CASE STUDY BOOKLET

Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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Enhancing ES mapping for policy and decision making

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CASE STUDY FACTSHEET

Mapping ES in Malta

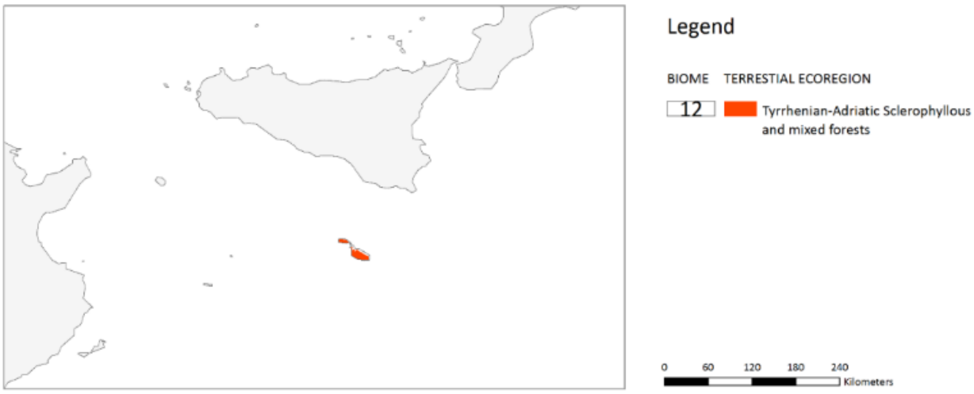
WS4_cs3

NAME AND LOCATION OF STUDY AREA	Maltese Islands
COUNTRY	Malta

STATUS OF MAES IMPLEMENTATION		
Stage 1	Stage 2	Stage 3

BIOMES IN COUNTRY

1 Tropical & Subtropical Moist Broadleaf Forests	4 Temperate Broadleaf & Mixed Forests
5 Temperate Conifer Forests	6 Boreal Forests/Taiga
8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
14 Mangrove	



SCALE		
national	sub-national	local

AREAL EXTENSION: 316 km²

THEMES

nature conservation	climate, water and energy	marine policy	natural risk
urban and spatial planning	green infrastructures	agriculture and forestry	business, industry and tourism
health	ES mapping and assessment		

ECOSYSTEM TYPES

urban	cropland	grassland	woodland and forest
heatland and shrub	sparsely vegetated land	wetlands	rivers and lakes
marine inlets and transitional waters	coastal	shelf	open ocean

1. Overview of the study area

The Maltese archipelago is a group of low-lying, small islands situated in the Central Mediterranean Sea at 96 km south of Sicily, almost 300 km east of Tunisia and some 350 km north of the Libyan coast. The archipelago is made up of three inhabited islands (Malta, Gozo and Comino) and several uninhabited islets, with a total land area of 316 km^2. The landscapes of the Maltese Islands have been shaped over several millennia by the geo-climatic conditions, and human exploitation, but nonetheless harbour considerable biodiversity; a consequence of the interesting biogeography of the Archipelago.

The Maltese Islands also have a long cultural history and the earliest evidence of settlement dates back to around 7200 BC. With agriculture being as old as humankind's remote origins on the archipelago, the landscapes of the Maltese Islands have been highly modified over the millennia. The first settlements were associated with deforestation for agriculture, the introduction of livestock and grazing activities. Today agricultural land cover occupies around 51% of the territory, whilst built-up, industrial and urban areas occupy more than 30% of the Maltese Islands. With a population density of 1,346 persons per km^2, the highest in the European Union, and a booming tourism industry, the Maltese Islands' biodiversity would be expected to be subject to substantial pressure. Within this context, the Maltese Islands make for an interesting model for analysis of the role of mosaic and multi-functional landscapes in the delivery of ecosystem services (ES).

2. Questions and Themes

The present ES assessment and mapping has been mainly scientifically-driven, with the objective of this study being that of carrying out a first assessment of the capacity and flow of ES in the Maltese Islands (Central Mediterranean). ES capacity is defined as the potential of ecosystems to provide services appreciated by humans, while ES flow refers to the actual use of the ES and occurs at the location where an ES enters within a utility or production function.

Given the insular and urbanized environment, and the dependence on local ecosystems for the delivery of key ES, a policy objective could be that of analysing the spatial variation of ES in Malta. This would permit for the identification of spatially overlapping bundles of ES, and for analyses of the impact of policies and developments on the ecosystems' capacity to deliver key ES, and on their actual flow.

This work is particularly relevant to policy objectives of Malta's National Biodiversity Strategy and Action Plan, which highlight the contribution of biodiversity to human well-being, set targets for the conservation and restoration of ecosystems providing key ES, and promote the mainstreaming of biodiversity concerns in relevant sectors and the recognition of the full range of values of biodiversity and ES.

3. Stakeholders' Involvement

Within the ES mapping and assessment process, stakeholders were involved as experts for selected ES or for data requests. In the latter case, governmental departments and authorities provided baseline environmental data. Within this study, two groups of stakeholders were consulted in the ES assessments, and data collected from stakeholder participation was used to generate maps of these services. In order to assess the aesthetic value (CICES 4.3 - Aesthetic) of landscapes of the Maltese Islands, a questionnaire was conducted with members of the public. Whilst in the assessment of the capacity of ecosystems in the provisioning of honey (CICES 4.3 - Reared animals and their outputs), data was collected from questionnaires and focus groups with beekeepers.

The study was presented to scientific officers and biodiversity experts at the Environment and Resources Authority (ERA). In its mission to safeguard the environment for a sustainable quality of life, the ERA plays a pivotal, lead role on a number of dossiers. These include air quality, biodiversity and protected areas, environmental noise, radiation, environmental permitting services, soil, waste management and water.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

The assessment of ES in Malta, presents a number of challenges, mostly associated with the availability of land use and other spatial data at relevant scales, and the scale of the existing spatial data. Corine Land Cover (2006, 2012) is available for Malta but given the heterogeneity of the landscapes, the presence of small landscape units, and the coarse categorization of agricultural areas that makes up almost half of Malta's land area, this was not used as a baseline map. For this purpose a land use land cover (LULC) map was developed. In addition, within this case-study, a tiered mapping approach, which makes use of different land-use datasets and ES assessment methods, was implemented. A LULC map was created based on Sentinel 2 satellite images provided by Copernicus. These were converted to reflectance. Images were then processed and mapped by applying a supervised multispectral classification with the maximum likelihood method. Ground truth areas were used during spectral signature creation, and for the evaluation of accuracy. The final classification consisted of a LULC map with 13 classes (see Figure 4.1).

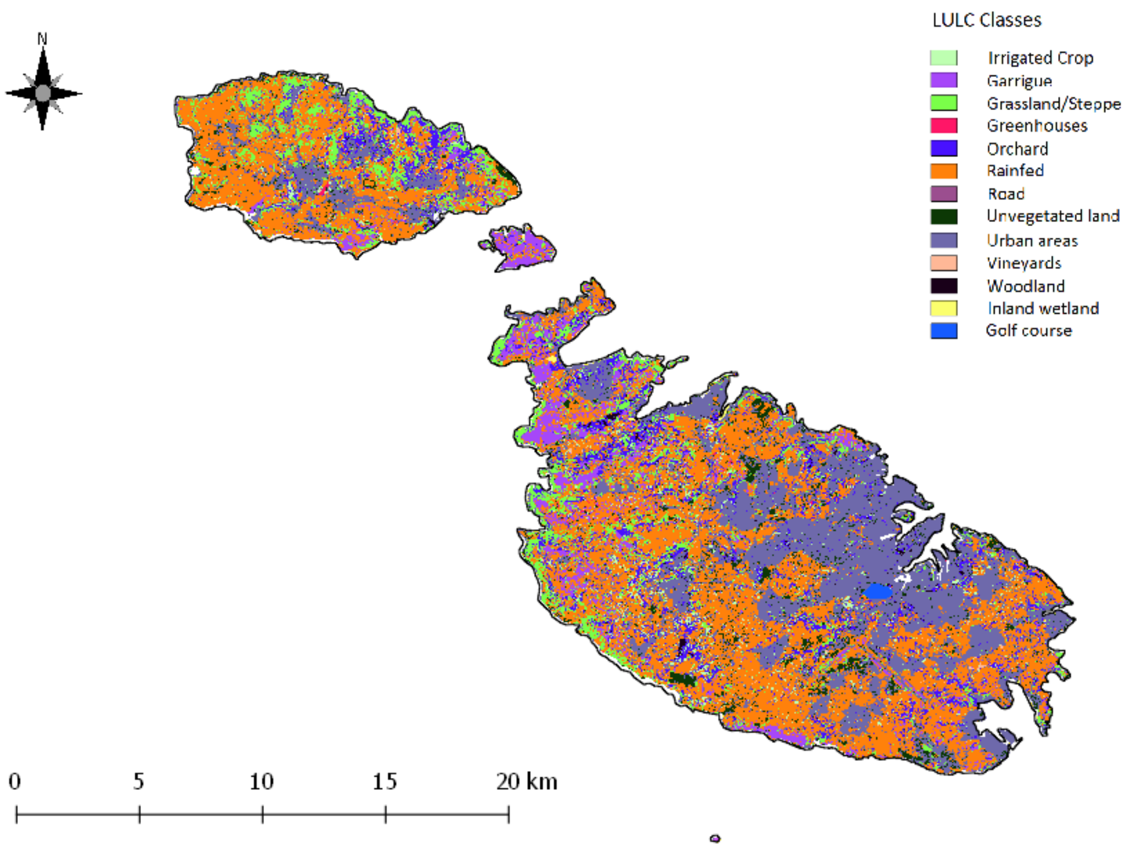


Figure 4.1. A land use land cover map of Malta was developed using Sentinel 2 satellite images.

4.2. Assessing ecosystem conditions

Ecosystem condition, defined as the effective capacity of an ecosystem to provide services relative to its potential capacity (MA, 2005), was not directly assessed within this case-study. However, the characterization of the habitats and landscapes through the use of satellite images within this study may be considered as a starting point for the assessment of ecosystem conditions. The produced land use land cover map characterizes the landscapes in terms of the ecological successional stages recorded in Malta, hence providing a proxy of the habitat and species characteristics and the pressures and disturbances acting on ecosystems.

In addition, the following spatially projected data was used to provide an indication of the ecosystem condition, and to assess the relative ability of ecosystems to deliver the selected ES, within this case-study:

- status of species and habitats (Art.17, Habitats Directive – see Figure 4.2)
- pollinator diversity in key habitats
- area of irrigated agricultural land

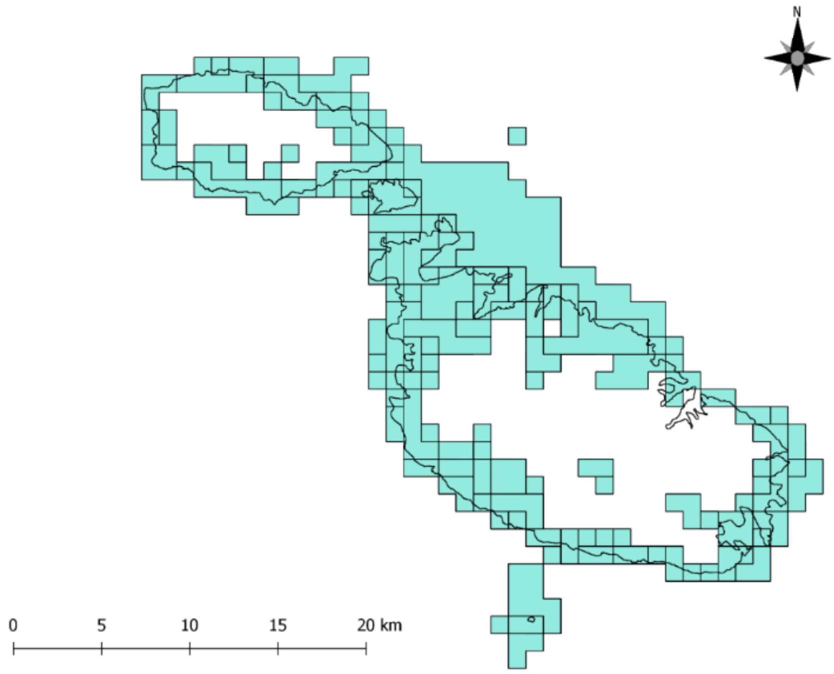


Figure 4.2. Shaded areas representing Annex I habitats' range in 1 km² cells (Art. 17, Habitats Directive).

4.3. Selecting Ecosystem Services

The selection of ES was based on expert knowledge and the availability of data and quantification methods, most of which have been used during or obtained from past and on-going research relating to the delivery of ES in the landscapes of the Maltese archipelago. Selected indicators were used to assess the ES capacity and flow in the landscapes of the Maltese Islands. Given the focus on the capacity and flow of ES in landscapes, only the ES delivered by terrestrial ecosystems were investigated in this study. For the purpose of this case-study a tiered mapping approach, which makes use of different land-use dataset and ES assessment methods, was implemented. Table 4.1 lists the selected ES in the case study, classified using the CICES v4.3 (2013) classification, and the related assessment method categories.

Table 4.1. Overview of the ES and related mapping and assessment methods in the Malta case study

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.1.1 Cultivated crops	X		
1.1.1.2 Reared animals and their outputs		X	
1.2.1.2 Materials from plants, algae and animals for agricultural use	X		
2.1.2.2 Dilution by atmosphere, freshwater and marine ecosystems	X		
2.3.1.1 Pollination and seed dispersal	X		
2.3.1.2 Maintaining nursery populations and habitats	X		
3.1.1.2 Physical use of land-/seascapes in different environmental settings		X	

* ES selected for further discussion during ESMERALDA workshops 4 in Amsterdam;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

The assessment and mapping of ES was performed using the developed land use land cover map for the study area and available data sets. The biophysical methods included the delineation of areas for crop and fodder cultivation and the downscaling of national statistics (Tier 2), and the modelling of the relationship between biophysical structure of ecosystems and ES delivery using available data sets (Tier 3).

5.1.1. Mapping of provisioning services

1.1.1.1 Cultivated crops
Indicator: *Irrigated agricultural land (Capacity/Flow)*
Downscaling crop cultivation national data for irrigated agricultural land.

1.2.1.2 Materials from plants, algae and animals for agricultural use
Indicator: *Rain-fed agricultural land (Capacity/Flow)*
Downscaling fodder cultivation national data for rainfed agricultural land

5.1.2. Mapping of regulating and maintenance services

2.3.1.1 Pollination and seed dispersal
Indicator: *Pollinator Diversity (Capacity)*
A spatial proxy model that relates pollination ES to the land cover was developed during this study. The objective, in this case, was to analyse the contribution of different land cover categories to the diversity of pollinators in a number of points within landscapes of the Maltese Islands. Subsequently, spatial proxy models were developed to link pollinator diversity to the area cover of different land uses. The model estimates for significant variables were then used to predict the contribution of different landscape units to the delivery of pollination ES within the landscapes.

2.1.2.2 Dilution by atmosphere, freshwater and marine ecosystems
Indicator: *Pollutant deposition velocity (Capacity)*

Indicator: *Dilution of atmospheric pollutants (Flow)*

NO_2 dry deposition velocity [Air quality regulation - Capacity] on vegetation was considered as a proxy to assess the ecosystems' capacity to remove pollutants from the atmosphere. The method used here follows the work by Pistocchi et al. (2010) which estimates deposition velocity as a linear function of wind speed at 10 m height. NO_2 dry deposition flux [Air Quality Regulation - Flow]: NO_2 removal flux was based on the predicted concentration of NO_2. A statistical model was used to relate point NO_2 concentration data to environmental variables, and then this model was used to predict the NO_2 concentration in a grid. Point data was then interpolated using inverse distance weighting. Annual NO_2 removal was estimated as the total pollution removal flux in the areas covered by vegetation, calculated as the product of NO_2 concentration and deposition velocity maps (see Figure 5.1).

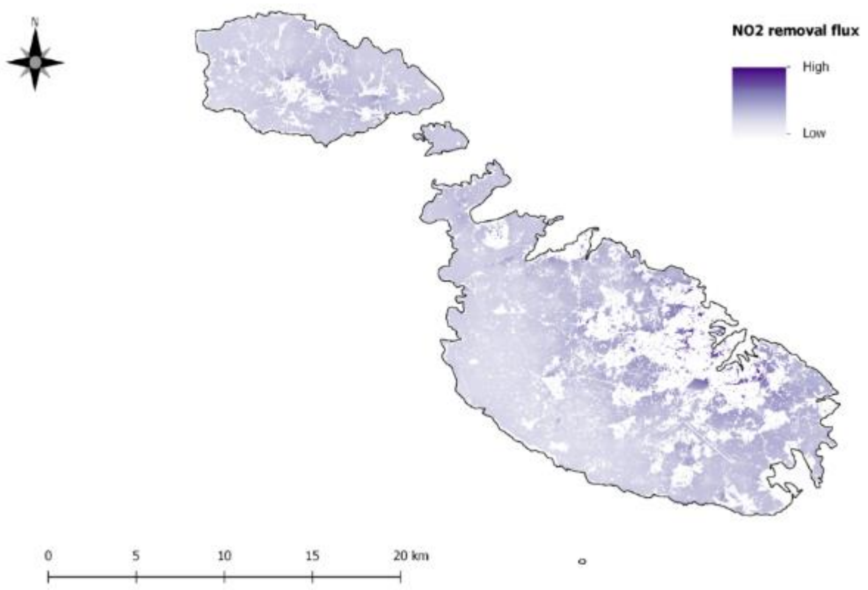


Figure 5.1. Removal of NO2 flux

5.1.3. Mapping of cultural services

3.1.1.2 Physical use of land- /seascapes in different environmental settings

Indicator: *Habitats of community importance (Capacity)*

The number of habitats protected in Annex 1 of the Habitats Directive was used as a proxy for the capacity of ecosystems to provide opportunities for experiential uses of landscapes. Point values, extracted from 1 km^2 grid cells, were interpolated using inverse distance weighting.

5.2. Socio cultural methods for ES mapping and assessment

The used social methods are based on preference assessments conducted with ES users (Tier 1). In the first case, a two-stage process was used for data collection on the importance of local ecosystems for beekeeping and honey production. This methodology involved the use of questionnaires and focus groups. In the assessment of physical use of landscapes, questionnaires were conducted with locals. Data relating to the uses in these sites, as well in green urban areas, were collected in this study but only the data set relating to site visitation is presented here.

5.2.1. Mapping of provisioning services

1.1.1.2 Reared animals and their outputs – Honey Production

Indicator: *Honey Production (Capacity)*

A preference assessment exercise was carried out with beekeepers to determine the characteristics of ecosystems preferred for honey production and beekeeping. Questionnaires were used in the initial stages of the research to determine the preferred plants and habitats, and their contribution to the delivery of the ES. This was followed by a focus group with another group of beekeepers, during which they were asked to provide information about the role of different ecosystems across time and space. In this case, an emphasis is placed on collective preferences of service users (see Figure 5.2).

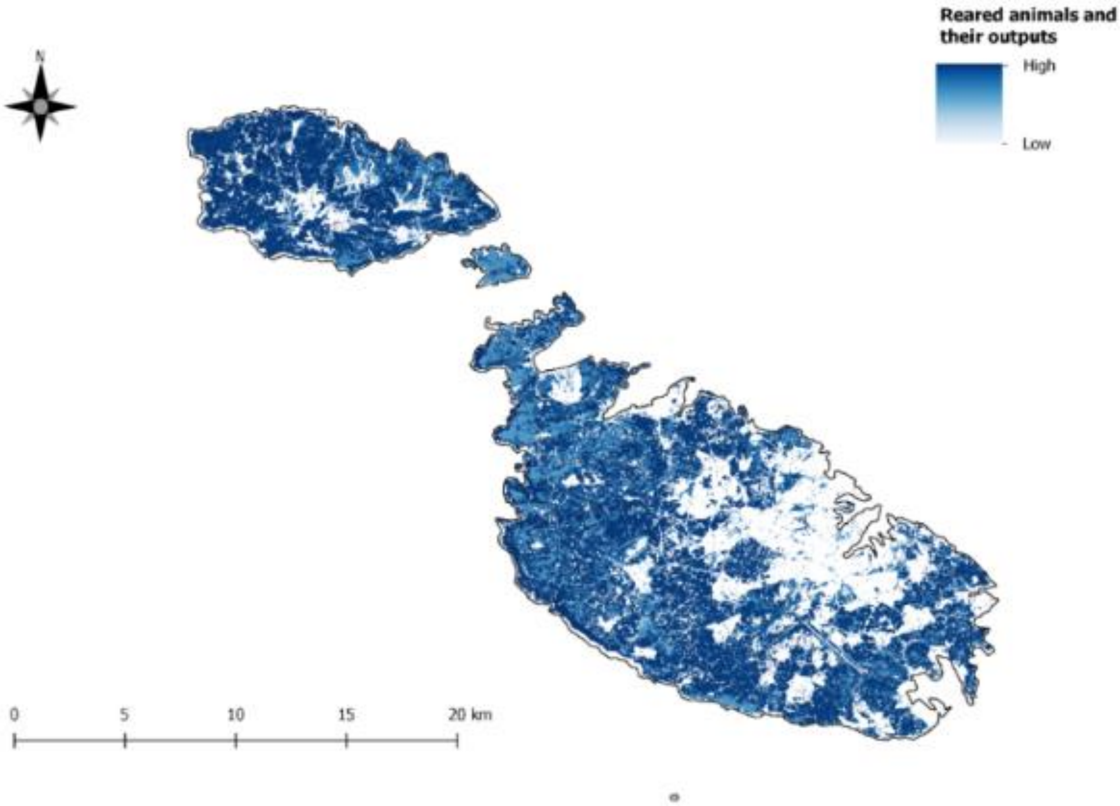


Figure 5.2. Map based on preference assessment for beekeeping and honey production.

5.2.2. Mapping of cultural services

3.1.1.2 Physical use of land- /seascapes in different environmental settings.

Indicator: *Site visitation/Preference Assessment (Flow)*

A questionnaire was submitted to locals, who were asked to identify places and landscapes (n=118) in Malta that they have visited and are of high aesthetic value, and the type of activities they normally carry out at these sites.

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5.3. Integration of ES mapping and assessment results

Results obtained in this study provide a first assessment of the contribution of ecosystems to the delivery of key ES in the multi-functional landscapes of the Maltese Islands, and enhance our understanding of the existing links between biodiversity and ES capacity and flows.

A statistical analysis of the generated ES maps, using multivariate and environmental modelling techniques, demonstrates how Malta's rural landscapes, characterized by patches of semi-natural and agricultural areas, are important for the delivery of these key ES. Results obtained here demonstrate how these ecosystems within multi-functional landscapes contribute to the delivery of more than one ES, effectively resulting bundles of ES that repeatedly appear together across space or time. Moreover, these results indicate that whilst in some cases the capacity and flow of ES overlap spatially (e.g. nursery habitats and experiential use), in other cases capacity and flow vary with environmental characteristics and hence also spatially (e.g. NO_2 deposition velocity and NO_2 removal flux).

6. Dissemination and communication

Results obtained in this case-study have been disseminated during scientific conferences, and were presented to some of the key stakeholders. Through stakeholder participatory meetings with beekeepers, it has been possible to disseminate results and better develop an understanding of the links between their activities/preferences and the environment. This case-study has been presented to the Environment and Resources Authority (ERA). In addition, dissemination meetings conducted for practitioners, students and members of the public have been used to communicate some of the results presented in this case-study. Future activities should work on the science-policy-society interface in order to make the results useful for natural resources management and urban planning.

7. References & Annexes

References

Nowak, D.J., Crane, E.D & J.C. Stevens (2006). Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening 4, p. 115-123.

Pistocchi, A., Zulian, G., Vizcano, P & D. Marinov (2010). Multimedia Assessment of Pollutant Pathways in the Environment, European Scale Model (MAPPE-EUROPE). Publications Office of the European Union, Luxembourg.