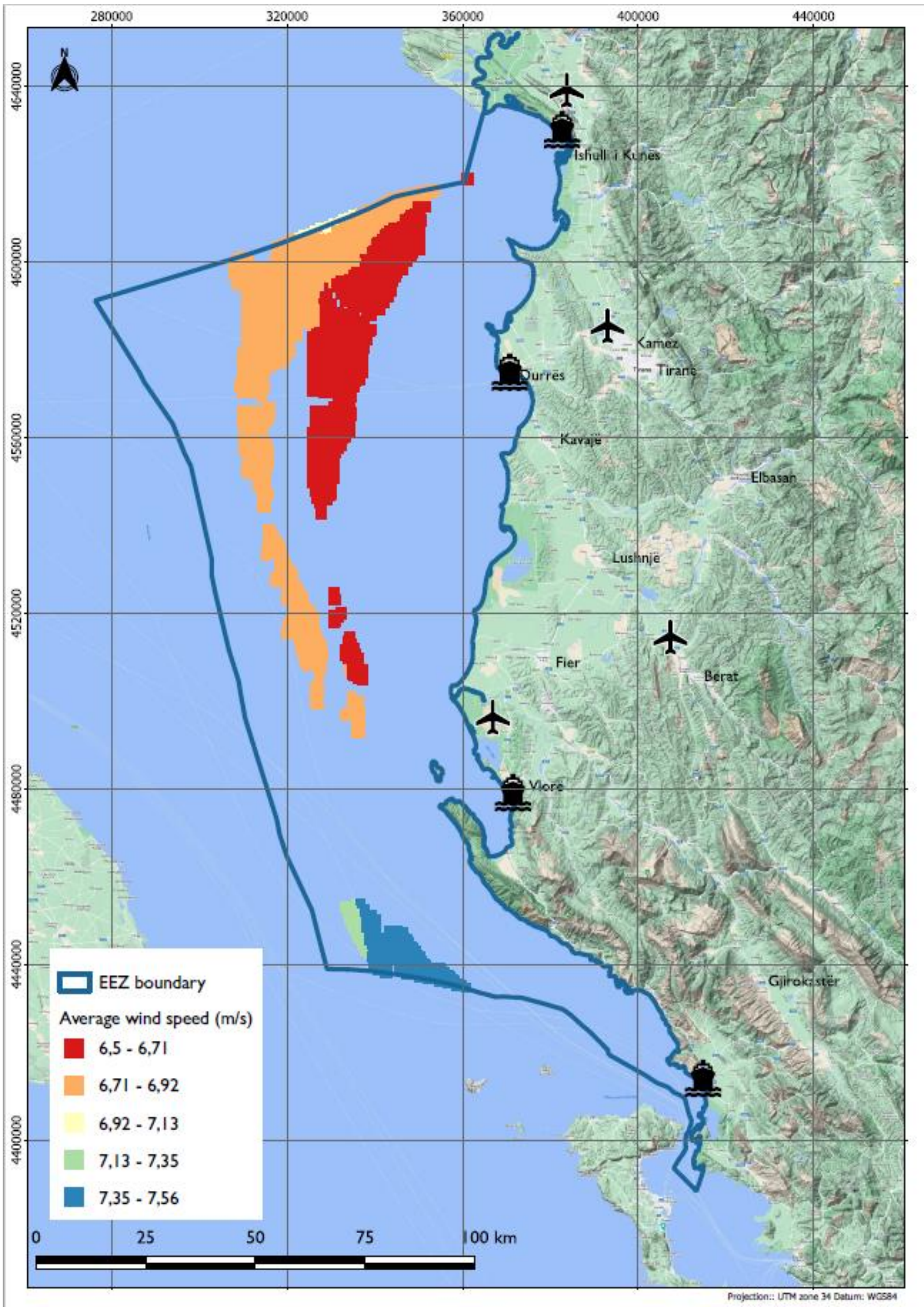
FIGURE 7. SUITABILITY CLASSES (QUINTILES) FOR OFFSHORE WIND PROJECTS



7.4 MAP OF WIND SPEED IN MOST SUITABLE SITES

Figure 8 (see also Appendix E) shows the wind-speed classification of areas of very high suitability. The windiest areas (around 7.5 m/s) are shown in the southern portion of the map, about 30-40 km off the Karaburun Peninsula. Comparison with the map in Figure 9 shows that the windiest areas are also located in a very deep area (900-1,000 m). The ultimate suitability of these areas will have to be evaluated according to the development of floating offshore technology.

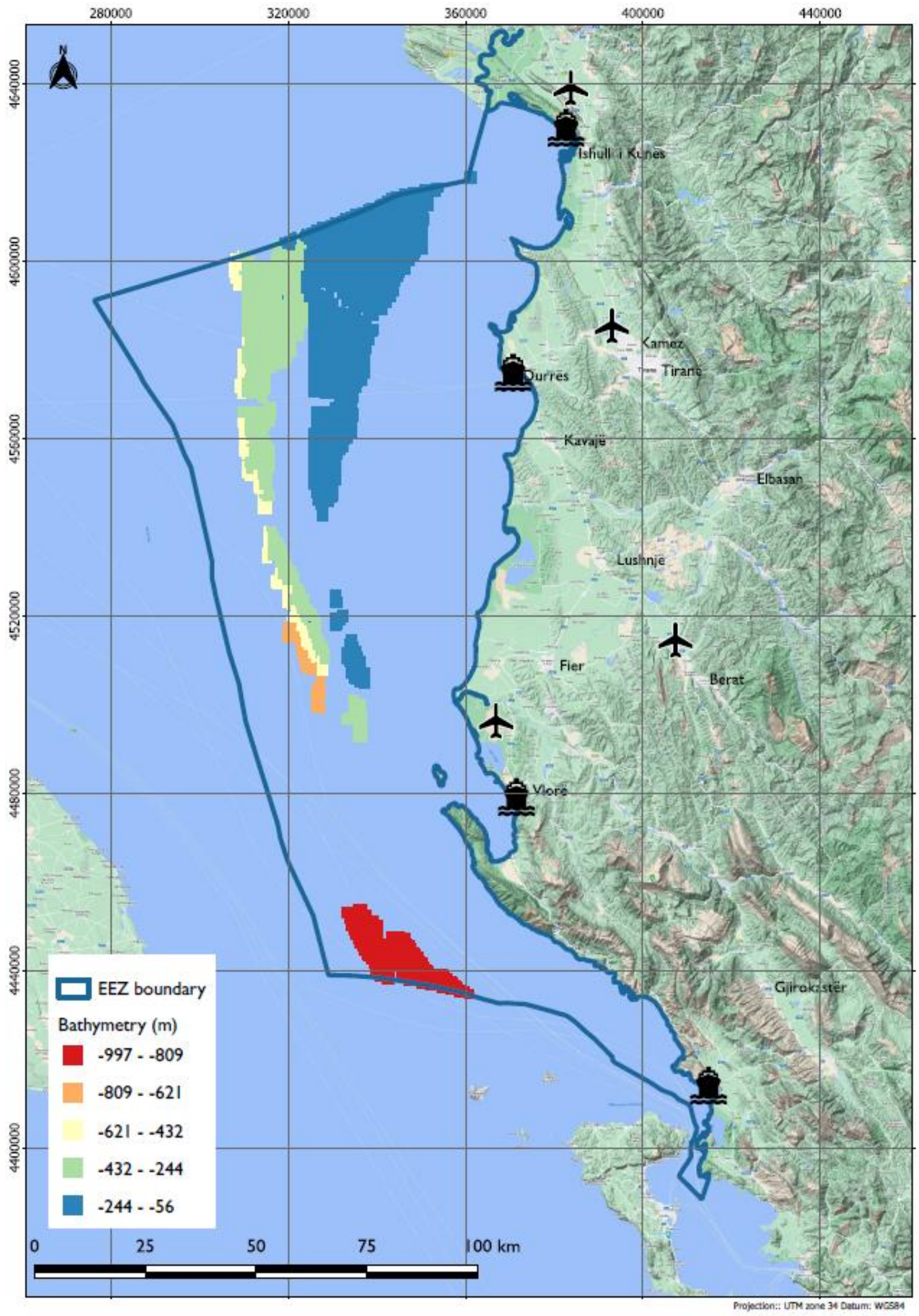
FIGURE 8. MAP OF WIND SPEED IN MOST SUITABLE SITES



7.5 MAP OF BATHYMETRY IN MOST SUITABLE SITES

Figure 9 (see also Appendix F) shows the bathymetry classification of areas of very high suitability. The shallower areas (from 50 to 250 m deep) are located in the northern portion, where the average wind speed is approximately 6.5-6.7 m/s, which is currently at the lower limit of wind speed suitability.

FIGURE 9. MAP OF BATHYMETRY IN MOST SUITABLE SITES



8 STUDY LIMITATIONS

This study is a preliminary high-level analysis aimed at providing support to help identify areas off the coast of Albania that are best suited to offshore wind development. C4G intends this study to inform further stages of OWP development by serving as an initial reference point for authorities, developers, and any stakeholders, thereby enabling a more confident and efficient decision-making process. C4G does not intend for parties to use this study, in whole or in part, for other contexts or purposes.

This study adopted the methodology and criteria of the most authoritative information sources available as of the date of publication.

This study adopted the methodology and criteria of the most authoritative information sources available as of the date of publication.

The methodology and criteria were customized based on the specific characteristics of the study area, allowing for a country-specific suitability index that is not intended for direct comparison with suitability values obtained in other world regions.

Moreover, since OWP technology is constantly evolving, this study makes assumptions relating to future technical feasibility issues that developers and stakeholders should duly verify to inform the design of specific offshore wind farms.

The analysis is based on existing and public databases available at the time of data collection (June 2022) and information received during a consultation process with stakeholders. The completeness and accuracy of the study relies on the quality of the collected data. The study team assumed that the information in the collected data is correct and does not accept responsibility for incomplete or inaccurate external data. As this study's assessments are based on data and conditions from published sources, neither USAID or the C4G implementing partners represent, warrant, or guarantee that the actual conditions of an area will conform to the assessments contained in this study.

This study does not include a complete assessment of all possible conditions or circumstances that may exist at the sites. Thus, this study is intended neither as a feasibility assessment of a specific wind farm project nor for any impact assessment purposes.

Any use that a third party makes of this document, or any reliance on or decisions to be made based on it, is the responsibility of such third party. C4G accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this document.

Given the scope of this study, conditions may exist that this study could not detect. Variations in conditions may occur, and the study's data collection and analysis may not have identified or taken into account all special conditions of sites that may exist. Accordingly, additional studies and actions may be necessary.

9 BIBLIOGRAPHY

This section includes the reference bibliography for the study methodology.

TABLE 14. BIBLIOGRAPHY

	YEAR	AREA	TYPE	DOCUMENT
1	2022	Northwest Turkey	Systematic review and criteria for NW Turkey	Caceoğlu E.; Yildiz H.K.; Oğuz, E.; Huvaj, N. & Guerrero, J. M. (2022). Offshore wind power plant site selection using Analytical Hierarchy Process for Northwest Turkey. Ocean Engineering, 252, [111178]. https://doi.org/10.1016/j.oceaneng.2022.111178
2	2020	California	Assessment of floating offshore wind energy coast	Philipp B.; Musial W.; Duffy P.; Cooperman A.; Shields M.; Heimiller D. and Optis M. 2020. The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-77384. https://www.nrel.gov/docs/fy21osti/77384.pdf
3	2020	General	Systematic review of selection criteria	Spyridonidou, S.; Vagiona, D.G. Systematic Review of Site-Selection Processes in Onshore and Offshore Wind Energy Research. Energies 2020, 13, 5906. https://doi.org/10.3390/en13225906
4	2019	North Sea B, Dk, F, D, NL, N, Scotland	Review of North Sea regions criteria	SEANSE Planning Criteria for Offshore Wind Energy North Sea region overview 2019
5	2018	Greece, South Aegean	Main criteria - recent	Vagiona, D.G.; Kamilakis, M. Sustainable Site Selection for Offshore Wind Farms in the South Aegean—Greece. *Sustainability* 2018, *10*, 749. https://doi.org/10.3390/su10030749
6	2018	Baltic Sea	Simple step by step criteria	Baltic Lines - A practical guide to the designation of energy infrastructures in maritime spatial planning - 2018 Interreg EU https://vasab.org/wp-content/uploads/2019/01/BalticLINes_Guidance_Energy_final.pdf
7	2017	Baltic sea	Complex multi criteria	Chaouachi, A.; Covrig, C.F.; Ardelean, M. Multi-criteria selection of offshore wind farms: Case study for the Baltic States. Energy Policy 2017, 103, 179-192
8	2011	EU - ORECCA Combined Wind-Wave criteria	Complete list of criteria	Murphy, J.; Lynch, K.; Serri, L.; Airdoldi, D.; Lopes, M. Site Selection Analysis for Offshore Combined Resource Projects in Europe. Report of the Off-Shore Renewable Energy Conversion Platforms—Coordination Action (ORECCA) Project 2011. http://www.orecca.eu/documents

APPENDIX A

WORKBOOK

ALBANIAN OFFSHORE WIND PROJECT – SITING EVALUATION

Indicators and Exclusion Criteria

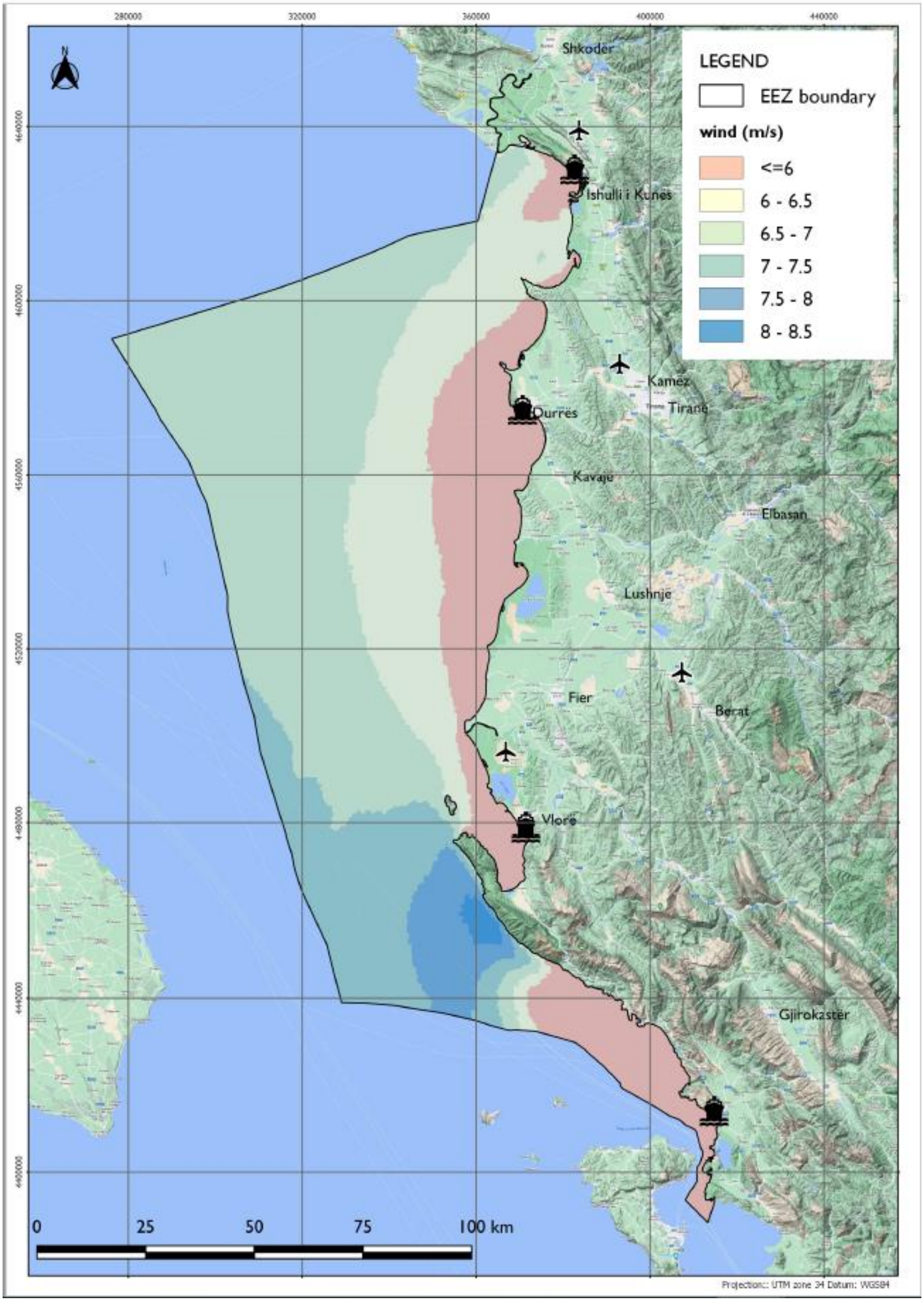
1. Average wind speed at 100 m hub height
2. Bathymetry
3. Shoreline distance
4. Seismic faults
5. Protected areas
6. Route density (all vessel)
7. Fishing route density
8. Distance from ports
9. Submarine cables and pipelines
10. Distance from power transmission lines
11. Distance from IBAs
12. Distance from IMMAs

WIND SPEED

The data represent the average annual wind speed at 100 m hub height (Source: Global Wind Atlas).

The study considered wind speed suitability from a minimum of 6.5 m/s.

The northern part of the map shows a wind speed < 7 m/s, just above the minimum limit. The windiest areas (with an average wind speed between 7 and 8.5 m/s) are in the Otranto Channel and in the proximity of the Karaburun Peninsula: i.e., in areas with the highest sea depth, high natural and tourist values, possible interference with migratory bird routes, and crossed by high-density naval routes.

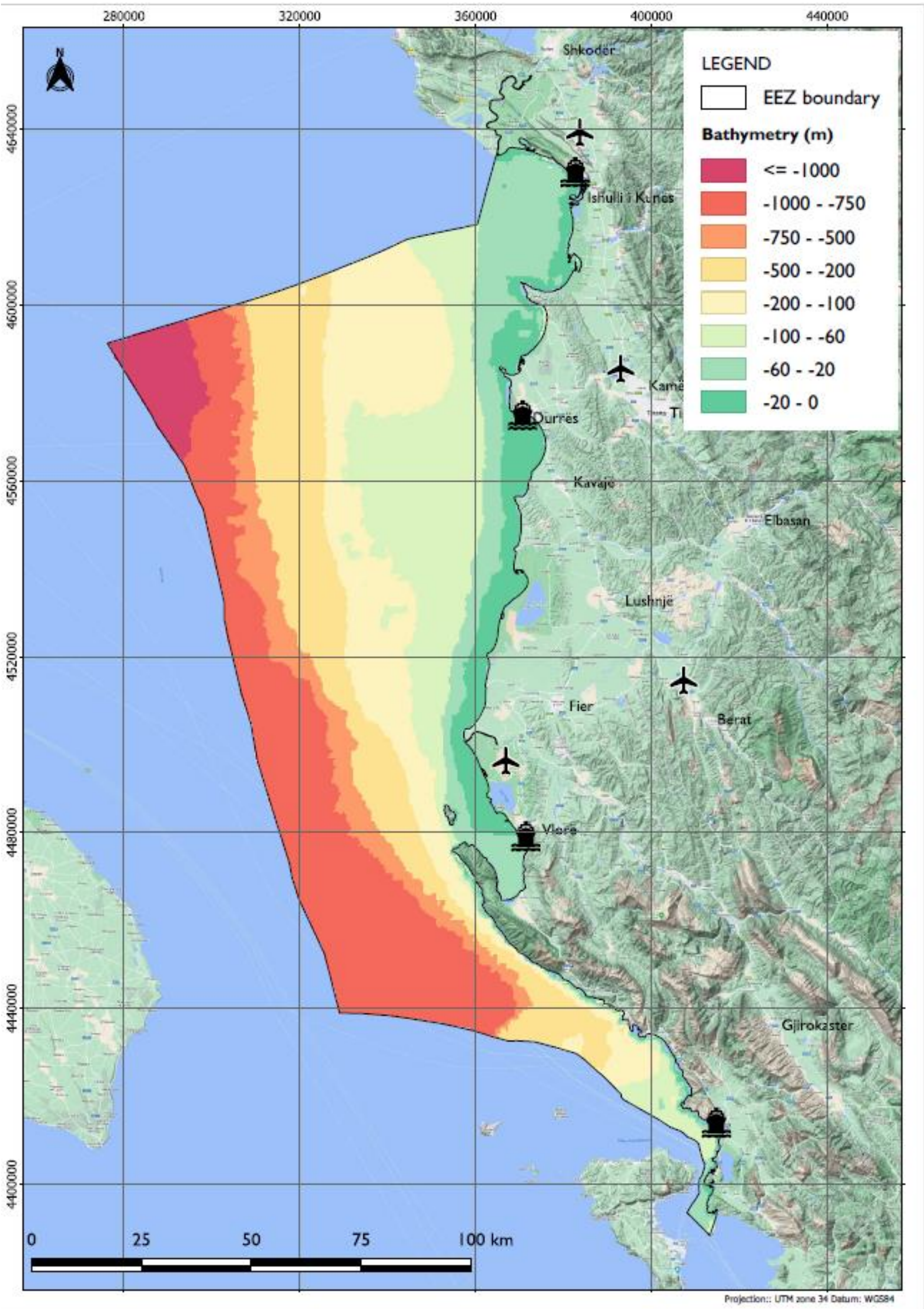


BATHYMETRY

The data represent the sea depth (m) (Source: GEBCO - General Bathymetric Chart of the Ocean).

Sea depth suitability is < 60 m for a bottom-fixed foundation and is considered to reach 1,250 m with developments in floating foundations in the near future. The study excluded areas with depth < 30 m for the protection of natural values of shallow waters.

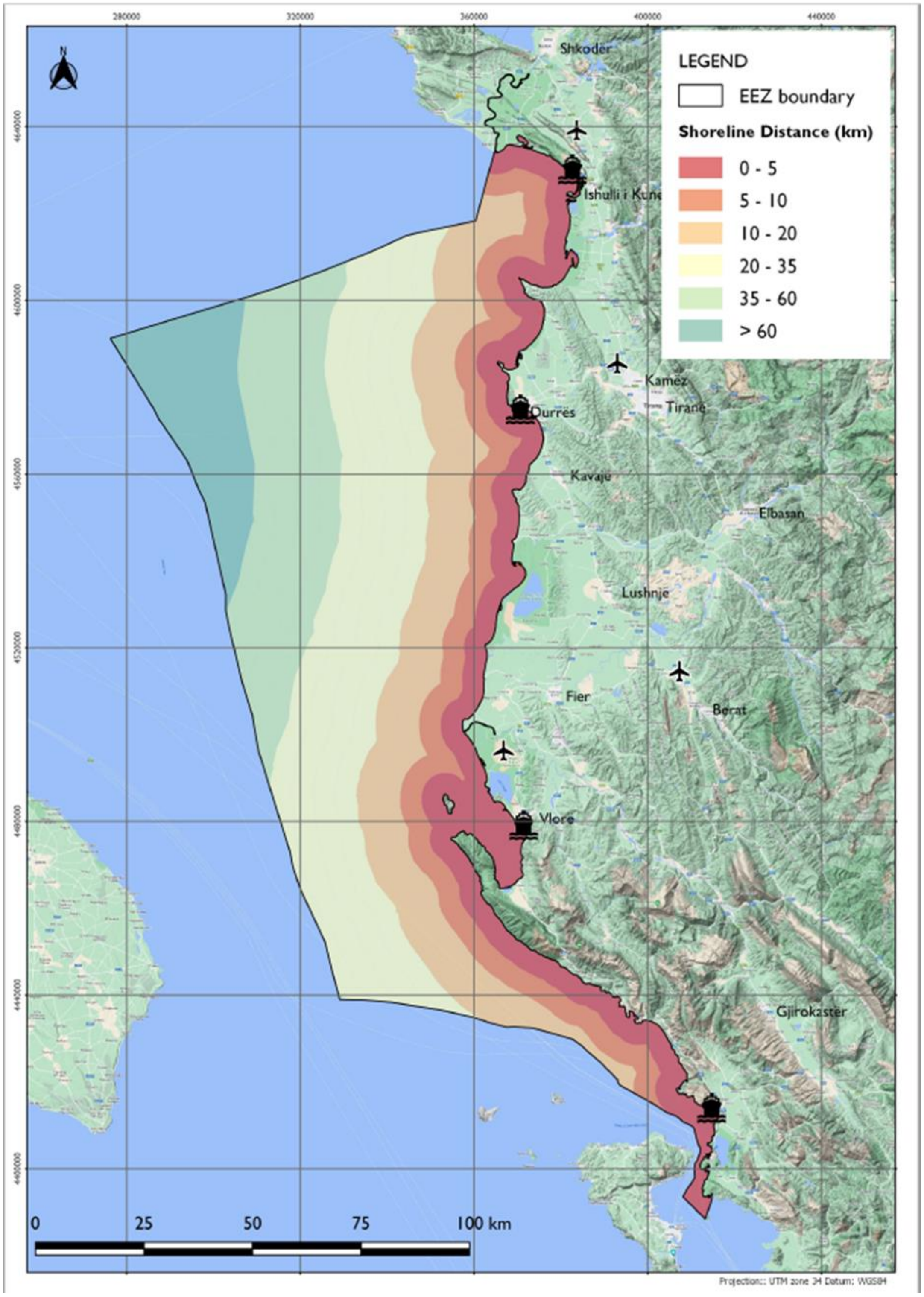
The seabed slope is modest in the north, where a depth of 200 m is reached at a distance of circa 40 km from the coast; while it is very steep in the Otranto Channel, where the 500 m sea depth is reached at a distance < 10 km from the coastline, and 1,000 m sea depth at a distance around 20 km.



DISTANCE FROM SHORELINE

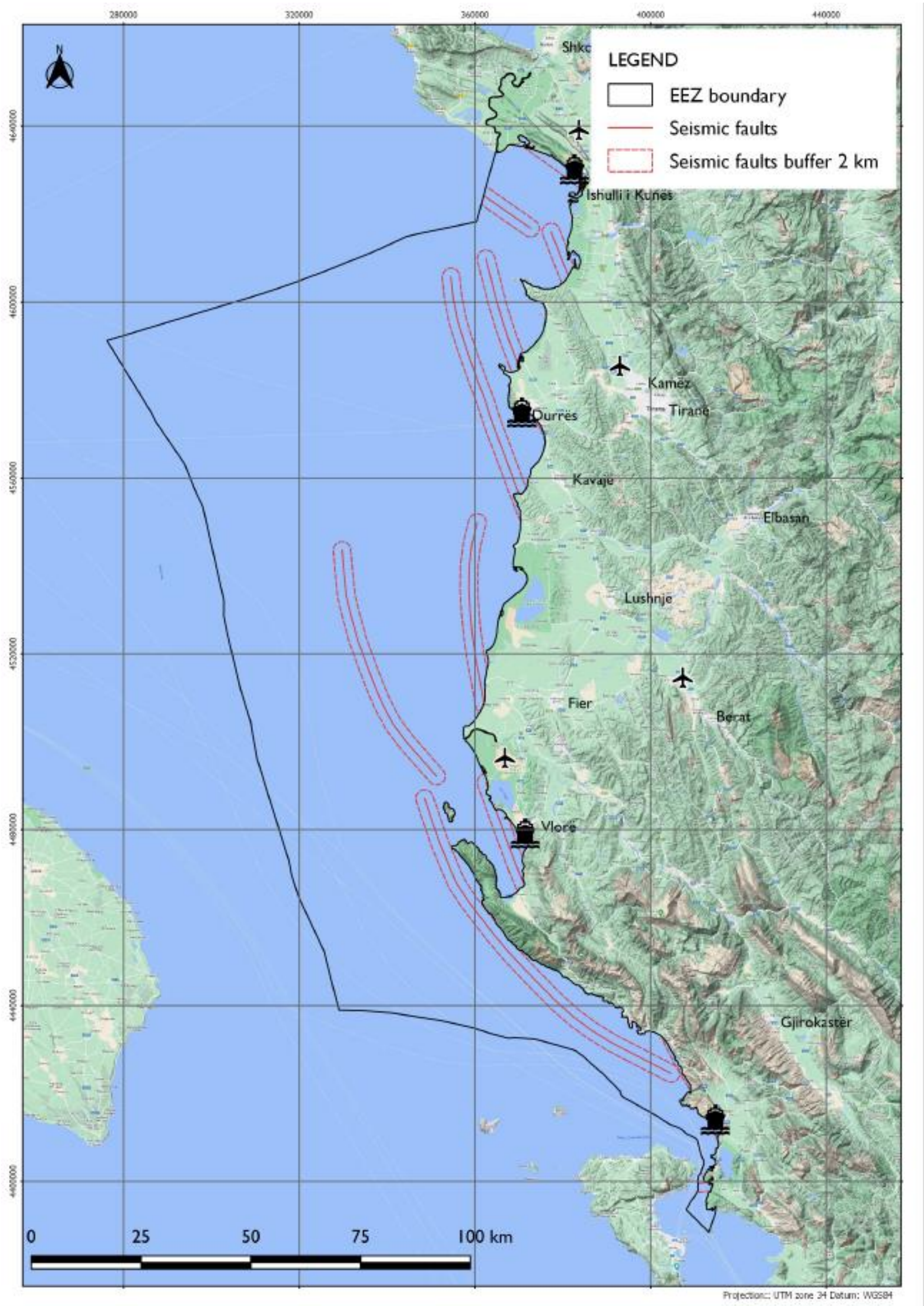
The data represent the distance from the Albanian shoreline (km).

International best practices recommend a minimum distance of 10 km from the shoreline to reduce visibility and the potential impact on coastline activities and the environment. The optimal distance is set in the range 30-40 km, where visibility from the cost and interference with other uses are usually very low. The maximum distance from the coast to the far border of the EEZ reaches around 90 km in the north and around 40 km in the south.



SEISMIC FAULTS

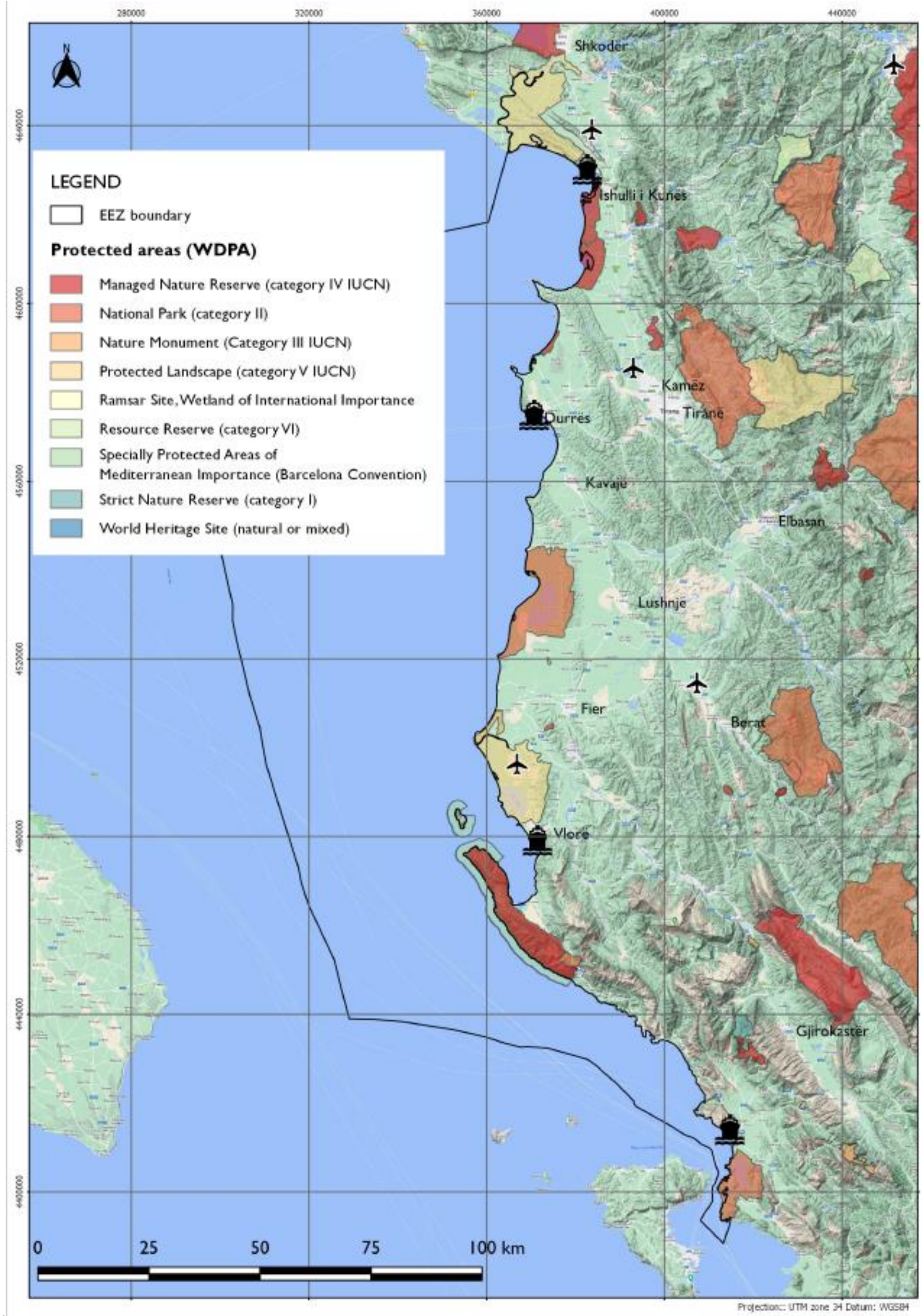
The data represent seismic fault line in the study area (source: European Fault-Source Model 2020). International best practices recommend an excluded area of a 2 km buffer from fault lines.



PROTECTED AREAS

The data set includes areas from the World Database on Protected Areas (WDPA), a global database of marine and terrestrial protected areas that is updated monthly. The data are categorized based on International Union for the Conservation of Nature (IUCN) criteria.

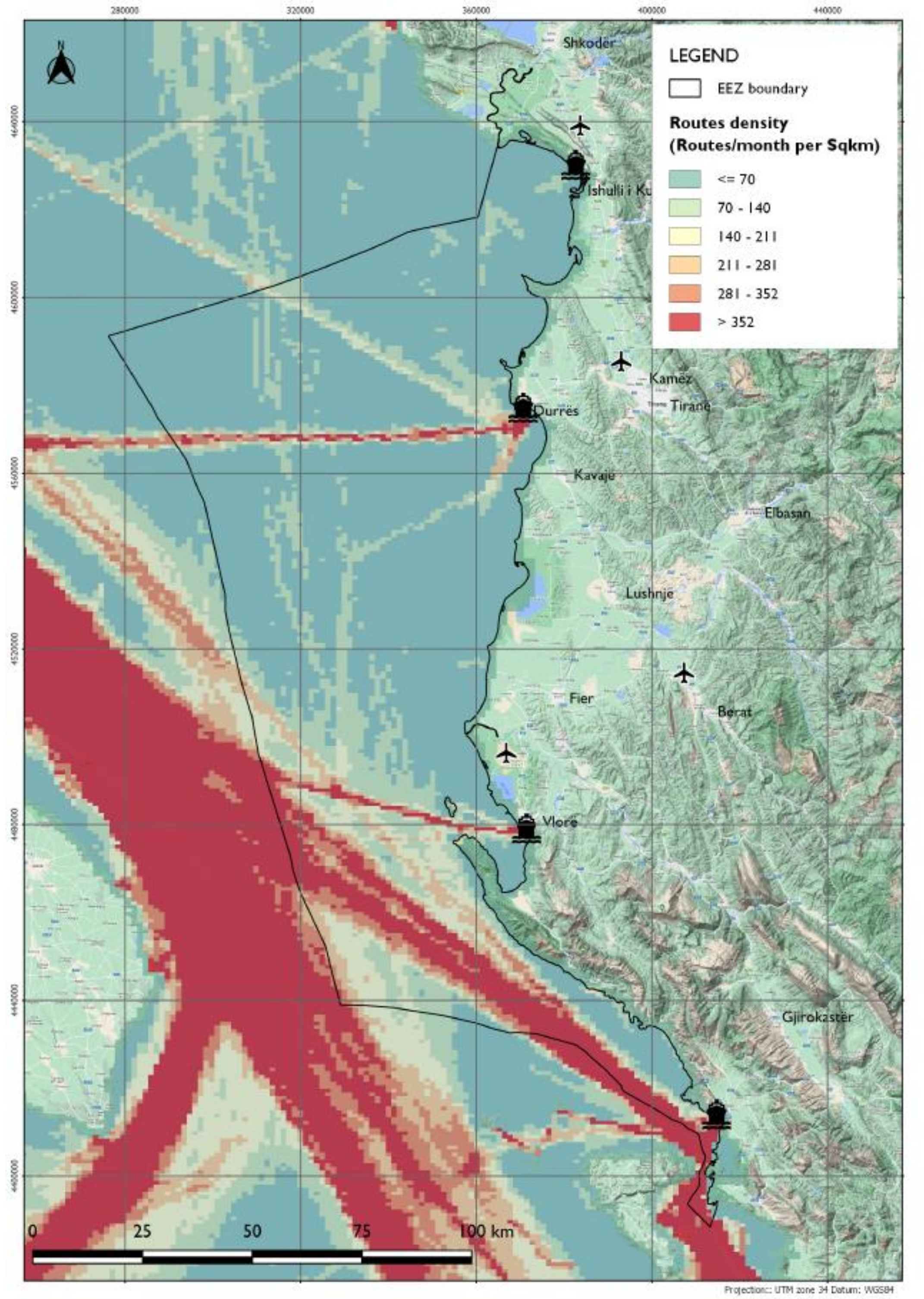
International best practices recommends a conservative no-go area from the footprint of each protected area to a buffer of 5 km; with an equally conservative optimal distance > 20 km.



VESSEL ROUTE DENSITY

The map shows the vessel route density (routes/month per km^2, for all vessels). Source: www.emodnet-humanactivities.eu; maps provided by European Maritime Safety Agency – (EMSA).

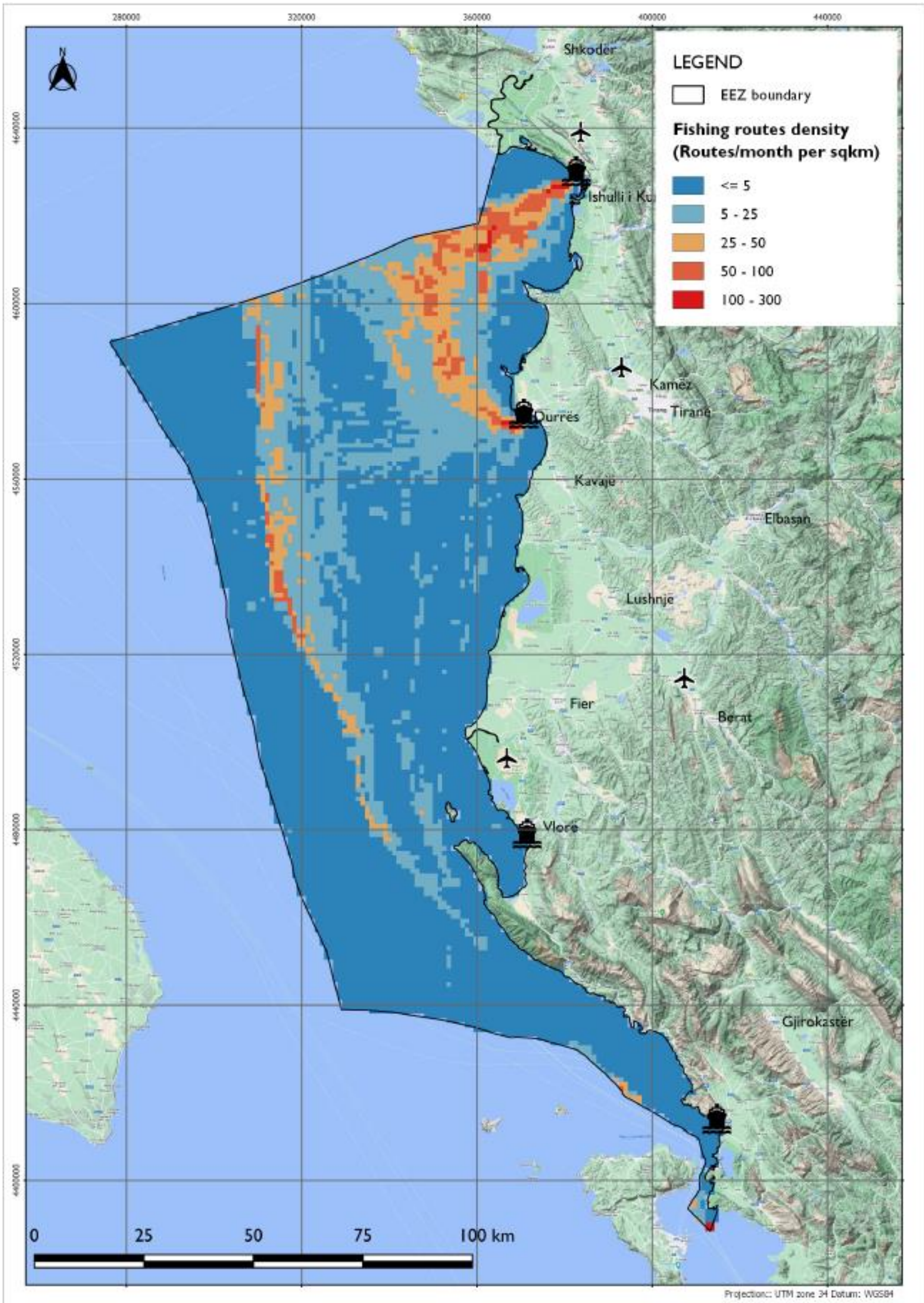
The study excluded areas with route density > 350 from suitability. The team considered an optimal route density to be < 70 routes/month/km^2. An area with major interference with high route densities is in the Otranto Channel.



FISHING ROUTE DENSITY

The map shows the fishing vessel route density (routes/month/km²). Source: www.emodnet-humanactivities.eu; maps provided by European Maritime Safety Agency – (EMSA). The map is provided only for information, considering that the optimal distance from an OWP project or shared use can be better evaluated in micro-siting and during the authorization procedure.

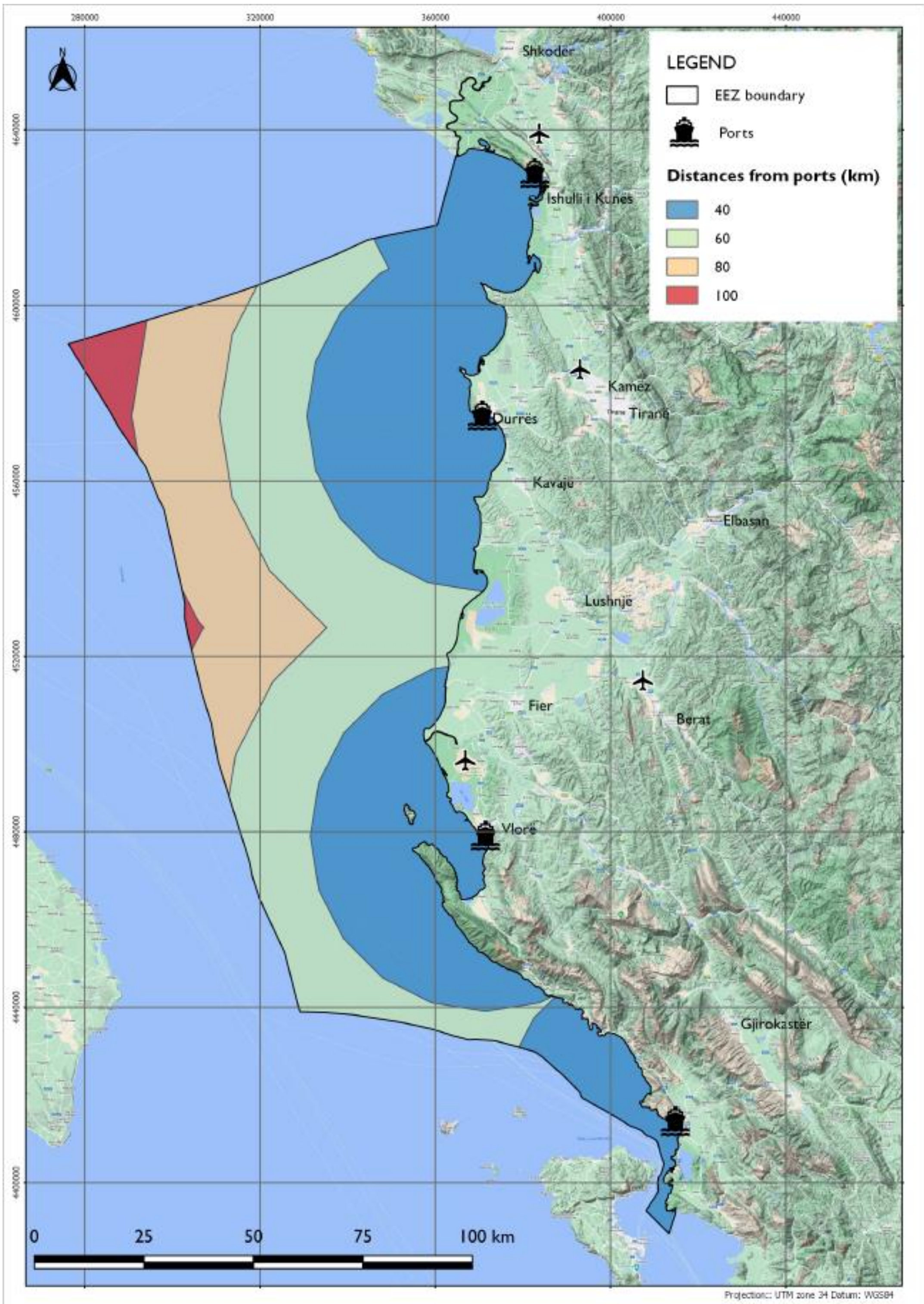
The major fishing route densities are in the north between Durres and Velipoje and along the 400 m sea depth isobath, around 30-50 km from the coast.



DISTANCE FROM PORTS

The map shows the radial distance from Albanian ports.

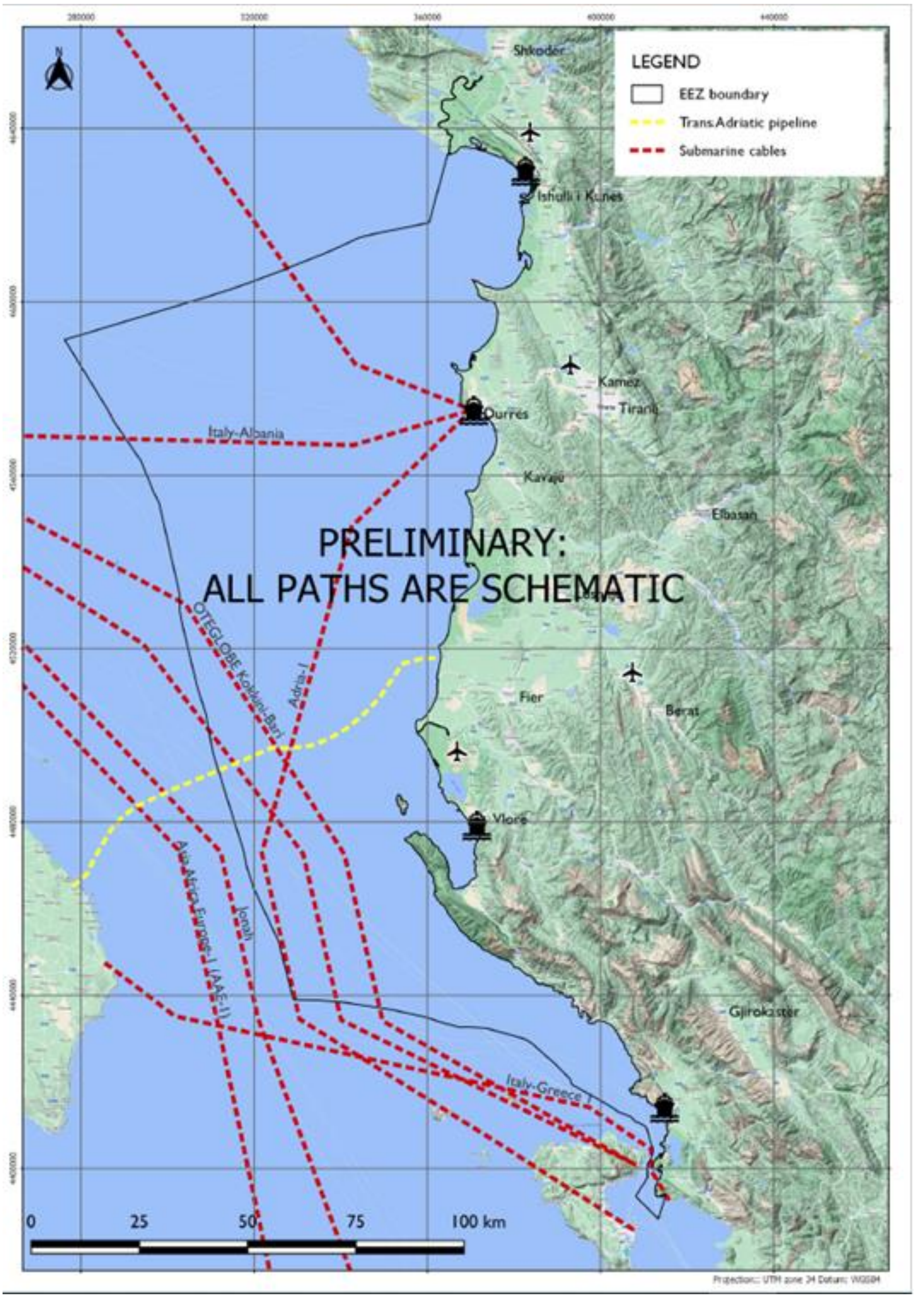
The maximum distance is about 115 km. The study considered a distance < 40 km optimal for operation and maintenance activities.



SUBMARINE CABLES AND PIPELINES

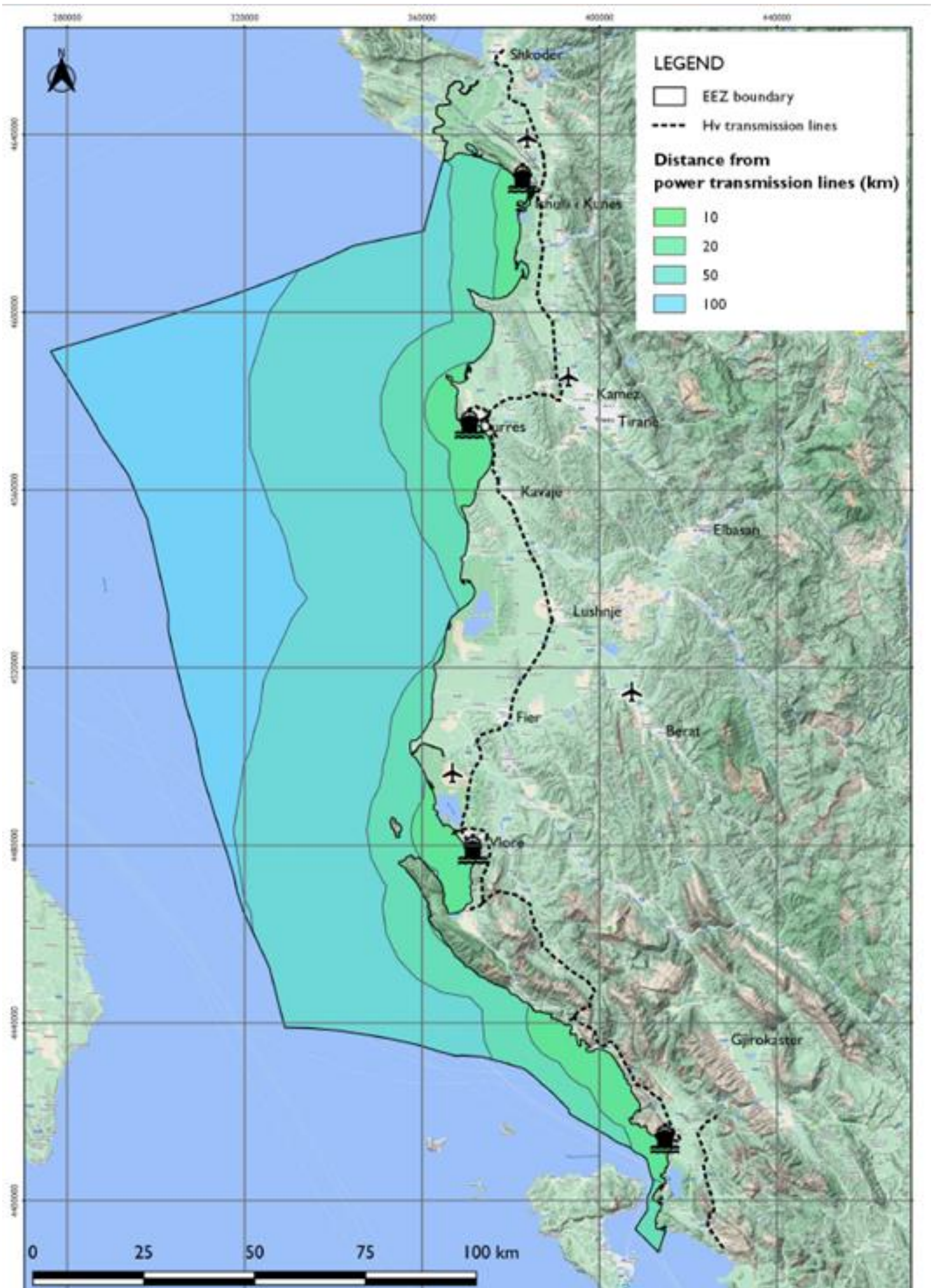
The map shows the Trans Adriatic Pipeline (TAP) and the schematic routes of telecom cables (for information). The study considered an excluded buffer zone of 500 m on each side of the TAP.

It was not possible to accurately reconstruct the route of the main subsea cables and pipelines due to a limited availability of information. This information will have to be evaluated in the micro-localization phase.



DISTANCE FROM POWER TRANSMISSION LINES

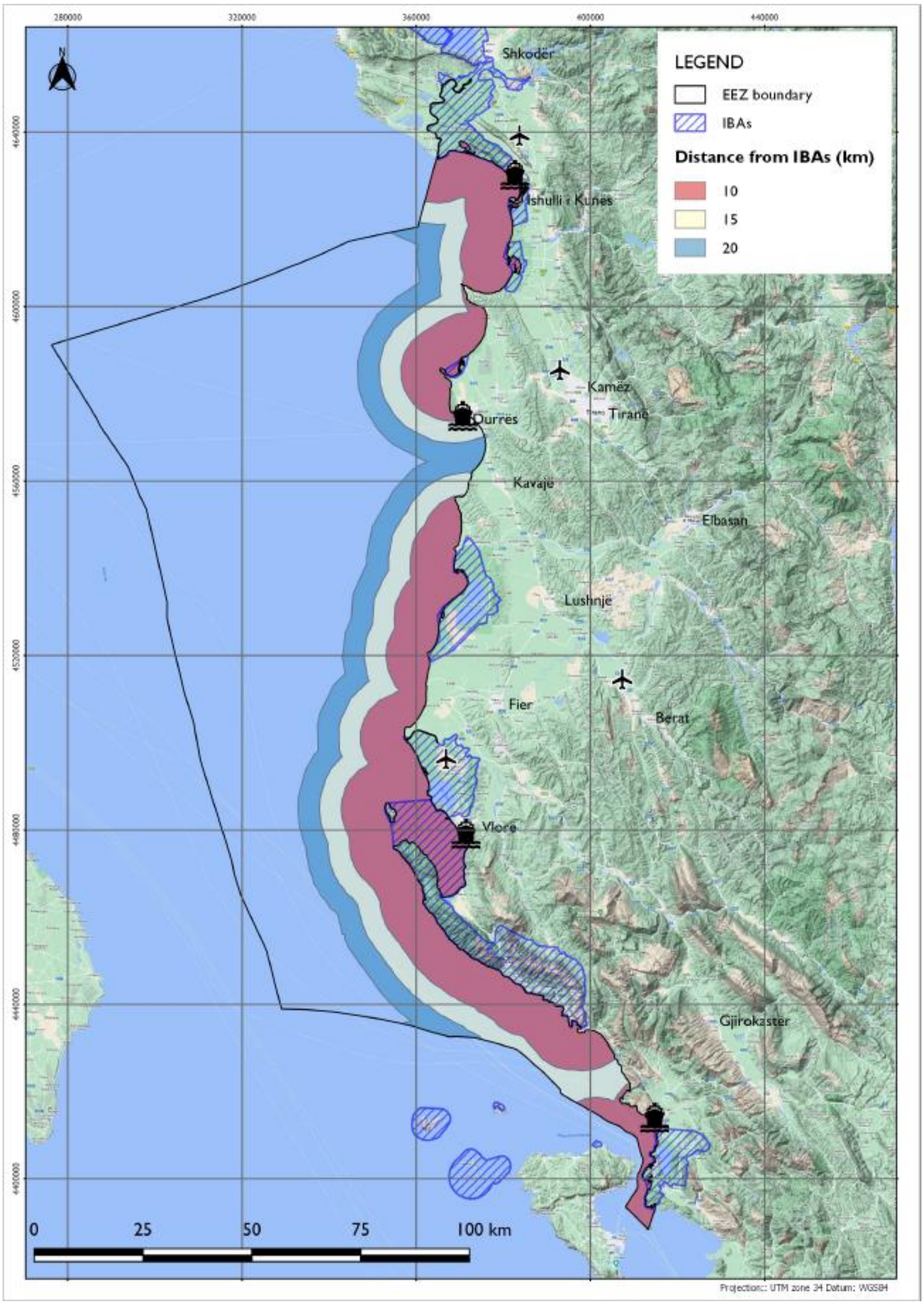
The map shows the radial distance from the high-voltage power transmission lines located closest to the coast. The team extrapolated the layout of the HV transmission lines from Albanian ASIG geoportal information. The radial distance varies from 0-100 km. The distance from the high-voltage grid affects connection costs and electrical losses.



IMPORTANT BIRD AREAS (IBAS)

The map shows the location and buffer distances from IBAs (Source BirdLife International 2022).

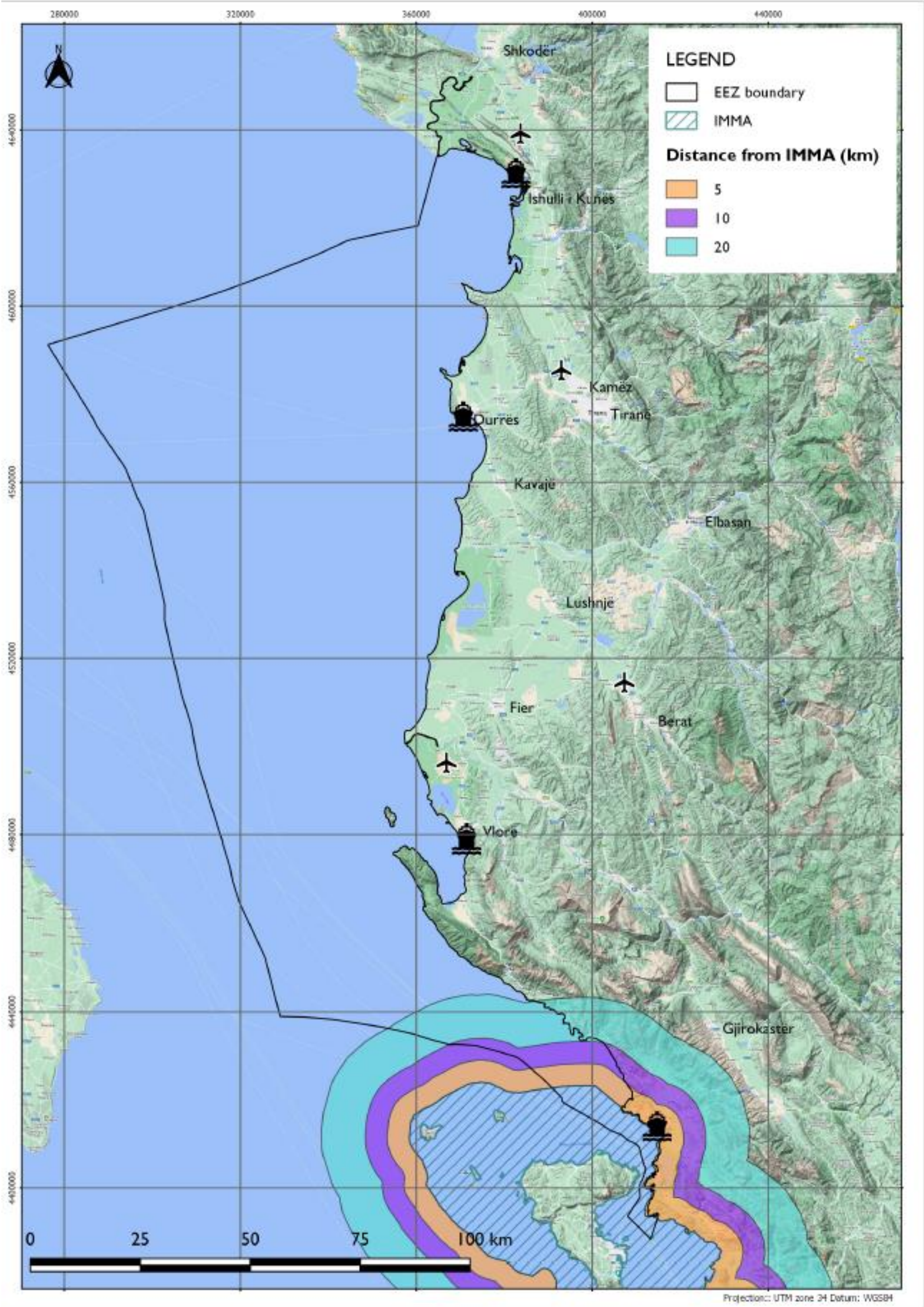
The major IBAs are located along the southern coastline. The team considered them no-go areas, with a buffer zone of 5 km around IBAs and an optimal distance > 20 km.



IMPORTANT MARINE MAMMAL AREAS

The map shows the location and buffer distances from the only IMMA marginally overlapping with the study area.

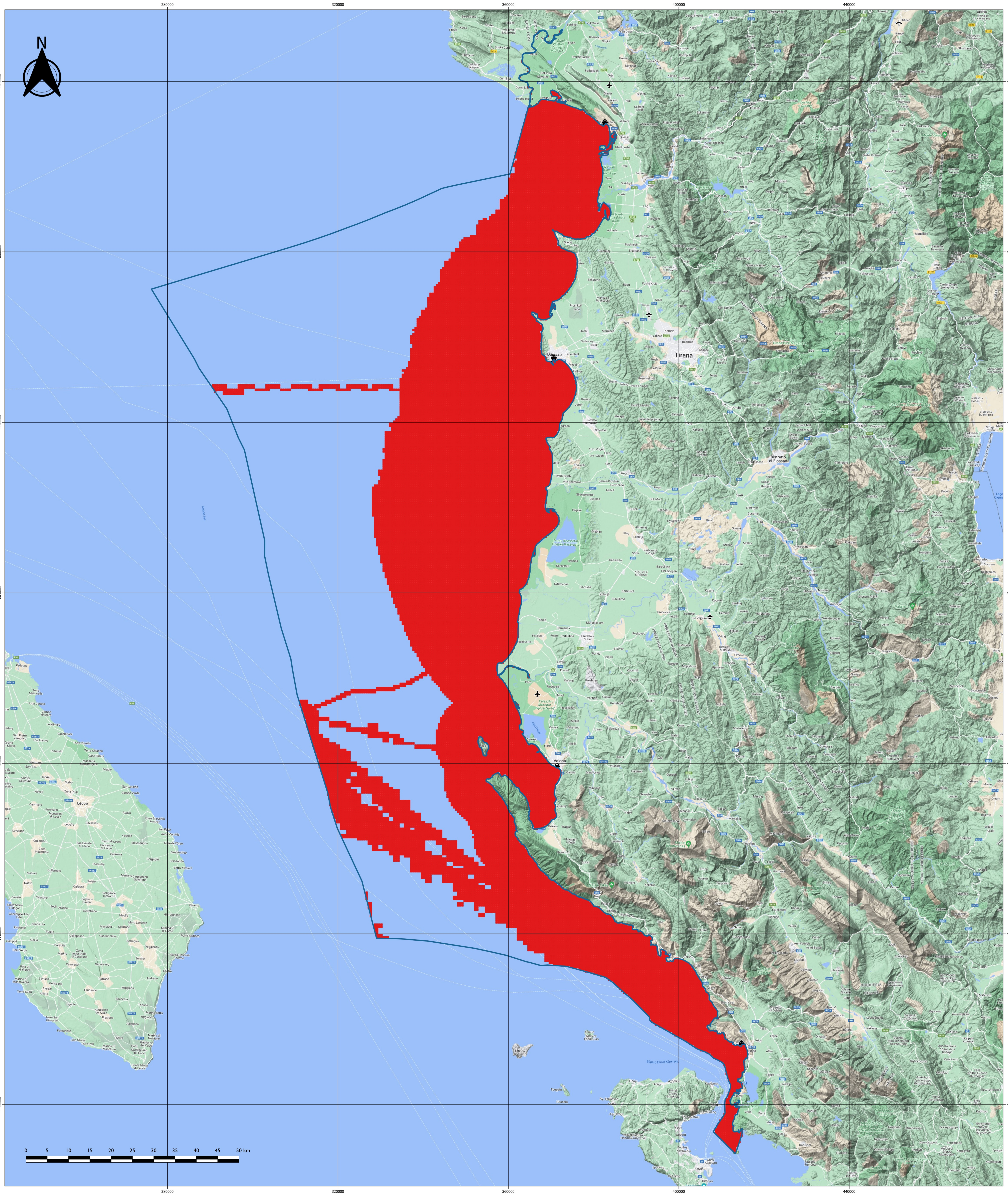
The team considered this IMMA a no-go area with a buffer zone of 5 km around the IMMA and an optimal distance > 20 km.



APPENDIX B

NO-GO AREAS MAP

PATH:



LEGEND

EEZ boundary

Excluded areas

CLIENT
MINISTRY OF INFRASTRUCTURE AND ENERGY

PROJECT
DEVELOPMENT OF OFFSHORE WIND POWER PROJECTS IN ALBANIA

TITLE
EXCLUDED AREAS

CONSULTANT
CESI
Shaping a Better Energy Future

PROJECT NO.

APPENDIX C

SUITABILITY MAP

PATH:

LEGEND

EEZ boundary

Wind velocity at 100 m

- <= 6.5
- 6.5 - 7
- 7 - 7.5
- 7.5 - 8
- 8 - 8.5

CLIENT
MINISTRY OF INFRASTRUCTURE AND ENERGY

PROJECT
DEVELOPMENT OF OFFSHORE WIND POWER PROJECTS IN ALBANIA

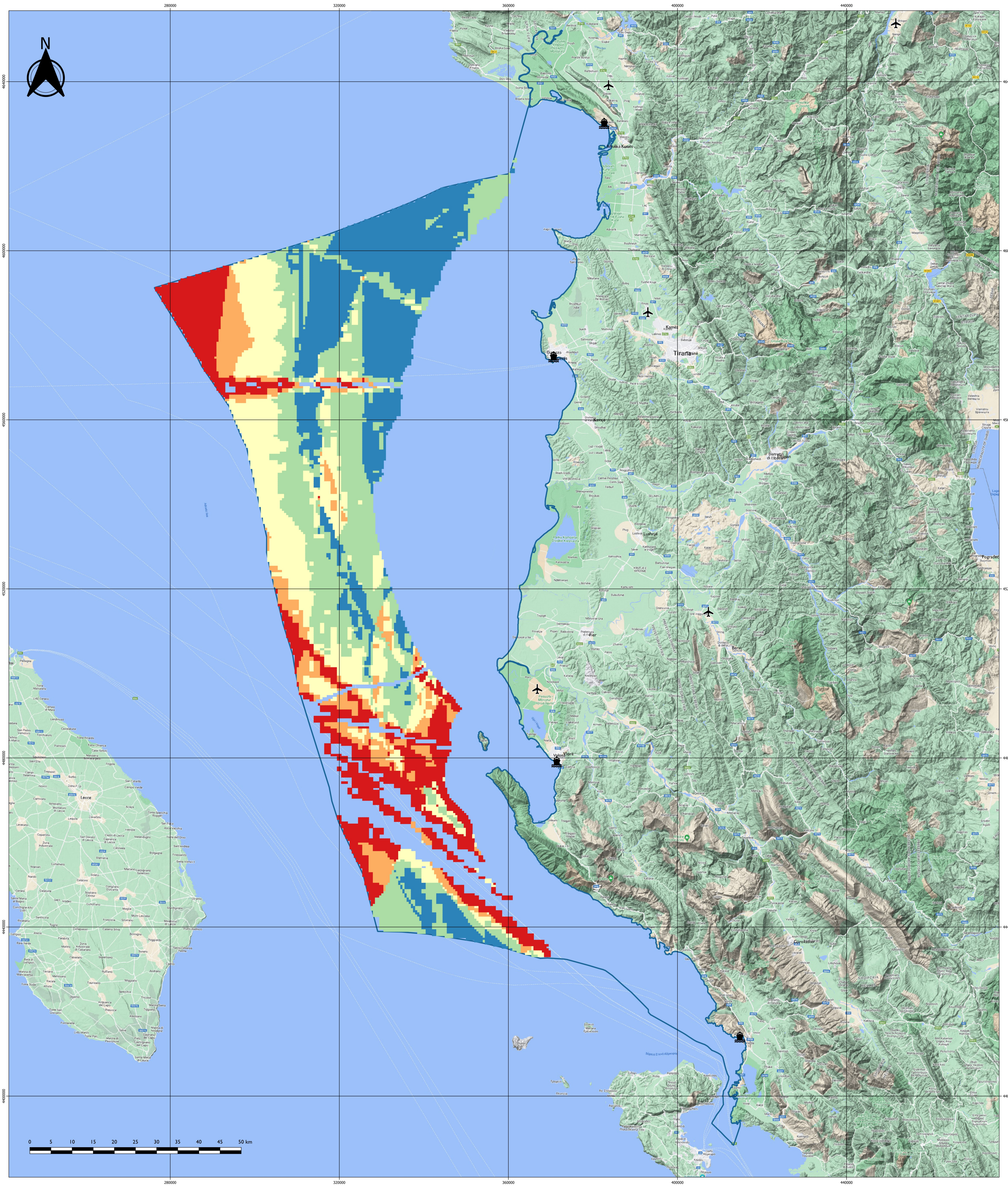
TITLE
POTENTIALLY SUITABLE AREAS (WITH WIND VELOCITY)

CONSULTANT
CESI
Shaping a Better Energy Future

PROJECT NO.

APPENDIX D
SUITABILITY CLASSES MAP

PATH:



LEGEND

EEZ boundary

Suitability rank (quintiles)

- 59,8 - 72,9
- 72,9 - 74,4
- 74,4 - 76,4
- 76,4 - 79,1
- 79,1 - 85,1

CLIENT
MINISTRY OF INFRASTRUCTURE AND ENERGY

PROJECT
DEVELOPMENT OF OFFSHORE WIND POWER PROJECTS IN ALBANIA

TITLE
SUITABILITY MAP R

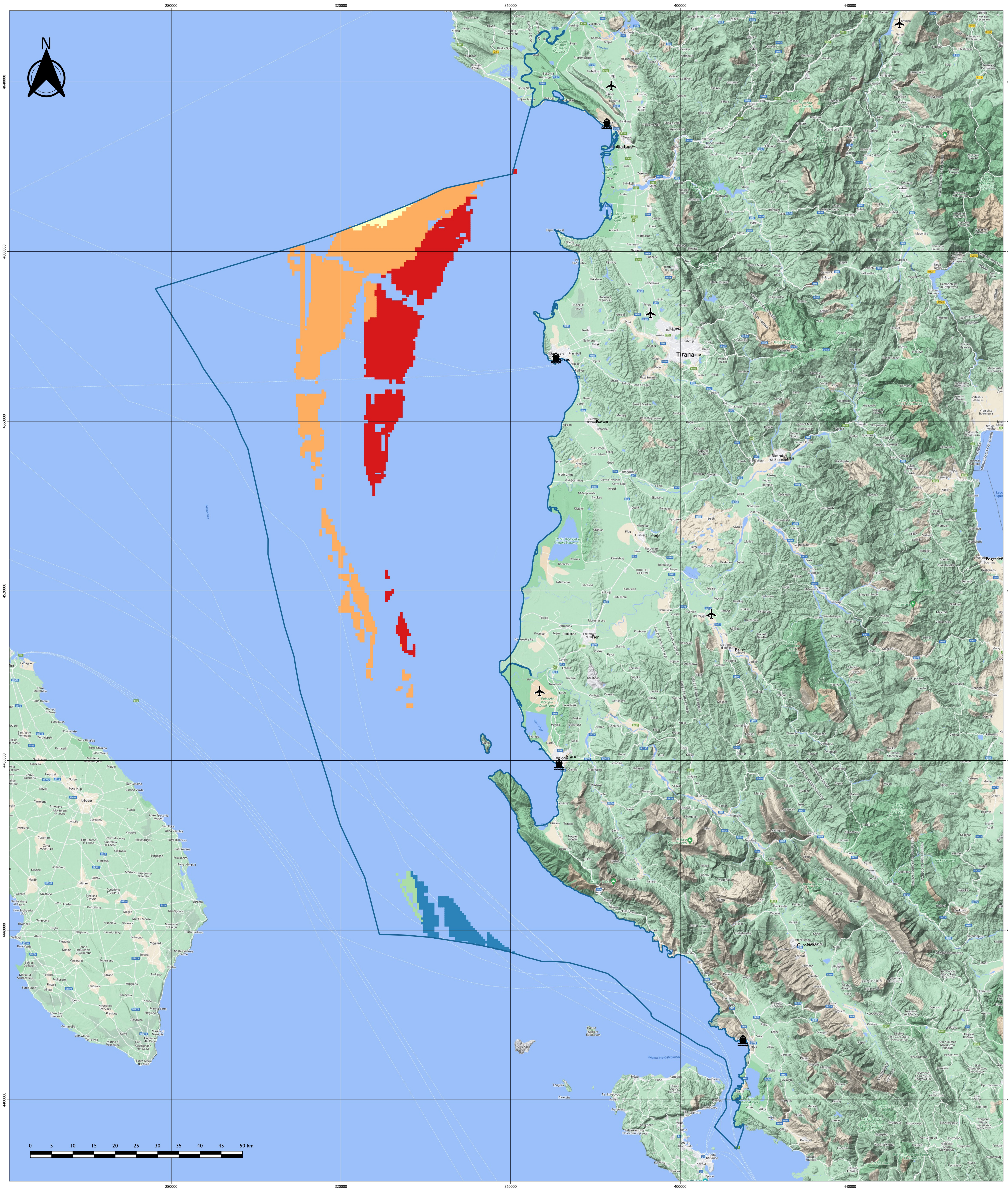
CONSULTANT
CESI
Shaping a Better Energy Future

PROJECT NO.

APPENDIX E

SUITABLE AREAS WIND SPEED MAP

PATH:



LEGEND

EEZ boundary

Average wind speed (m/s)

- 6,5 - 6,71
- 6,71 - 6,92
- 6,92 - 7,13
- 7,13 - 7,35
- 7,35 - 7,56

CLIENT
MINISTRY OF INFRASTRUCTURE AND ENERGY

PROJECT
DEVELOPMENT OF OFFSHORE WIND POWER PROJECTS IN ALBANIA

TITLE
SUITABLE AREAS WIND SPEED MAP

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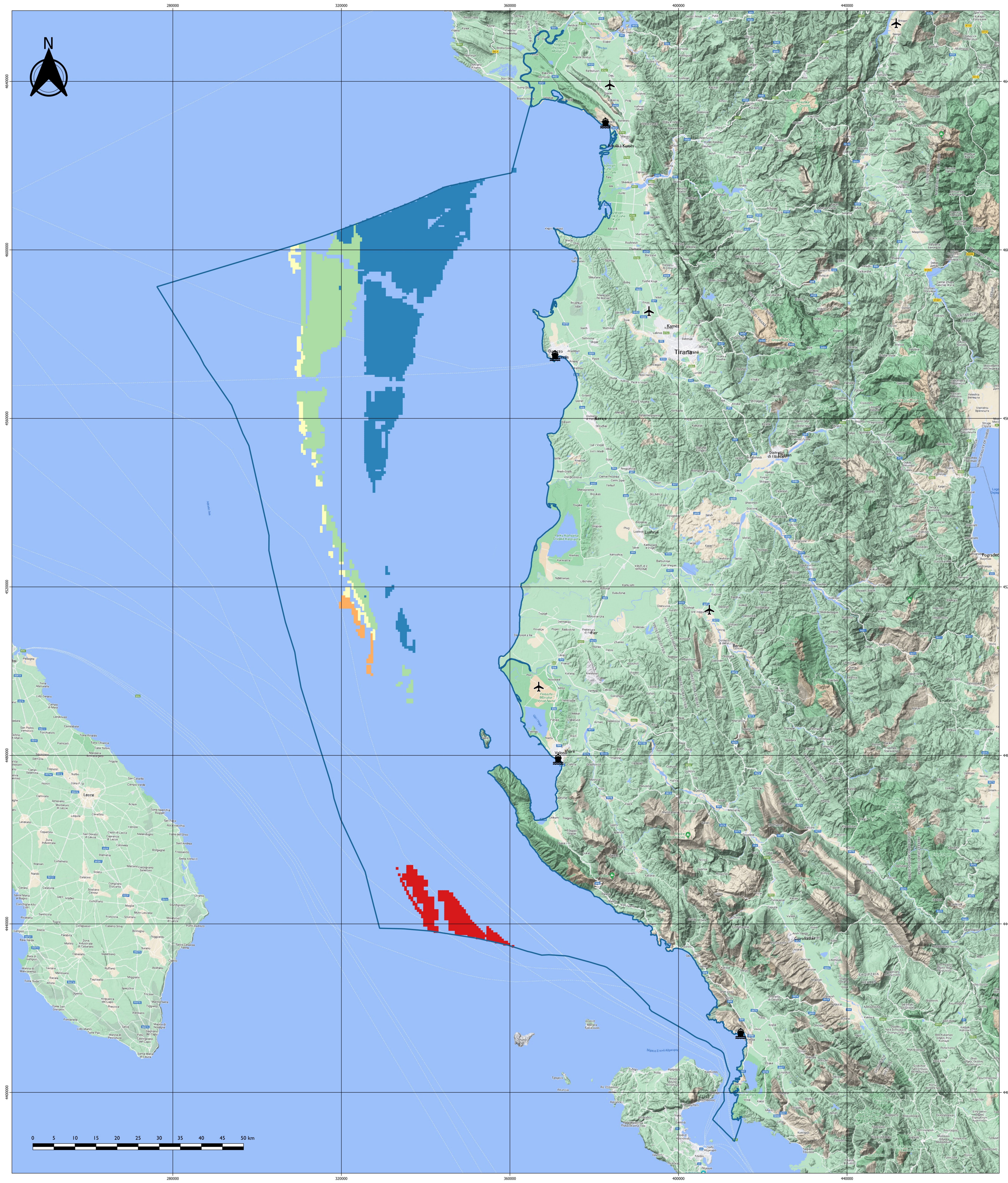
PROJECT NO.

APPENDIX F

SUITABLE AREAS BATHYMETRY MAP

PATH:



LEGEND

EEZ boundary

Bathymetry (m)

- -997 - -809
- -809 - -621
- -621 - -432
- -432 - -244
- -244 - -56

CLIENT
MINISTRY OF INFRASTRUCTURE AND ENERGY

PROJECT
DEVELOPMENT OF OFFSHORE WIND POWER PROJECTS IN ALBANIA

TITLE
SUITABLE AREAS BATHYMETRY MAP

CONSULTANT
CESI
Shaping a Better Energy Future

PROJECT NO.

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