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Land use and land cover classes affected by possible sea level rise in Mersin city center

Onur Güven [*1], **Ümit Yıldırım** [2], **Cüneyt Güler** [3], **Mehmet Ali Kurt** [4]

[1]*Bayburt University, Central Research Laboratory, Bayburt, Türkiye*
[2]*Bayburt University, Faculty of Applied Sciences, Department of Emergency Aid and Disaster Management, Bayburt, Türkiye*
[3]*Mersin University, Engineering Faculty, Department of Geological Engineering, Mersin, Türkiye*
[4]*Mersin University, Engineering Faculty, Department of Environmental Engineering, Mersin, Türkiye*

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Abstract

In this study, a sea level rise (SLR) investigation was carried out in an area representing the Mersin city center located in the south of Turkey. The study area covers an area of *ca*. 385 km^2. Future projections provided by the IPCC were used for the SLR assessment. These projections are for the years 2100, 2200, 2300, 2400, and 2500 and the SLR for these periods are 0.83 m, 2.03 m, 3.59 m, 5.17 m, and 6.63 m, respectively. It is aimed to determine the areas affected by the SLR that will occur according to these projections. In this context, land use and land cover (LULC) data were obtained from the CORINE 2018 dataset. The data obtained were adapted within the boundaries of the study area and processesed using various GIS analyses. The results have shown that all LULC classes are greatly affected by the SLR, but in varying degrees. Land losses as a result of SLR are as follows: 0.4% at 0.83 m SLR, 9.8% at 2.03 m SLR, 16.7% at 3.59 m SLR, 21.6% at 5.17 m SLR, and 25% at 6.63 m SLR.

1. Introduction

Coastal regions are areas of critical importance in terms of the possible effects of climate change. Sea level rise (SLR) is one of the most important consequences of climate change affecting people living in coastal regions. (Antonioli et al., 2020). It is inevitable that Turkey, which is surrounded by the sea on three sides and has a coastline of 8333 km (Demirkesen et al., 2008), will be affected by SLR. Sea water levels are rising due to two different parameters defined as increasing the water volume of the seas and cumulative expansion (EPA, 2016). The sea water level has increased by 98 mm from 1993 to the present (NASA, 2023) and has increased by 3.2 mm/yr over the last decades (Antonioli et al., 2020). According to data based on tide measurements, the SLR in the Mediterranean basin is 1.8 mm/yr (Antonioli et al., 2020).

Mersin is the city that has the longest coastline in Turkey, with a length of 321 km (MCT, 2023). The population of Mersin is 1,916432 as of the end of 2022, and it is one of the most populous cities in Turkey (TSI, 2023). 53% of the Mersin city consists of forests, 21% is agricultural lands, 22% is non-agricultural lands, and 4% is meadows and pastures (MTSO, 2023). In addition, Mersin, which ranks 1st in Turkey with a container business volume of 2.1 million TEU, has an essential economic infrastructure in maritime trade (MIP, 2021).

There are many studies on this subject in Turkey, but studies on micro-scale areas are limited (Demirkesen et al., 2008; Geymen and Dirican, 2016; Kuleli et al., 2009; Kurt and Li, 2020; Simav et al., 2015; 2016; Üstün, 2019; Zengin, 2023). In this study, Mersin city center was chosen, and the study area resides within the borders of three districts. In the study, LULC types affected by SLR was evaluated using GIS technology and climate projections.

2. Materials and Method

2.1. Study area

The study area, which covers an area of 385.4 km^2, constitutes the center of Mersin City, located on the Mediterranean coast in the south of Turkey (Fig. 1). While the study area is a narrow coastal plain in the west, it expands like a fan towards the east. Müftü Stream and

* **Corresponding Author**

*(onurguven@bayburt.edu.tr) ORCID ID 0000-0001-5608-7633
(umityildirim@bayburt.edu.tr) ORCID ID 0000-0002-7631-7245
(cguler@mersin.edu.tr) ORCID ID 0000-0001-8821-6532
(malikurt@mersin.edu.tr) ORCID ID 0000-0001-7255-2056

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Deliçay River are the important rivers of the study area. It is estimated that approximately 695,000 people live in this area. Transportation is provided by highways (O-51 and D400), railway (Adana-Mersin), and seaway. On the other hand, there is a marina and a port (MIP) where international trade takes place.

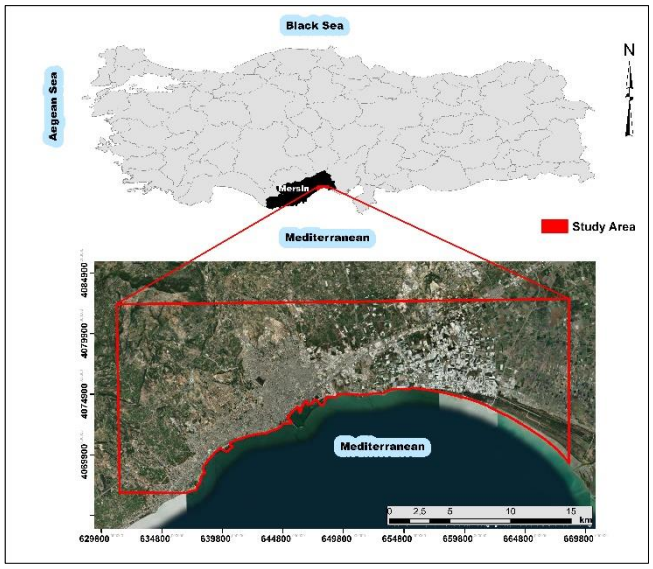

Figure 1. Map of the study area representing Mersin city center.

2.2. Sea level rise

A digital elevation model (DEM) was used to create a SLR database and determine future flood areas. Contour lines were taken as a basis when creating the DEM. DEM with a resolution of 10×10 m was obtained by digitizing 1:25000-scale topographic maps (Fig. 2) using ArcGIS 10.4 software. All data used in this study were georeferenced using the WGS 1984 UTM Zone 36N coordinate system.

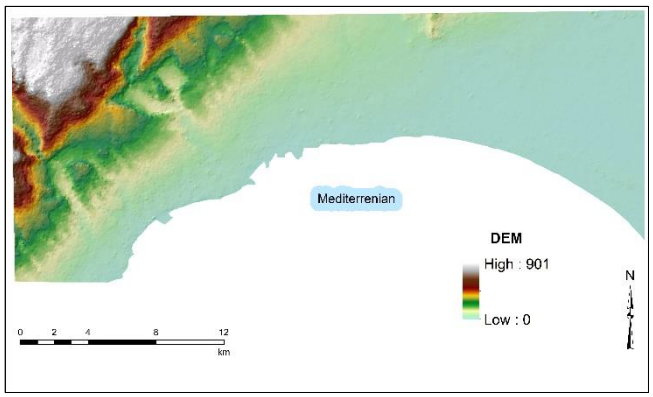

Figure 2. Digital elevation model (DEM) of the study area.

The scenarios in the Intergovernmental Panel on Climate Change (IPCC) report (IPCC, 2014) revealed the risk situation due to SLR in the study area. The report includes SLR scenarios for the years 2100, 2200, 2300, 2400, and 2500. SLR scenarios are divided into three categories based on low, medium, and high CO_2 concentrations (IPCC, 2014). In this study, the SLR scenario applied according to high CO_2 concentration is taken as a reference, and SLR values are presented by the years in Table 1.

Table 1. IPCC 5th Assessment Report SLR scenarios.

Scenario	2100	2200	2300	2400	2500
SLR (m)	0.83	2.03	3.59	5.17	6.63

2.3. Land use and land cover

This study aims to determine the LULC classes affected by the SLR for Mersin City. LULC data in grid format obtained from the CORINE dataset (EEA, 2018) was used to create the LULC layer for the study area. LULC parameters (Fig. 3) adapted to the study area are classified into 13 individual classes (Table 2).

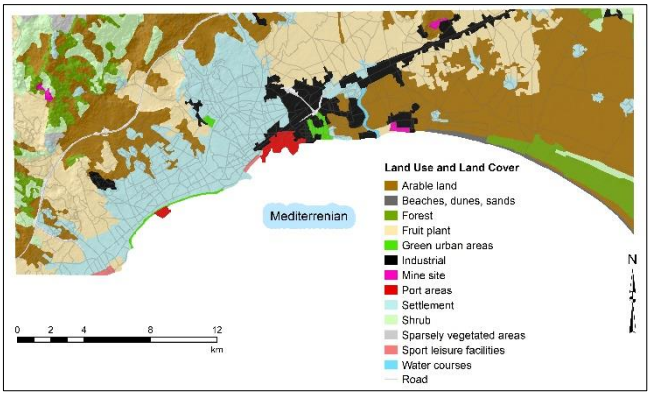

Figure 3. Map of the LULC classes of the study area.

Table 2. LULC types of the study area.

LULC	Area (km^2)	LULC	Area (km^2)
Arable land	145.0	Sparsely vegetated areas	2.1
Fruit plants	89.0	Green urban areas	2.1
Settlement	72.9	Beaches, dunes, sands	2.1
Forest	23.2	Mine site	1.1
Industrial	22.6	Sport-leisure facilities	0.6
Shrub	21.6	Water courses	0.6
Port areas	2.5	**Total**	**385.4**

3. Results

In this study, five different SLR scenarios (0.83 m, 2.03 m, 3.59 m, 5.17 m, and 6.63 m) were considered for the Mersin City. The areas most affected by these scenarios are located at the east of the study area (Fig. 4). This area is a coastal plain formed by alluvial deposits brought by the Deliçay and Tarsus rivers. This area's slope, characterized by a delta environment, varies between 0-10°. In addition, the city's important agricultural areas are located in the most sensitive area with respect to SLR.

LULC types affected by the combination of SLR and LULC were determined spatially (Table 3). Except for sparsely vegetated areas, all LULC classes were affected by different SLR scenarios. The most affected classes were arable land and forest. A section of the Adana-Mersin highway (D400) is inundated when sea levels rise by 6.63 m. LULC losses in SLR scenarios for 2100, 2200, 2300, and 2500 are 0.4%, 9.8%, 16.7%, 21.6%, and 25.0%, respectively.

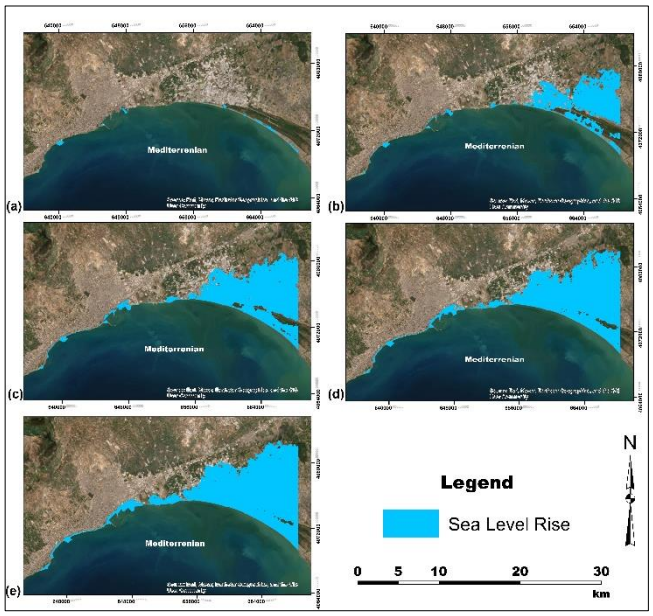

Figure 4. Map of SLR: (a) 0.83 m, (b) 2.03 m, (c) 3.59 m, (d) 5.17 m, (e) 6.63 m.

Table 3. LULC classes affected by SLR.

LULC	Effect on LULC (km²)				
	0.83 m	2.03 m	3.59 m	5.17 m	6.63 m
Arable land	0.3	30.8	49.2	61.3	68.1
Fruit plants	0.03	0.2	1.2	2.8	4.6
Settlement	0.07	0.3	1.1	2.4	3.6
Forest	0.09	3.8	7.8	9.4	10.2
Industrial	-	0.1	0.3	1.1	2.2
Shrub	-	0.02	0.2	1.0	1.7
Port areas	0.5	0.7	1.6	2.0	2.3
Sparsely vegetated areas	-	-	-	-	-
Green urban areas	0.03	0.1	0.4	0.5	0.7
Beaches, dunes, sands	0.7	1.6	2.0	2.1	2.1
Mine site	-	0.005	0.1	0.1	0.2
Sport-leisure facilities	0.02	0.1	0.2	0.3	0.4
Watercourses	0.01	0.1	0.1	0.1	0.2

4. Discussion

The Mersin city center, home to various LULC classes, was selected for the evaluation of the SLR effect. In addition, this city plays an important role in international trade.

Many studies conducted in Turkey are large-scale studies covering all coastal provinces. This study can be considered as a micro-scale when considered on a country basis. Studying smaller areas is essential in terms of climate change and water management. In this study, only global scenarios presented by IPCC are considered.

The delta region of the study area is in great danger due to rising sea levels. Economic activities here will be interrupted. These studies reveal the fact that SLR has socio-economic effects as well as ecological effects. With SLR, not only land loss but also population migration is inevitable. Therefore, branches of science such as climate change, economics, sociology, and ecology should be considered together.

5. Conclusion

To evaluate the SLR effect, the study area within the borders of Mersin city center and three districts was selected. 10×10 m resolution DEM data served as the basis for the SLR investigation. Contour lines were used to produce the DEM. CORINE 2018 LULC dataset was adapted to the study area to evaluate LULC types affected by SLR. A total of 13 LULC classes were defined in the study area. These LULC classes were combined with the SLR, and the affected areas were calculated.

According to data collected, arable land was the most impacted LULC class (6.63 m SLR). It was followed by forests, fruit plants, settlements, port areas, industrial, beaches-dunes-sands, shrubs, green urban areas, sports-leisure facilities, mine sites, water courses LULC types. Land losses as a result of SLR are as follows: 0.4% at 0.83 m SLR, 9.8% at 2.03 m SLR, 16.7% at 3.59 m SLR, 21.6% at 5.17 m SLR, and 25% at 6.63 m SLR.

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