mspmed

D29 – Italy: modules implementation

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1 Introduction

1.1 Aim of the deliverable

The deliverable D.29 “Italy: modules implementation” is included inside the MSPMED work package 3 “Data use and sharing” and, specifically, in the task 3.2 “Data use and sharing in Italy”.
That task aims to support the implementation of the Italian MSP-related data and information sharing facilities including the maintenance and upgrade of the collected datasets. The task is organised into two sub-activities: 3.2.1 - Consolidation of the national Geoportal for MSP, in connection with existing data infrastructures; and sub-activity 3.2.2 Development of tools for data ingestion and processing.
D.29 named “Demo of tools for data ingestion and processing useful for the Italian national geoportal” describes the outcomes of the sub-activity 3.2.2 and consists of three software tools which have been developed in python programming language and are online distributed as public notebook documents.
The present document introduces the three tools, describing the architectures and the main technological aspects, and provides the references to the online module demos.

1.2 Tools implementation: overview

The activity of designing and implementing the tools was divided into the following phases:

1. Tools identification. The developed tools were identified by combining: i) the needs of the Italian MSP process and especially the need to publish the spatial representation of the plan as part of the Italian institutional portal (SID - Il Portale del Mare[1]); ii) the need to link the italian plan with ongoing harmonisation processes at the European level (e.g. EMODNet Data Model; EMODnet, 2021); iii) the need to provide a systematic analysis of the spatial representation of the plan in order to facilitate the identification of possible issues and patterns by the planners and the decision makers.
2. Tools design. The three tools follow a sequential design pattern where no interactions by the users are required and where the main input is represented by the Italian MSP plan structured through the “Italian MSP Data Model” specification (see Figure 1 and Section 2). Outputs are automatically produced by the module and consist mainly of geospatial layers, data tables, charts.
3. Tools development. The Python[2] programming language have been adopted to develop the tools and the python libraries for scientific and geospatial data analysis (eg. NumPy[3],

[1] SID - Il Portale del Mare: https://www.sid.mit.gov.it/
[2] Python: https://www.python.org/
[3] NumPy - fundamental package for scientific computing in Python: https://numpy.org/

GeoPandas[4]) are widely used. This allows for a highly efficient tool and an easy-to-read code.

4. Demo publication. The tools are released as open source software through the use of notebooks documents[5] which are human-readable documents containing both the analysis description (eg. rich text elements like paragraph, equations, figures, links) and the results (eg. figures, tables, etc..) as well as executable documents which can be run to perform data analysis. This is an excellent solution to effectively demonstrate how the tools work and encourage software reuse.

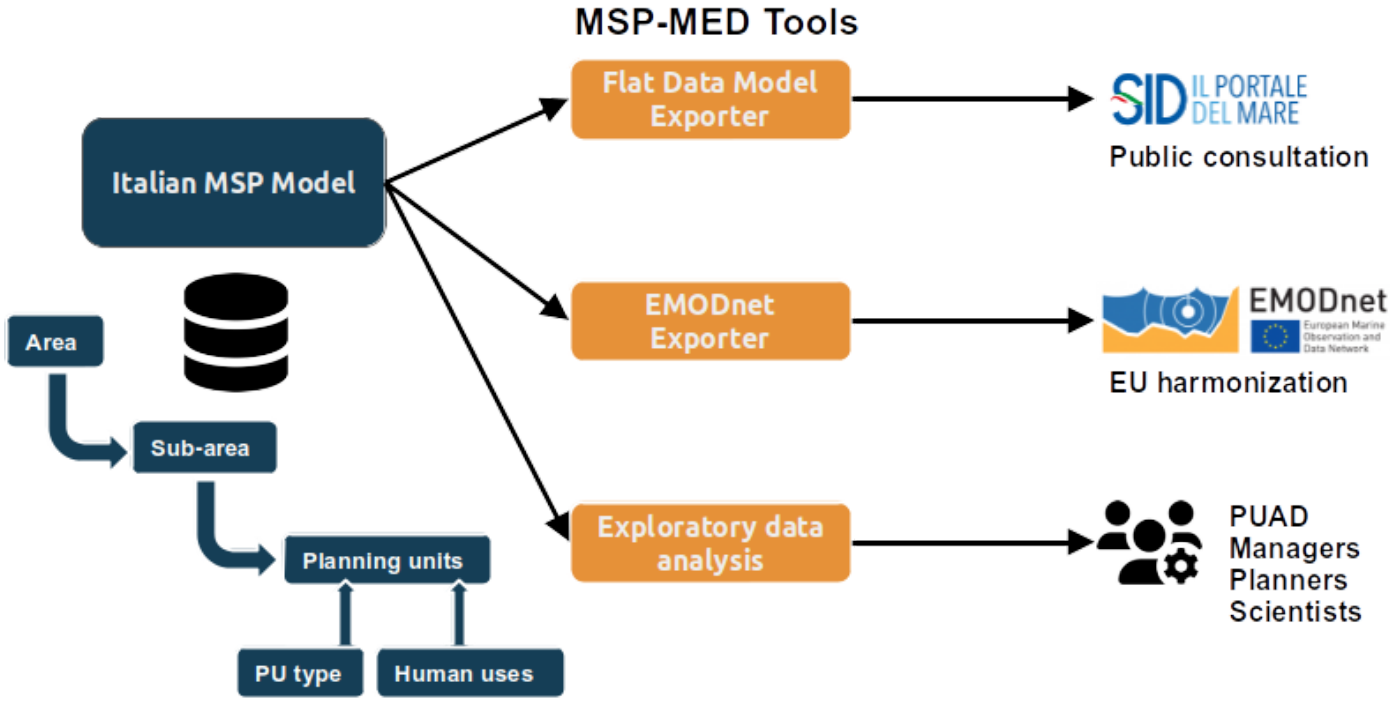


Figure 1.1: overview of the three implemented modules.

As result of the first phase (Tools identification) it was decided to focus on the development of the following modules (see Figure 1.1):

- MSP Italy – Flat Data Model Exporter: tool to automatically export the spatial MSP data (represented according to the Italian MSP Data Model), in a standard format ready-to-use for the official MSP data portal of the Italian competent authority (ie. SID - Il Portale del Mare). The module also incorporates logics, functionalities and symbologies to obtain correct graphical representation of the planning units for single-use and multi-use cases.
- MSP Italy – EMODnet Exporter: tool to automatically export the spatial MSP data according to the MSP EMODnet model (EMODnet, 2021), which has been created for

[4] GeoPandas - to make working with geospatial data in python easier: https://geopandas.org/
[5] Notebook documents: https://jupyter-notebook-beginner-guide.readthedocs.io/en/latest/what_is_jupyter.html

the European Marine Observation and Data Network (EMODnet) for incorporating and harmonising the plans of all European member states and represent them at the pan-European scale.

- MSP Italy – Exploratory Data Analysis: tool to perform exploratory data analysis on MSP plans to identify issues and spatial patterns and to summarise their main characteristics. The module incorporates a graphical functionality to investigate multi-use interactions statistics.

The Italian MSP data model, which is the main input for all tools, will be initially introduced (Section 2). Then the three developed tools will be described (Section 3) and conclusions and considerations on possible future development will be finally provided (Section 4).

2 The Italian MSP Data Model

The Italian MSP plan has been composed as a set of legal documents that mainly use a descriptive language, tables, and maps for each of the three italian maritime areas (Adriatic Sea, Ionian Sea and Central Mediterranean Sea).
The geospatial representation and visualisation (eg. layers, maps) of the plan is based on the new Italian MSP Data Model which consists on the following main elements:

- Areas: polygonal layer representing the 3 MSP areas (layer **areas**)
- Subareas: polygonal layer representing the sub-areas (layer **subareas)**
- Planning Units (PU): polygonal layer containing the planning units (layer **planning)**
- Sea uses list: human activities and themes (table **pu_uses**)

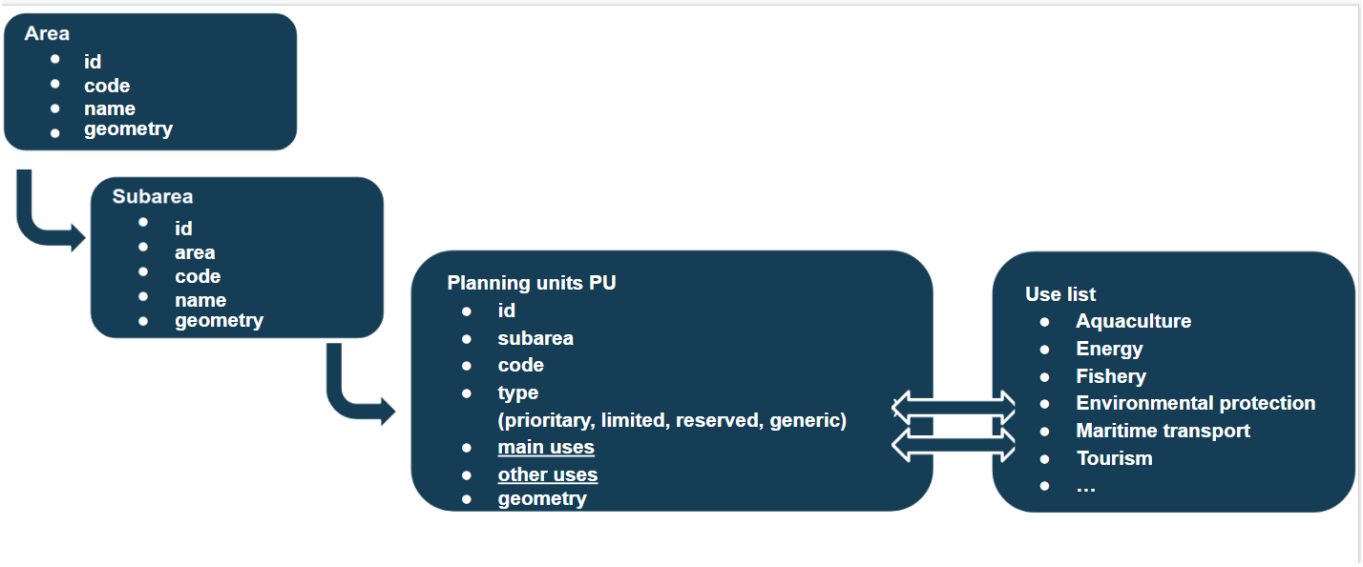


Fig. 2.1: Italian MSP data model with attributes (attributes name are translated to english).

Altogether, the legal documents, the three maritime areas, the maritime subareas and the planning units form a unitary multi-scalar approach to MSP in Italy, enabling to zoom-in along the zoning process (Ramieri et al, submitted).

In Table 2.1 the codes used to uniquely characterise the different human activities and cross-cutting themes in the Italian MSP plan are presented. The table also includes the color codes which have been carefully selected in order to ensure optimal geographic visualisation of the plan.

Code	Use name Ita	Use name En	Label	Color
0100	Pesca	Fishery	p	#F4AAAE
0200	Trasporto marittimo e portualità	Marine Traffic and Ports	tm	#6E7C97
0300	Protezione ambiente e risorse naturali	Environmental protection and resources	n	#88BC91
0400	Energia	Energy	e	#C04B4B
0500	Prelievo di sabbie	Sand extraction	sa	#FCD154
0600	Difesa	Military	d	#CCAE99
0700	Turismo costiero e marittimo	Tourism	t	#F4A166
0900	Telecomunicazioni	Submarine cables	#	#BBC8E4
1000	Paesaggio e Patrimonio Culturale	Landscape/Seascape Cultural Heritage	ppc	#778775
1100	Immersione sedimenti dragati	Offshore (other than oil) discharge location	sd	#999999
1200	Difesa costiera, protezione dalle alluvioni, ripristino della morfologia dei fondali	Coastal defence, seabed restoration	dc	#999999
1300	Sicurezza marittima, della navigazione e sorveglianza	Safety and security	s	#9C6F69
1400	Ricerca scientifica e innovazione	Scientific research & Innovation	r	#999999
1500	Acquacoltura	Aquaculture	a	#B9829F

Table 2.1: human uses classification within italian MSP data model: the list contains sea-use (eg. Fishery) and relevant cross-cutting themes (eg. Landscape and cultural heritage)

The three maritime areas have a code and a name attribute, subareas also have a reference to the parent area element (it is also the first letter of the subarea code) and a name attribute indicating whether the element is within territorial waters or offshore (location).

country	area	name	KM²
Italy	IMC	Ionio - Mediterraneo Centrale	176270.99
Italy	MO	Tirreno - Mediterraneo Occidentale	309478.33
Italy	A	Adriatico	62268.2

Table 2.2: layer areas

name	subarea	area	area_km
acque terr	A/5	A	3444.26
off-shore	A/7	A	11248.5
off-shore	A/8	A	6851.67
off-shore	MO/9	MO	13119.35
off-shore	MO/11	MO	96604.83
off-shore	MO/10	MO	101777.62
acque terr	IMC/1	IMC	7793.09
off-shore	IMC/7	IMC	111384.15
off-shore	IMC/6	IMC	23813.5

Table 2.3: sample of layer subareas

2.1 Relationship between uses and planning units

The type of relationship between the Planning Unit (PU) and Human Uses mainly depends on the category to which the PU belongs (PU_type).
In fact, PUs can be assigned to one of the following four categories, providing an increasing level of exclusive use of the area (Ramieri et al, submitted):

G - Generic: areas where all maritime uses are equally considered, with specific regulation mechanisms aiming to guarantee safety, reduce and control environmental impacts and favour coexistence between uses. For this typology of planning units, vocations of use are not defined.
P - Priority: areas for which the MSP plans identify priorities for existing or developing uses, also indicating the other uses to be guaranteed through specific regulation mechanisms.
L - Limited: areas where a prevalent use is indicated, with other uses that may be present, with or without specific limitations, if compatible with the prevalent use.
R - Reserved: areas reserved for a specific use. Other uses are permitted exclusively for the needs of the reserved use or in case of specific concessions provided by the manager of the reserved use.

code	unit_type	tipo_unita
100	Generic	Generico
200	Prioritary	Prioritario
300	Limited	Limitato
400	Reserved	Riservato

Table 2.4: PU_types codelist and planning unit types

According to the PUs categorization the following link to the Human Uses are supported:

- R - one and only sea-use is permitted.
- L - one sea-use is qualified as main use and maybe one or two additional uses can be permitted.
- P - one sea-use is qualified as main use and all other compatible uses are listed, some of them are explicitly described in the planning document and the remaining are possible (if practicable and not explicitly forbidden).
- G - no use is specified.

This link between PU and uses is modelled as two independent one-to-many relationship one for **main uses** as described above, one for the **other uses** that could be either uses explicitly

envisioned in the plan or possible in theory. The table with the list of PU's uses contains the PU code as a foreign key and a field "notes" that can describe in detail the presence of the use in that place (table 2.5).

type	pu_code	use_code_s	notes
other	A/3_04	0700	
main	A/3_05	0700	
other	A/3_05	0100	
other	A/3_05	0300	
other	A/3_05	1200	
main	A/3_06	1500	
other	A/3_06	0300	
compatible	A/3_06	1200	
main	A/3_07	0400	presenza piattaforme; divieto nuove istanze idrocarburi; potenziale rinnovabili
compatible	A/3_07	1200	
other	A/3_07	0100	

Table 2.5: sample from the uses_pu table that map relationships between main_uses and other/compatible uses with the PU code as foreign key

2.2 Spatial types, data types and codelists

Summarising: "Areas", "Subareas" and "Planning Units" layers are the main components of the Italian MSP data model. In addition, the "Uses" codelist (table 2.1) defines the human uses classification adopted by the plan and includes the use description in both Italian and English languages, the label (a use abbreviation of one, two or three letters) and the color code. Finally, the codelist "PU_Types" (table 2.4) completes the structure of the data model.
While "Areas" and "Subareas" layers have only standard attributes (Code, name, location and parent area see figure 2.1), the "Planning Units" layer also include the read-only attribute "Type" which is automatically calculate concatenating the single-letter abbreviation of the "PU_type" with the label abbreviation of PU main uses. For example a prioritary PU for

Maritime transport and Aquaculture will be labelled as **P(tm,a)** (see table 2.1). This attribute is used to describe in a highly compact form the main characteristics of the PU.

2.3 File format and management tool

The native format chosen for the Italian MSP plan is geopackage (OGC, 2021), which is an open, standards-based, platform-independent, portable, self-describing and compact format for transferring geospatial information. Geopackage relies on a SQLite[6] container that provides the capabilities of a relational database and is managed through standard SQL statements (OGC 2021).
The geopackage format overcomes the limitations of the better-known and widely used ESRI shapefile[7]. In fact, despite the shapefile specifications being public and it's well supported by all the GIS applications and platforms, the format presents several constraints that do not make it suitable for managing rich data models containing multiple and linked relationships. The main limitations of the shapefile format are: i) the maximum length of field names is 10 characters; ii) it supports only few field types: floating point, integer, date (no time storage), and text (maximum 254 characters); iii) and it cannot combine within a single file/container multiple spatial layers and non-spatial data tables.

In order to ensure robust and relatively simple management of the geopackage contents, a dedicated procedure based on the QGIS[8] application has been developed. The procedure uses a dedicated QGIS project (Planning project) which already includes configurations, shortcuts and actions to visualise the layers and to manage the internal relationships between the Data Model objects.
For example, for managing the spatial relations between PUs and multiple Uses, a dummy layer has been incorporated into the data model. Through that table, relationships are made spatially explicit (see FIg. 2.2) and thus manageable directly from the map display interface of QGIS without the need to access the attribute table. When the dummy layer is saved, the standard foreign key between PUs and Uses are automatically created and the new relationships become easily viewable when querying the PU (see the two lists on Fig. 2.3).

[6] SQLite database engine: https://www.sqlite.org/
[7] ESRI shapefile - ESRI Shapefile Technical Description
https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/shapefile.pdf
[8] QGIS - free and open-source GIS: https://qgis.org/

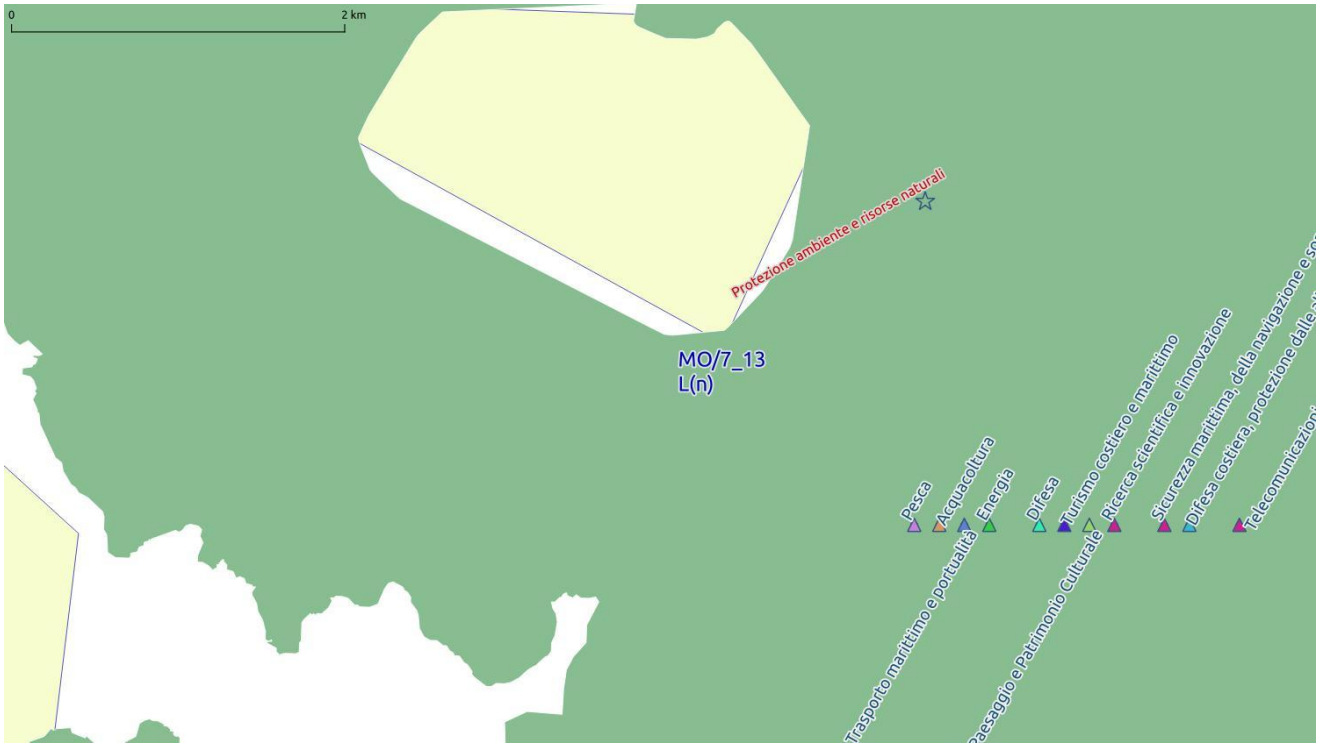


Figure 2.2: example of a planning unit with “use pins”, dummy geometries that are used as placeholders to create a spatial relationship with the planning units for main uses (star) and other/compatible uses (triangle).

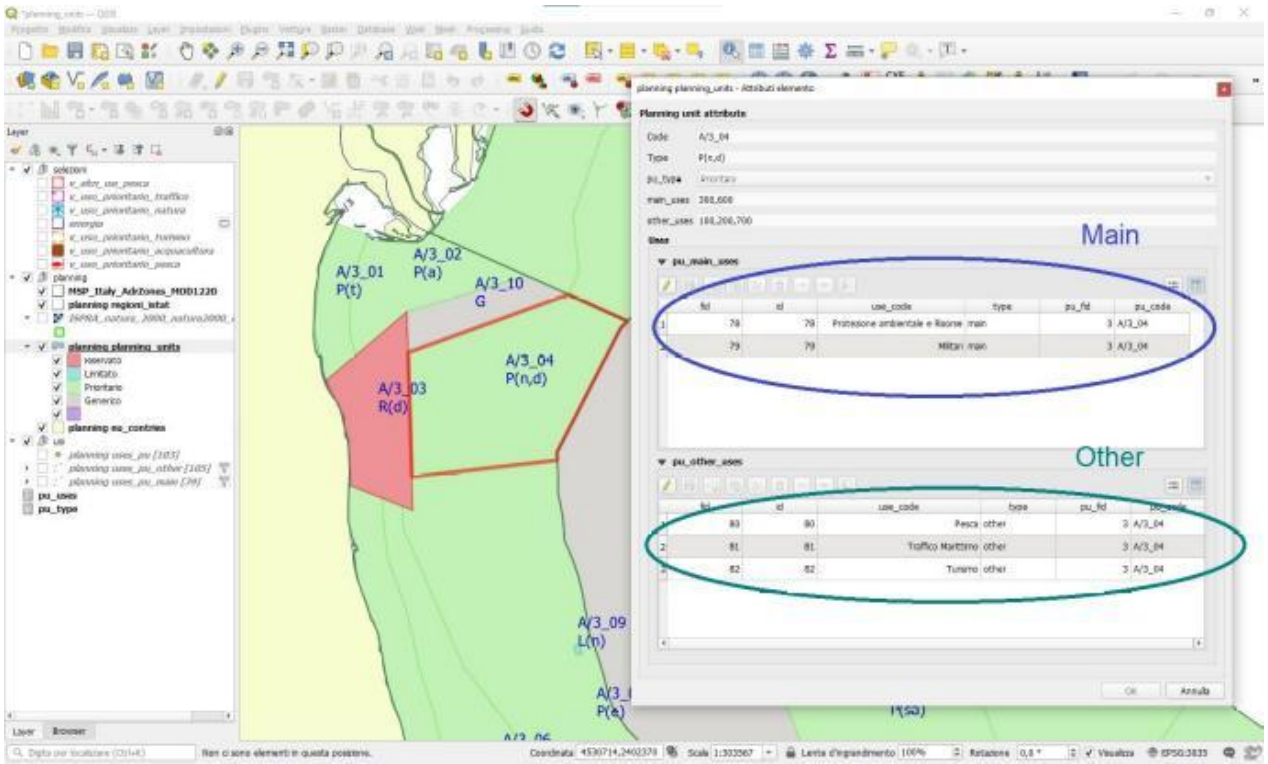


Figure 2.3: the QGIS custom interface to query and manage relationships for main uses and other uses

3 Software modules

3.1 MSP Italy - Flat Data Model Exporter

Module name	Flat Data Model Exporter
Module aim	Allow the publication of the geospatial components of the Italian MSP plan through the national portal by producing a simplified and ready-to-use data format and introducing all the necessary graphic elements (e.g. symbology, styles) for correct and effective representation of planning units, even in multi-use situations.
Programming language	Python
Platform	Jupyter notebook or other web-based platform
Requirements	Python scientific and geospatial stack (eg. numpy, pandas, geopandas)
Licence	Apache licence 2.0
Distribution	Download from Github repository: https://github.com/CNR-ISMAR/MSP-MED-Italian-Modules-/blob/main/MSP-Flat_data_model._exporter.ipynb
Inputs	Dataset of the Italian MSP plan structured through the “Italian MSP Data Model” specification and stored into a single geopackage file.
Outputs	Shapefiles, SLDs
Module details	The module export the DB data for MSP italian plan to a flat data model in ESRI shapefile format joining the uses linked to each PU in a single list by use code and by use name, both for main uses (u_p and u_p_txt attributes) and for other and compatible uses (u_a and u_a_txt attributes). The tool also generates all needed styles in XML format and SLD standard (OGC, 2007) according to the thematic symbology adopted in the vocation maps (see deliverable D5).

This module is a key element for the dissemination and publication of the cartographic view of MSP Italian plans. As described in the Section 2, the Italian MSP Data Model is managed and viewed using QGIS open source software which is available for free to all public.

To publish and share online the geographic representation of the three plans is necessary to convert the Italian MSP Data Model into a flat model and format that can be easily imported into the national geoportal SID (see deliverable D28) and disseminated through interoperable webservices.

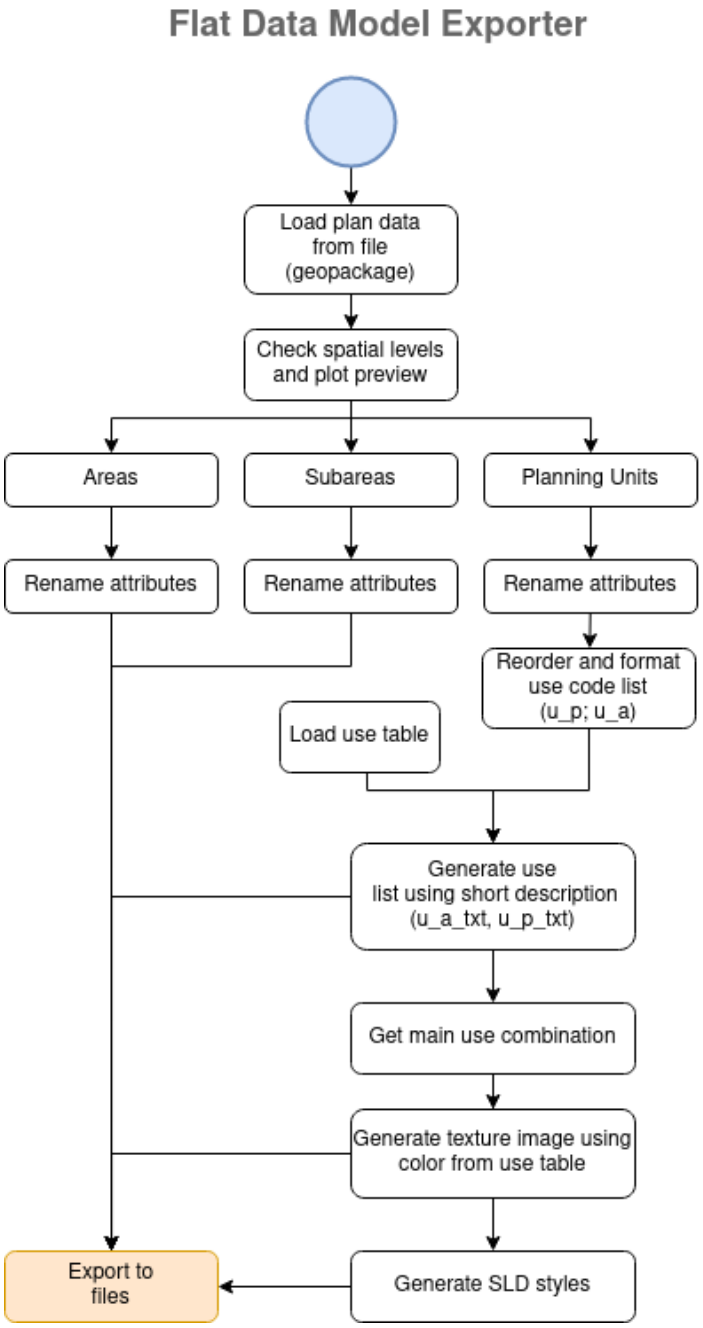


Figure 3.1 flowchart of flat model exporter module

The flowchart of the Flat Data Model Exporter is shown in Fig 3.1. After a first check of the attributes and the necessary fields, the Areas and Subareas layers are directly exported as shapefiles.
For processing the PU layer, the tool loads the “Uses” tables and generates (for each PU) a new text attribute with the list of the main uses and a new text attribute with the list of the other uses. The content of the new attributes is checked to be less than 255 characters and avoid truncation due to the limit of text available in ESRI shapefile format. The PU layer is then exported as a new shapefile.
After that, all combinations of different uses are considered and the tool generates texture images (PNG) to facilitate rendering of multi-use patterns. All symbologies and multi-use patterns are combined into a unique texture-based SLD document which is exported as a new .sld file to be paired with the PU shapefile previously created.
The symbology has been developed for representing the vocational maps of the plan (see deliverable D5) and texture-based SLD consent to recreate the same visual appearance as in the GIS environment (figure 3.2).

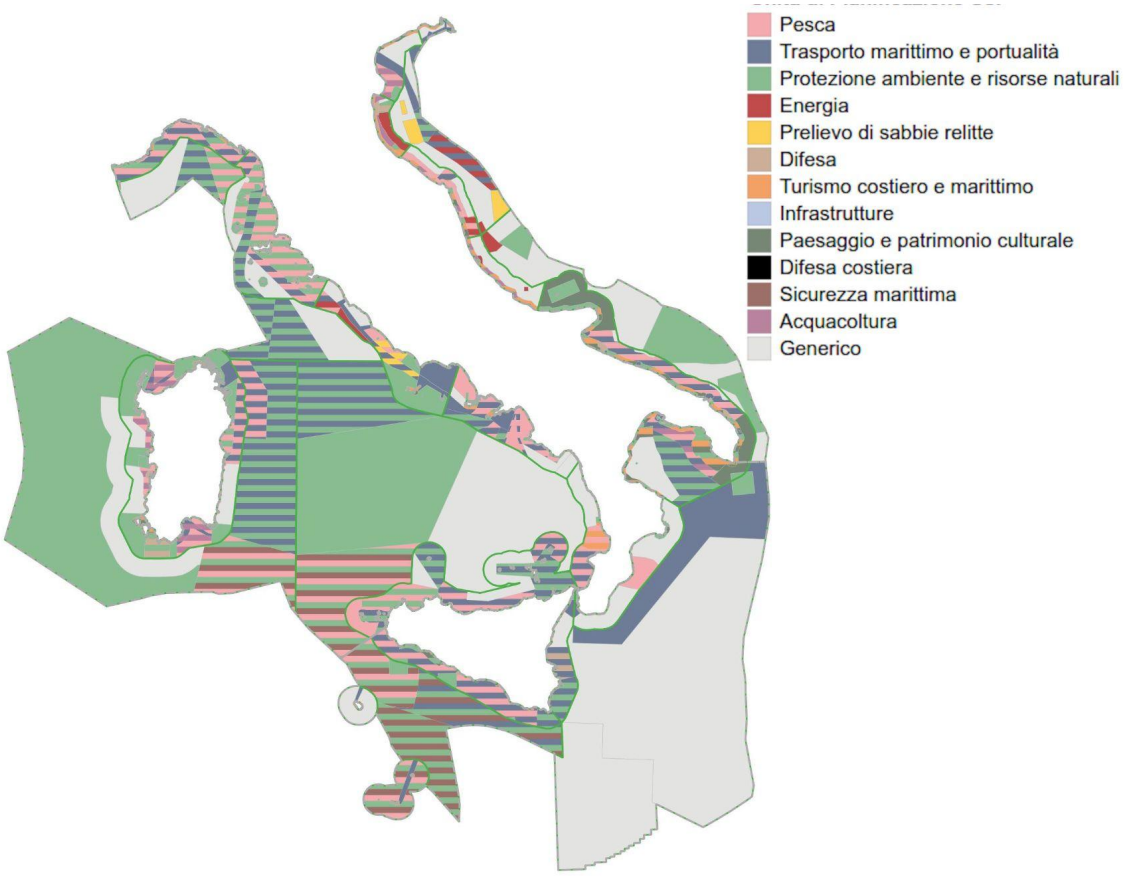


Figure 3.2: map rendered with texture-based SLD style that aggregate different colors in PUs with more than one main use.

Finally, additional SLD styles are generated for each use in the use list. PUs in which the use is reserved, limited or prioritary are rendered as solid color, while PUs where the use is permitted as other use are rendered with a cross-hatch (see. Fig. 3.3).

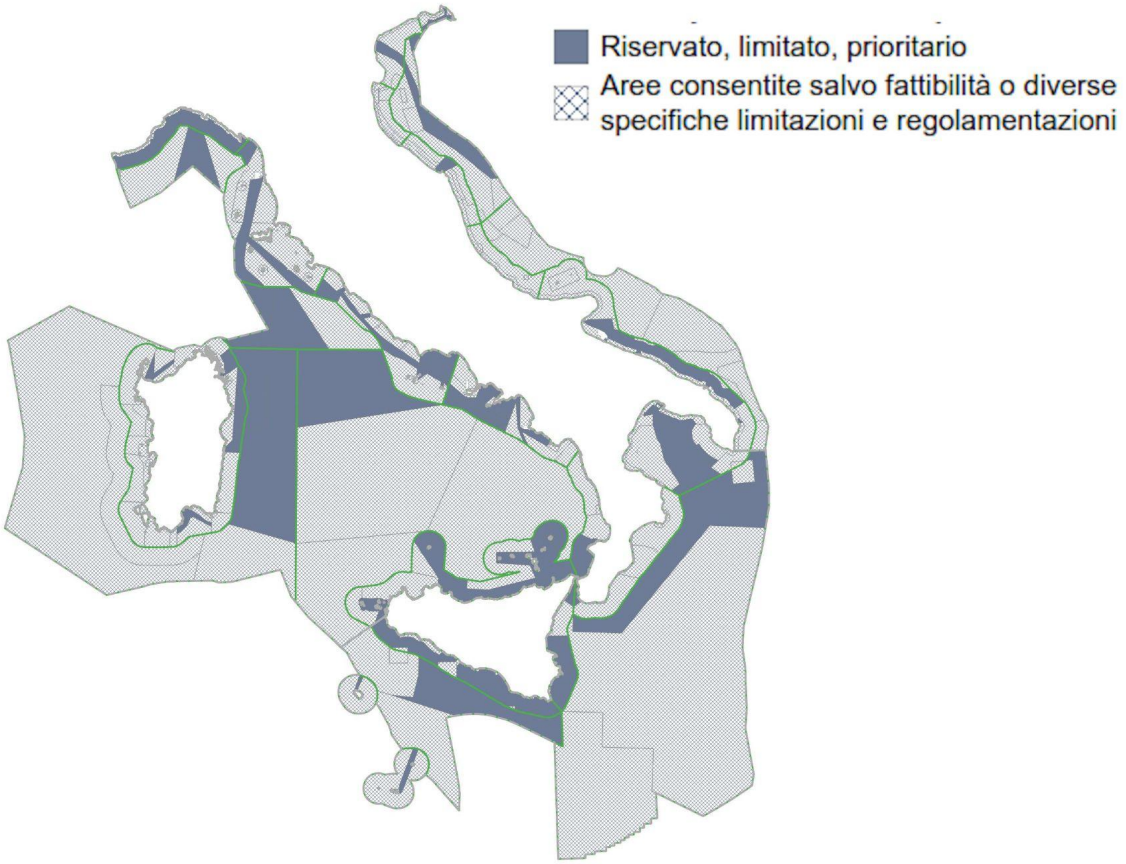


Figure 3.3: map for a single use (maritime transport)

3.2 MSP Italy - EMODnet Exporter

Module name	EMODnet Exporter
Module aim	Facilitate the consultation of the Italian MSP plan through EMODnet Human Activity geoportal. The module converts the spatial MSP data into the EMODnet MSP Data Model
Programming language	Python
Platform	Jupyter notebook or other web-based platform
Requirements	Python scientific and geospatial stack (eg. numpy, pandas, geopandas)
Licence	Apache licence 2.0
Distribution	Download from Github repository: https://github.com/CNR-ISMAR/MSP-MED-Italian-Modules/blob/main/MSP-EMODNet_exporter.ipynb
Inputs	Dataset of the Italian MSP plan structured through the "Italian MSP Data Model" specification and stored into a single geopackage file. Two configuration files in CSV format.
Outputs	Three geospatial layers in ESRI shapefile format
Module details	Attribute names and main contents (eg. human uses) are translated and re-mapped. Spatial representation (polygon) of PUs having multi-use destinations are replicated to multiple Zoning Elements because the EMODnet Data Model doesn't support many-to-many relationships between Zoning Elements and Uses. Subareas layer (containing plan specifications and prescriptions) is mapped to the Supplementary Regulation Featuretype. Outputs (shapefile) are intended to be ready-to-use for the EMODnet ingestion mechanism.

This module converts the Italian MSP Data Model to the EMODnet MSP Data Model (EMODnet, 2021). The EMODnet Data Model is closely related to the "INSPIRE model of Planned Land Use" (INSPIRE, 2013) and is structured in 4 many Feature Types: MSP Spatial Plan, MSP Zoning Element, MSP Supplementary Regulation and MSP Official documentation). Details for converting / mapping the Italian plan into the EMODnet feature types are:

1. **MSP Spatial Plan**: the main spatial element. It is derived from the Italian MSP **areas**. Attributes are translated.
2. **MSP Zoning Element**: all the spatial objects included in the plan, defining activities and specific land uses in certain areas. It is derived from the **Planning Units** layer. Multi-use PUs are replicated to multiple Zoning Elements features. Italian land use definitions are remapped according to the HILUCS (Hierarchical Land Use Classification System) attribute of the INSPIRE conceptual model and to the HILUCS MSP attribute of MSP INSPIRE data model (Abramic et al. 2018, 2019).
3. **MSP Supplementary Regulation:** documentation, defined mainly in regulations, reporting on existing limitations in the use of land in a given area. It is a non-mandatory spatial feature. It is derived by the Subareas layer which contains plan specifications and prescriptions).
4. **MSP Official Documentation**: all the documentation, included in the regulation or other official sources, that defines the 3 previous feature types. This is a non-spatial feature, and therefore will not be represented graphically in the EMODnet geoportal. **Documentation** of the Italian plan is published in the national geoportal aside the map.

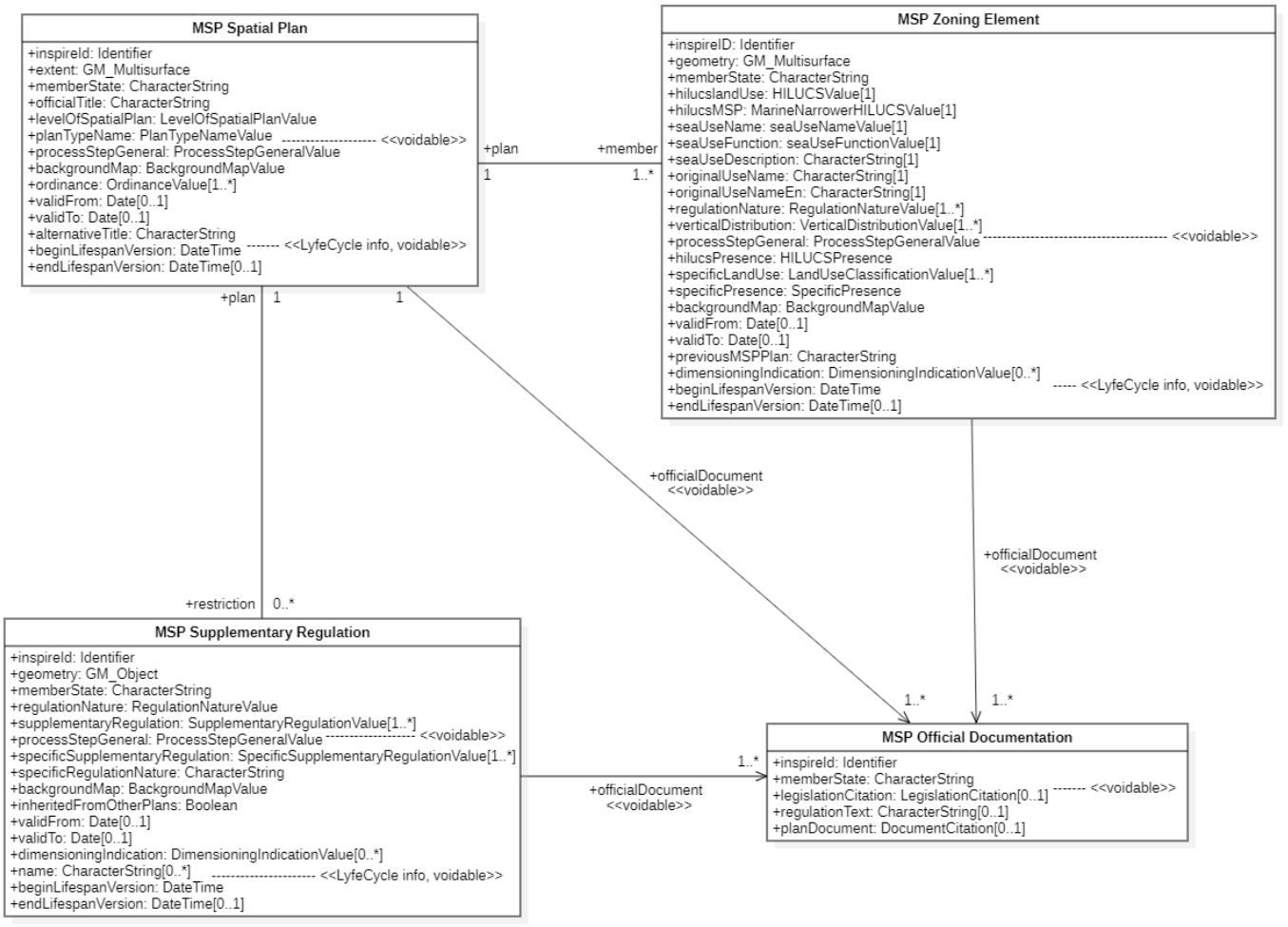


Figure 3.4: EMODnet MSP data model (EMODnet 2021)

To translate the attributes from italian MSP data to the EMODnet specification the module relies on two **configuration files:**

1. ***msp_emodnet_uses.csv***: extends the table pu_uses adding columns with value of emodnet theme, description, HILUCS and HILUCSMSP link for each use code of the Italian plan. A few rows are also added: a row with code "0000" for generic PU that is translated to the EMODnet model as a zoning element with "other/misc" use and two additional rows for energy use (0400) distinguishing between renewable energy (0410) and Oil&Gas extraction (0420). A dedicated function in the code assigns the correct use to each zoning element considering the notes field in the child element of each PU.
2. ***msp_emodnet_dictionary.csv:*** provides the field names of the EMODnet model layers (in the short form compatible with ESRI Shapefile format) (see table 3.1).

italian_msp_fieldname	**italian_msp_staticvalue**	**emodnet_ha_fieldname**
'IT'+Code + Type		LocalID
	1	VersionID
	https://www.sid.mit.gov.it	OffSource
	Italy	MS
[code, hilucs]		HilucLU
[code, hilucsmsp]		hilucsMSP
[code, emodnet]		SeaUseName
[pu_type, function]		SeaUseFct
[code, emo_desc]		SeaUseDsc
[code, use_ita]		OriginUN
[code, use_eng]		OriginUNEn
	Decree	RegNature

Table 3.1: dictionary for zoning elements layer. A two element list in fieldname column means that the software will query another table with first element and retrieve the second

3.3 MSP Italy - Exploratory data analysis

Module name	Exploratory data analysis
Module aim	Provide planners and decision makers with a systematic investigation of the main spatial and non-spatial characteristics of the MSP plan. The tool includes features for assessing data quality, detecting inconsistency and for analysing and visualising multi-use interactions.
Programming language	Python
Platform	Jupyter notebook or other web-based platform
Requirements	Python scientific and geospatial stack (eg. numpy, pandas, geopandas)
Licence	Apache licence 2.0
Distribution	Download from Github repository: https://github.com/CNR-ISMAR/MSP-MED-Italian-Modules/blob/main/MSP-Exploratory_data_analysis.ipynb
Demo visualisation	Nbviewer https://nbviewer.org/github/CNR-ISMAR/MSP-MED-Italian-Modules/blob/main/MSP-Exploratory_data_analysis.ipynb
Inputs	Dataset of the Italian MSP plan structured through the “Italian MSP Data Model” specification and stored into a single geopackage file.
Outputs	Profile report for the Planning Units dataframe (eg. quantile statistics, descriptive statistics, histograms, correlative statistics), multiple maps for marine areas, sub-areas and planning units, PUs statistics, maps and statistics for main use classifications, multi-use analysis.
Module details	The module incorporates functionalities to check data quality and identify possible inconsistencies.

Flowchart of the Exploratory Data Analysis tool is presented in Fig. 3.5. After initially data loading, the validation task will check for possible errors and issues (eg. duplicated rows, missing values, invalid geometries) on PUs records. Then the areas, sub-areas, and planning units are analysed sequentially. For each of these analyses, a series of summary graphs and

tables are immediately displayed to the user and simultaneously saved as CSV or PNG files (see Fig. 3.6).
The analysis of PUs is structured in several parts. First of all, an interactive report is produced (using the functionality offered by the pandas-profiling library[9]) that allows the user to investigate several aspects of the PUs (eg. quantile statistics, descriptive statistics, histograms, correlative statistics).
Then the three main characteristics of PUs are investigated in more detail:

- by location: coastal or offshore
- by PU_type: Generic, Prioritary, Limited and Reserved
- by main uses

Finally, an innovative approach has been developed to specifically investigate and analyse the multi-use nature of the Italian MSP plan. This approach is based on the UpSet plots[10] which were specifically designed for showing set data with more than three intersecting sets. In this case the plot is very useful to investigate how multi-use patterns occur in the PUs. Examples of UpSet analysis for the Italian MSP plan are shown in Fig. 3.7 where the characterization of PUs of the Adriatic MSP (top) and Ionian / Central Mediterranean MSP (bottom) in terms of number, size and assigned vocations of use are presented. The bottom panel provides a common legend for the understanding of the other three panels: single black dots refer to PUs (of priority, limited and reserved typology) with a single vocation, the grey dot to PUs of generic typology (where all maritime uses are equally considered), and connected dots to PUs (of priority, limited and reserved typology) with coexisting vocations (of 2 to 4 uses).
The upper panel illustrates the number (each orange dot represents a coastal PU, while each blue dot represents an offshore PU) and size (in km2) of PUs with single and coexisting vocations as well as of those categorised as generic. The panel in the middle shows the surface assigned to a single vocation of use, to combinations of different vocations and to the PUs of generic typology, expressed as percentage of the total surface of the maritime area. Finally, the panel at the bottom left shows the surface (still expressed as percentage of the total surface of the maritime area) assigned to each vocation of use, independently whether this is combined or not with others. PU = planning units (Ramieri et al., submitted).

The last block of the flow chart (cross-referenced analysis) will be included in a next version of the tool.

[9] Pandas-profiling python library: https://pandas-profiling.ydata.ai/
[10] UpSet plots: https://en.wikipedia.org/wiki/UpSet_Plot

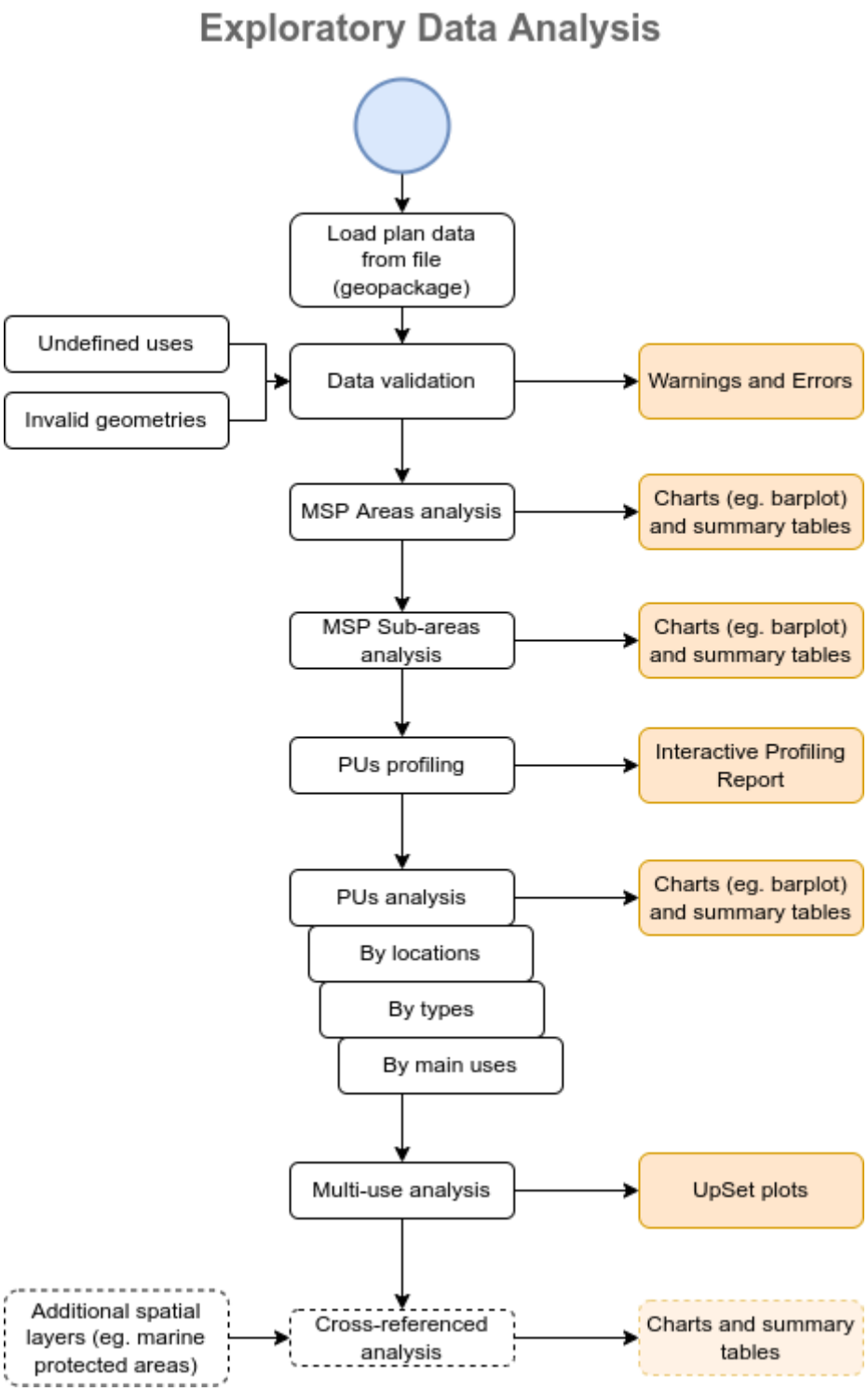


Figure 3.5 flowchart of the Exploratory Data Analysis tool.

Output examples

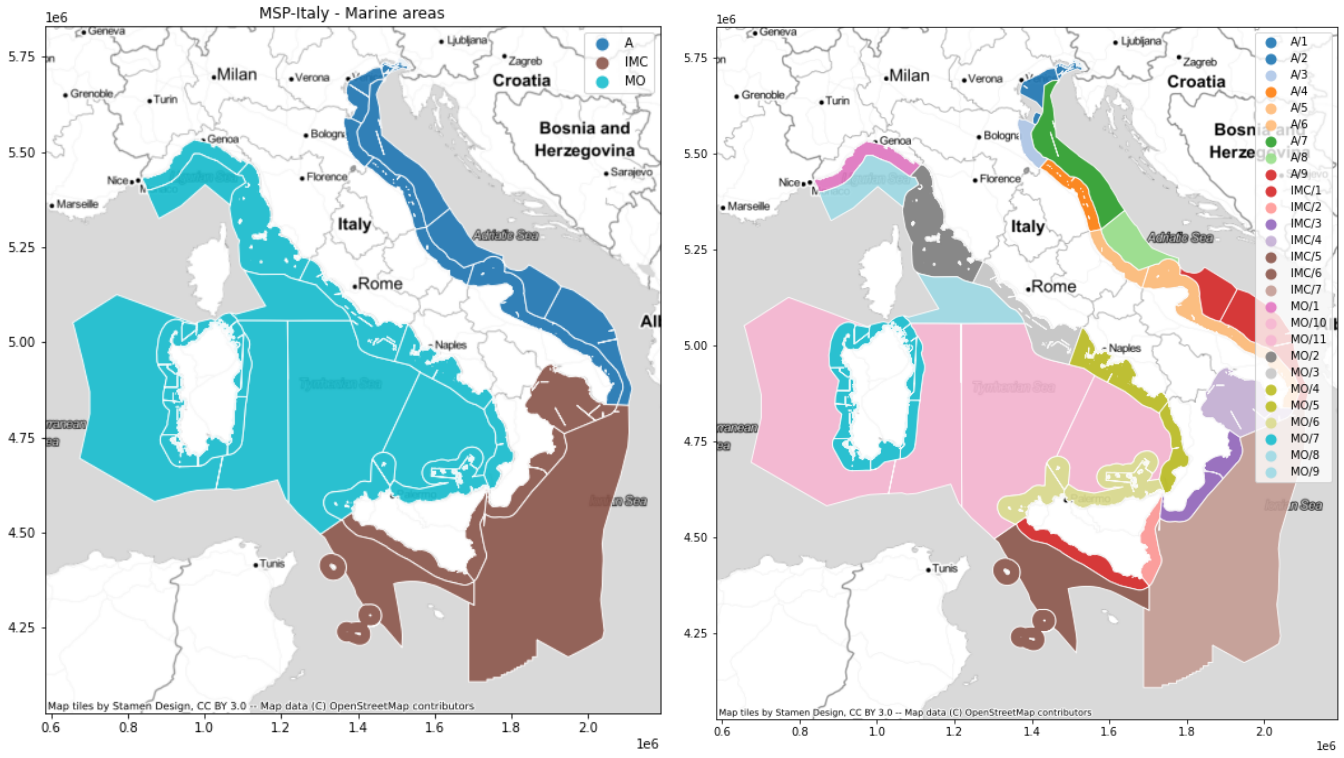
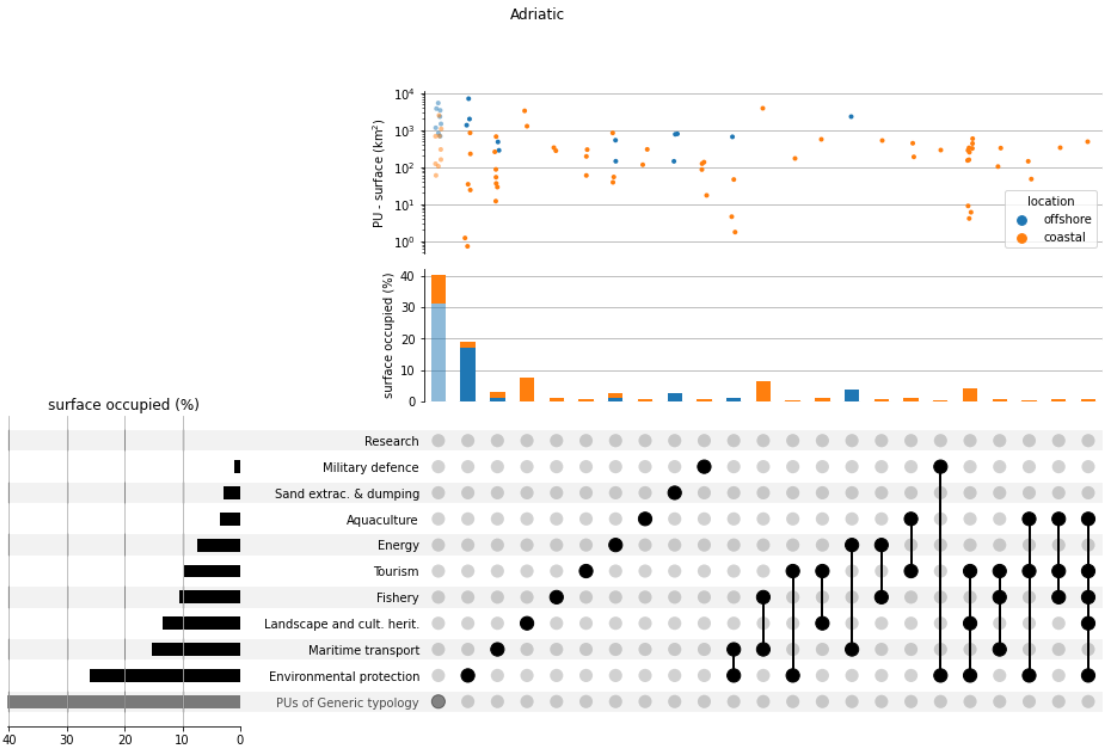


Figure 3.6 spatial representation of the Italian MSP areas (left) and sub-areas (right). Prefixes for the MSP areas are A - Adriatic; IMC - Ionian/Central Mediterranean and MO': Tyrrenian/Western Mediterranean.



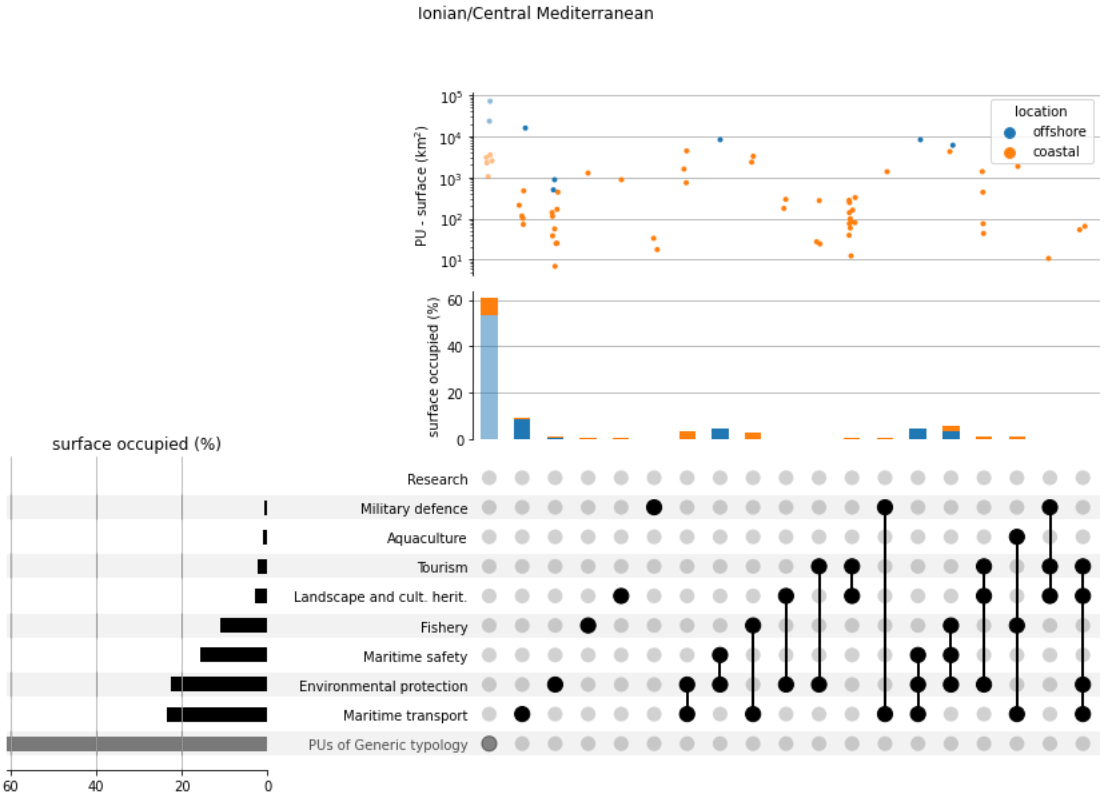


Figure 3.7 UpSet plots for the Adriatic MSP (top) and Ionian / Central Mediterranean MSP (bottom). UpSet plot facilitates analysis of intersecting sets and understanding of their interactions.

4 Conclusions and further developments

Tools developed under the 3.2.2 task of the MSP-MED project have proven to be critical in supporting the Italian MSP process and in particular the management, maintenance, analysis and sharing of geographic information contents associated with the plan.

The "Flat Data Model Exporter" tool was used to officially publish the geospatial components of the plan through the national portal which is at the moment open to the public to support the formal consultation phase.

The “EMODnet Exporter” will be used, as soon as the Italian plan is adopted, to pour information into the EMODnet Human Activities portal in accordance with the guidelines “Proposal for making harmonized MSP plan data available across Europe” produced by the Technical Expert Group (TEG) on MSP data (TEG, 2021).

Finally, the “Exploratory data analysis” tool was used during the preparation phase of the plan to identify in advance possible errors and issues on planning units and on other planning elements, and to provide overview statistics on plan characteristics.

In the course of activity T3.2.2, close collaboration was initiated with the TEG on MSP Data, which helped the design and identification phase of the tools and supported their development.
While so far the tools have proved suitable in supporting the plan process, they present a series of limitations that can be the object of future development and improvement.
In general all modules should be made more robust in handling exceptions and more flexible in adapting to erroneous or incomplete inputs and to minor changes in MSP structure.
Functionalities for checking and validating input data should be increased, made more robust and comprehensive and should be shared among all modules.
An important improvement comes from the need to incorporate into export files (for flat and emodnet models) not only the provisions contained in the planning units, but also those contained in the other levels in the plan. The Italian plan is in fact multiscalar, consisting of three levels: area, subarea and planning unit, each of which may contain specifications and provisions.
Within the tools (particularly the Flat Data Model Exporter and the EMDOnet Exporter) some statistical and graphical (eg. chart, diagrams) indicators should be introduced to allow the users to check in real time the quality of the produced outputs.
The statistics supported by the Exploratory Data Analysis need to be improved, for example by introducing new features to extract cross-referenced statistics between planning units and other MSP-related information layers (e.g., spatial distribution of human uses, conservation areas, bathymetry, distance from the coast, cumulative effects assessments).
In addition, in the next future, the tools will need to evolve in order to follow the next phases in the MSP plan implementation such as the need to incorporate information, data and indicators that will be provided by the monitoring systems. Extension of the Italian MSP Data Model will be necessary and which will consequently result in the addition of new features to the tools, especially in the the Exploratory Data Analysis and the EMDOnet Exporter.
To conclude, the three tools developed within the MSP-MED projects offer excellent insights and starting points for further development within national initiatives or new EU-funded projects where the tools can be extended to address cross-border issues (eg. extending the Exploratory Data Analysis tool to assess the transboundary coherence of plans).

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