MODELING LAND DEGRADATION USING REMOTE SENSING DATA: THE CASE OF SEYHAN BASIN

T. Akin, S. Berberoglu

Cukurova University, Department of Landscape Architect, 01380, Adana, Turkiye
tugbaakin21@gmail.com, suha@cu.edu.tr

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ABSTRACT:

Land degradation is a global barrier to ecological, economic and sustainable developments. Climate change, natural disasters, human activities may result changes in soil organic carbon content, land productivity and land use/cover. Climate change is accelerating and expanding these degraded areas. If land destruction is not minimized, cause increasing population, inappropriate land use, climate change and rapid depletion of natural resources etc. in the coming years. It is estimated that land degradation and desertification will be the most important environmental problems. Mapping of land degradation using remote sensing techniques; determining sensitive areas for land degradation and taking protection measures; sustainable management of natural resources, ensuring sustainable agricultural production, etc. are the key factors. This study was conducted in the Seyhan basin, which is suffer from soil loss processes, changes in land cover and land use. These indicators are; trends in land productivity dynamics, land cover change and change of soil organic carbon stocks. The data set utilized to reveal the land degradation was including; 1 km resolution Land Productivity from JRC GLOBAL (1999–2013) and 250 m resolution NDVI from MOD13Q1 (2000–2015), Land Cover ESA CCI's with 300 m resolution LC (2000–2015), SOC stock from LUCAS (JRC) with 250 m resolution, 2000–2018 data from CORINE. The land degradation of the Seyhan basin was mapped using the specified land degradation indicators together with the One Out All Out (1OAO) rule.

1. INTRODUCTION

In the coming years, increasing population, inappropriate land use, climate change and rapid depletion of natural resources etc. resulted land degradation and desertification which are the most important environmental problems and one of the largest challenges facing humanity. The most visible indicator of land degradation is the rapid increase of arid areas at the worldwide as a result of desertification. Arid areas cover about 40% of the world's land area and also support about two billion of the human population, 90% of which live in developing countries. It is clearly seen that food security is under threat due to decreased productivity in agricultural areas, serious changes in land cover and land use, human pressure on natural resources and agricultural lands, climate change and soil erosion (Abuzaid et al., 2021; Lucatello et al., 2020; Mitran et al., 2021). Land destruction, as a result of these negative factors and deeply affects the environmental integrity. It threatens sustainable development worldwide by bringing along social, economic and ecological problems.

The Sustainable Development Goals (SDG), which are a call for a global struggle to minimize poverty in the global world, to protect natural and cultural resource values, to adapt the changing climate conditions with the effect of global warming, and to ensure that all humanity lives in peace and prosperity, that desired to be achieved by 2030. It contains 17 titles and Among these goals, the title of "Terrestrial Life" aims to "balance land degradation until 2030" (Ateşoğlu & Şenyaz, 2018).

As a result of technological development, different methods are came into use to reveal the land degradation, and these methods include remote sensing (UA) and Geographic Information System (GIS) techniques. Remote sensing and GIS, which are widely used for modelling and assessment of land degradation sensitivity, have been developed and are still being developed today. Remotely sensed data compared to traditional methods, provide better representation of earth and evaluation of various spatial data are practical, fast, consistent, reliable and cost-effective for large areas (Abuzaid et al., 2021; Bakr & Bahnassy, 2019).

1.1. Land degradation

Like air and water, soil is a vital resource for humanity. Land degradation or loss of the productive capacity of soils today and in the future is a global problem affecting the entire world through food insecurity, high food prices, climate change, environmental hazards, and loss of biodiversity and ecosystem services (GEF, 2023). Land degradation is increasing at an alarming rate and is causing a dramatic decline in the productivity of cropland, forests and pastures worldwide. Land degradation is a global barrier to ecological, economic and sustainable developments. Climate change is accelerating and expanding these degraded areas. Population increase, inappropriate land use, climate change and rapid depletion of natural resources will result severe degradation in the coming years.

2. MATERIAL AND METHODS

2.1. Material

The Seyhan Basin extends from the Iskenderun Bay to the inner parts of Central Anatolia and is located between 36º 55' and 38º 72' north latitudes and 35º 45' and 37º 81' east longitudes in the Eastern Mediterranean Region of Turkey. The Seyhan Basin, which consists of steep mountainous lands and wide alluvial plains. Seyhan Basin covers 2.73% of Turkey with an area of 21730.38 ha. and 87.61% of the Seyhan basin in Kahramanmaras, 94.41% of the province of Osmaniye and 28.08% of the province of Adana. The geographical location of study area is shown in Figure 1.

Figure 1. Geographic location of Seyhan Basin

2.2. Methods

The study used three reference years, 2000, 2015 and 2020, and utilised Trends.Earth model (Gonzalez-Roglich et al., 2019), developed by FAO with the guidance of UNCCD . Trends.Earth is a free and open source tool powered by a cloud-based system offered as a QGIS add-on. Trends.Earth model performs both a global and a temporal-spatial analysis of changes in land cover, changes in soil organic carbon content, soil productivity, and land use type (Bogdanets & Nosenko, 2022). The model calculates land degradation by taking into account 3 basic indicators. These three sub-indicators are created separately and combined to calculate indicator SDG 15.3.1. These indicators are land cover, land productivity, soil organic carbon. The final results are produced based on One Out All Out (1OAO) approach. If one of the sub-indicators is negative (or stable when degraded in the baseline or previous monitoring year) in a specific land unit, it would then be considered as degraded, and subject to ground validation by national authorities (UNCCD, 2017).

2.3. Sub-indicator for SDG 15.3.1

2.3.1 Land cover and Land cover change: ESA CCI land cover with 300 m resolution of 2000, 2015 and 2020 was used including, Tree-Cover, Grassland, Cropland, Wetland, Artificial, Other Land and Waterbody classes to model the land degradation accurately. The land cover maps are given in Figures 2, 3 and 4.

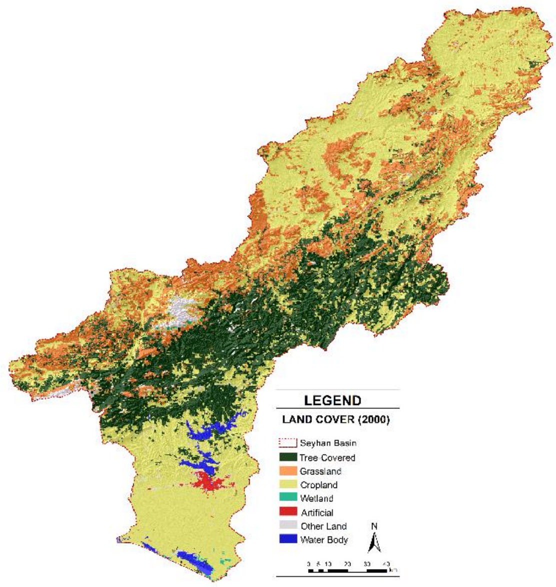

Figure 2. Land cover of Seyhan Basin (2000)

The tree-cover class appears to be more common in the middle parts of the Seyhan Basin, while the settlement and agricultural areas in the south of the basin appear to be widespread when the land cover map is examined.

Land cover change rates of the Seyhan basin is 13% in Artificial surfaces from 149.39 km in the past to 168.90 km today (Table 1).

	Initial area (sq. km)	**Final area (sq. km)**	**Change in area (sq. km)**	**Change in area (percent)**
Tree-covered	5 906.31	6 026.12	119.81	2%
Grassland	4 536.82	4 532.66	-4.16	0%
Cropland	10 520.42	10 389.66	-130.76	-1%
Wetland	40.24	40.18	-0.06	0%
Artificial	149.39	168.90	19.50	13%
Bare land	438.57	434.49	-4.08	-1%
Water body	258.95	258.70	-0.25	0%

Table 1. Land cover change of Seyhan Basin

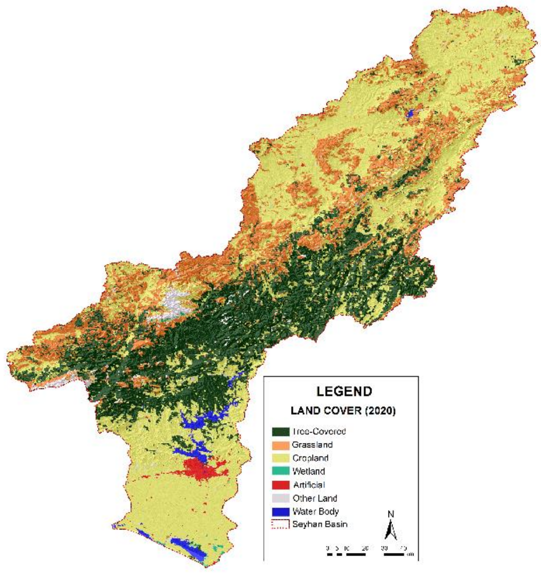

Figure 3. Land cover/Land use of Seyhan Basin (2020)

2.3.2 Land Productivity: The land productivity was assessed within Trends.Earth using the MODIS MOD13Q1 product, while the default datasets were used for the other sub-indicators (Cherif et al., 2023). Land productivity trends are an indicator that must be accurately presented to identify changes in the health and productive capacity of the land.

The Land Productivity Trajectory and Land Productivity Dynamics of the Seyhan Basin are given in Figure 5 and Figure 6.

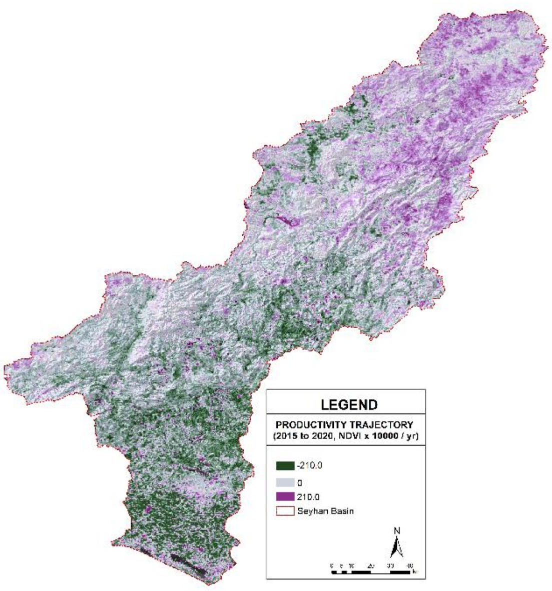

Figure 4. Land Productivity Trajectory for Seyhan Basin (2015 to 2020)

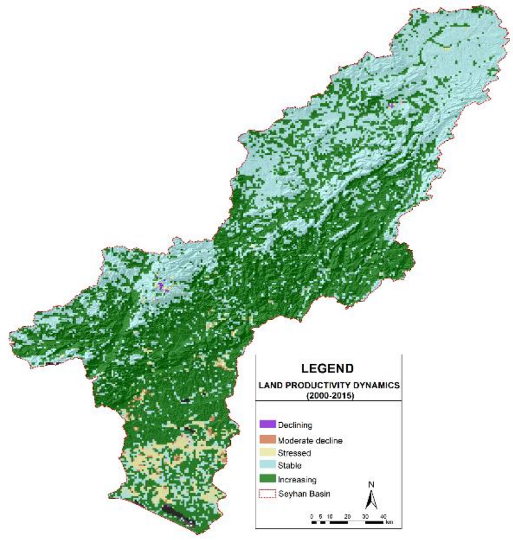

Figure 5. Land Productivity Dynamics for Seyhan Basin (2000-2015)

2.3.3 Soil Organic Carbon: Soil organic carbon information enables to understand to quantify overall soil quality associated with nutrient cycling and its aggregate stability and structure with direct implications for water infiltration, soil biodiversity, vulnerability to erosion, and ultimately the productivity of vegetation, and in agricultural contexts, yields (Giuliani et al., 2020). The third sub-indicator is the spatial variability of soils which lack of consistent time series data and standard soil organic carbon (SOC) information system etc. It can be produced using satellite EO data although the evaluation is complicated (Angelopoulou et al., 2019; Assennato et al., 2020; Stumpf et al., 2018).

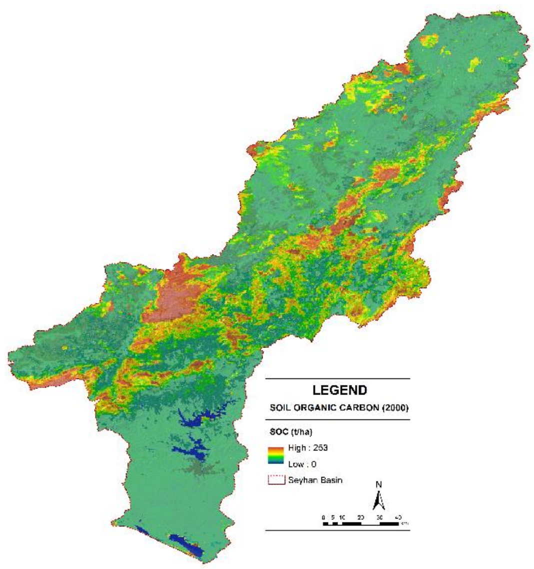

Figure 6. Soil Organic Carbon of Seyhan Basin (2000)

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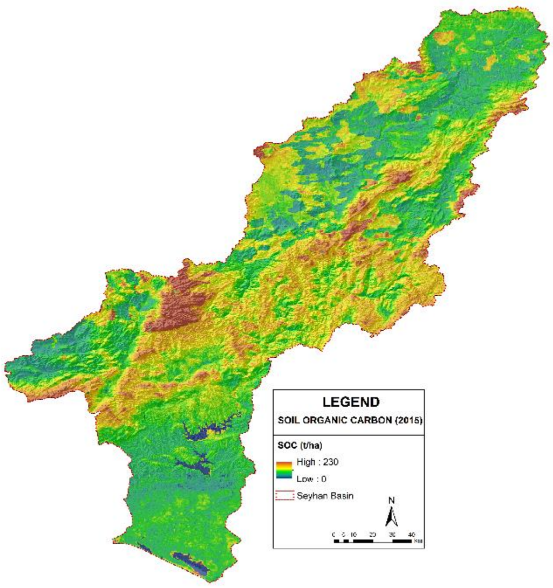

Figure 7. Soil Organic Carbon of Seyhan Basin (2015)

In general, an increase in land productivity or in SOC stocks in the absence of significant land cover change, was considered to be an improvement in land condition, whereas a reduction in these sub-indicators was usually considered to indicate degradation (Sims et al., 2020).

3. RESULTS

3.1 Indicator for SDG 15.3.1

In line with SDG 15.3.1 indicator the land destruction of the Seyhan Basin is examined, it is seen that the land destruction due to settlement surfaces and agricultural surfaces towards the southern parts of the basin is intense.

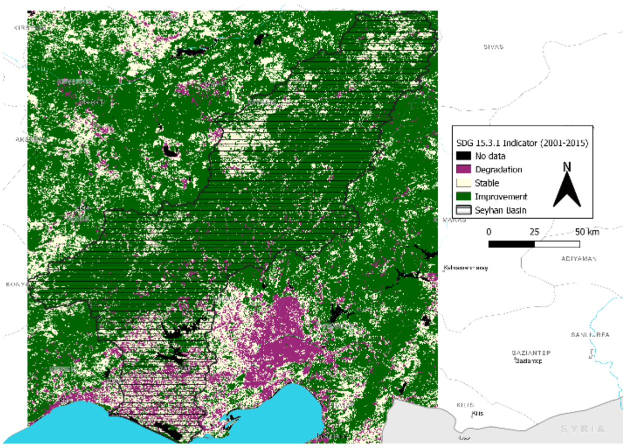

Figure 8. SDG 15.3.1 Indicator for Seyhan Basin (2001-2015)

It is seen that the land productivity of the Seyhan Basin has been damaged in the southern and middle parts of the basin. The main causes of this destruction in the central parts of the basin are land conversions and the increase in built up surfaces. The main reason for the widespread rate of land degradation in the middle parts of the basin is the increase in built up surfaces (Figure 10).

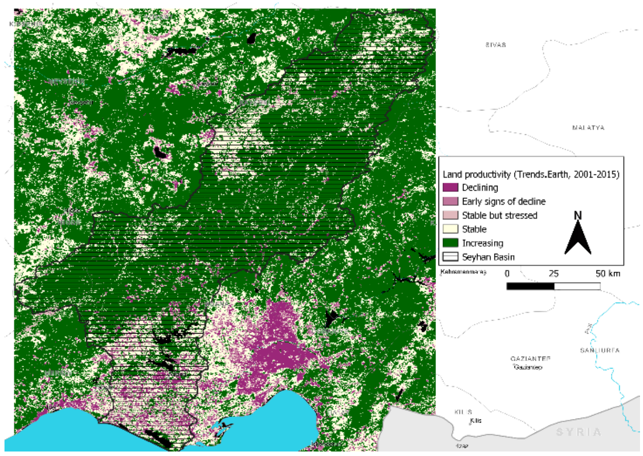

Figure 9. Land productivity for Seyhan Basin (2001-2015)

3.2 Summary of SDG 15.3.1 Indicator

Data derived through Trends. Earth indicated that averaging the period of 2001-2015, shows 0.02% of degraded lands, 58.35% of land area stable, 38.53% of land area improved for the basin (Table 2).

	Area (sq km)	Percent of total land area
Total land area:	21 730.38	100.00%
Land area improved:	8 418.27	38.53%
Land area stable:	12 750.36	58.35%
Land area degraded:	388.41	0.02
Land area with no data:	293.66	0.01

Table 2. Summary of SDG 15.3.1 Indicator for Seyhan Basin

3.3 Summary of change in productivity

Considering the change in the productivity of the Seyhan Basin; With a surface area of 8476.1 km, approximately 0.4% of the basin with improved productivity and 59.47% Land area with stable productivity (Table 3).

	Area (sq km)	Percent of total land area
Total land area:	21 730.38	100.00%
Land area with improved productivity:	8 476.1	0.4
Land area with stable productivity:	12 994.07	59.47%
Land area with degraded productivity:	282.6	0.0
Land area with no data for productivity:	97.9	0.0

Table 3. Summary of change in productivity for Seyhan Basin

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3.4 Summary of change in soil organic carbon

99.65% of Seyhan Basin have Land area with stable soil organic carbon (Table 4).

	Area (sq km)	Percent of total land area
Total land area:	21 730.38	100.00%
Land area with improved soil organic carbon:	12.09	0.00
Land area with stable soil organic carbon:	21 515.49	99.65%
Land area with degraded soil organic carbon:	53.18	0.00
Land area with no data for soil organic carbon:	10.99	0.00

Table 4. Summary of change in soil organic carbon for Seyhan Basin

3.5 Summary of change in land cover

0.01% of Seyhan Basin have Land area with improved land cover, 99.59% of the Basin Land area with stable land cover and 55% of the Basin Land area with degraded land cover (Table 5).

	Area (sq km)	Percent of total land area
Total land area:	21 730.38	100.55%
Land area with improved land cover:	130.86	0.01
Land area with stable land cover:	21 640.55	99.59%
Land area with degraded land cover:	7929.23%	0.36%
Land area with no data for land cover:	0.00%	0.00%

Table 5. Summary of change in land cover for Seyhan Basin

4. CONCLUSIONS

The variation of the indicators based on remotely sensed data described within the Trends. Earth model approach enabled evaluating the soil organic carbon change over time.
Considering the past studies, there is no mechanism routinely produces accurate and consistent land degradation data in accordance with the UN SDG indicator framework. However, the land degradation modelling offered by the Trends. Earth model is presented at a high resolution with very few input data. Overall results showed that a total of 0.02% of degraded lands for the Seyhan Basin was mapped, averaging over the period of 2001–2015. More accurate assessment of land degradation requires the groundwork for sustainable land management tools and programs. In addition, a strong basis for considering alternative scenarios of future land problems and for quantitatively explaining how land degradation on a national-international scale can affect ecosystem services and functions are needed.

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