Seagrass mapping in Cyprus area of interest with pixel-based classification

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ABSTRACT

Seagrasses are one of the most valuable ecosystems in the sea. Seagrasses provide shelter and protection to newborn fish, and food, it is an indicator of the health of coastal ecosystems and plays a key role in the protection of erosion. Seagrasses provide many ecosystem services. In order to act helpfully for the health of this kind of valuable ecosystem, it is very important to map the seagrass beds. Seagrass mapping allows us to detect, monitor, and finally protect them from different sources of pressure. Seagrasses are very sensitive to changes, and this can affect the health of this type of ecosystem. For the first step, we have to detect what exists in Cyprus's area of interest. There are many ways we can implement the detection and mapping of seagrass. We will provide an estimation with pixel-based image analysis. The purpose of the paper proceedings is to detect seagrass with pixel-based image analysis, in Cyprus's area of interest, and especially the broader area of Paphos district.

Keywords: Seagrass, Sentinel-2, Pixel-based classification

1. INTRODUCTION

Seagrass is one of the most valuable ecosystems and species on planet earth providing a plethora of ecosystem services [1]. Seagrasses are characterized as critical marine ecosystems because they participate in crucial marine processes such as protection and conservation, coastal protection, and carbon sequestration. Seagrasses help in the protection and conservation of marine ecosystems as they act as ecological indicators. They are protected from the legislation under 'The Wildlife Protection Act, 1972', the Notifications under the 'Environment (Protection) Act, 1986' and the 'Biological Diversity Act, 2002'. Under the Water Framework Directive (WFD 2000/60/EC) they are used as indicators for the ecological status for coastal waters[2,3]. They are highly productive ecosystems as young juvenile fishes and other fish species can find food, shelter and protection from predators [4].
Seagrass act against the coastal erosion [1,5]. They have the ability to trap in their roots and rhizome sediment, stabilizing it (sediment accumulation and stabilization) [5]. Seagrass meadows have the ability to store big amounts of carbon making them large blue carbon stocks [4,6].
Remote sensing helped humanity to gather information from distance, even in the most unreachable places on Earth. It provided many applications such as bathymetry estimation, ocean and coastal monitoring, land use mapping, weather forecast, natural hazards monitoring in many sectors, such as geography, chemistry, geomorphology, oceanography, agriculture, topography, and many other sectors. Earth Observation (EO) has the ability to scan the Earth from a distance, contributing to the monitoring, protection and conservation of the different seagrass species. It has different key components and one of these is the multi-spectral sensors.

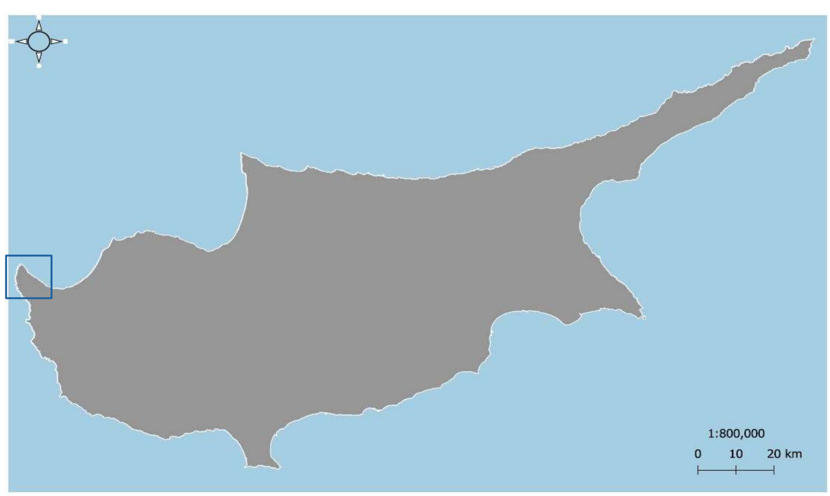

Figure 1:Study site- Boarder area of Paphos District- Cyprus

Mapping seagrass based on Earth Observation (EO) techniques have been used for a regional [7] or a global [8] scale. In Cyprus, through literature review we found the research of Yfantidou and Hadjimitsis (2019) that used remote-sensing and GIS techniques to map seagrass with different classifiers[9]. In Vasiliko Bay, in the coastline of Cyprus, implemented a GIS-based technique to map seagrass [10].
In the regional scale of seagrass mapping for the whole Mediterranean area there are four approaches we investigated through literature review. The research of Telesca et.al (2015) stated that there are 9,040 ha of *Posidonia oceanica* meadows but the investigated area was 30%[11]. Pergent-Martini et.al (2021) found in a mapped area of 23% that 3,627 ha are *Posidonia oceanica* meadows[6]. Traganos et.al (2022) provided an estimation of seagrass coverage in the Mediterranean and found 9,040 ha from which 4445ha are in depth of 0-25m.
In this paper, we provide a regional scale seagrass estimation for the Cyprus area of interest. It is a cost-effective approach and can be combined with different approaches and methods.

2. METHODOLOGY

For the estimation of seagrass distribution, a single image of Sentinel-2A, Level 2A, was used. Level 2A data gives the opportunity to end users, to combine different approaches and methodologies. The image used for the analysis, refers below:

- S2A_MSIL2A_20230123T083241_N0509_R021_T36SVD_20230123T111558

The image is Sentinel-2A and Level 2A was acquired 23 January 2023, scans the area of 36 SVD with the MultiSpectral Instrument.

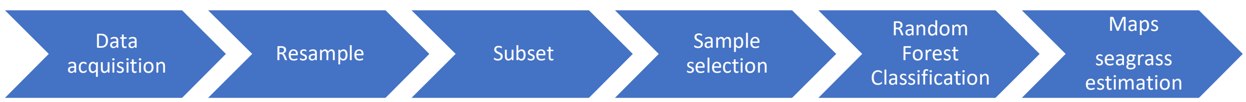

Figure 2:Methodological Framework applied for the seagrass distribution estimation.

The methodological framework applied in the Sentinel Application Platform (SNAP) software (version 8.0 used since 04/2023) that is freely available from ESA's website (http://step.esa.int/main/download/snap-download/). On the website is available, also, the 9th version.
The first and crucial part of the methodology is to download the most suitable data for the analysis. It is important to download data without clouds, and the sea state to be free of wind waves and swells.
The first step of the analysis in the software is to resample the data. Due to the combination of different spatial resolution of bands of Sentinel-2 images, it is important to implement this type of method, to proceed to other steps.
The second step refers to the subset in the desired area of interest. We selected and cut the boarder area of Paphos district, for the estimation of seagrass distribution.
We used the photo interpretation keys, of color, pattern, and shape, to extract the samples we used for the analysis. Finally, the Random Forest classification used for detecting seagrass. The processing parameters are shown in the Table below:

Table 1:Processing parameters for the classification

Processing Parameters	
Number of training samples	5000
Number of trees	20
Training vectors	Seagrass, soft bottom, deep water
Feature bands	B2, B3, B4, B5, B6, B7, B8

The classification result refers to the estimation of the seagrass presence in the area of interest.

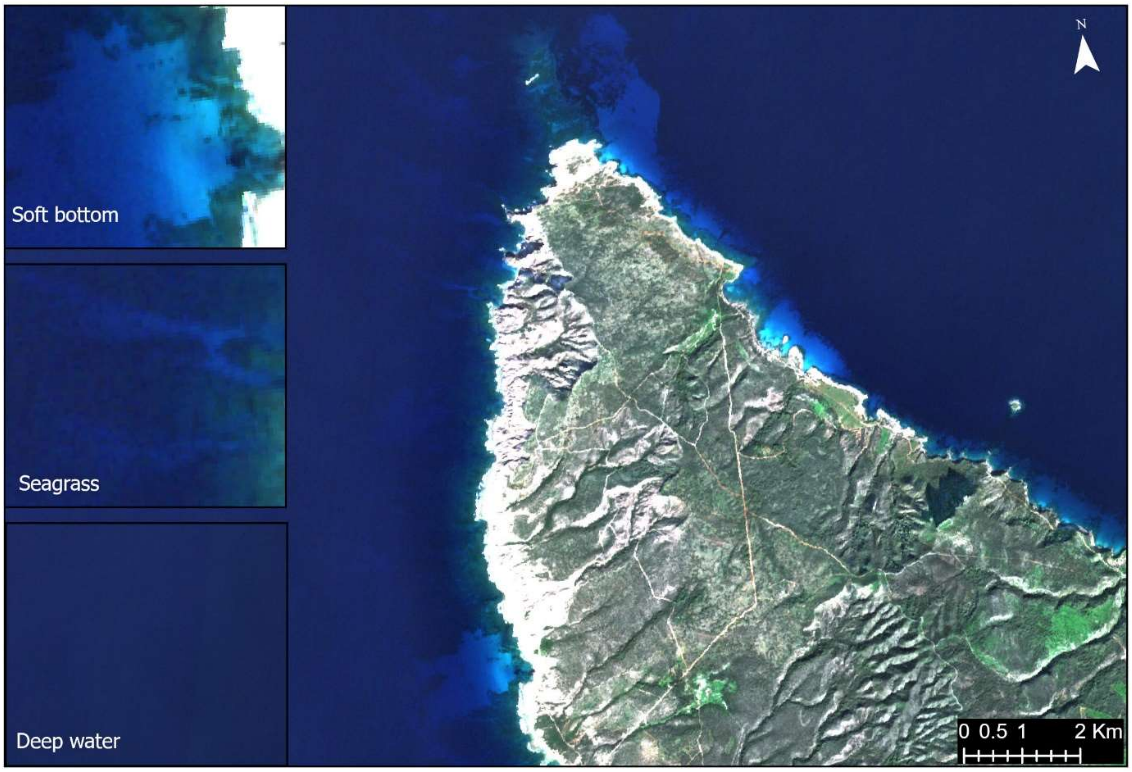

Figure 3:The three desired classes which participate in the image analysis; soft bottom, seagrass presence, deep water. The classes were extracted via photointerpretation.

3. DATA

The study area is located south of the Anatolian Peninsula in the eastern Mediterranean. Cyprus is the easternmost Mediterranean island in the Levantine basin. It is the third largest island in terms of extent and population. Cyprus border on north of Egypt, east of Greece, south of Turkey, and west of Lebanon and Syria. It is a critical geopolitical site for the EMMENA region. The climate is characterized by wet winters (short period) and dry summers (long period). The island's geomorphology can be described by two mountain ranges: Troodos and Pentadaktylos. The first has Olympus which is the highest peak at 1951m and the latter at 900m. Between the ranges there is the Mesaoria plain. Finally, the coast is consisted of narrow and flat strips of land [12].

For the seagrass mapping estimation in the broader area of Paphos district, satellite data of Sentinel-2A, Level-2A, with the MSI (Multispectral Instrument) were used. Satellite Sentinel-2A was launched on 23 June 2015 with Copernicus Programme from European Space Agency (ESA). The high temporal resolution (every 10 days for single Sentinel-2 or every 5 days for combined constellation revisit) and the difference in spatial resolution, accordingly the bands (e.g., 4 bands in 10m: B2 (490 nm), B3 (560 nm), B4 (665 nm) and B8 (842 nm); 6 bands in 20m: B5 (705 nm), B6 (740 nm), B7 (783 nm), B8a (865 nm), B11 (1610 nm) and B12 (2190 nm); 3 bands in 60m: B1 (443 nm), B9 (940 nm) and B10 (1375 nm); make the data useful for many applications. In the present study, the data mainly used had a spatial resolution of 10 and 20 m and concerned the part of Cyprus of 36 SVD. The data are provided free from Copernicus Open Access Hub (website last visit: 04/2023: https://scihub.copernicus.eu/dhus/#/home). We used a single image of Sentinel-2A and implemented the seagrass mapping classification.

Figure 4: Sentinel-2A image, that we implemented seagrass mapping classification.

4. RESULTS

In this study, we provide an estimation of the presence or absence of seagrass meadows in Cyprus area of interest. The estimation derives from satellite remote-sensing with Sentinel-2, Level-2A data. Our analysis is based on the careful photointerpretation for the sample extraction in the four desired classes.

In this part of the island, we can see the western part that is consisted of soft bottom, mainly, partially distributed seagrass meadows. In the eastern part of the area of interest, seagrasses are linear and follow the coastline. There are three major beaches with soft bottom. All the above mentioned is a result of photointerpretation.

In general, in the area of interest, the biggest part of the image pixels which participate in the analysis, are classified as Deep water in a percentage of 66% and Land in percentage of 30%. There is also a small percentage of 1.91% which is classified as soft bottom and the presence of seagrass consists of the 1,58%.

Table 2: Analysis results for the estimation of seagrass distribution in percentage cover

Classes	Percentage
Deep water	66.18%
Land	30.33%
Soft bottom	1.91%
Seagrass presence	1.58%

There is a trend of increase from the eastern to western part of Cyprus. We have to combine the results with further meteorological or climatical data.
Further analysis and in-situ measurements are important to reassure the existence of seagrass in the different areas of interest, and to check the estimation.

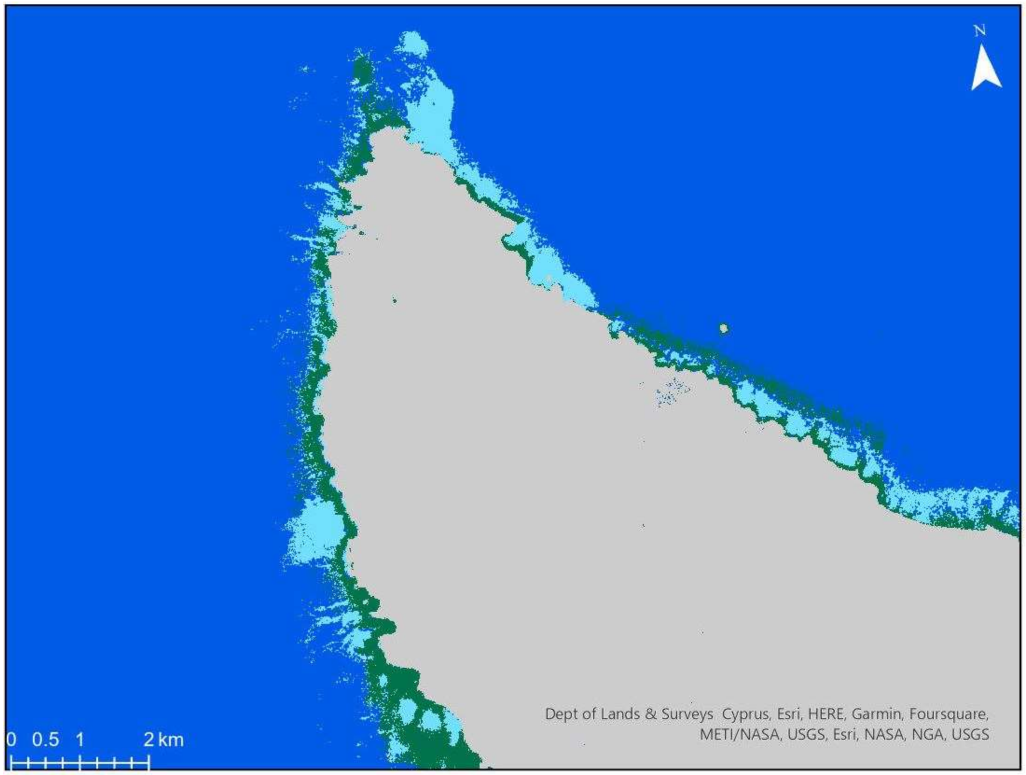

Figure 5: Estimated seagrass distribution; the results were produced via Random Forest Classification

5. CONCLUSIONS

Seagrass meadows provide plenty of ecosystem services. Seagrass meadows are key factors for water quality and are one of the elements to evaluate the status of the coastal waters. It is included in the Water Framework Directive and the monitoring programmes. It is crucial to provide monitoring services on a seasonal or yearly basis for better understanding the spatio-temporal behavior and how climate change affects the growth or their life cycle.
There is a gap in the literature for Cyprus. We have to map and monitor all seagrasses that exist in the desired area and provide useful information in the different Departments and Stakeholders.
Earth Observation is the key component in the monitoring, as it provides a cost-effective approach in large area coverage. Further analysis has to be carried out in different disciplines. First, we have to map all the seagrass meadows in the whole area of Cyprus. We will combine different approaches with satellite and in-situ data. We will implement object-based image analysis and/or combined methods with Google Earth Engine.

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