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Green Growth Through Natural Capital Accounting in Türkiye

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Environment Department

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This report was prepared under the Türkiye Green Growth Analytical and Advisory Program by a World Bank team led by Neeta Hooda (Senior Natural Resources Management Specialist) and supported by VITO consultants. The team was composed of Daniel Besley (Senior Climate Change Specialist), Hande Bilir (Natural Capital Accounting Specialist), Bora Surmeli (Agriculture Economist), Craig Meisner (Senior Economist), Stavros Papageorgiou (Senior Natural Resources Management Specialist), and Lesya Verheijen (Senior Operations Officer). The VITO consultant team members included team (Bruno Smets, Steven Broekx, Lieven De Roo, Lori Giagnacovo, Mathilde De Vroey, Maarten Van Loo, Marcel Buchhorn). The team received expert advice from peer reviewers Sjoerd Schenau (Project Manager Environmental Accounts, Statistics Netherlands), Sofia Elisabet Ahlroth (Senior Natural Resources Economist, World Bank), and Bekele Ambaye Shiferaw (Senior Environmental Economist, World Bank). The team acknowledges the kind assistance of Linh Van Nguyen (Senior Program Assistant) and Nevma Deniz Naz Ozbal (Program Assistant).

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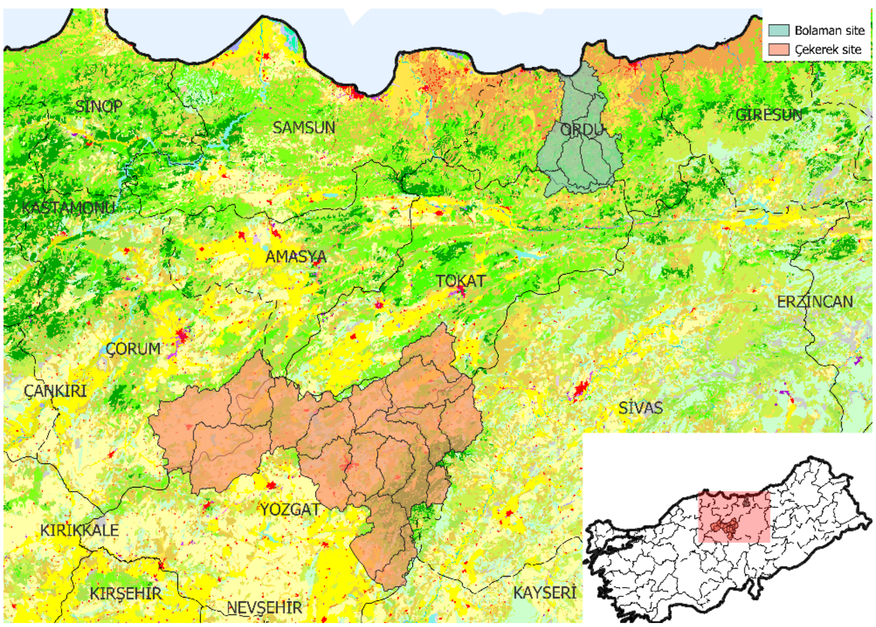
EXECUTIVE SUMMARY: NATURAL CAPITAL ACCOUNTING IN TÜRKIYE

Background

Natural capital is essential for sustaining ecosystems and the services they provide. By accounting for it, businesses and governments can make more informed decisions that balance economic growth with environmental sustainability. **Natural capital accounting** (NCA) helps to highlight the dependencies on natural resources, the risks associated with their depletion or degradation, and the vital contributions of nature to human economy and well-being.

Figure 1: Bolaman and Çekerek pilot sites



Source: Compiled by VITO

The **Global Program on Sustainability (GPS)** (administered by the World Bank) aims to integrate environmental and other sustainability considerations into public and private decisions, by providing policy makers and the financial sector with the necessary metrics and tools. This approach involves looking beyond gross domestic product (GDP) and traditional financial metrics to include systematic accounting for environmental risks and opportunities and valuing natural capital and ecosystem services, strengthening the national statistical system. Türkiye has been selected as one of the GPS Core Implementing Countries. The activities within this project focus on providing Technical Assistance (TA) on NCA and its application in policies and programs which can further inform Türkiye's green transition. More specifically, the objectives of this project are to support the compilation of ecosystem accounts at the national level and in two pilot sites (Bolaman and Çekerek watersheds) by compiling accounts and supporting capacity building. The **Bolaman and Çekerek watersheds** are part of the Türkiye Resilient Landscape Integration Project (TULIP, P172569).

Method

A statistical framework to develop internationally comparable natural capital accounts, the **System of Environmental Economic Accounting - Ecosystem Accounting** (SEEA EA), established by the United Nations in 2021, is applied in this project. The framework consists of three types of accounts. The **ecosystem extent accounts** measure the size of different ecosystem types and how they change over time. The **ecosystem condition accounts** measure the quality of those ecosystem types by recording data on various abiotic, biotic, and landscape characteristics of ecosystems such as carbon stocks, species diversity, and the degree of fragmentation. The **ecosystem services** (**flow) accounts** record the supply of various ecosystem services such as crop provision, tourism and flood protection by different ecosystem types, and the use of those services by economic units, including households and industry (UN, 2021). The supply and use of ecosystem services can be expressed in physical and monetary terms.

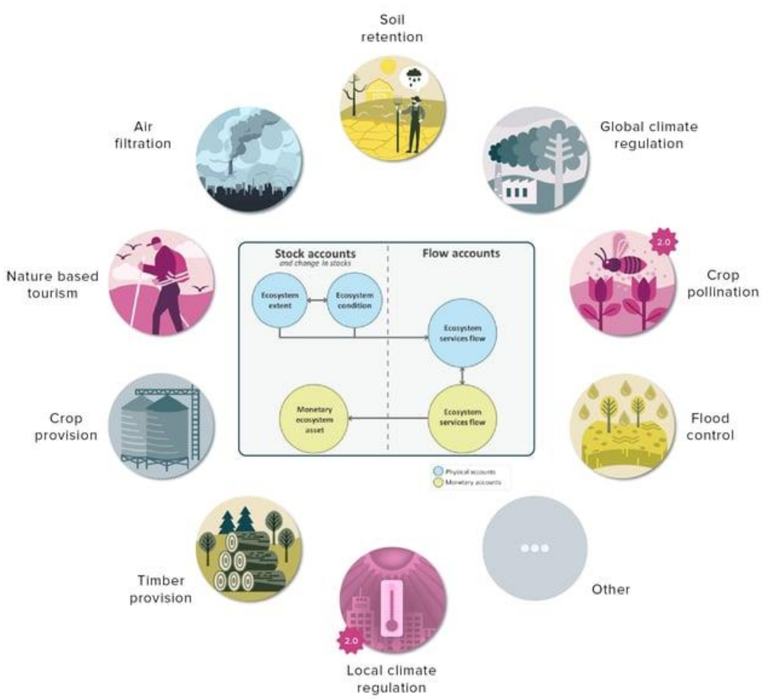
Disclaimer.

This report is meant as a demonstration of how Natural Capital Accounts can be developed in Türkiye using the SEEA-EA framework and within EU regulation (EU) No 691/2011 on ecosystem accounting, using the data that was officially available for this purpose. The results, including accounting tables and figures in this report should be interpreted within this context and read together with the recommendations planned for further improving the ecosystem accounting.

As an example, one such limitation is that the term ' Forest and woodland' ecosystem is related to the forest land cover according to the European definition of Forests. This term should not be confused with the officially managed forest areas designated as 'forest land' by the Department of Forestry (OGM).

The definition of forest area in Türkiye is based on the legal status of forest land according to the land registry. Therefore, the legal forest areas may not exactly overlap with the forest land cover areas reported in the Corine Land Cover data. The forest land cover may change temporarily due to various reasons such as forest fires, opening of the forest area for mining activities due to public interest, reforestation activities, etc., while the legal forest areas are not subject to change except for 2B and Annex 16 applications.

Figure 2: Schematic overview ecosystem services and SEEA-EA



Source: Compiled by VITO

In 2022, the European Commission adopted a legal proposal to develop ecosystem accounts. Its implementation in the European Union will follow the SEEA EA framework. If adopted by the European Parliament and the Council, it will be mandatory for member states to submit environmental accounts on the extent and condition of ecosystems and the services they provide for the year 2024 to be delivered by 2026. To prepare the European member states for this legal proposal, Eurostat, the European Statistical Office, is currently developing methodological and practical guidance on how accounts can be developed. The methodologies applied in this project follow the latest state of the art of these guidance notes. Besides practical guidance, a tool (the Integrated Natural Capital Accounting (INCA) tool) is also being developed to support the development of the accounts. The methodologies applied in this project build heavily on these guidance documents and the INCA tool.

Results

Early technical workgroup meetings led to selecting the accounting years of 2018 and 2021. This was based on the availability of local data for those years and policy relevance, as it assists in the monitoring of implemented measures part of the TULIP project during 2020–2021.

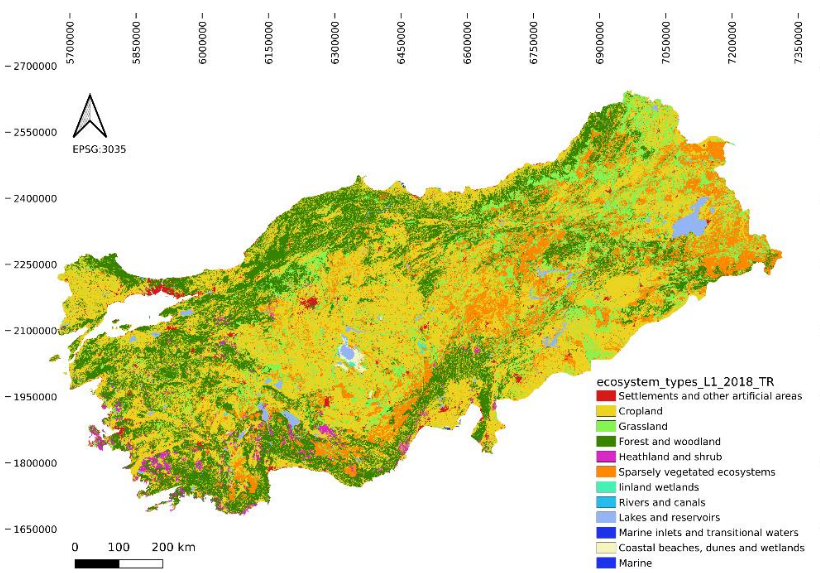
The ecosystem extent accounts give insight into the share of different ecosystem types in a country or region and how they change over time. One of the objectives of the project was to compile a national ecosystem extent account. As no national datasets are available for 2021, a Tier-1 extent account was calculated for Türkiye for 2012 and 2018 based on the European Corine Land Cover maps, according to the EU Typology Level-1.

The extent accounts show that 41 percent of the land is occupied by cropland, 25 percent is covered by forest and woodland, 14 percent by grassland, and 14 percent by sparsely vegetated ecosystems. About 2 percent of the land is assigned to settlements and other artificial areas.

According to the 2024 activity report of the General Directorate of Forestry, forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025).[1]

Disclaimer: Numbers in the extent account differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30% of Türkiye (Orman Genel Müdurlügü, 2025).

Figure 3: Extent map of Türkiye



Source: Compiled by VITO

[1] Page 8 in the 2024 activity report of the General directorate of Forestry. https://www.ogm.gov.tr/tr/e-kutuphane-sitesi/FaaliyetRaporu/2024%20-%20Orman%20Genel%20M%C3%BCd%C3%BCrl%C3%BC%C4%9F%C3%BC%20Faaliyet%20Raporu.pdf

Between 2012 to 2018, changes occurred in ecosystems covering 273,000 ha of land (0.35 percent). The majority of this change took place from cultivated land into settlements or other anthropogenic land covers, while another major change is from grassland to cultivated land.

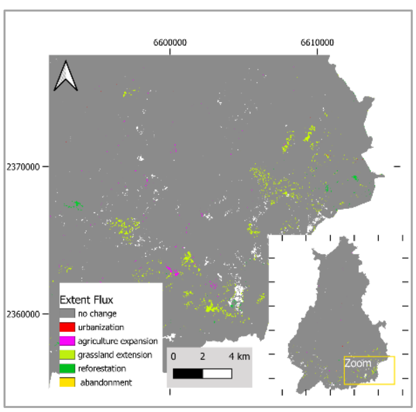
Since no European maps are available after 2018 and to enable the use of extent accounts at local scale, a new method was developed and tested based on the National Land Cover and Land Use Classification and Monitoring System (UASIS) regional maps (Bolaman and Çekerek) provided by the Directorate-General for Combating Desertification and Erosion (ÇEM). A Tier-2 extent account from 2018 to 2021 was generated for both pilot sites.

Table 1: Extent table Bolaman

	Ecosystem type (level 1) TULIP Bolaman	Opening area 2018 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2021 (ha)	Closing area 2021 (%)
1	**Settlements and other artificial areas**	2,335	14	20	- 6	2,328	1.5%
2	**Cropland**	94,848	822	120	702	95,550	60.4%
3	**Grassland**	25,227	61	770	- 708	24,518	15.5%
4	**Forest and woodland**	35,869	475	489	- 13	35,855	22.7%
5	**Heathland and shrub**	-	-	-	-	-	0.0%
6	**Sparsely vegetated ecosystems**	-	3	-	3	3	0.0%
7	**Inland wetlands**	-	-	-	-	-	0.0%
8	**Rivers and Canals**	-	23	-	23	23	0.0%
9	**Lakes and reservoirs**	-	0	-	0	0	0.0%
10	**Marine inlets and transitional waters**	-	-	-	-	-	0.0%
11	**Coastal beaches and transitional waters**	-	-	-	-	-	0.0%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**158,278**	**1,399**	**1,399**	**- 0**	**158,278**	**ha**
						1,583	km^2

Source: Vito estimates

Figure 4: Land cover change of Bolaman, a detailed view



Source: Compiled by VITO

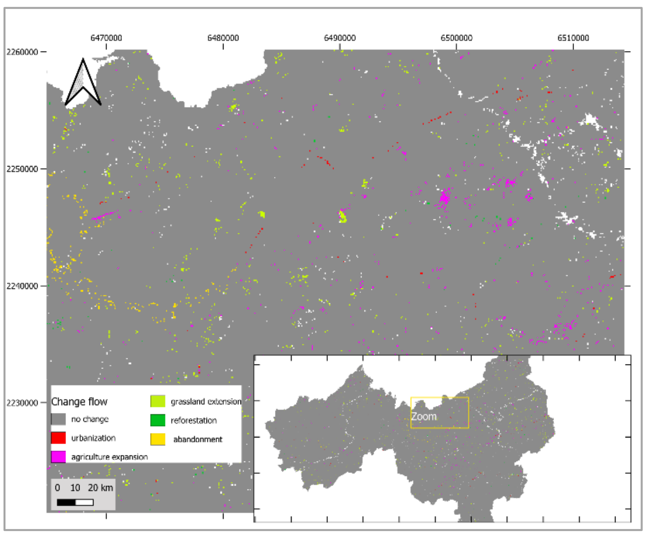
The ecosystem extent accounting table for the Bolaman region shows that 60 percent of the accounting area is covered with cropland, followed by 15 percent grassland and 22 percent forest and woodland mainly located in the South of the region. From 2018 to 2021, the primary transformation detected is a rotation between grassland and cropland (agriculture expansion). In the South, an area of potential reforestation (from grassland) is detected. Further validation is required to acknowledge this change.

Table 2: Extent table Çekerek

	Ecosystem type (level 1) TULIP Cekerek, clean backward	Opening area 2018 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2021 (ha)	Closing area 2021 (%)
1	**Settlements and other artificial areas**	11,640	441	592	-151	11,489	1.3%
2	**Cropland**	346,418	6,738	2,565	4,173	350,591	40.2%
3	**Grassland**	191,723	1,116	5,198	-4,082	187,641	21.5%
4	**Forest and woodland**	297,457	895	2,435	-1,540	295,917	33.9%
5	**Heathland and shrub**	-	-	-	-	-	0.0%
6	**Sparsely vegetated ecosystems**	18,307	2,152	175	1,977	20,284	2.3%
7	**Inland wetlands**	-	-	-	-	-	0.0%
8	**Rivers and Canals**	-	-	-	-	-	0.0%
9	**Lakes and reservoirs**	6,900	60	441	-381	6,519	0.7%
10	**Marine inlets and transitional waters**	-	4	-	4	4	0.0%
11	**Coastal beaches and transitional waters**	-	-	-	-	-	0.0%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**872,445**	**11,406**	**11,406**	**-**	**872,445**	**ha**
						8,724	km^2

Source: VITO estimates

Figure 5: Land cover change map Çekerek, a detailed view



Source: Compiled by VITO

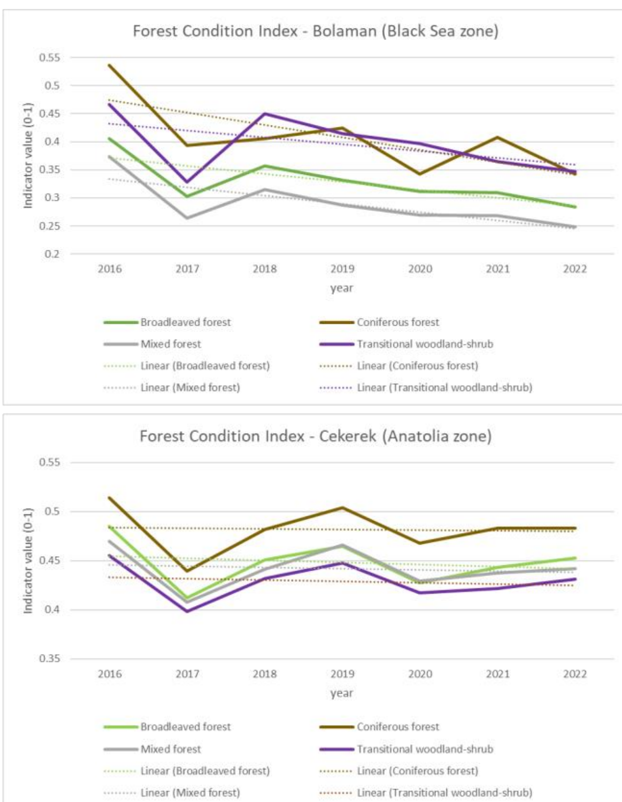
The ecosystem extent accounting table for the Çekerek region shows that 40 percent of the accounting area is covered with cropland, followed by forest and woodland (34 percent) and grassland (21 percent). From 2018 to 2021, the primary transformation was detected between cropland and grassland. A second important area of change was noticed as cropland and grassland are converted into sparsely vegetated ecosystems (both 900 ha), which could potentially be attributed to land abandonment. Further validation is required to acknowledge this change.

The latter ecosystem extent mapping method, based on UASIS data, shows it is possible to generate ecosystem extent accounts according to the EU typology Level-1. The next step would be to statistically validate the results for both regions such that it can be scaled up to the national level. Furthermore, a theoretical exercise shows the potential to generate ecosystem extent maps at higher thematic details, EU typology levels 2 and 3, based on the raw UASIS data.

Condition accounts measure and report the health of an ecosystem type. In the first step, several variables (abiotic physical and chemical state; biotic compositional, structural and functional state; and landscape level characteristics) are selected to best measure the condition of an ecosystem type. Thereafter, the variable expressed in a biophysical unit is rescaled into an indicator (ranging from 0 to 1) by comparing its value to a reference value which represents the optimal condition (value 1). In the final step, these indicators are weighted and aggregated into a single '*condition index' (ranging from 0 to 1)*, which can be tracked over time to evaluate if the ecosystem health is improving or deteriorating. The weights for indicator accounts are determined according to their spatial resolution, their temporal resolution, their temporal frequency, and the dataset quality (referring to the proximity of the latest year to the present).

Forest condition accounts measure and report the condition of forests and woodlands ecosystems. Five condition variables across four of the five characteristic domains were used to best present the health of this ecosystem type: Normalized Difference Water Index (NDWI), Threatened Forest Bird Species Diversity (TFBSD), Above Ground Biomass (AGB), Net Primary Productivity (NPP), and Forest Connectivity Percentage (FCP). These variables are converted into indicators using the forest type (Broad-leaved, coniferous, mixed, and transitional) per ecological zone (Black Sea for Bolaman and Anatolia for Çekerek) before being aggregated into the '*Forest Condition Index'* (FCI). Reference forest sites, representing the optimal condition, were provided by the Turkish authorities. The forest condition account was generated for the two pilot sites from 2016 to 2022 on an annual basis

Figure 6: The forest condition index for Bolaman and Çekerek



In Bolaman, one could notice a slightly decreasing trend in FCI but the standard deviations (not depicted in the diagram) indicate that the trend is uncertain. We can also notice that the health, especially of transitional woodland, is lower compared to the Anatolia zone.

In Çekerek, the trend can be considered as stable. We can also notice that the health of the coniferous forest type is slightly better compared to the other forest types.

The main factor for the fluctuation across the period is the Net Primary Productivity (NPP) which is, among other things, highly influenced by monthly precipitation and monthly maximum temperatures. This explains the drop in 2017 which is recovered thereafter. Short-term fluctuations in forest condition are dependent on yearly weather conditions and not necessarily an indication of a decreasing or increasing condition.

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

The Forest Condition Index could only be evaluated for a short period (7 years), so one should be careful with deriving conclusions by looking at the trend of the FCI before at least a period of 10 to 15 years can be presented. In general, we can state that the condition in Çekerek is stable, while in Bolaman further investigation is needed to confirm (or deny) the negative trend.

The coastal zone condition accounts are measured as the share (in %) of artificial impervious area cover within the coastal zone, as defined by the EU regulation on ecosystem accounting. According to this definition there are no additional variables to be selected, or transformed into an indicator on index. The transformation of the (semi-) natural land cover or water surface in coastal areas into an artificial, impervious cover is an indicator for ecosystem condition degradation, reflecting the encroachment of built-up land in the coastal zone (for example, roads, residential development, holiday houses). A yearly imperviousness degree layer covering the coastal area of the Bolaman basin from 2018 to 2023 was generated. Since Çekerek contains no coastal zone, this account is only generated for the Bolaman pilot site.

able 3: Percentage of sealed coastal area in Bolaman

Index	**2018**	**2019**	**2020**	**2021**	**2022**	***2023***
Sealed %	32.5%	32.6%	32.2%	32.4%	33.7%	34.4%

Source: VITO estimates

We can see that more than 32 percent of the coastal area (a 1-km zone from the intertidal line has been used) is sealed. Over the last 5 years, about 2 percent additional area has been sealed, illustrating a decrease in the coastal zone condition.

Condition accounts for other ecosystem types are developed according to the draft EU regulation on ecosystem accounting. The following indicators are used:

- Soil organic carbon (SOC) stock in topsoil in kg C ha^{-1} for cropland and grassland,
- Concentration of particulate matter (PM10 and PM2.5) in annual average µg m^{-3} in settlement and other artificial areas,
- Green area in cities and adjacent towns and suburbs in percentage of total area in settlement and other artificial areas.

Due to data limitations, the accounts were only calculated for the year 2018. The accounts are derived from global datasets, as no local information was yet available.

Table 4: Other conditions accounts for Bolaman and Çekerek

Ecosystem condition account – 2018	**Bolaman**	**Çekerek**
Relative SOC stock in topsoil – cropland [kg C ha^{-1}]	64,281	46,186
Relative SOC stock in topsoil – grassland [kg C ha^{-1}]	88,940	62,540
Mean concentration of particulate matter (PM2.5) in cities and adjacent towns and suburbs [µg m^{-3}]	13.90	11.69
Mean concentration of particulate matter (PM10) in cities and adjacent towns and suburbs [µg m^{-3}]	20.07	16.08
Green area in cities and adjacent towns and suburbs [%]	23.85	12.20

Source: VITO estimates

We can see that Bolaman has a higher carbon storage (in the topsoil) than Çekerek for both cropland and grassland ecosystem types. Also, the mean concentrations of both particulate matter show higher values in Bolaman, indicating the air quality is lower in cities and adjacent towns and suburbs compared to Çekerek. However, the extent of green vegetation cover in these cities and adjacent towns is higher in

Bolaman compared to Çekerek. The filtration of air particles by green vegetation is important but not dominant in influencing local air quality. This heavily depends on emissions by transportation, industry and households, and weather conditions.

Ecosystem services accounts are developed for seven different services. A supply table records per ecosystem type the contribution of nature while the use table the beneficiaries of those services by economic units. The supply and use tables are expressed in physical and monetary terms. Monetary values can be expressed in nominal values, using market prices of the same year and real values by adjusting the market prices for inflation between 2018 and 2021. The ratio to correct for inflation between 2018 and 2021 is 2.90 (GDP deflator Türkiye according to World Bank 2024).

The selection of seven services was agreed with World Bank and Turkish stakeholders. It is a combination of mandatory services in the draft EU legislation (crop provision, wood provision, global climate regulation, nature-based tourism) and non-mandatory services (soil retention, water regulation) which are considered relevant for the pilot sites. The methodologies applied in this project are calculated through the INCA tool, a QGIS plugin which can be applied at regional, country, or continental level in Europe. The ecosystem service models included in the INCA tool are based on the INCA models originally developed by the Joint Research Centre, and further refined by VITO (as contractor for Eurostat) on compliancy to the European ecosystem service guidelines.

The service accounts were calculated for the years 2018 and 2021, with the limitation that the ecosystem extent areas per ecosystem type were kept consistent since the newly generated ecosystem extent Tier-2 maps were not yet statistically approved.

Crop provision accounts record the ecosystem contributions to plant growth as approximated by the amount of harvested crops for different uses. In physical terms, it is reported as net increment in thousand m³ over bark. Based on the Material Flow Account, the amount of crops produced per crop type is derived. Monetary valuation is performed by using market prices for each crop type and multiplying it by the harvested quantity.

Between 2018 and 2021, there was an increase (+23%) in the provisioning of all crops in Bolaman. The crop provision in Çekerek remained more or less stable (−2%). The monetary value of the crops, expressed in real terms, increased by 15%.

Wood provision accounts record the ecosystem contributions to the growth of trees and other biomass. In physical terms, it is reported as net increment in thousand m³ overbark. This amount is derived from the forestry statistics delivered by the Ministry of Agriculture and Forestry. The physical amount is multiplied by the average selling price of coniferous and non-coniferous roundwood to derive the monetary account.

In Çekerek, there is an important increase of wood provision expressed in m³ overbark (+45 percent) while a decrease (−22 percent) is observed in Bolaman. In monetary values, wood provision doubled (+101 percent) between 2018 and 2021. Market prices for wood are higher compared to the general inflation.

Non-wood provisioning accounts the contribution to the gathering or collection of non-cultivated products like wild mushrooms or berries, medicinal plants, herbs for cosmetics. The SEEA methodology was tested and proved on the mushroom Morella Esculenta for Çekerek. However, the results are not reported as the proposed methodology could not be applied sufficiently accurately based on the data made available during the project.

Global Climate regulation accounts record the ecosystem contributions to reduce concentrations of greenhouse gases (GHGs) in the atmosphere through the removal (net sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems. The contributions are reported in terms of ton of net sequestration of carbon and ton of organic carbon stored in terrestrial ecosystems including above ground and below ground in the first 0.3 meters of the soil (including peatlands). The physical amount of sequestration is based on GHG Emission statistics delivered by Turkstat. The monetary value is based on the average annual European Union's Emissions Trading Scheme (ETS) prices in the EU.

The estimated sequestration values of 2021 are approximately half the values of 2018, which is inconsistent with the stable extent of forest and woodland present in Türkiye. It is important to note that carbon sequestration statistics were only made available at the national level. According to Land Use, Land-Use Change and Forestry (LULUCF) report on page 291 section 6[2] , the change is due to an increase in logging, to meet the demand of the growing wood industry, large scale forest fires and other natural disturbances triggered by climate change. Turkish national data are extrapolated to the basins based on land cover data and the dry matter productivity. This could result in discrepancy in that the national trends may not be consistent with trends observed at the sub national level in Bolaman and Çekerek specifically, but at present there is no better alternative to the methodology used here and the therefore limitations in interpretation of the results arrived at using national data and extrapolating it at the sub national level are noted. Further validation through ground truthing or sub national data availability in future can help refine the methodology.

Water regulation or flood control quantifies the regulation of water flow by ecosystems that mitigates or prevents the potential damage to economic assets and human lives due to flooding. The protection of economic assets is measured in ha of settlements and cropland in floodplains protected by upstream ecosystems. The monetary value is based on the avoided material damages we can expect due to water regulation upstream. The calculation is based on the potential runoff retention as proxy for the identification of the Service Providing Areas (SPA).

The Bolaman basin is characterized by many differences in height and heavy rainfall and is thus prone to floodings. Flood control is important for protecting households in the coastal city '*Fatsa*' and the croplands in the bottoms of the valleys. In Bolaman, close to 90% of the assets are protected by upstream ecosystems. The avoided damage amounts up to Turkish Lira (TRY)170 million. This was only assessed with 2018 extent data, but we expect very small differences between 2018 and 2021.

Soil retention services are the ecosystem contributions, particularly the stabilizing effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). It is reported in terms of thousand tonne of soil retained. The calculation is based on the revised Universal Soil Loss Equation (RUSLE) equation and comparing the erosion we can expect with the existing vegetation cover compared to a worst-case scenario (areas without vegetative cover). The monetary value is based on the costs of replacing the soil on agricultural land and restoring the nitrogen and phosphorus content which are important elements determining the soil fertility.

[2] https://unfccc.int/documents/644387.

The ecosystems in both basins retain 47 million tons of soil. The economic value is estimated at TRY0.9 billion in 2018. Also, this service was only assessed with 2018 extent data, but here too we expect very small differences between 2018 and 2021.

Nature-based tourism is defined as the ecosystem contribution, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical, and experiential interactions with the environment. These contributions are reported in the number of overnight stays in hotels, hostels, camping grounds, etc. that can be attributed to visits to ecosystems. Tourism statistics are combined with a recreation potential map, to derive the number of overnight stays that can be attributed to different ecosystem types. The monetary value is based on tourism expenditure data, available from Turkstat.

Bolaman and Çekerek are both regions not (yet) known for their tourist attraction. Tourism statistics are delivered by Turkstat for the years 2019 and 2022. In 2019, 362,988 tourists' nature-based overnight stays are recorded which rose to 388,433 (+7 percent) in the year 2022. This increase is mainly due to the Bolaman pilot site where the number of overnight stays increased by 30 percent. As tourism expenditures increased slightly per stay between 2022 and 2019, the monetary values increased slightly more (+13 percent) compared to the physical values.

Integrated monetary accounts

The integrated monetary accounts demonstrate the relative importance of individual ecosystem services and the degree to which ecosystem types contribute to the delivery of ecosystem services. Bolaman and Çekerek are low populated areas where crop provision plays a major role. This is confirmed in the integrated monetary account where crop provision is the most important service, expressed in monetary units.

Soil retention is the second-most valued service in the table. This service has also a close connection to crop provision and the potential loss of fertile soils due to erosion. Especially in Bolaman, this service is very important as this is an erosion-sensitive area. The safeguarding of ecosystems like forests is in that sense important for the supply of crucial services like soil or water retention. The local challenges due to the high presence of slopes, rainfall, or climate change vulnerability will stress the value of these regulating services even more.

Expressed in monetary terms, nature-based tourism is of less importance. Tourism in general in these two pilot sites is of less importance compared to other areas in Türkiye.

Table 5: Integrated summary table for Bolaman in 2018

Supply table 2018 **Bolaman** **In TRY Million**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**Total**

Crop provision		620	109							**729**
Wood provision				23						**23**
Global climate reg.				1						**1**
Flood control	1	70	0	39	0	0	0	0	0	**111**
Soil retention	-	684	-	-	-	-	-	-	-	**684**
Nature-based tourism	1	13	0	20	-	-	-	1	-	**35**
Total in million TRY	**2**	**1,387**	**109**	**83**	**0**	**0**	**0**	**1**	**0**	**1,584**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Table 6: Integrated summary table for Bolaman in 2021

Supply table 2021 **Bolaman** **in Million TRY**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**total**
Crop provision		705	133							838
Wood provision				28						28
Global climate reg.				1						**1**
Flood control	1	70	0	39	0	0	0	0	0	**111**
Soil retention	-	684	-	-	-	-	-	-	-	**684**
Nature-based tourism	1	19	0	28	-	-	-	2	-	-
Total in million TRY	**2**	**1,480**	**133**	**95**	**0**	**0**	**0**	**2**	**0**	**1,712**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Table 7: Integrated summary table for Çekerek in 2018

Supply table 2018 **Çekerek** **in Million TRY**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Total
Crop provision		483	281							**764**
Wood provision				59						**59**
Global climate reg.				7						**7**
Flood control	0	28	4	27	0	0		0	0	**59**
Soil retention	-	297	-	-	-	-	-	-	-	**297**
Nature-based tourism	1	26	27	50	-	22	-	-	1	**128**
Total in million TRY	1	834	312	143	0	22	0	0	1	**1,314**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Table 8: Integrated summary table for Çekerek in 2021

Supply table 2021 **Çekerek** **in Million TRY**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**total**
Crop provision		719	166							**885**
Wood provision				137						**137**
Global climate				4						**4**
Flood control	0	28	4	27	0	0	0	0	0	**59**
Soil retention		297								**297**
Nature-based tourism	2	27	30	56		24			2	**140**
Total in million TRY	**2**	**1,072**	**201**	**223**	**0**	**24**	**0**	**0**	**2**	**1,523**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Conclusions and recommendations

This study is a first pilot to test the application of NCA in Türkiye. Based on experiences and stakeholder contacts during the project and the development of the pilot accounts, different recommendations can be formulated to support the development of a further roadmap toward creating a national account and policy uptake.

Currently, methodologies and default datasets to do so are being developed, building further on the SEEA EA guidelines provided by the United Nations. With national data on NCA becoming more and more accessible, NCA is increasingly incorporated in national policies, spurred by international and European regulations. Türkiye's environmental statistics (SEEA Central Framework) have been covering air, water, wastewater, waste, and environmental expenditures since 1990. Türkiye has also begun efforts to produce land use and spatial data information within the context of the EU's Inspire Directive. Turkstat has been actively pursuing the implementation of EU Regulation 691/2011 on European Environmental and Economic Accounts and, following Eurostat's guidance, has begun developing new accounts as per the Regulation's requirements. These new EU accounts include ecosystem accounts and forestry accounts.

In this project, a set of NCA modelling approaches were tested for two basins in Türkiye, i.e., Çekerek and Bolaman, and recommendations for scaling up natural capital accounting to the national level are made. Recommendations consider ecosystem accounting data management and related processes, capacity need development and advancements from global remote sensing sets toward more local datasets. We list some specific recommendations for individual accounts:

Extent: International datasets such as Corine Landcover are not sufficiently accurate to monitor the extent of different ecosystem types in Türkiye and how they evolve over time. The regional approach demonstrated in this study with the UASIS land cover map as a basis provides a starting point for future work on the extent account. Ground-truth collection of data on ecosystem types will always be necessary to validate these outcomes.

Condition: The work on condition focused mainly on forests. A Forest Condition Index was derived for 7 years, which is too short a period to derive whether the condition is improving or not. To extend these time series, expanding the number of indicators, improving the weighting procedure to reduce the influence of yearly climate conditions, and enhancing the selection of reference sites are the major recommendations for the condition account.

Ecosystem services: The methods applied build heavily on the INCA tool and the default methods making use of international datasets. Besides the improvement of specific datasets, it is important to crop type and crop yield map, forest production statistics, flood risk maps, survey data on tourism and soil datasets to perform RUSLE calculation for soil retention. Also, monetary valuation techniques can be improved to better identify the ecosystem contribution instead of the total delivery of services such as crop provision, wood provision and nature-based tourism.

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ABBREVIATIONS AND ACRONYMS

(F)AWS	(Forest) Available for Wood Supply
(F)NAWS	(Forest) Not Available for Wood Supply
AGB	Above Ground Biomass
ANA	Anatolian climate zone
ARIES	Artificial Intelligence for Ecosystem Accounting
BF	Broad-leaved forest
BLS	Black Sea climate zone
C02	Carbon Dioxide
CAMS	Copernicus Atmosphere Monitoring Service
ÇEM	Directorate-General for Combating Desertification and Erosion
CF	Coniferous forest
CH4	Methane
CLC	Corine Land Cover
CLC BB+	Corine Land Cover Backbone +
CLCACC	Corine Land Cover Accounting
CLMS	Corine Land Monitoring Service
CN	Curve Number
CRF4A	Chapter in LULUCF report on Carbon Retention for Forest
CRS	Coordinate Reference System
DEM	Digital Elevation Model
Destatis	Deutsche Statistisches Bundesamt
DG	Directorate General
EA	Ecosystem Asset
EA	Ecosystem Accounting
EBBA2	European Breeding Bird Atlas version 2
EBCC	European Bird Census Council
ECA	Europe and Central Asia
ECT	Ecosystem Class Type
EEA	Ecosystem Accounting Area
EEA	European Environment Agency
EFA	European Forest Accounts
ESA	European Space Agency
ET	Ecosystem Type
ETS	Emission Trading Scheme
EU	European Union
EU25 (2014)	All members states of European Union in 2014

EUNIS	European Nature Information System
FAPAR	Fraction of Absorbed Photosynthetic Active Radiation
FCI	Forest Condition Index
FCOVER	Fraction of Green Vegetation Cover
FCP	Forest Connectivity Percentage
FF	Forest Fragmentation
GDMP	Gross Dry Matter Productivity
GDP	Gross Domestic Product
GET	Global Ecosystem Typology
GHGs	Greenhouse gases
GIS	Geographic Information System
GPS	Global Program for Sustainability
HRL	High Resolution Layer
HRVPP	High Resolution Vegetation Phenology Productivity
IMD	Imperviousness Density
INCA	Integrated Natural Capital Accounting
IUCN	International Union for Conservation of Nature
JRC	Joint Research Center of the European Union
LAI	Leaf Area Index
LN	Landscape Naturalness (LN)
LULUCF	Land Use, Land Use Change and Forestry
MDM	Mediterranean Mountains climate zone
MDN	Mediterranean North climate zone
MDS	Mediterranean South climate zone
MF	Mixed forest
MFA	Material Flow Account
MMU	Minimum Mapping Unit
N	Nitrogen
N02	Nitrogen Dioxide
NBT	Nature Based Tourism
NCA	Natural Capital Accounting
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NPP	Net Primary Productivity
OECD	The Organization for Economic Co-operation and Development
OGM	Orman Genel Müdürlügü (General Directorate of Forestry)
OSM	Open Street Map

P	Phosphor
PEOPLE-EA	Pioneering Earth Observation Applications for the Environment - Ecosystem Accounting project
PM	Particulate Matter
PPI	Plant Phenology Index
PPP	Purchasing Power Parity
QGIS	Software to handle Geographic information System
RP map	Recreation Potential Map
RUSLE	Revised Universal Soil Loss Equation
SBB	Turkish Strategy and Budget Office
SD	Drought Severity
SDAs	Service Demanding Area
SDGs	Sustainable Development Goals
SEEA-EA	System of Environmental Economic Accounting - Ecosystem Accounting
Sentinel-x	Satellite Missions
SNA	System National Accounts
SOC	Soil Organic Carbon
SPA	Service Providing Area
SUT	Supply Use Table
TA	Technical Assistance
TCD	Tree Cover Density
TFBSD	Threatened Forest Bird Species Diversity
TUIK, Turkstat	Turkish Statistical Institute
TULIP	Türkiye Resilient Landscape Integration Project
TWG	Technical Working Group
TWS	Transitional woodland-shrub
UASIS	Ecosystem type map developed by Directorate-General for Combating Desertification and Erosion for Bolaman and Çekerek
UN	United Nations
UNSD	United Nations Statistics Division
VITO	Vlaams Instituut voor Technologisch Onderzoek
WB	World Bank
WHO	World Health Organization

1 INTRODUCTION

1.1 Global Program on Sustainability (GPS) and Natural Capital Accounts (NCA) in Türkiye

The **Global Program on Sustainability** (GPS), administered by the World Bank, aims to integrate environmental and other sustainability considerations into public and private decisions by providing policy makers and the financial sector with the necessary metrics and tools. This approach involves looking beyond GDP and traditional financial metrics to include systematic accounting for environmental risks and opportunities and valuing natural capital and ecosystem services, strengthening the national statistical system.

Türkiye has been selected as one of the GPS Core Implementing Countries. The activities focus on providing Technical Assistance (TA) on Natural Capital Accounting (NCA) and its application in policies and programs which can further inform Türkiye's green transition. The aim of the GPS TA is to strengthen the existing NCA data and capacities for their use in Türkiye by supporting the development of new accounts, conducting training on policy analysis, as well as strengthening national capacities in implementing NCA in selected sectors through WB operations. As such, it comprises two work packages: (i) Strengthening capacities for NCA data and use; (ii) Piloting of ecosystem accounts at project and national levels.

Türkiye's environmental statistics have been covering air, water, wastewater, waste, and environmental expenditures since 1990. Türkiye has also begun efforts to produce land use and spatial data information within the context of the EU's Inspire Directive. Turkstat has been actively pursuing the implementation of EU Regulation 691/2011 on European Environmental and Economic Accounts and, following Eurostat's guidance, has begun developing new accounts per the Regulation's requirements. These new EU accounts include ecosystem accounts and forestry accounts.

The scope of the work package on ecosystem accounting is twofold: 1) pilot land and ecosystem accounts (ecosystem extent account) at the national level, following emerging Eurostat Guidance, 2) pilot a basic set of ecosystem accounts including a condition and ecosystem services account at the subnational level. For the latter pilot, the Bolaman and Çekerek watersheds have been selected, which are part of the Türkiye Resilient Landscape Integration Project (TULIP, P172569).

TULIP is an active World Bank project (2021–2028) that aims to improve livelihoods and resilient infrastructure services for rural communities in the Bolaman River Basin, located in the eastern Black Sea Region, and in the Çekerek River Basin in the central Anatolia Region. Both basins are highly vulnerable to climate change impacts, including seasonal floods and droughts, soil erosion, and landslides. The positive environmental, economic, and social impacts of the project are expected to be significant, given the focus on strengthening the resilience of landscapes and livelihoods in the two river basins with a focus on nature-based solutions.

1.2 Natural Capital Accounts in the EU and its legislation

The work on NCA is implemented in partnership with the United Nations Statistics Division (UNSD), the custodian agency of the **System of Environmental Economic Accounting** (SEEA) which is the statistical standard that underpins NCA[3].

The SEEA provides countries with a framework to derive internationally comparable environmental-economic accounts, supporting measurement of progress toward the 2030 Agenda and its Sustainable Development Goals (SDGs), the Global Biodiversity Framework, and other policy frameworks such as green growth strategies. The United Nations Statistical Commission (UNSC) adopted the SEEA Central Framework (SEEA CF) in 2012 as an international statistical standard. In 2021, the UNSC adopted the SEEA Ecosystem Accounting (SEEA EA) as an international statistical standard and encouraged countries to implement the SEEA EA.

In 2022 the European Commission adopted a proposal[4] for amending Regulation (EU) No 691/2011 by adding among other topics a new module on ecosystem accounts. The module on ecosystem accounts comprises the implementation of SEEA EA in the European Union. If adopted by the European Parliament and the Council, it will be mandatory for member states to submit environmental accounts on the extent and condition of ecosystems and the services they provide. More specifically, statistics shall be compiled and transmitted:

- Every 3 years for ecosystem extent and ecosystem condition accounts.
- On a yearly basis for ecosystem services accounts.

Statistics shall be transmitted within 24 months of the end of the reference year. The first reference year for which accounts are expected is 2024.

To prepare the Commission and member states for this legal module, Eurostat has established a Task Force to provide methodological and practical guidance to EU compilers of ecosystem accounts and assure that progress in the implementation of ecosystem accounting in the EU is well coordinated and methodologically robust. The guidance developed in this Task Force builds heavily on the results from a pilot project Integrated system for Natural Capital and ecosystem services Accounting in the EU (INCA). The project aimed to pilot the implementation of the SEEA EA in the EU and has produced ecosystem accounts for the EU that are largely based on data officially reported by member states to the Commission and models available at the time the project was conducted. All public outputs of INCA can be accessed on the INCA platform[5]. Besides practical guidance, a tool (the INCA tool) is also being developed to support the development of the accounts. The methodologies applied in this project build heavily on these guidance documents and the INCA tool.

[3] https://seea.un.org/es/ecosystem-accounting
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:329:FIN
[5] https://ecosystem-accounts.jrc.ec.europa.eu/

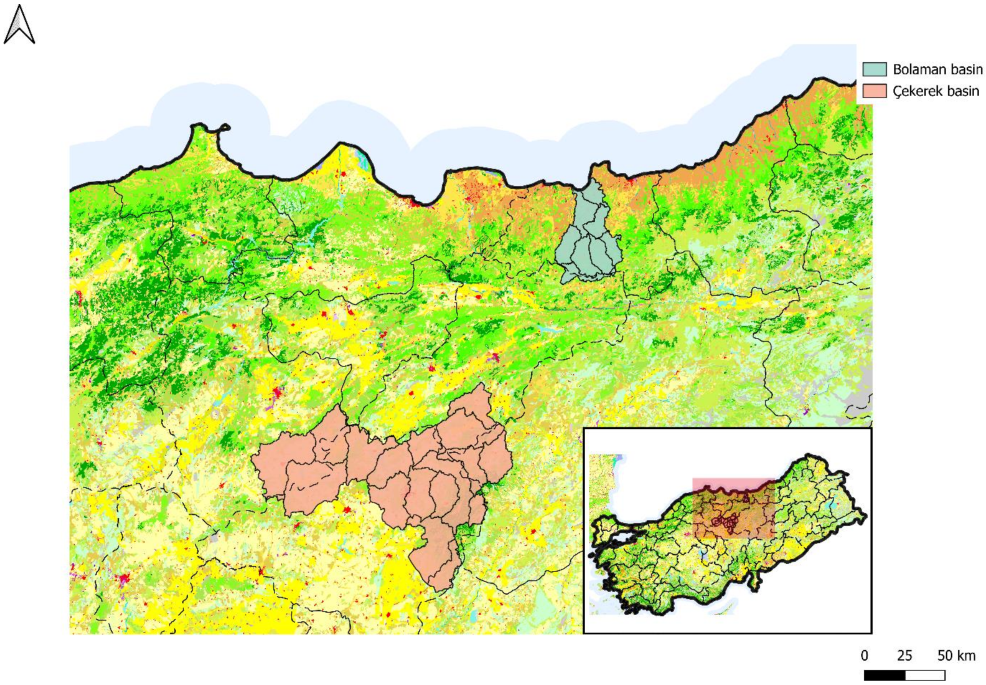
1.3 Project goals

The objective of this project is to support the compilation of ecosystem accounts at the national level and in two pilot sites (Bolaman and Çekerek watersheds).

This objective includes:

- A comprehensive data needs assessment for the development of Ecosystem Accounts in Türkiye (complementing the preliminary one), identifying the institutions that need to be involved for compiling the necessary data.
- Compilation of a national ecosystem extent account.
    - Compilation of ecosystem condition accounts for the two pilot sites, aggregating multiple condition variables (in line with Eurostat Guidelines).
    - Compilation of ecosystem services accounts for the two pilot sites. This includes the modeling of selected ecosystem services in physical units for two different years (linked to ecosystem extent accounts) and presenting the results in the form of maps and in summary tabular format (the amount of ecosystem services provided by ecosystem type). The modelling of selected ecosystem services should be aligned as much as possible with (emerging) Eurostat guidelines and where possible the INCA tool (including assessing the possibility of extending the INCA tool coverage to include Türkiye) must be applied.
    - Prepare a summary report with the compiled ecosystem accounts at the pilot site level (Bolaman and Çekerek watersheds) and provide recommendations for a roadmap to scale up at the national level.
    - Build capacity at Turkstat, OGM, and other agencies as relevant for compiling the account for future iterations, and in valuation of relevant ecosystem services by foreseeing a training program.

Figure 7: Overview of land cover of the pilot basins.



Source: Compiled by VITO

1.4 Scope

1.4.1 Reference years for accounts

Before discussing individual accounts, it is important to highlight the reference years for which accounts are produced. Based on the results from a stakeholder workshop, reference years **for the accounts are 2018 and 2021**. These reference years are on the one hand feasible from a data availability perspective and on the other hand relevant for policy use, as it assists in the monitoring of implemented measures part of the TULIP project during 2020–2021 and its subsequent impact.

1.4.2 Extent accounts

Ecosystem extent is the size of the ecosystems in the area. Ecosystem extent accounts record the area and change in area for each ecosystem type within the national territory.

Ecosystem extent is a key component for all the accounts using SEEA-EA because it provides the total areas of every ecosystem component and requires a consistent time-series. The calculation of the other accounts (condition, ecosystem services) builds further on the ecosystem extent account.

The project aims to deliver Tier-1 and Tier-2 ecosystem extent accounts. Tier-1 accounts will be delivered at national scale. Tier-2 accounts will be delivered for two pilot basins (Bolaman and Çekerek).

1.4.3 Condition accounts

Ecosystem condition reflects the quality of an ecosystem measured in terms of its abiotic, biotic, and landscape characteristics, by ecosystem types.

Measuring ecosystem condition over time provides insights in the development of the health of the ecosystem as a function of, for instance, human use, ecological variability, and climate change. Ecosystem condition variables are quantitative metrics describing individual properties or characteristics of an ecosystem asset.

Ecosystem condition accounts will be developed at the watershed level, for both Bolaman and Çekerek.

The condition account to be developed within the project consists of the following variables per ecosystem type:

For forest and woodland:

- Tree cover density
- Deadwood
- Normalized Difference Vegetation Index (optional)
- Normalized Difference Water Index (optional)
- Leaf Area Index (optional)
- Net Primary Productivity (optional)
- Forest fragmentation (optional)
- Burnt Area/Forest Fire indicator (optional).[6]

For cropland and grassland:

- Soil organic carbon stock in topsoil
- Common farmland bird index.

For settlements and other artificial areas:

- Green area in cities and adjacent towns and suburbs
- Concentration of particulate matter (PM10 and PM2.5).

For coastal beaches, dunes, and wetlands:

- Share of artificial imperviousness area.

1.4.4 Ecosystem services accounts

Ecosystem services are the benefits ecosystems provides to economic and other human activities. They include (i) provisioning, (ii) regulating and maintenance, and (iii) cultural services. Ecosystem services accounts record the actual supply and use of ecosystem services.

The ecosystem service accounts developed in this project will contain the following services both in physical and monetary terms:

Provisioning services:

- Crop (Including cultivated nuts) provision
- Wood provision.

Regulating services:

- Global climate regulation

[6] Added after the first technical workgroup on forest condition and ecosystem services.

- Soil retention
- Flood control and water flow regulation.

Cultural services:

- Nature-based tourism (limited to physical terms).

Non-wood forest products provision (honey, chestnuts, mushrooms,…) by forests were also considered important by the Turkish stakeholders. Based on available data, some calculations were performed. However, results are too incomplete to present them in this report.

Ecosystem services accounts will be generated at the watershed level, for both Bolaman and Çekerek.

Services which are considered mandatory services in the draft EU legislation and which are not within the scope of this project are pollination, air filtration, and local climate regulation. Non-wood, forest products provision and flood control are non-mandatory, but are included in this project because of their high policy relevance. Mandatory services in the draft EU legislation are limited to biophysical indicators; monetary indicators are not mandatory.

1.5 Ecosystem service accounting with the INCA tool

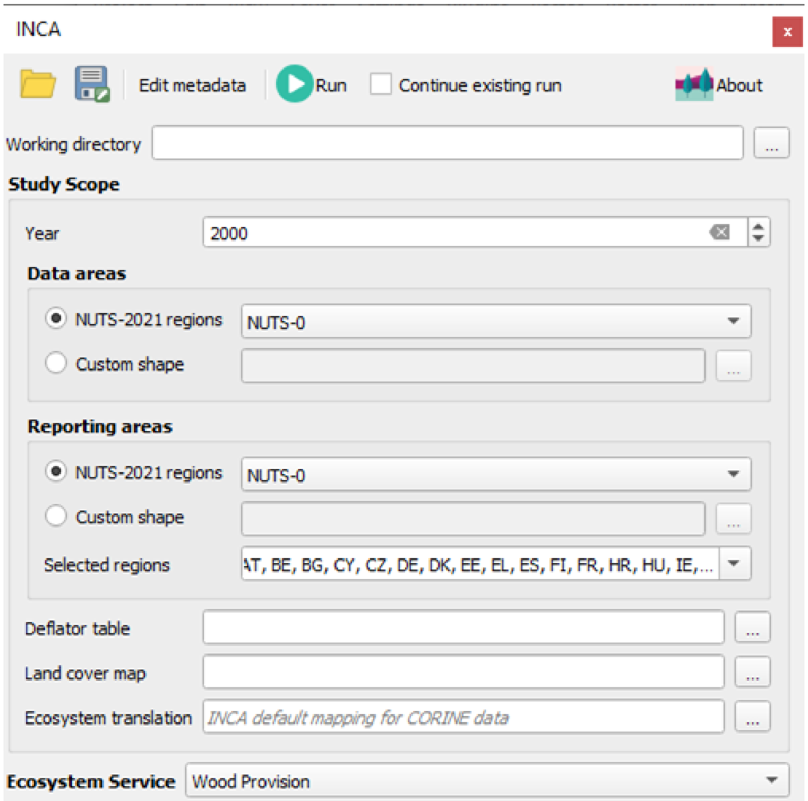
To facilitate the development and production of ecosystem services accounts in Europe, the INCA tool supports member states in the regular production of service accounts according to the requirements defined in the proposed amendment to the EU Legislation 691/2011[7].

The INCA tool is a QGIS plugin, which can be applied at regional, country, or continental levels in Europe, or any other part in the world where the necessary input data is provided. The models are based on the INCA models originally developed by the Joint Research Center of the European Union (JRC)[8], and further refined by *Vlaams Instituut voor Technologisch Onderzoek* (VITO) (as contractor for Eurostat) on compliancy to the European ecosystem service guidelines. Currently, nine services are available in the INCA tool:

1. Crop provision service (including nuts)
2. Wood provision service
3. Global climate regulation service, including both carbon retention and carbon sequestration
4. Nature-based tourism recreation service
5. Air filtration service
6. Crop pollination service
7. Local climate regulation service
8. Soil retention service
9. Flood control service.

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:329:FIN
[8] https://ecosystemaccounts.jrc.ec.europa.eu/

Figure 8: Screenshot of the INCA tool



Supply Use Tables (SUTs) together with physical and monetary maps are provided after running the INCA tool. The INCA tool calculates a supply-and-use table in monetary (fe. millions of EUR, TRY) and physical (thousands of tonne of C, number of visits, and so on) terms. The supply table shows the contribution of each ecosystem type to the actual flow, the use table reports who is using and benefiting from the service (f.e. Government final consumption, Households final consumption, etc.). The **physical and monetary maps** (raster maps) are also produced, where these supply values are distributed on the map according to the chosen proxy or spatial calculation method.

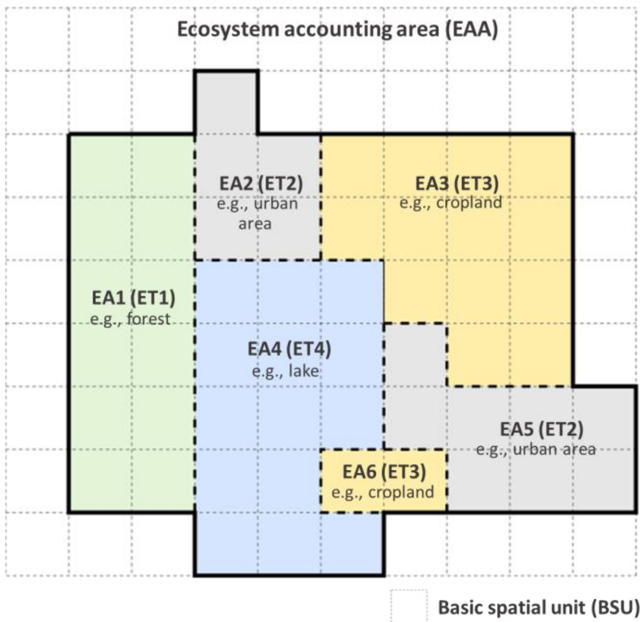
2 ECOSYSTEM EXTENT ACCOUNT

2.1 Definition

An area or region is delineated into contiguous, mutually exclusive units, each covered by a specific ecosystem. An ecosystem is composed of a range of ecological and non-ecological characteristics, including vegetation type, soil type, hydrology, climate, land management, land use and ownership.

As depicted in Figure 9, an ecosystem extent is the (physical area) **size of an ecosystem asset (EA)** and usually is measured in terms of spatial area. It provides an overview of the compositing of, and changes in, **ecosystem types (ET) within an ecosystem accounting area (EAA)**.

Figure 9: SEEA EA ecosystem extent terminology



Source: UNSD.

The European Commission, under guidance of its statistical division (Eurostat), has created a guidance note to assist EU compilers with the compilation of ecosystem extent accounts to meet the reporting obligation (amended Regulation (EU) 691/2011) and help harmonize compilation approaches across the EU. The guidance follows the SEEA Ecosystem Accounting 2021 (SEEA EA) and added further details regarding the ecosystem types found in Europe, and to relevant European classifications and datasets.

The guidance note includes a three-level EU ecosystem typology to support the compilation of extent accounts with a growing level of detail. **Level-1 (L1 EU**) captures the 12 ecosystems mandated for reporting as shown in Table 9. **Level-2 (L2 EU)** and **Level-3 (L3 EU)** are targeted and add more details for voluntary reporting or to support the identification of classes for national or regional ecosystem accounts. Level-1 and most terrestrial LLevel-2 classes can, in principle, be mapped using existing remote sensing data like CORINE land cover. The latter dataset has been adopted and approved by statistical agencies. Level-3 is a more flexible classification, partly based on the EUNIS habitat classification. At L3 EU, countries may add or reduce classes depending upon national and regional needs for the compilation of ecosystem accounts. Any new classes introduced should be clearly linked to one of the available and appropriate L2 EU classes to enable aggregation at a harmonized L1 EU and L2 EU.

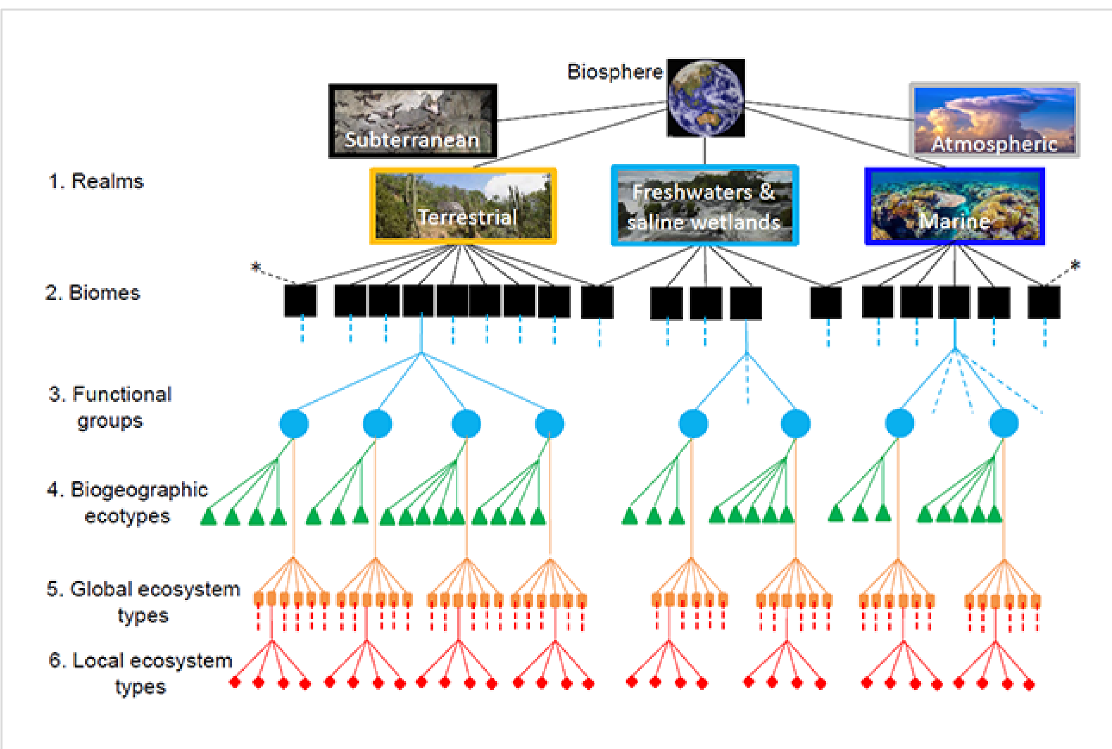
Table 9: EU ecosystem typology, Level-1

Category	Name of ecosystem type
1	Settlements and other artificial areas
2	Cropland
3	Grassland (pastures, semi-natural and natural grasslands)
4	Forest and woodland
5	Heathland and shrub
6	Sparsely vegetated ecosystems
7	Inland wetlands
8	Rivers and canals
9	Lakes and reservoirs
10	Marine inlets and transitional waters
11	Coastal beaches, dunes and wetlands
12	Marine ecosystems (coastal waters, shelf and open ocean)

Source: EEA

The EU ecosystem typology was proposed as a common classification to harmonize the reporting on ecosystem accounts in the EU. For international reporting, the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology (GET) has been selected, as shown in Figure 10, and hence the EU guidance has included an alignment (crosswalk) to this international typology at Level-3 (functional groups) at the best possible. Some IUCN classes have been merged in the EU typology given their limited extent in the EU or even left out (e.g., tropical forest) if not present at all, while some other (mainly anthropogenic influenced) ecosystems are too limited in GET.

Figure 10: IUCN Global Ecosystem Typology



Source: IUCN

At the end of 2023, early 2024, a first voluntary data collection[9] was initiated for ecosystem extent accounts for countries that are part of the European Statistical System. The experienced gained by 12 participating countries during this data collection is being processed as part of the task force on ecosystem accounting. The latest available guidance note is expected to be (slightly) revised when consensus is reached on the main outstanding issues, which are summarized here:

- Length of the accounting period for voluntary reporting is set to annual starting from the 2024 data collection.
- Revision on the delineation of the coastline.
- Treatment of agroforestry areas.
- Guidance how to deal with discrepancies between stocks and flows, related to uncertainties.
- Addition of some country example datasheets.

A final version of the Guidance note on ecosystem extent accounts for EU is expected to be available as part of the handbook for ecosystem accounting in 2025.

This component will compile national ecosystem extent accounts, following the Guidance Note by Eurostat. To kick-start the other components (condition and service accounts), and the applicability of the accounts for the watersheds, a 2-step approach is applied.

First, fast-track extent accounts were generated based on the Corine Land Cover Accounting layers for the years 2012 and 2018 in absence of 2021 data. A crosswalk between with the EU Ecosystem Extent Typology Level-1 and between years was applied. The results are **Tier-1 extent maps** which are to be used for the generation of the initial condition and service accounts, at least for the 2018 reference year. A Tier-1 account is modelled from global (or continental) datasets with no or little user input. Results are not validated with on-site observations.

Thereafter, the extent accounts are to be extended in time, at least till 2021 to have a more recent version; and in thematic (EU typology Level-2 or Level-3 for specific classes, and/or additional missing classes at Level-3) and spatial (better Minimum Mapping Unit) for regional use (TULIP Bolaman and Çekerek watershed areas). The method to achieve these **Tier-2 or Tier-3 ecosystem extent accounts** depends on the availability of data and discussed in the Technical Working Group (TWG). Tier-2 accounts are modelled from national datasets customized for national contexts with some validation. Tier-3 accounts are modelled through integration of local datasets and validated at sub-national scale.

2.2 Tier-1 extent accounts

2.2.1 Methodology and data sources

As explained earlier, Tier-1 (also named fast-track) accounts will use the European continental wide Corine Land Cover Accounting layers (CLCACC[1]) to generate Level-1 ecosystem accounts. The CLCACC are Corine Land Cover (CLC) status layers modified for the purpose of consistent statistical analysis in the land cover change accounting system. The modification combines the CLC status and change layers in the 100m raster form to create homogeneous quality time series for accounting. The layers use the official CORINE Land Cover nomenclature guidelines. It covers the entire EAA39 zone, including Türkiye and is available for the years 2000, 2006, 2012 and 2018. Since the dataset is based on CLC, the level of spatial detail is 25ha and 5ha for changes. The CLC dataset is commonly used for statistical analysis and an independent

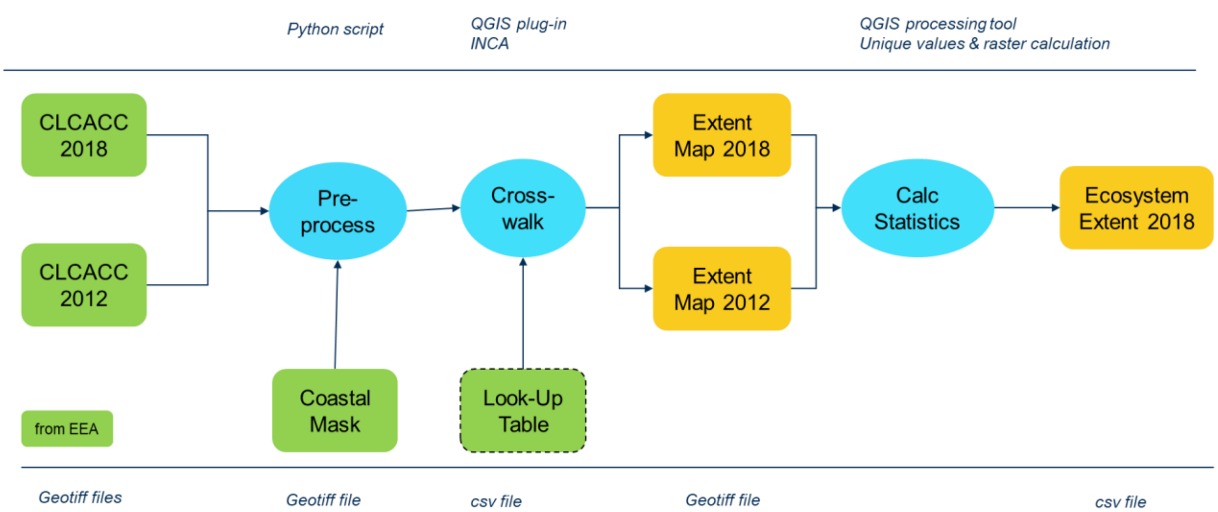
[9] See https://ecosystem-accounts.jrc.ec.europa.eu/news/2024/02/19/voluntary-data-collection-ecosystem-extent-accounts

validation defines an accuracy (correctness) of the change from 2012 to 2018 for Türkiye is around 85 percent[2]. It should also be noted that the numbers for the ecosystem type 'Forest and Woodland' do represent forest land cover, according to the European definition, and do not exactly represent the legally designated forest area as managed by the Department of Forestry (OGM).

The decision to use the Corine land cover datasets was made by the technical workgroup, leading this work. This was based on Corine being commonly used and being a statistically approved dataset. Corine has a wide coverage in space (entirety of Türkiye) and time, the Corine data is produced every 6 years since 2000 up till 2018. Eurostat guidelines suggest using the CORINE or another standardized national land cover dataset for ecosystem accounting. In order to obtain statistical data closer to the present situation, the 2021 Corine land cover data based on UASIS produced by the General Directorate of Combating Desertification and Erosion (ÇEM) and the official 2018 Corine land cover data were also studied. [10] [11]

Figure 11 describes the workflow to generate ecosystem extent accounts derived from the CLCACC layers. The 2012 and 2018 CLCACC dataset (geotiff files in EPSG:3035 projection) were downloaded and clipped to the Türkiye extent. After some pre-process operation (see further below the figure), a crosswalk was done using a Look-Up Table (csv file) to transform every CLCACC class into an EU L1 class. The QGIS plug-in tool INCA[12] was used for this purpose. The tool provides the ecosystem extent EU L1 maps (geotiff raster files at 100 m spatial resolution) for Türkiye. The QGIS processing tool (unique raster values or zonal histograms) can be used to count the number of pixels for 2012 and for 2018.

Figure 11: Spatial workflow to generate fast-track ecosystem accounts



Source: Compiled by VITO

Two pre-processing steps have been applied on the CLCACC layers:

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[10] Data can be downloaded from https://www.eea.europa.eu/en/datahub/datahubitem-view/a55d9224-a326-4cb1-9b9c-3a324520341a

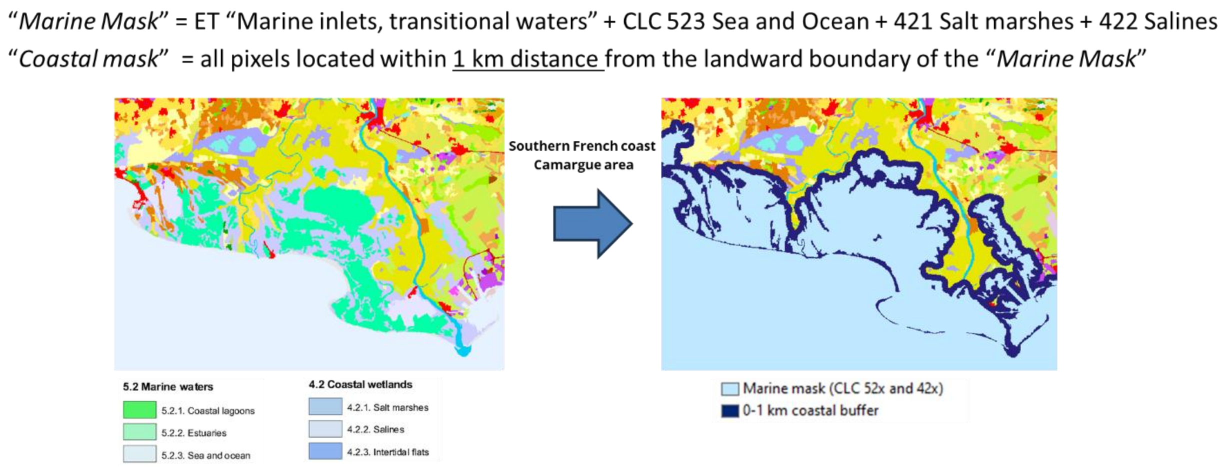
[11] See Annex-1 of https://land.copernicus.eu/en/technical-library/clc-2018-and-clc-change-2012-2018-validation-report/@@download/file

[12] INCA tool can be downloaded from https://ecosystem-accounts.jrc.ec.europa.eu/inca-tool.

1. Split of some CLC classes between coastal and sparse vegetation ecosystem types, according to Annex 5 of the EU guidance note.
2. Reverting of Burned Area CLC class.

Figure 12 shows an overview of the coastal mask as provided by EAA. This mask was used to split the classes dunes and sands (331), bare rocks (332), and sparsely vegetated areas (333), adding the number 1,000 if the class was located within the mask. The crosswalk table thereafter uses this split to assign the CLC classes to the correct ecosystem type 331 to 333 to ecosystem type 6 (sparsely vegetated) and 1331 to 1333 to ecosystem type 11 (coastal). Note the exact definition of this mask is still under discussion in the EU ecosystem accounting Task Force and may be changed in due time.

Figure 12: Annex 5 of EU guidance note, current EEA proposal for coastline / coastal mask



Source: Compiled by VITO

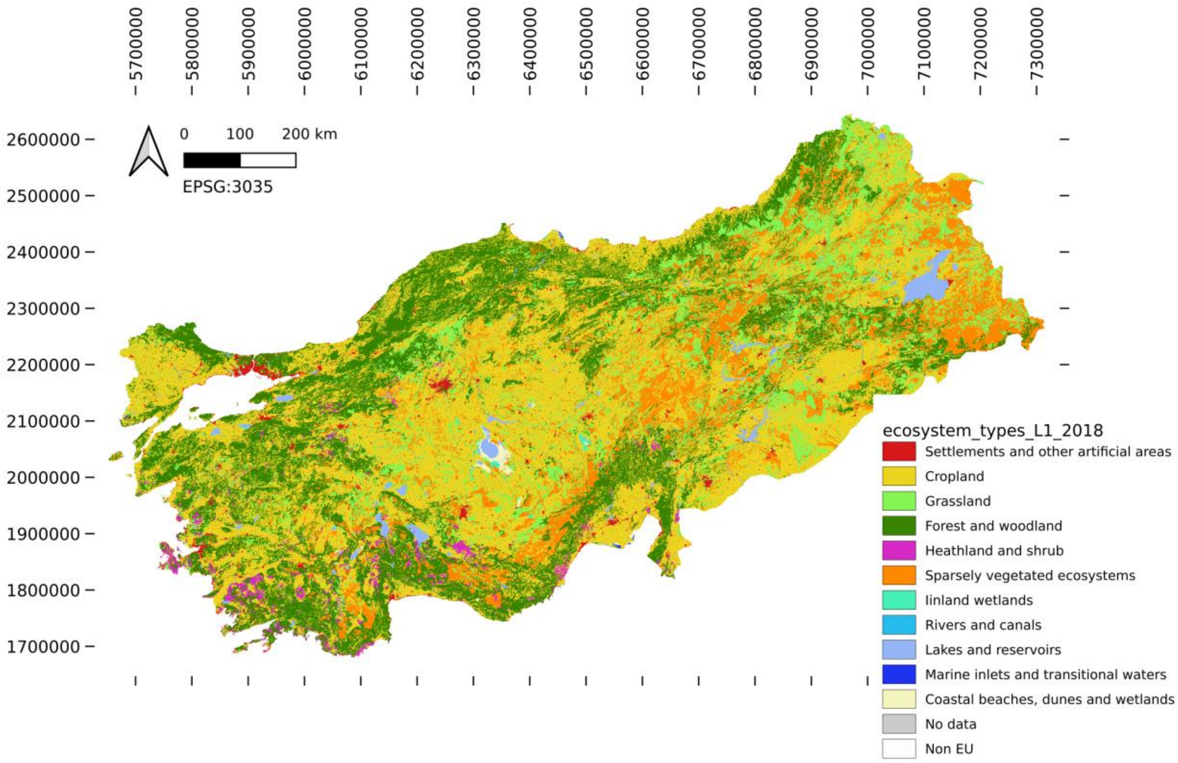
Second, CLC contains the class 224 (Burnt area) which cannot be assigned to a specific ecosystem type. There are two strategies, the first one assigns them to unknown[13] and the second one assumes that a burned area is only a temporal phenome and will not change the ecosystem type. Therefore, we can start from the latest available CLCACC (here 2018) and revert any burned pixels to the class of the previous timestep (here 2012) and so forth going to the initial ecosystem type (here 2000).

2.2.2 Results at national scale

Figure 13 shows the result from the ecosystem extent Tier-1 workflow for the year 2018 across Türkiye, more particular the extent map at EU L1.

[13] Assigning them to a transitional ecosystem type would be an alternative option, however such type is not available at Level-1.

Figure 13: Ecosystem extent map at Tier-1 for 2018 for Türkiye



Source: Compiled by VITO

We can see that 41 percect of Türkiye is allocated to the cropland ecosystem type, followed by 25 percent forest and woodland. The 15 percent sparsely vegetated area is mainly located in the East and South, while a large part of the 14 percent grassland is located in the North-East. About 2 percent of the land is settlement and other artificial area. Table 10 further shows that a net value of 139.000 ha was added to the settlements. According to the 2024 activity report of the General Directorate of Forestry, forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025). [14]

[14] Page 8 in the 2024 activity report of the General directorate of Forestry. https://www.ogm.gov.tr/tr/e-kutuphane-sitesi/FaaliyetRaporu/2024%20-%20Orman%20Genel%20M%C3%BCd%C3%BCrl%C3%BC%C4%9F%C3%BC%20Faaliyet%20Raporu.pdf

Table 10: Ecosystem extent accounting table at Tier-1 for 2018 for Türkiye

	Ecosystem type (level 1)	Opening area 2012 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2018 (ha)	Closing area 2018 (%)
1	**Settlements and other artificial areas**	1,476,268	155,766	5,999	149,767	1,616,286	2.1%
2	**Cropland**	32,052,494	55,165	94,653	- 39,488	32,013,086	41.1%
3	**Grassland**	10,918,555	2,811	73,898	- 71,087	10,847,312	13.9%
4	**Forest and woodland**	19,310,144	15,903	51,834	- 35,931	19,283,693	24.7%
5	**Heathland and shrub**	1,057,425	342	7,030	- 6,688	1,050,860	1.3%
6	**Sparsely vegetated ecosystems**	11,304,569	2,374	31,358	- 28,984	11,275,323	14.5%
7	**Inland wetlands**	208,368	542	1,705	- 1,163	207,223	0.3%
8	**Rivers and Canals**	103,074	4,917	691	4,226	107,336	0.1%
9	**Lakes and reservoirs**	1,236,749	32,829	5,676	27,153	1,263,831	1.6%
10	**Marine inlets and transitional waters**	14,959	10	66	- 56	14,857	0.0%
11	**Coastal beaches and transitional waters**	233,402	2,411	160	2,251	235,827	0.3%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown	- 373					
	Total	**77,915,634**	**273,070**	**273,070**	**-**	**77,915,634**	**ha**
						779,156	km^2

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

Table 11 provides more details on how exactly the ecosystems are converted from 2012 to 2018. We can see that 1.47 million of ha settlements have no changes. However, some limited (6,000 ha) settlements have change mainly in water (rivers and canals or lakes and reservoirs) while a large area (145 ,000 ha) has been converted into settlements mainly by cropland (70,000), grassland (30,000). The changes in the 'forest and woodland' ecosystem are related to the forest land cover.

Table 11: Ecosystem extent fast-track conversion matrix 2012 to 2018 for Türkiye at Tier-1

	2018 (closing in ha)	100	200	300	400	500	600	700	800	900	1000	1100	1200				
	2012 (opening in ha)	Settlements and other artificial areas	Cropland	Grassland	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and Canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches and transitional waters	Marine ecosystems		No-change	Change (reduction)	relative change in%
1	Settlements and other artificial areas	1469667	235	409	1583	6	578	0	1366	1793	0	29	0		1469667	5999	0.4%
2	Cropland	70468	31957294	1543	1136	0	75	94	1911	19413	10	3	0		31957294	94653	0.3%
3	Grassland	29232	35389	10844252	5970	25	0	53	509	2720	0	0	0		10844252	73898	0.7%
4	Forest and woodland	38774	5549	358	19267120	277	1012	0	496	5368	0	0	0		19267120	51834	0.3%
5	Heathland and shrub	2623	863	0	3453	1050198	0	0	0	91	0	0	0		1050198	7030	0.7%
6	Sparsely vegetated ecosystems	13960	9954	301	3729	34	11272843	0	587	2793	0	0	0		11272843	31358	0.3%
7	Inland wetlands	72	1434	40	0	0	0	206644	24	135	0	0	0		206644	1705	0.8%
8	Rivers and Canals	164	0	0	0	0	11	0	102317	516	0	0	0		102317	691	0.7%
9	Lakes and reservoirs	316	1672	160	32	0	698	395	24	1231001	0	2379	0		1231001	5676	0.5%
10	Marine inlets and transitional waters	66	0	0	0	0	0	0	0	0	14832	0	0		14832	66	0.4%
11	Coastal beaches and transitional waters	91	69	0	0	0	0	0	0	0	0	232869	0		232869	160	0.1%
12	Marine ecosystems	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0.0%
	No-change	1469667	31957294	10844252	19267120	1050198	11272843	206644	102317	1231001	14832	232869	0		77649037	273070	0.4%
	Change (addition)	155766	55165	2811	15903	342	2374	542	4917	32829	10	2411	0		273070		
	relative change in %	11%	0.2%	0.0%	0.1%	0.0%	0.0%	0.3%	4.8%	2.7%	0.1%	1.0%	0%		0.4%		

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

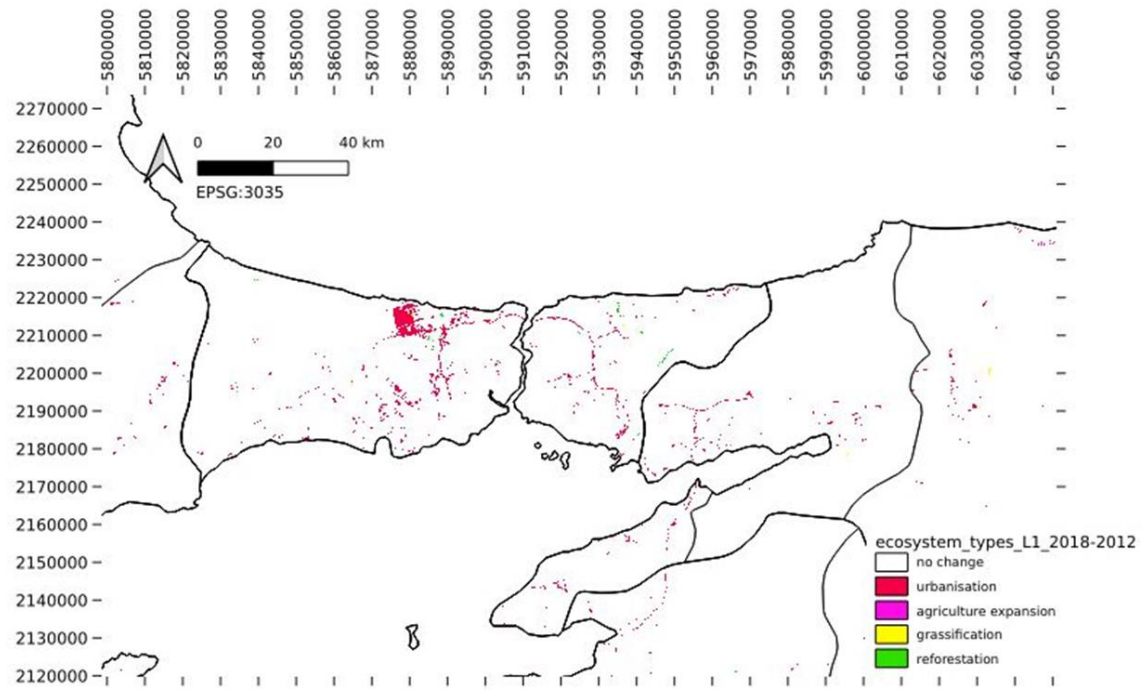
	2018 (closing in ha)	100	200	300	400	500	600	700	800	900	1000	1100	1200				
	2012 (opening in ha)	**Settlements and other artificial areas**	**Cropland**	**Grassland**	**Forest and woodland**	**Heathland and shrub**	**Sparsely vegetated ecosystems**	**Inland wetlands**	**Rivers and Canals**	**Lakes and reservoirs**	**Marine inlets and transitional waters**	**Coastal beaches and transitional waters**	**Marine ecosystems**		**No-change**	**Change (reduction)**	**relative change in%**
1	**Settlements and other artificial areas**	1469667	235	409	1583	6	578	0	1366	1793	0	29	0		1469667	5999	0.4%
2	**Cropland**	70468	31957294	1543	1136	0	75	94	1911	19413	10	3	0		31957294	94653	0.3%
3	**Grassland**	29232	35389	10844252	5970	25	0	53	509	2720	0	0	0		10844252	73898	0.7%
4	**Forest and woodland**	38774	5549	358	19267120	277	1012	0	496	5368	0	0	0		19267120	51834	0.3%
5	**Heathland and shrub**	2623	863	0	3453	1050198	0	0	0	91	0	0	0		1050198	7030	0.7%
6	**Sparsely vegetated ecosystems**	13960	9954	301	3729	34	11272843	0	587	2793	0	0	0		11272843	31358	0.3%
7	**Inland wetlands**	72	1434	40	0	0	0	206644	24	135	0	0	0		206644	1705	0.8%
8	**Rivers and Canals**	164	0	0	0	0	11	0	102317	516	0	0	0		102317	691	0.7%
9	**Lakes and reservoirs**	316	1672	160	32	0	698	395	24	1231001	0	2379	0		1231001	5676	0.5%
10	**Marine inlets and transitional waters**	66	0	0	0	0	0	0	0	0	14832	0	0		14832	66	0.4%
11	**Coastal beaches and transitional waters**	91	69	0	0	0	0	0	0	0	0	232869	0		232869	160	0.1%
12	**Marine ecosystems**	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0.0%
	No-change	1469667	31957294	10844252	19267120	1050198	11272843	206644	102317	1231001	14832	232869	0		77649037	273070	0.4%
	Change (addition)	155766	55165	2811	15903	342	2374	542	4917	32829	10	2411	0		273070		
	relative change in %	11%	0.2%	0.0%	0.1%	0.0%	0.0%	0.3%	4.8%	2.7%	0.1%	1.0%	0%		0.4%		

Source : VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30% of Türkiye (Orman Genel Müdurlügü, 2025)

Such a change matrix at EU L1 is comprised of 12×12 or 132 potential changes which is not possible to analyze on a map. Therefore, the changes are combined into some change flows (urbanization, agriculture expansion, reforestation, etc.) which can be visualized on a map, as shown in Figure 14. The figure shows the urban and cropland expansion around Istanbul from 2012 to 2018 based on the ecosystem extent (and change) maps.

Figure 14: Land cover change flows from 2012 to 2018, zoom-in around Istanbul



Source: Compiled by VITO

2.2.3 Results at regional scale – Çekerek

Çekerek is one of the two areas for the World Bank TULIP project. Condition and service accounts will be calculated and evaluated for this (ecosystem accounting) area, hence it is important to also create and evaluate the ecosystem extent account for this area. The ecosystem extent results using the fast-track approach, as explained before for the national scale, are explained within this session.

A shapefile was received and contained 16 districts, as shown in Figure 18. The shapefile was provided in UTM33 projection and converted to EPSG:3035 to be compliant with the national ecosystem extent maps. The ecosystem extent accounts for 2012 and 2018, including its conversion matrix, were calculated for this region.

Table 12 shows that the TULIP Çekerek region is mainly composed of cropland (more than 47 percent). Most of the forest and woodland ecosystem (30 percent) is located in the South-East region, as shown in Figure 18.

Table 12: Ecosystem Extent Account for Çekerek

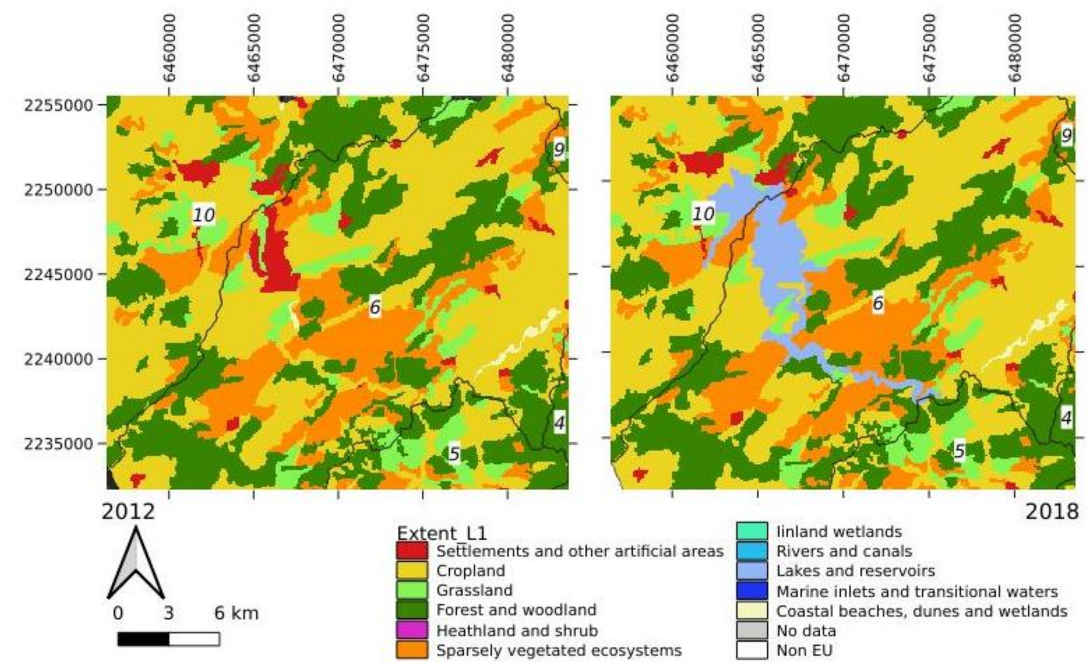
	Ecosystem type (level 1) TULIP Cekerek	Opening area 2012 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2018 (ha)	Closing area 2018 (%)
1	**Settlements and other artificial areas**	13,078	863	771	92	13,170	1.5%
2	**Cropland**	419,817	21	2,697	- 2,676	417,141	47.6%
3	**Grassland**	79,143	-	423	- 423	78,720	9.0%
4	**Forest and woodland**	266,312	-	228	- 228	266,084	30.4%
5	**Heathland and shrub**	-	-	-	-	-	0.0%
6	**Sparsely vegetated ecosystems**	96,722	-	512	- 512	96,210	11.0%
7	**Inland wetlands**	-	-	-	-	-	0.0%
8	**Rivers and Canals**	-	-	-	-	-	0.0%
9	**Lakes and reservoirs**	877	3,737	-	3,737	4,614	0.5%
10	**Marine inlets and transitional waters**	-	10	-	10	10	0.0%
11	**Coastal beaches and transitional waters**	-	-	-	-	-	0.0%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**875,949**	**4,631**	**4,631**	**-**	**875,949**	**ha**
						8,759	km^2

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

Between 2012 and 2018, hardly 0.5 percent of the area was identified as a change of ecosystem type. We can see a slight (only 92 ha net) increase of settlement as expected. This increase is decreased by the transition mainly to lakes and reservoirs as shown in the figure below. The addition of lakes and reservoirs (mainly from cropland) is in districts 6 and 12 and caused by a change in the input CLCACC layers, as shown in Figure 15. The numbers depicted on the figure identify the 16 districts. The ecosystem extent accounting figures for 2018 per district can be found in Table 13.

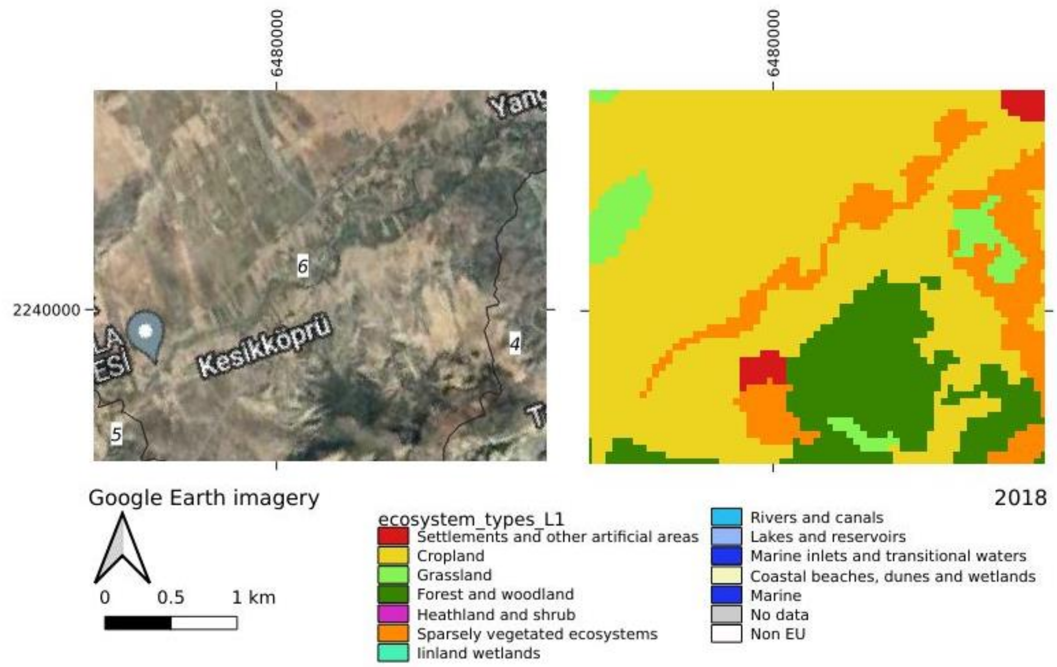
Figure 15: Ecosystem extent account for 2012 and 2018 for subregion 6 in Çekerek zone, change in water reservoir



Source: Compiled by VITO

Another observation is that a small area (236 ha) is assigned to, respectively, Sparse vegetation (ecosystem type 6), which seems more a river. The latter is also located in Zone 6 and caused by a misclassification by the CLCACC input layers (identified as class 331).

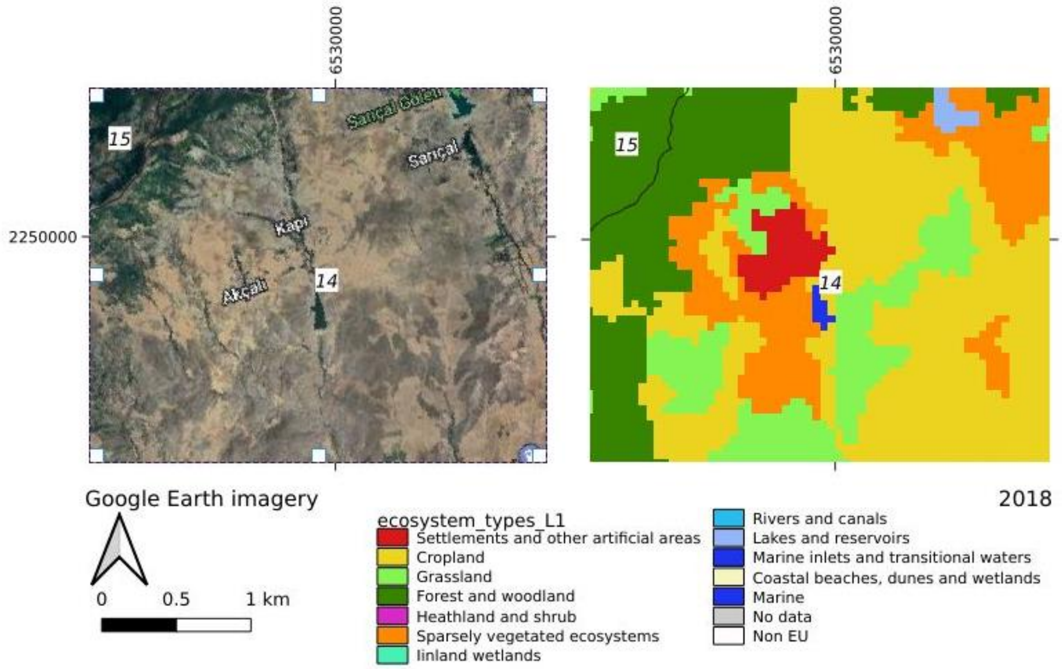
Figure 16: Ecosystem extent account for 2018 for subregion 6 in Çekerek zone, potential misclassification of a river



Source: Compiled by VITO adapted from Google Earth (2024).

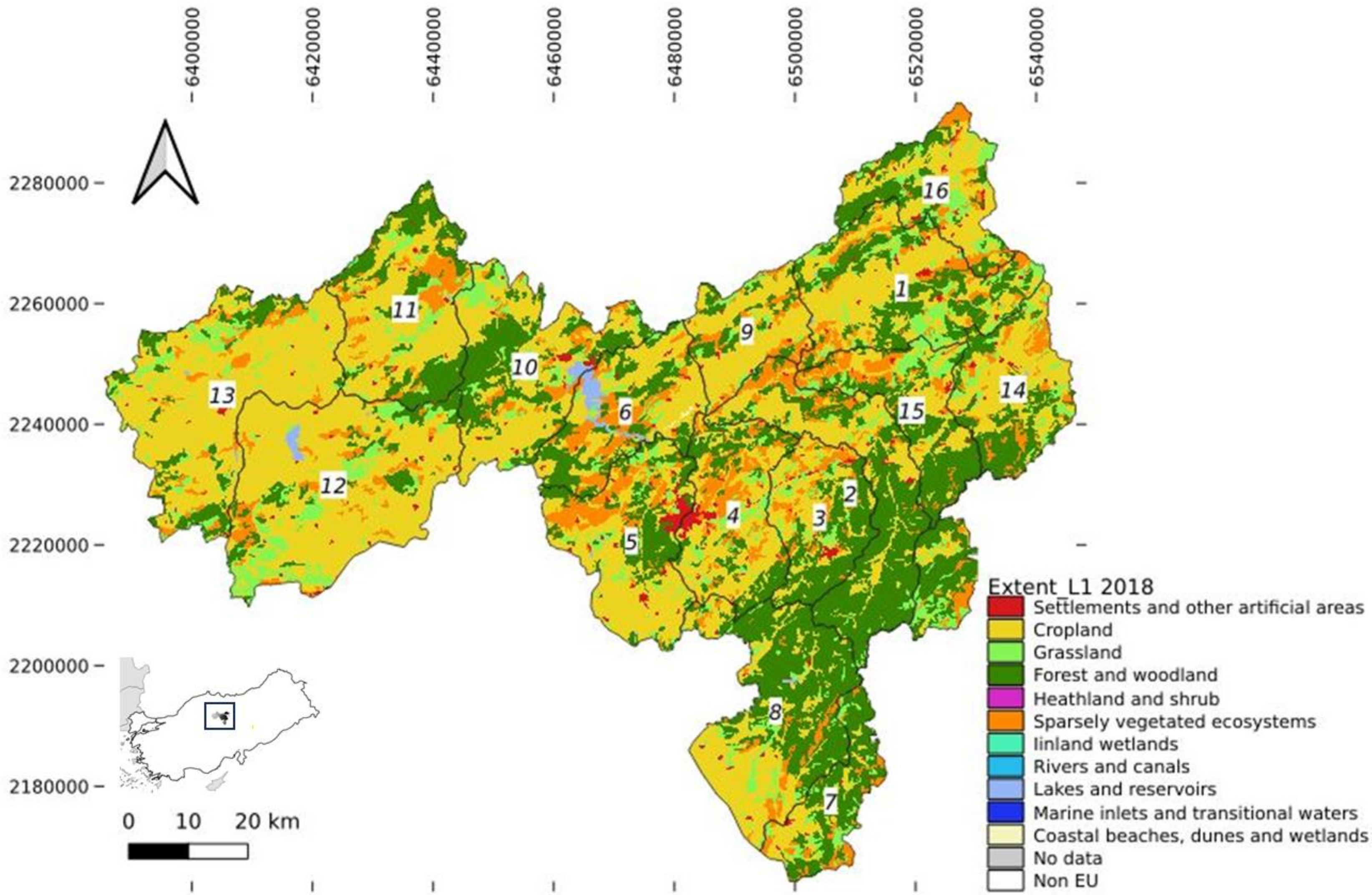
The 10 ha of Marine inlet and transitional waters (ecosystem type 10) are due to the CLCACC input layers. In 2012, these were classified as 243 (agriculture mosaic) and in 2018 as 521 (coastal lagoon), as shown in Figure 17.

Figure 17. Ecosystem extent account for 2018 for subregion 14 in Çekerek zone, potential misclassification of a lake



Source: Compiled by VITO adapted from Google Earth (2024).

Figure 18: Ecosystem extent map at Tier-1 for 2018 per Çekerek TULIP zone



Source: Compiled by VITO

Table 13: Ecosystem Extent account for 2018 per district in Çekerek

	Ecosystem type (level 1) **Closing area 2018 (hectares)** **Cekerek**	**Zone1**	**Zone2**	**Zone3**	**Zone4**	**Zone5**	**Zone6**	**Zone7**	**Zone8**	**Zone9**	**Zone10**	**Zone11**	**Zone12**	**Zone13**	**Zone14**	**Zone15**	**Zone16**
1	**Settlements and other artificial areas**	1001	359	899	1935	2387	466	243	450	358	893	464	691	1134	415	467	1008
2	**Cropland**	29034	17879	12315	20180	26930	17891	7844	25574	18800	29813	30411	68273	65066	19105	10513	17513
3	**Grassland**	8214	2514	2649	3833	3742	2502	6189	4939	1844	5759	4625	11439	7339	3855	4073	5204
4	**Forest and woodland**	19999	33163	15908	11490	13792	12867	23598	34364	5005	19655	17556	8657	10484	12885	16432	10229
5	**Heathland and shrub**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	**Sparsely vegetated ecosystems**	7536	5316	4777	8483	7844	8890	5654	4030	4118	4341	6999	7380	5912	5070	5856	4004
7	**Inland wetlands**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	**Rivers and Canals**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	**Lakes and reservoirs**	102	0	0	0	109	2276	0	124	0	726	37	981	136	69	-	54
10	**Marine inlets and transitional waters**	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
11	**Coastal beaches and transitional waters**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	**Marine ecosystems**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**65,886**	**59,231**	**36,548**	**45,921**	**54,804**	**44,892**	**43,528**	**69,481**	**30,125**	**61,187**	**60,092**	**97,421**	**90,071**	**41,409**	**37,341**	**38,012**
	875,949																

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30% of Türkiye (Orman Genel Müdurlügü, 2025)

2.2.4 Results at regional scale – Bolaman

Condition and service accounts will be calculated and evaluated for the area of Bolaman as well, hence it is important to also create and evaluate the ecosystem extent account for this area. The ecosystem extent results using the fast-track approach, as explained before for the national scale, are explained within this session.

A shapefile was received and comprised eight districts, as shown in Figure 19. The shapefile was provided in UTM33 projection and converted to EPSG:3035 to be compliant with the national ecosystem extent maps. The ecosystem extent accounts for 2012 and 2018, including their conversion matrix, were calculated for this region.

Table 14 shows that the TULIP Bolaman region is mainly composed of cropland (more than 65%). Most of the grassland (10%) is located in the South of the region, while the forest and woodland ecosystem (23%) is very fragmented scattered throughout the region, as shown in Figure 19. We can see that the largest settlement areas are located in districts 1 and 5, hence at the coast. Since the coastal area is almost entirely composed of anthropogenic influence (construction and cropland), we see no values in ecosystem type 11 (coastal beaches and transitional waters).

Table 14: Ecosystem Extent Account for Bolaman

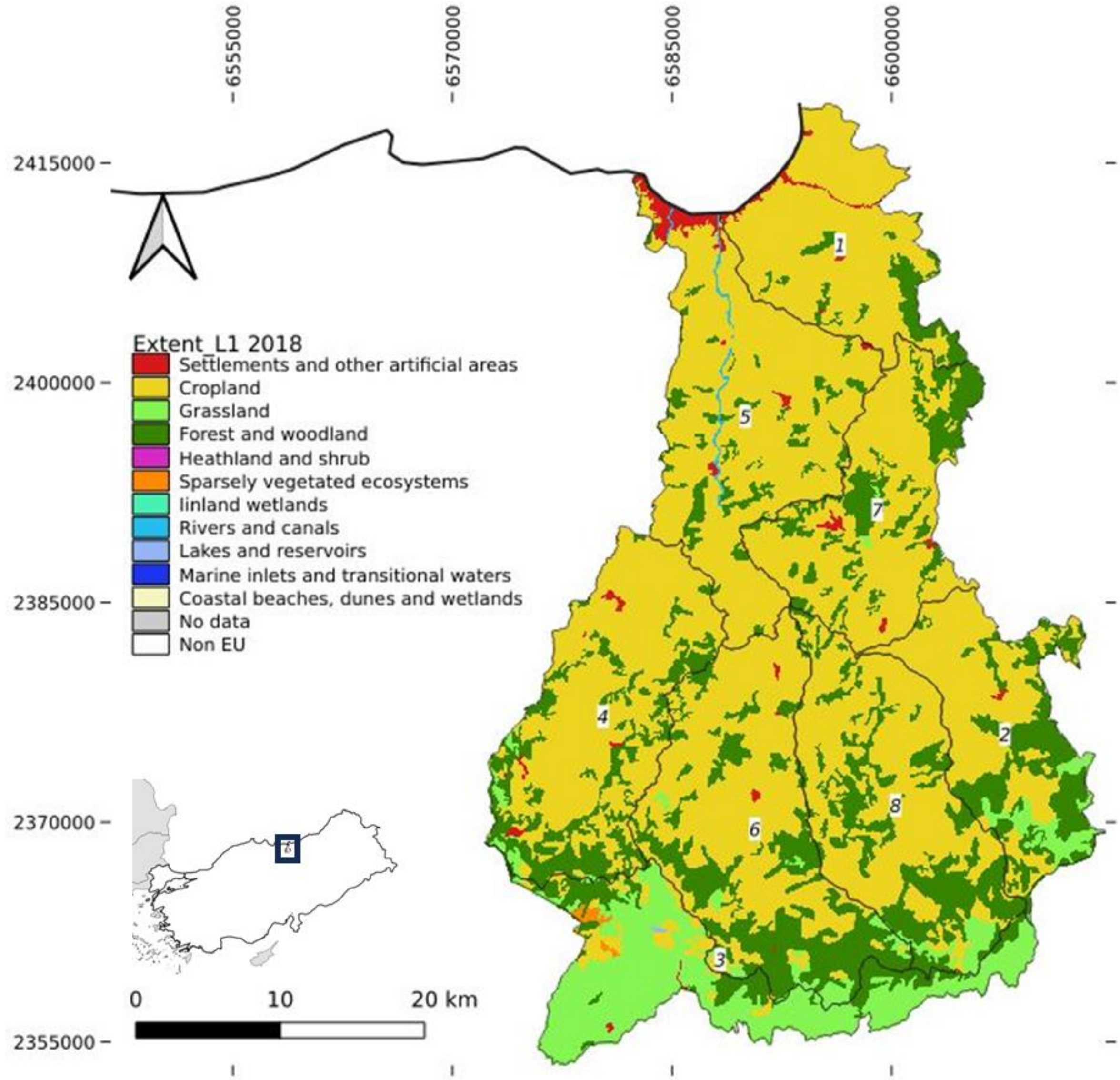
	Ecosystem type (level 1) TULIP Bolaman	**Opening area 2012 (ha)**	**Additions**	**Reductions**	*Net changes (voluntary)*	**Closing area 2018 (ha)**	**Closing area 2018 (%)**
1	**Settlements and other artificial areas**	1,620	218	-	218	1,838	1.2%
2	**Cropland**	103,655	133	150	-17	103,638	65.2%
3	**Grassland**	15,958	-	48	-48	15,910	10.0%
4	**Forest and woodland**	36,981	-	153	-153	36,828	23.2%
5	**Heathland and shrub**	-	-	-	-	-	0.0%
6	**Sparsely vegetated ecosystems**	235	-	-	-	235	0.1%
7	**Inland wetlands**	-	-	-	-	-	0.0%
8	**Rivers and Canals**	377	-	-	-	377	0.2%
9	**Lakes and reservoirs**	25	-	-	-	25	0.0%
10	**Marine inlets and transitional waters**	-	-	-	-	-	0.0%
11	**Coastal beaches and transitional waters**	-	-	-	-	-	0.0%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**158,851**	**351**	**351**	**-**	**158,851**	**ha**
						1,589	km^2

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

The region is very stable between 2012 and 2018 with only 0.2 percent change in ecosystems over the six years. We can identify the increase of settlements (222 ha) as expected and further some cropland expansion (133 ha).

Figure 19: Ecosystem extent map at Tier-1 for 2018 per district in Bolaman

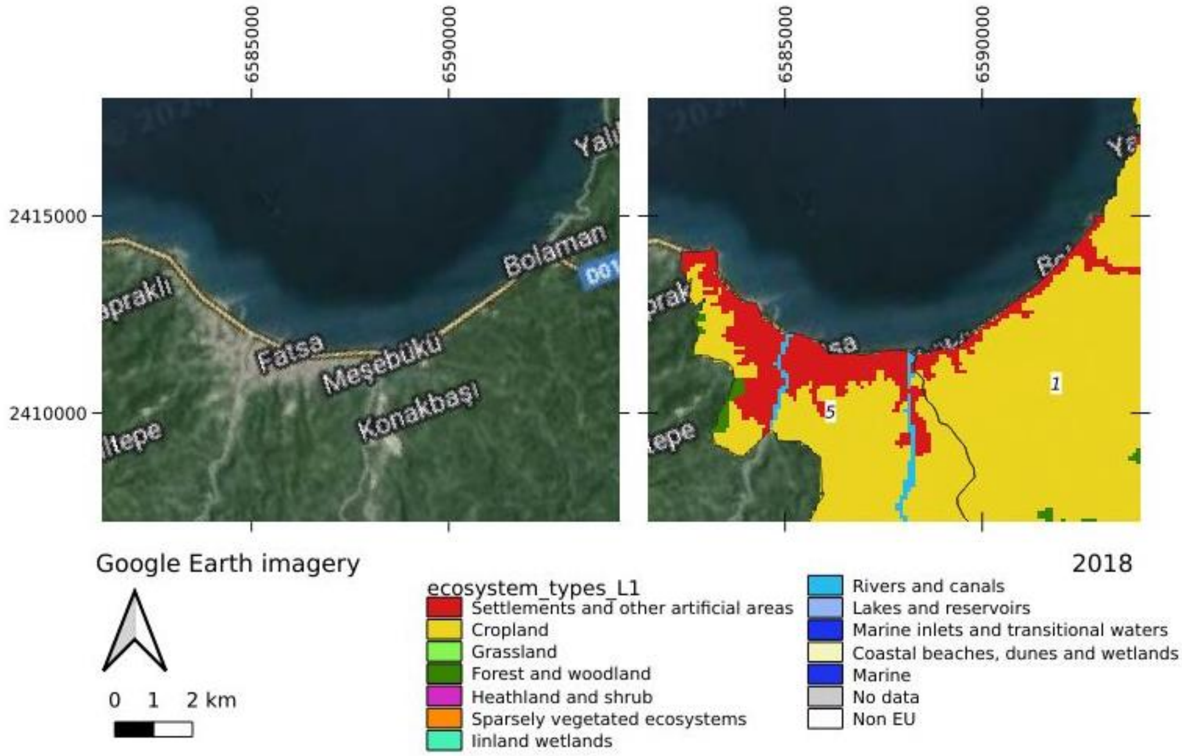


Source: Compiled by VITO

The numbers depicted in the figure above identify the 8 districts. The ecosystem extent accounting figures for 2018 per district can be found in Table 15.

As shown in Figure 20, the coastal areas in both district 1 and district 5 are classified as settlement and cropland, probably restricted to the Minimum Mapping Unit of the CLCACC input layer. Hence no coastal ecosystem type is identified for Bolaman in this Tier-1 account.

Figure 20: Ecosystem extent account for 2018 for district 5 in Bolaman zone, coastal area



Source: Compiled by VITO adapted from Google Earth (2024)

Table 15: Ecosystem Extent account for 2018 per Bolaman district

	Ecosystem type (level 1) Closing area 2018 (hectares) Bolaman	Zone1 Ilica çayi	Zone2 Medres e çayi	Zone3 Gokcebayir çayi	Zone4 Kes çayi	Zone5 Bolaman çayi	Zone6 Eceli çayi	Zone7 Sahsene çayi	Zone8 Direkli çayi
1	Settlements and other artificial areas	350	40	53	233	893	87	182	0
2	Cropland	13297	8852	1461	16091	21302	15672	12729	14234
3	Grassland	0	1332	12110	466	0	1087	77	838
4	Forest and woodland	1672	5238	2632	5463	2332	8253	4432	6806
5	Heathland and shrub	-	-	-	-	-	-	-	-
6	Sparsely vegetated ecosystems	-	-	235	-	-	-	-	-
7	Inland wetlands	-	-	-	-	-	-	-	-
8	Rivers and Canals	-	-	-	-	377	-	-	-
9	Lakes and reservoirs	-	-	25	-	-	-	-	-
10	Marine inlets and transitional waters	-	-	-	-	-	-	-	-
11	Coastal beaches and transitional waters	-	-	-	-	-	-	-	-
12	Marine ecosystems	-	-	-	-	-	-	-	-
	Total	**15,319**	**15,462**	**16,516**	**22,253**	**24,904**	**25,099**	**17,420**	**21,878**
	158,851								

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30% of Türkiye (Orman Genel Müdurlügü, 2025)

2.3 Tier-2 extent accounts

2.3.1 Methodology and data sources

As explained earlier, the fast-track Tier-1 method has, next to some detected errors, some limitations to generate the requested ecosystem extent accounts:

1. No officially published public CORINE data is available after 2018.
2. The spatial detail is limited to 25 ha (change at 5 ha), which makes it more difficult to detect changes at the regional (Bolaman and Çekerek) scale.
3. The thematic detail has several limitations for developing an extent account at EU Level-2 or Level-3 typology, which may be important at the regional (Bolaman and Çekerek) scale for at least some ecosystem types.
4. Some specific classes for Türkiye (especially the Anatolian biome) are not available.

Despite its acceptance for statistical calculations, another method is to be found/developed to generate Tier-2 (or Tier-3) accounts. In general, three protocols are known to generate extent accounts with more spatial and thematic detail:

1. Fuse national available datasets and complement where needed with Copernicus continental data, known as the '**national approach**'. This approach has the advantage that the base data is known and (most likely) more easily accepted for statistical purposes but requires the implementation of country-specific protocol that could require quite some efforts.
2. Fuse Copernicus available datasets and complement where possible with national data, known as the '**continental approach'**. This approach has the advantage to start from public available datasets, updated regularly at annual or 3-annual cycles, but has some limitations to reach the thematic details of some Level-2 and most Level-3 classes.
3. Based on EUNIS habitat maps, complement where needed with national or Copernicus data, known as the '**vegetation-centric approach'**. This approach immediately provides Level-3 classes for most natural habitats but requires additional data to classify ecosystems largely influenced by anthropogenic. The availability of habitat maps could also be another limitation.

In the following sections, we will first analyze the feasibility of each approach, considering that we want to achieve an MMU of maximum 1 ha, generate regular (minimum 3-yearly) accounts, and have the ability to provide for 'some' ecosystem types 'Level-2' or 'Level-3' classes to be used for land management decisions at the regional (e.g., Bolaman and Çekerek) scale.

2.3.2 Results of the 'national approach'

This approach typically starts from available land use maps. First, a crosswalk is developed to transform the national map(s) into EU L1 (and if possible L2), whereafter the limitations are identified. An evaluation is thereafter done to remove some limitations by integrating Copernicus EAA39 continental datasets or other national datasets.

This approach has been explored in Hungary and a few additional explorations by space4environment (in the Azores and Greece) are in progress. Table 16 provides an overview of the typical public datasets used in this approach.

Table 16: CLMS available continental and hotspot (priority areas) datasets

Layer	Details	Version current (next)	Update Freq.	Next availability
CLC BB+	CLC+ core, CLC+ Legacy instance, CLC+ LULUCF instance	2018 (2021)	2	Some products in production, others in tendering process. Availability probably 2025
Forest Type	10 m resolution	2018 (2021)	3	
Dominant Leaf Type (+change layer)	HRL-VLCC	2018 (2021)	Annually from 2024 (starting with 2019) Previously 3	
Broadleaved Cover Density (+change layer)	HRL-VLC10m resolution	2018 (2021)	Annually from 2024 (starting with 2019) Previously 3	
Coniferous Cover Density	HRL-VLCC	2018 (2021)		
Small Woody Features (SWF)	Woody Vegetation Mask & All Woody Features part of this from 2021	2018 (2021)		
Tree Cover/ Tree cover Presence Change	HRL-VLCC	2018 (2021)		
Natura 2000	Priority Area Monitoring	2018 (2021)	6	
Coastal Zones	Priority Area Monitoring	2018 (2021)	6	
Riparian Zones	Priority Area Monitoring	2018 (2021)	6	

Source: Compiled by VITO

Figure 21 shows an example where the national use map does not provide sufficient details on pasture cropland and hence the CLMS Corine Layer Backbone (10 m spatial resolution) was used to complement the national dataset, and hence get better accounting results.

Figure 21: Example of complementing national data with CLC+BackBone to map crop pastures

Source: space4environment.

The technical workgroup meeting on March 27, 2024 has identified that the UASIS project generated annual maps with 5 main classes (and 79 subclasses) derived from earth observation (Sentinel-2) and artificial intelligence. The maps are generated at the regional scale (TULIP project) and could be a potential source to apply this approach. This approach is further described as the ‘regional approach’ in the next section and is to be considered as a variant of the ‘national approach’.

2.3.3 Results of the ‘regional approach’

ÇEM has developed a workflow to create land cover using remote sensing and artificial intelligence. Though the results are still under evaluation, 2021 maps for Bolaman and Çekerek basins were shared to explore their use for extent accounting. Similar to the ‘national approach’, first a crosswalk to the EU extent typology is to be done, and further their quality (accuracy) and their use for statistical calculation is to be checked.

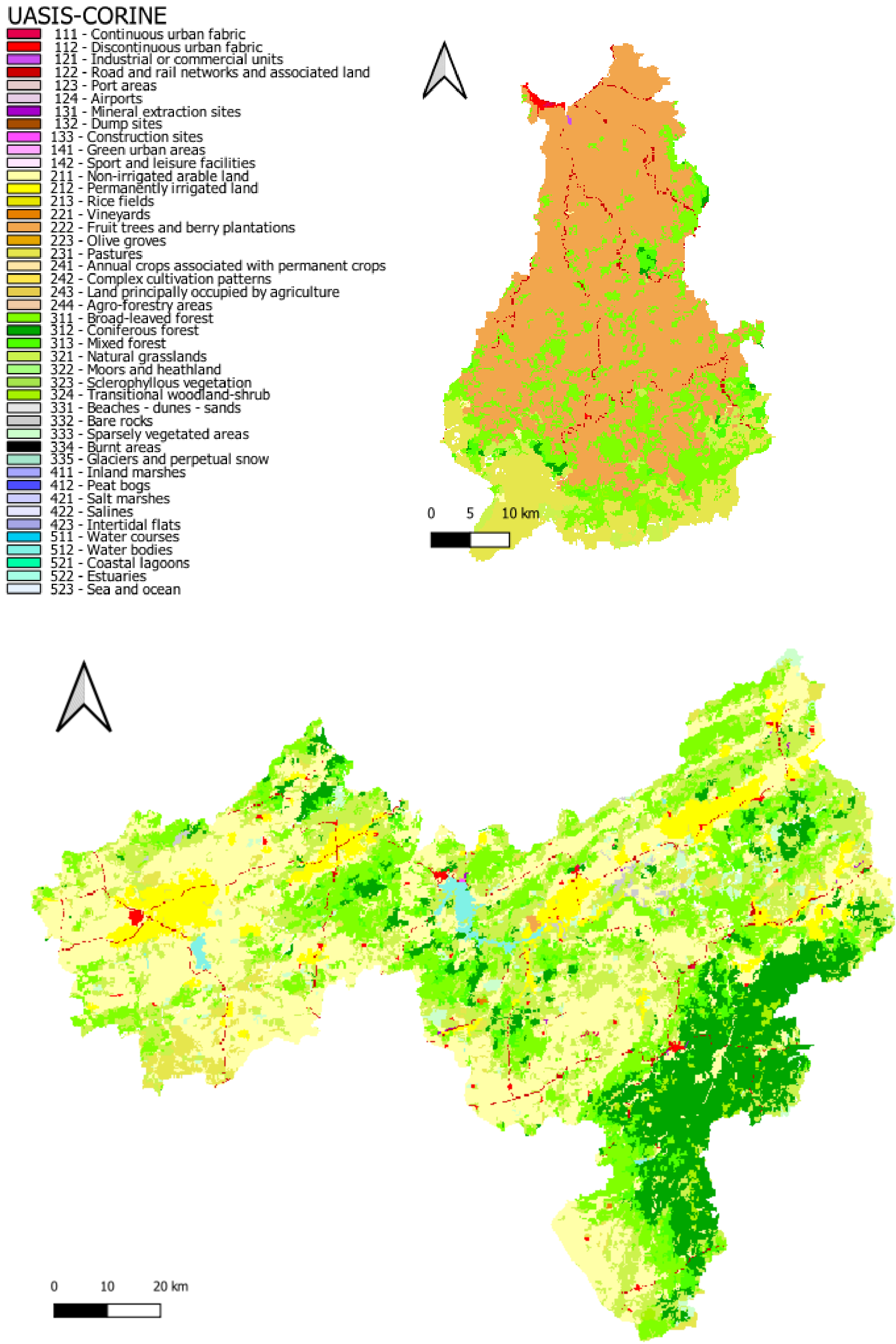
The maps were generated at 50 by 50-meter raster maps for UASIS (Türkiye-specific) classes. Thereafter, these classes were mapped to the Corine classes and merged into a 25-ha area (MMU of Corine) to be compliant with Corine. Classes that do not reach this area are either merged with other classes around it or added to the nearest class around. The roads were added with a slightly wider aspect. Contrary to Corine, which was largely a manual drawing process, this process is automated which can lead to differences, e.g. a city of 17 ha is stretched manually in Corine to 25 ha while in UASIS it may be ignored.

A crosswalk from the UASIS+ classes (80 classes in total) to CORINE classes (36 classes cross walked) was initially performed (Annex I Table 123 shows the crosswalk). This cross-walked map for Bolaman and Çekerek was provided for further analysis, hence aggregated to the 44 CORINE classes. Access to the raw mapped data, covering different classes, was not provided.

It should be noted that 8 CORINE classes are not present in the UASIS+ maps, while many UASIS+ classes are mapped to a single CORINE class, up to 23 UASIS+ classes for non-irrigated arable land (211). CEM provided further information and 3 classes are bit classified in the UASIS map because they do not meet the minimum mapping unit, 1 class is omitted because it does not match another source of data, 3 other classes are not included due to the manual drawing technique of the Corine maps and the algorithmic mapping of UASIS; these can be subject to further validation and versions. An overview of the number UASIS+ classes per CORINE class is shown in Annex I Table 124.

The UASIS+ maps cross walked to CORINE are shown in Figure 22.

Figure 22: UASIS cross-walked to CORINE maps of 2021, Bolaman (top) and Çekerek (bottom)

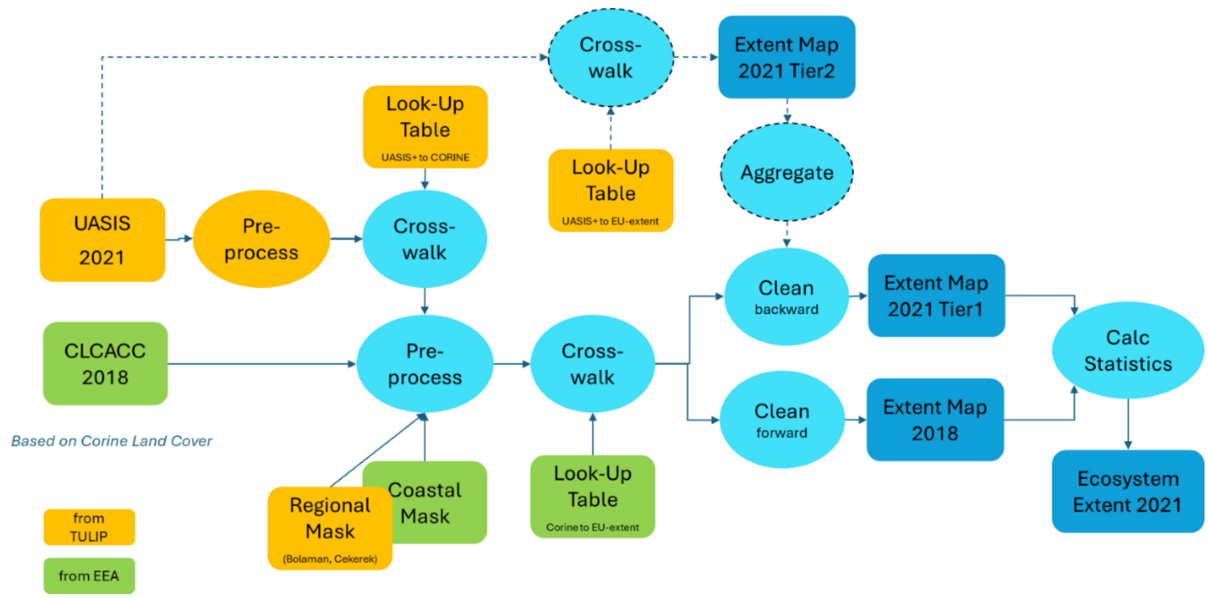


Source: Compiled by VITO adapted from General Directorate of Combating Desertification and Erosion (ÇEM)

To generate 'regional' ecosystem extent accounts based on the UASIS dataset, there are two main options, as shown in Figure 23 below:

- Option A. Mapping through intermediate CORINE classes.
- Option B. Direct mapping (depicted in dash lines).

Figure 23: Options for ecosystem extent accounting based on UASIS+ dataset



Source: Compiled by VITO

In option A, the UASIS maps will be first crosswalk to the Corine classes, and after applying a coastal mask crosswalk to the EU extent typology Level-1. For the 2018 data, the CLC-Accounting layer will be cropped to the region to be reported, hence Bolaman and Çekerek. The difference in method between 2018 and 2021 will introduce noise that needs to be cleaned before the account can be generated. This cleaning can be done in forward mode, using the 2021 map as a reference and adapt the 2018 extent map. Alternatively, the cleaning can be done in backward mode, using the 2018 map as a reference and adapt the 2021 extent map.

In Option B, the UASIS original data is immediately crosswalk to the EU-typology (mostly) Level-2. Thereafter, an aggregation can be done to turn to EU-typology Level-1 before a cleaning is required to make them consistent with the CLCACC 2018 derived extent map.

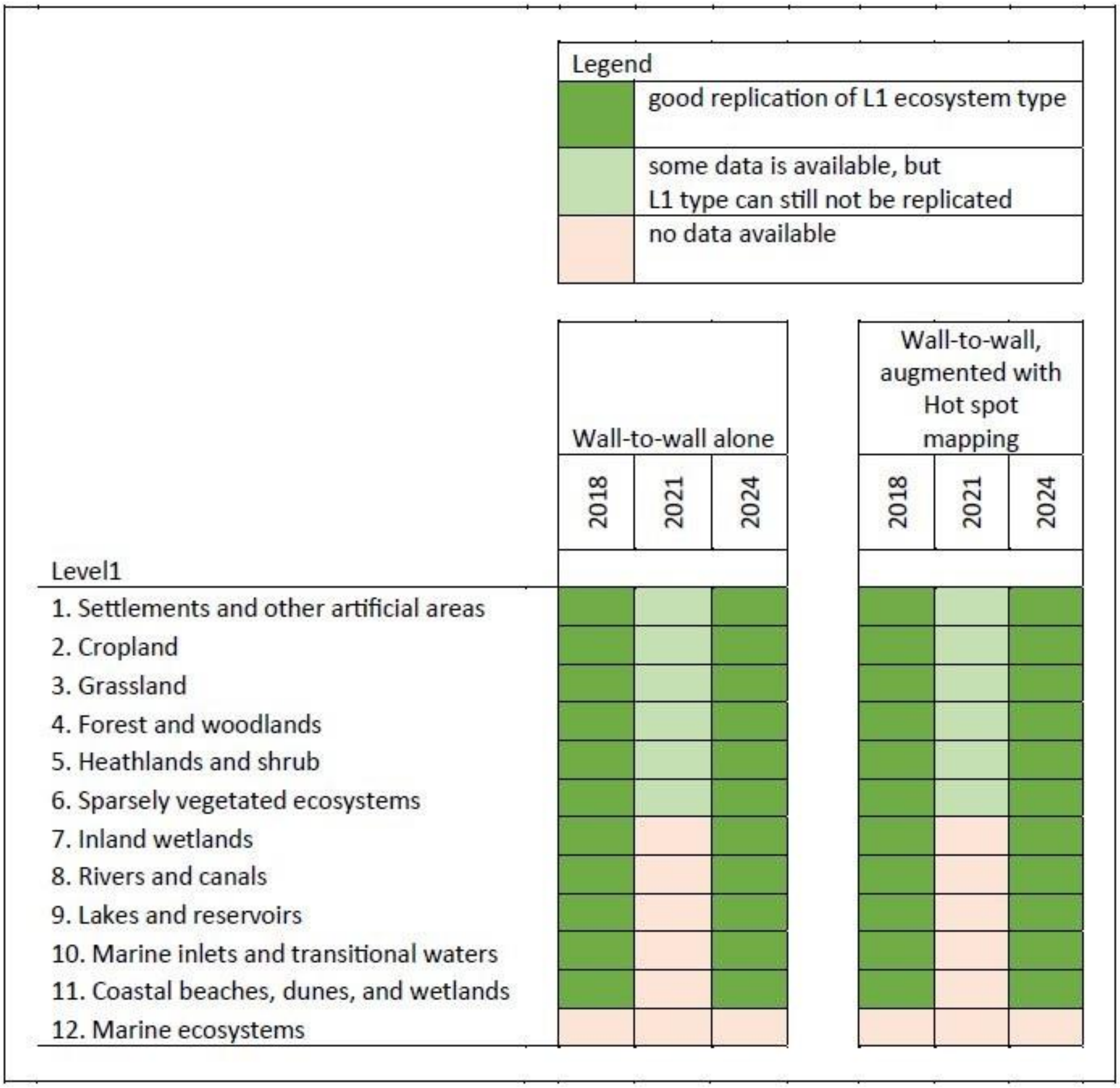
The advantage of Option A is that compliancy with Corine is searched for, such that the intermediate Corine maps can be used also for other reporting purposes. The advantage of Option B is that details of the new mapping approach are not lost and can be used for local policy decision-making, hence the Tier-2 account.

The key issue to generate the ecosystem accounts is to keep consistency over time and hence the cleaning method will decide the quality of the accounts, mainly the net change. Further exploration is needed and discussed further in this document.

2.3.4 Results of the ‘continental approach’

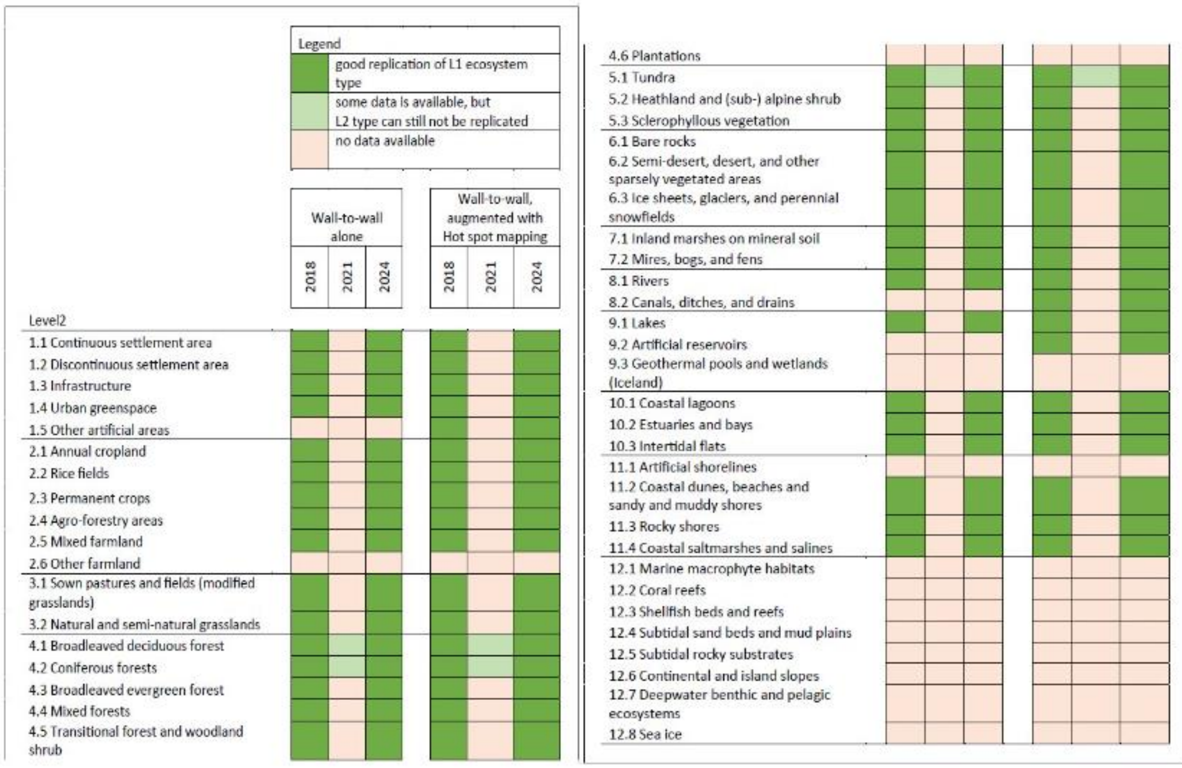
The European Environment Agency (EEA) has been analyzing this approach through integrating available Copernicus EU datasets (including Türkiye) and Copernicus hotspot datasets (mainly urban, coastal, and riparian) as shown in Table 16. The report (public unavailable) shows that the spatial resolution can be increased, however the thematic details are only partial achievable and more importantly, there are some datasets missing to generate a 2021 account, as shown in Figure 24 and Figure 25. Note that the 2018 and 2024 accounts still highly depend on the availability of Corine Land Cover maps, where there is no clear roadmap at this stage on their continuation.

Figure 24: Limitations for ‘continental approach’ to generate 2021 ecosystem account at EU L1



Source: EEA.

Figure 25: Limitations for 'continental approach' to generate 2021 ecosystem account at EU L2

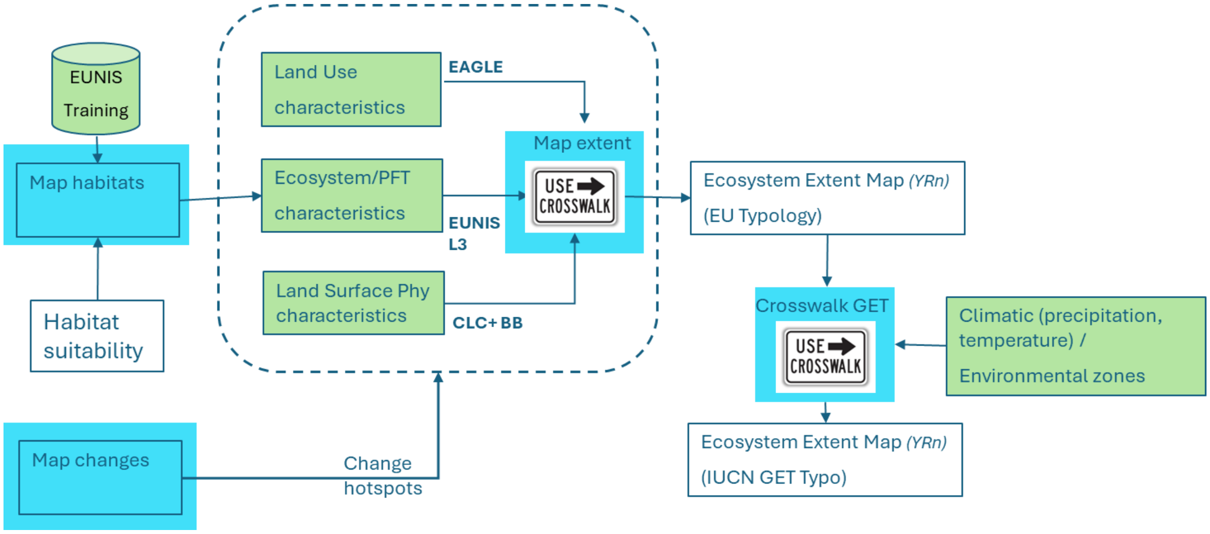


Source: EEA.

2.3.5 Results of the 'vegetation approach'

The third approach puts vegetation maps at the center of the workflow, as shown in Figure 26. First, EUNIS habitats (at Level-3) are to be mapped. Such mapping can be done based on Earth Observation time-series in combination with other (soil, climate, height, etc.) data. Such mapping is done with machine learning/artificial intelligence and requires sufficient Training data. Training data is to be gathered per environmental zone, as shown in Figure 27, so for Mediterranean Mountain (MDM), Mediterranean South (MDS), Mediterranean North (MDN), and Anatolian (ANA) zones. Note such training data may be shared with or come from surrounding countries with the same ecological characteristics.

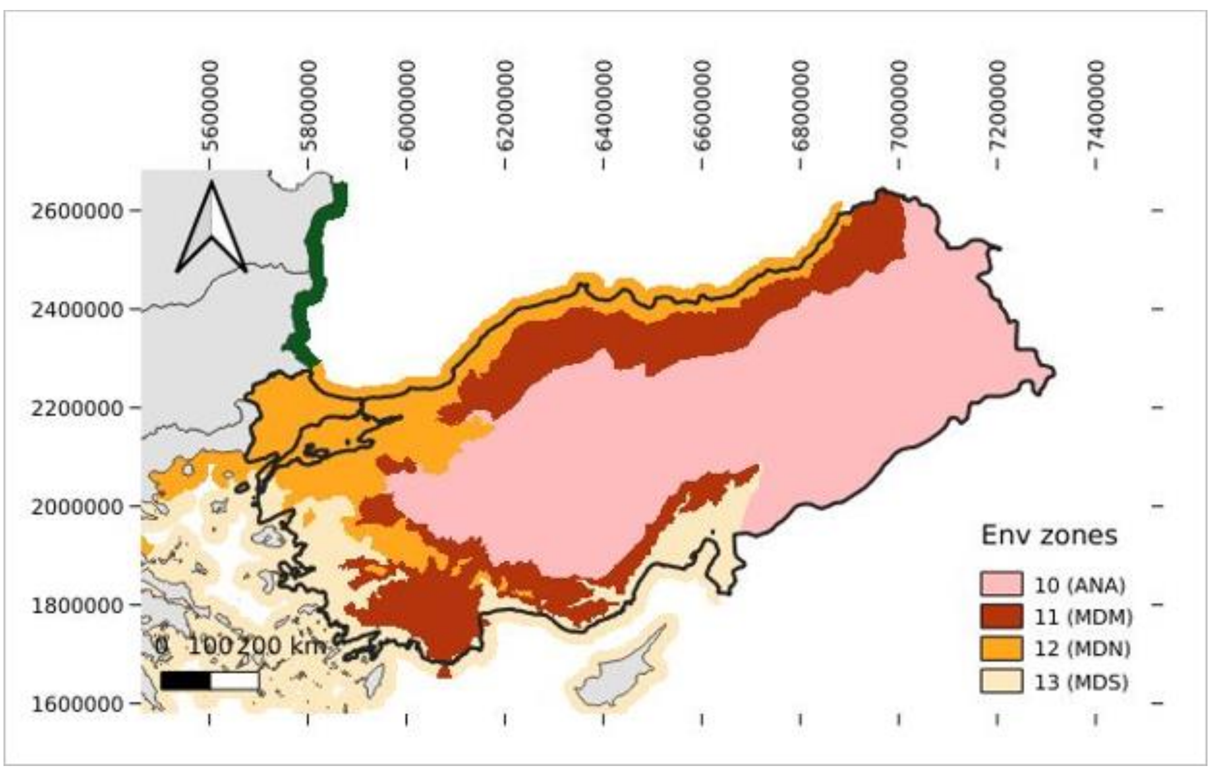
Figure 26: Workflow for vegetation-centric approach



Source: Compiled by VITO

Once the EUNIS maps are available, most of the natural ecosystem types (forest and woodland, grassland, heathland, sparse vegetation, etc.) can be mapped to EU L3. However, some more anthropogenic influenced ecosystems (settlement, rivers and canals, etc.) can only be mapped through the use of Copernicus datasets (CLC+ backbone or imperviousness layers) and/or national land use characteristics (OpenStreetMap, cadaster information).

Figure 27: Environmental zones to gather EUNIS training data

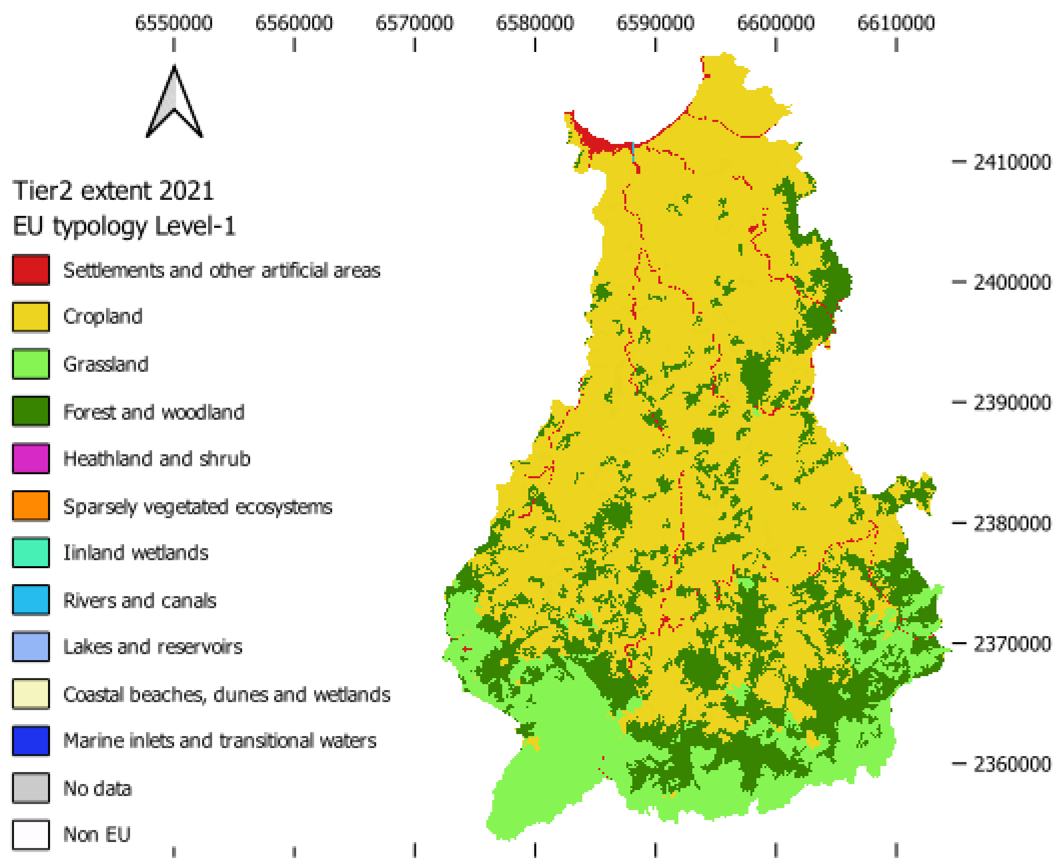


Source: Compiled by VITO

During the Technical Workgroup of 27 March 2024, this approach was considered valuable in the longer term. There are currently no EUNIS maps available, however for Natura 2000 protected area's habitat (DG Nature), information is available and more vegetation data could be potentially available and extracted from other available systems (ORBIS, etc.).

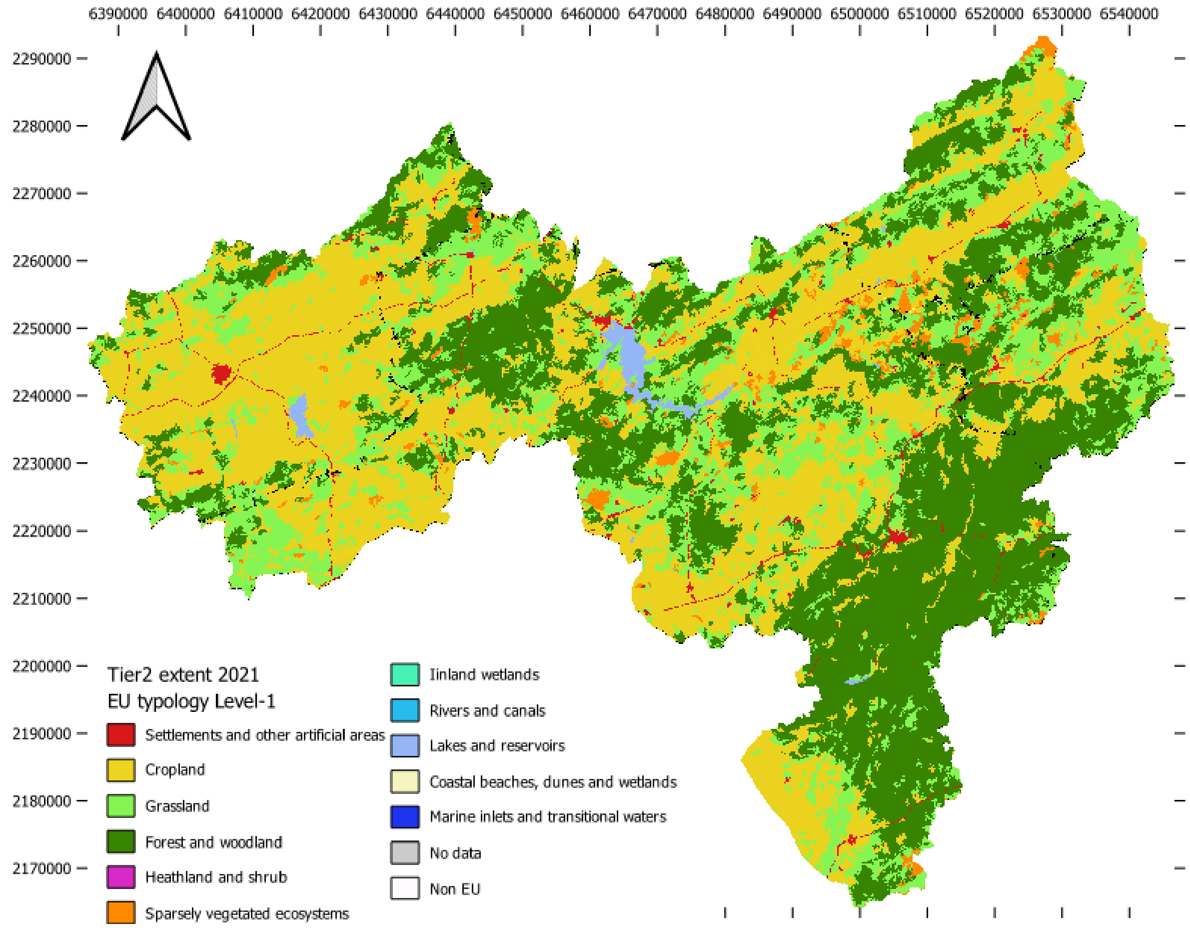
Similar to Tier-1, here the UASIS-Corine maps are cross-walked to the EU Ecosystem Extent Level-1 typology. More details on the mapping can be found in the Tier-1 approach. Their results are shown in the subsequent sections.

Figure 28: Tier-2 extent 2021 for Bolaman



Source: Compiled by VITO

Figure 29: Tier-2 extent for 2021 for Çekerek



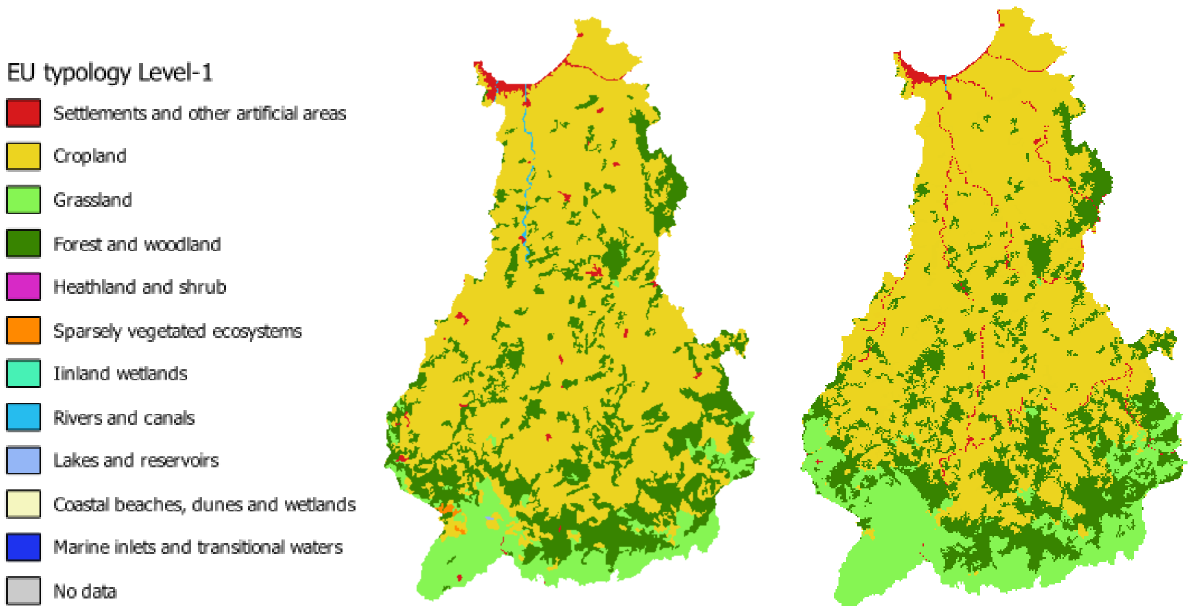
Source: Compiled by VITO

Tier-2 mapping change

As explained above, the 'regional approach' is at this moment the only option to create an ecosystem account 2018–2021. However, there is no consistent dataset across this period (CLCACC till 2018, UASIS-Corine for 2021). Though the UASIS-Corine targets are compliant with Corine (CLCACC), the methodology is different. As shown in the figures below, we can see that the general patterns do match between both ecosystem extent maps but due to the methodological differences, one can immediately see several differences, both in assigned classes and the spatial detail.

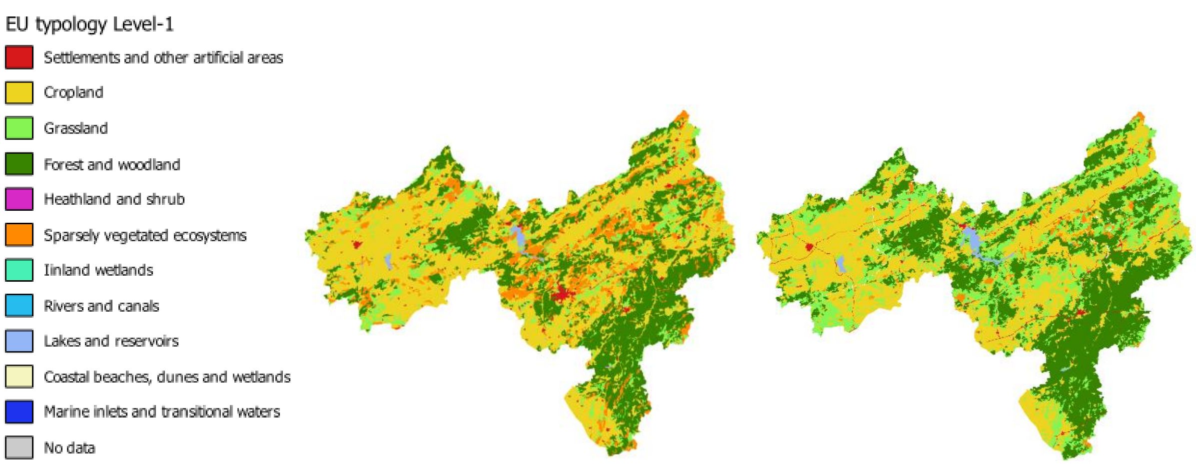
Extent maps before cleaning

Figure 30: Extent map before cleaning according EU typology Level-1 for Bolaman, Tier-1 2018 (left) and Tier-2 2021 (right)



Source: Compiled by VITO

Figure 31: Extent map before cleaning according EU typology Level-1 for Cekerek Tier-1 2018 (left) and Tier-2 2021 (right)

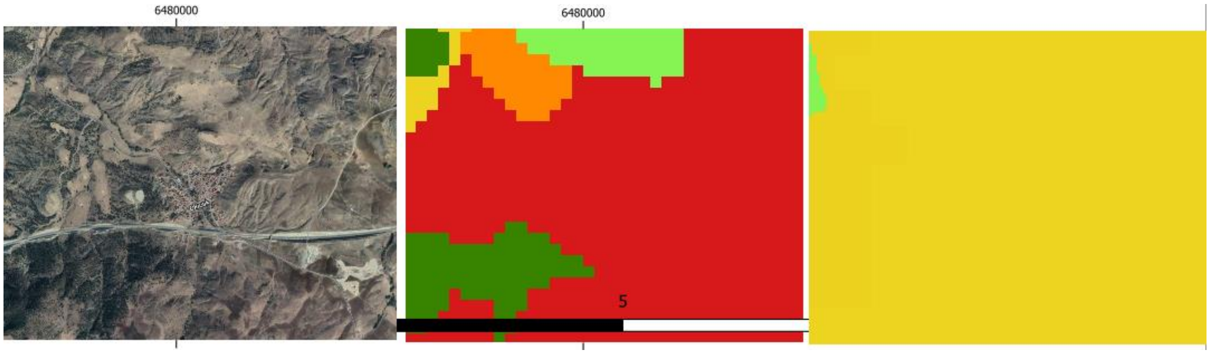


Source: Compiled by VITO

If we generate an ecosystem extent account based on these maps, the change (additions and reductions) per ecosystem type does not reflect the truth on terrain. Further analyzing the area of change, does not immediately reveal which of the maps show the truth, as shown in Figure 30 and Figure 31.

In Figure 32, the city of Olucak in Çekerek is over-dimensioned in the Tier-1 2018 map (derived from Corine Accounting layers) and not present at all in the Tier-2 2021 map (derived from UASIS-Corine).

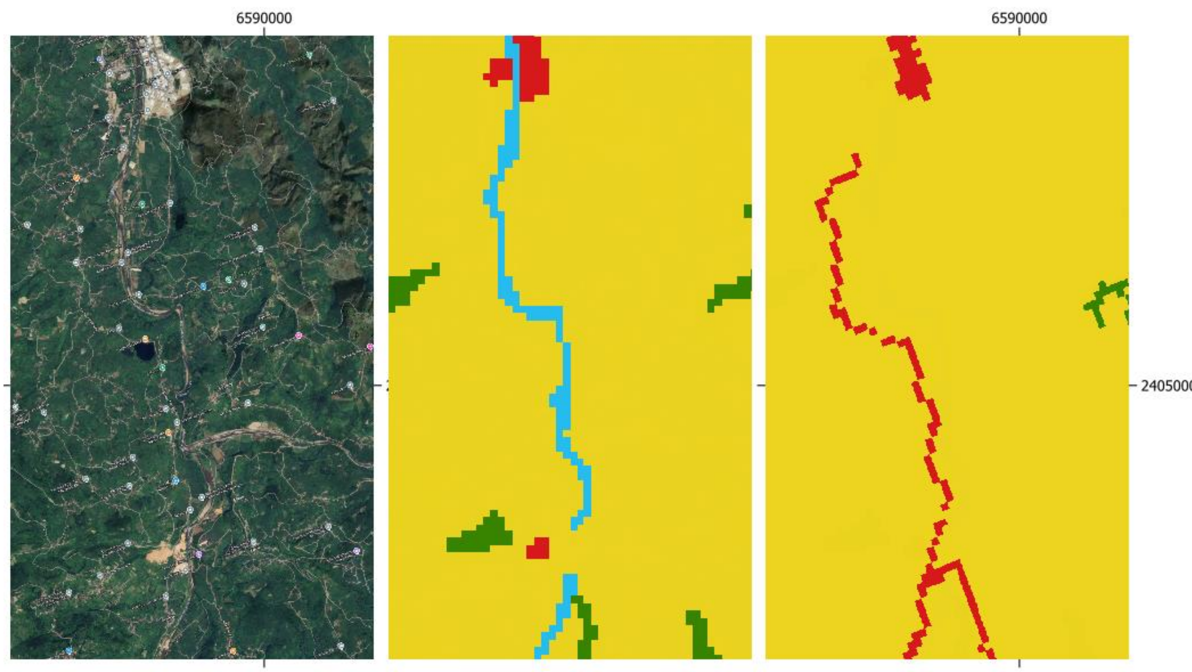
Figure 32: Zoom into Çekerek around city Olucak. Google Earth imagery (left), Tier-1 2018 (middle) and Tier-2 2021 (right)



Source: Compiled by VITO

In Figure 33, the Bolaman Creek river is detected by the Tier-1 account (derived from Corine accounting layers) but not detected in the Tier-2 account (derived from UASIS-Corine). Further, we can see in the same image that the road left to the river is not detected by Tier-1 but it is in Tier-2. The industrial area visible at the top of the image is seen by both extent maps

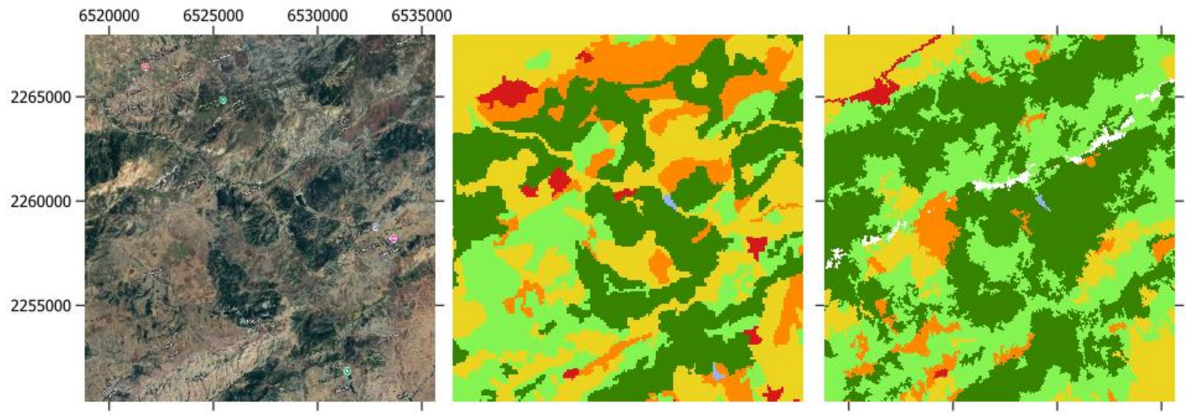
Figure 33: Zoom into Bolaman around Bolaman Creek. Google Earth imagery (left), Tier-1 2018 (middle) and Tier-2 2021 (right)



Source: Compiled by VITO

Finally, Figure 34 shows a zoom in the Center-East of Çekerek, the area around Topulyurdu, where the UASIS-Corine map has no values (depicted in white in the right figure). This obviously will also have an effect in the accounting table.

Figure 34: Zoom into Çekerek around Topylyurdu. Google Earth imagery (left), Tier-1 2018 (middle) and Tier-2 2021 (right)



Source: Compiled by VITO

The above images show that we cannot just calculate the account from both Tier-1 and Tier-2 extent maps and assign the differences to actual change. So first a cleaning strategy is to be foreseen to try to reduce the change error as much as possible. This strategy is described in the next section.

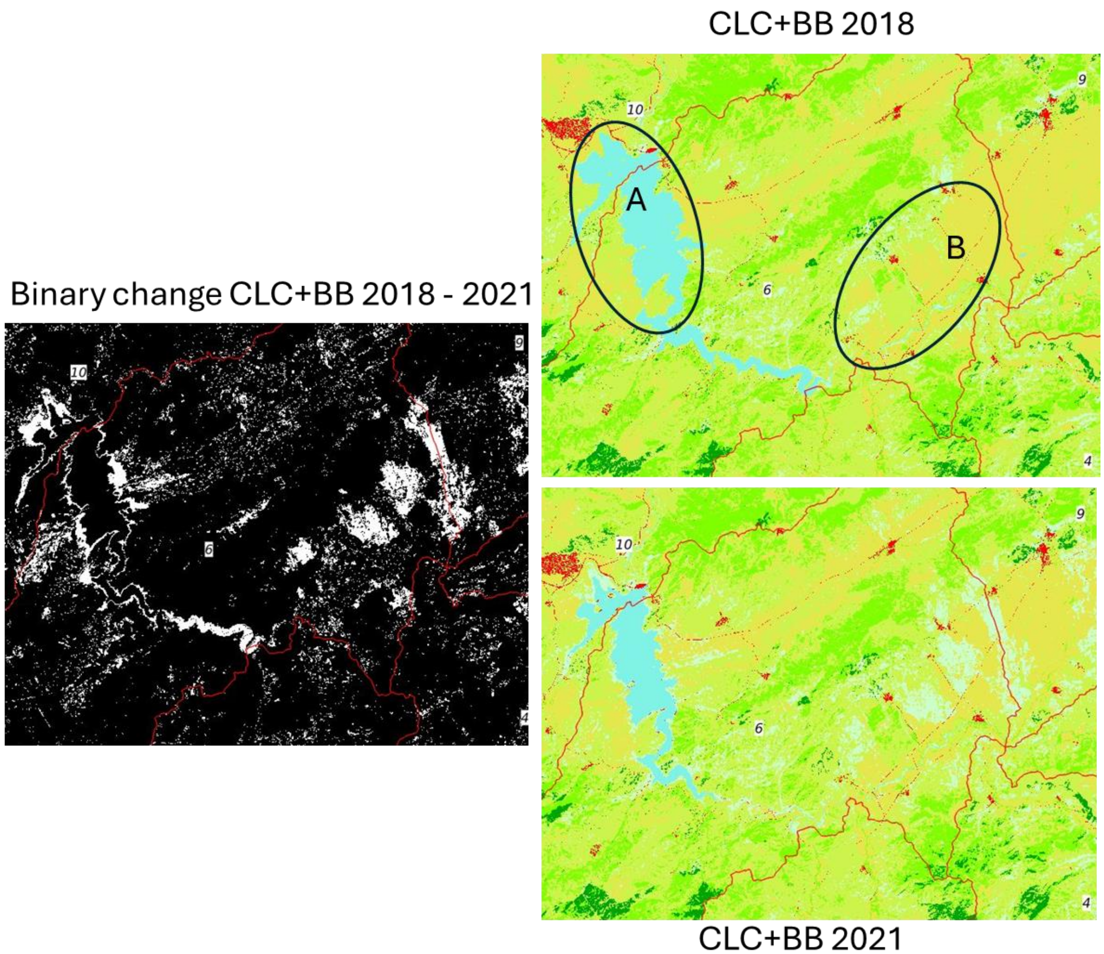
Cleaning Strategy

As explained above, the difference in methodologies between the 2018 and 2021 ecosystem extent map would lead to large errors in the accounting table. Change would be reported which is not change on the actual terrain but merely due applying different methodologies. Annex Table 127 shows the accounting table before the cleaning operation.

So, we can only properly clean the change by applying a third party dataset (defined as a geospatial proxy) that is available for the years 2018 and 2021 and with sufficient spatial detail to accompany the 2021 UASIS-Corine map. The 'change proxy' selected is the Copernicus CLCplus backbone land cover available for 2018 and 2021 at a 10 m spatial grid (MMU 0.5 ha). This dataset is provided with 11 land cover classes and was extracted for both Bolaman and Çekerek regions.

It should be noted that this 'change proxy' map only detects land cover changes, and hence not ecosystem changes. However, at Level-1, the ecosystem typology is close enough to land cover to justify this proxy. An important difference is that land cover maps the actual land cover in a given year which could reflect in detecting inter-annual land cover changes that do not necessarily result in ecosystem changes. An example of this is shown in Figure 35: Zone 'A' depicts a lake where the boundaries of the lake and the upstream river as water in 2018 and bare soil in 2021. Another example is Zone 'B' which depicts a steppe area, which is classified as sparse vegetation in 2018 and as grassland in 2021. Both land cover changes can be attributed to inter-annual changes in climate (precipitation, temperature).

Figure 35: Change proxy map from Copernicus Corine Backbone layer. Left image is difference map, upper right is 2018 land cover map, lower right is 2019 land cover map



Source: Compiled by VITO

A more detailed analysis of land cover changes per zone within Bolaman and Çekerek can be found in Annex.

So, this means only applying this third-party proxy will depict too many land cover changes that cannot necessarily be classified as ecosystem changes. Therefore, we apply a dual change strategy by combining the third-party proxy change (based on Corine Backbone land cover) with the change in ecosystem type maps.

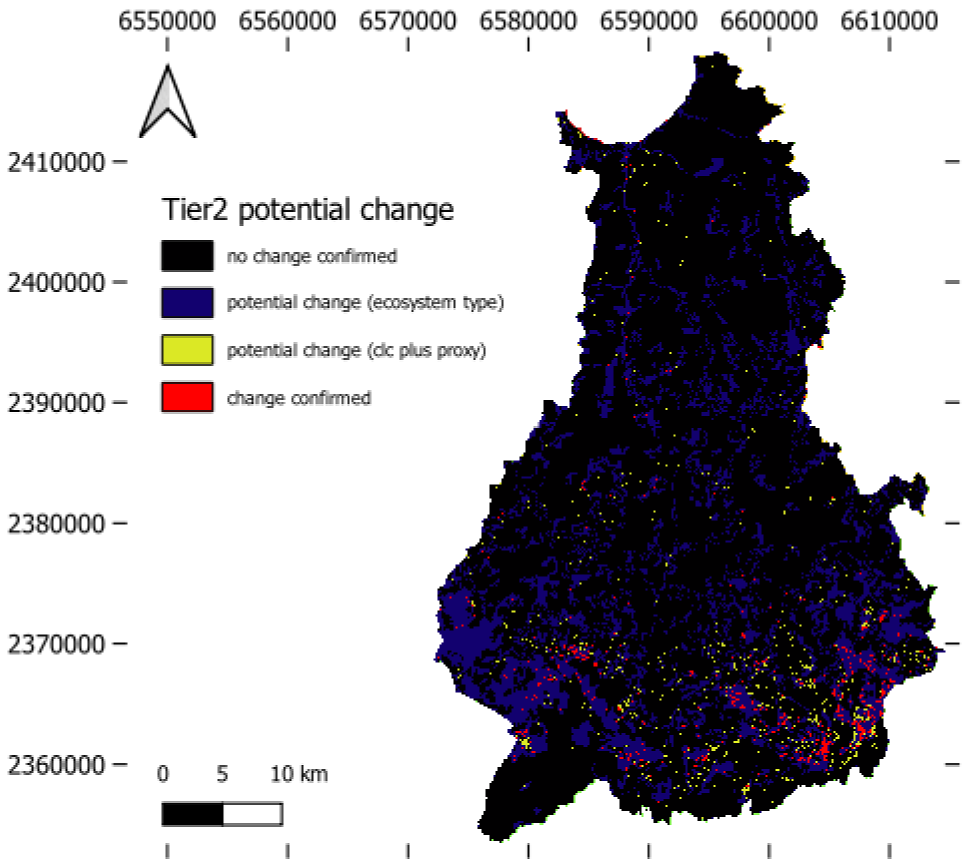
Preparing a binary change map

The following method is applied:

- Resample the Tier1_2018 map to 10 m resolution (use GQIS raster warp tool).
- Create a binary change map from the Ecosystem Type maps (Tier1_2018_10m != Tier2_2021_10m) by using the QGIS raster calculator tool.
- Create a binary change map from CLCplus (CLC_2018 != CLC_2021) and multiply * 2 by using the QGIS raster calculator tool.

- Combine both binary masks (binary_change_ET + binary_change_CLCplus), using the QGIS raster calculator tool. The result can be seen in Figure 36:
  - Zero means both maps do not identify a change, so no change is confirmed.
  - One means change detected by ET1 but not confirmed by CLC+
  - Two means change detected by CLC+, but not confirmed by ET1
  - Three means both maps do identify change, so the change is confirmed.

Figure 36: Dual proxy binary change map for Bolaman



Source: Compiled by VITO

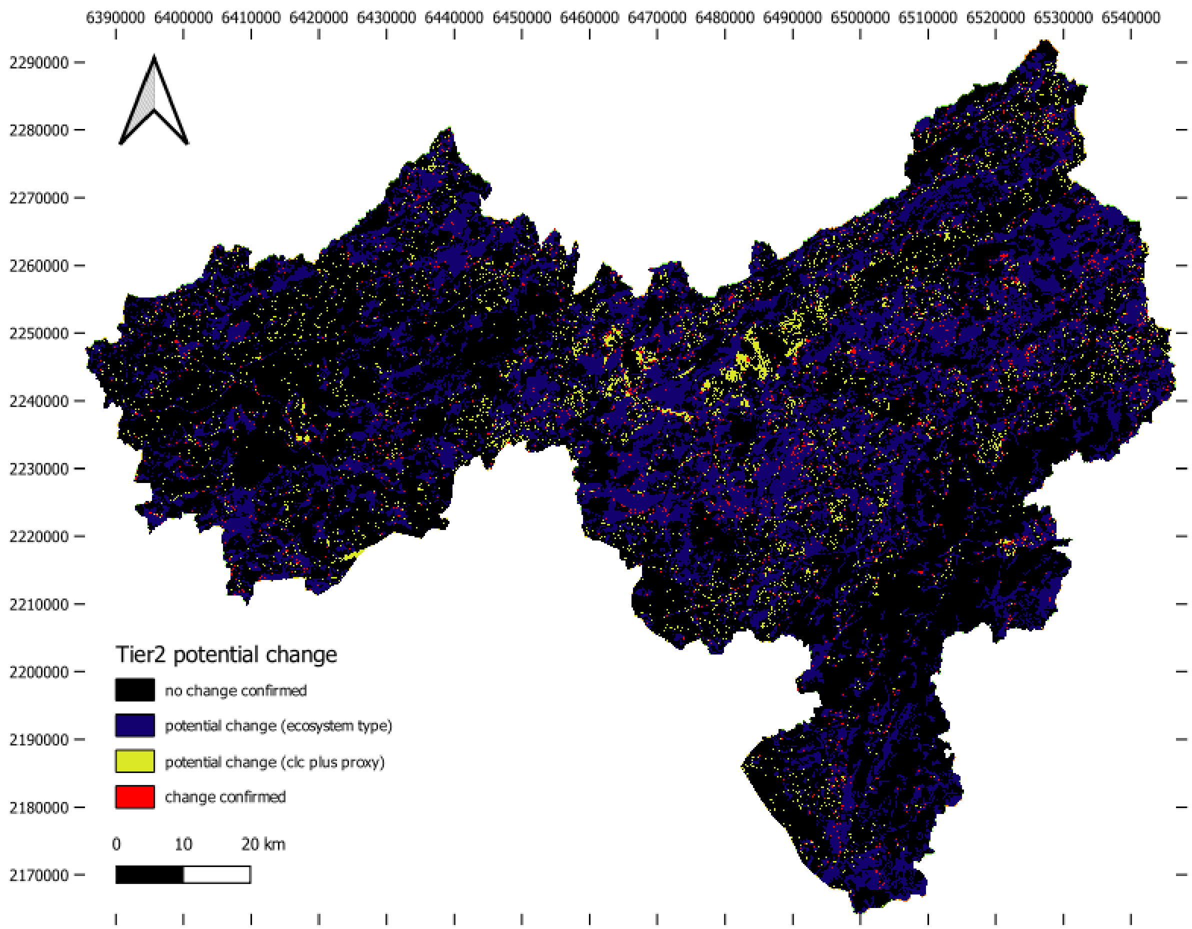
The statistics in the above figure shows that if we would not apply a dual proxy rather than just using the difference between both ecosystem maps would result in 19.3% change which certainly includes a very large commission error. Applying the dual-proxy change approach results in a confirmed change of 0.9% across the Bolaman region from 2018 to 2021.

Table 17: Change statistics for Bolaman region 2018–2021

Value	Area (ha)	Change type	
0	125,094	No change confirmed	78.8%
1	30,696	ET change un-confirmed	19.3%
2	1,610	CLC+ change un-confirmed	1.0%
3	1,417	change confirmed	0.9%
	158,817	**Total area**	

Note: The same dual-proxy binary change method is applied for Çekerek as shown below. *Source: VITO estimates*

Figure 37: Dual proxy binary change map for Çekerek



Source: Compiled by VITO

The statistics in the above figure shows that if we would not apply a dual proxy rather than just using the difference between both ecosystem maps would result in 29.1% change which certainly includes a very large commission error. Applying the dual-proxy change approach results in a confirmed change of 1.3% across the Çekerek region from 2018 to 2021. Validation with on-site observations were not performed.

Table 18: Change statistics for Çekerek region 2018–2021

Value	Area (ha)	Change type	
0	580,892	no change confirmed	66.3%
1	255,172	ET change un-confirmed	29.1%
2	28,149	CLC+ change un-confirmed	3.2%
3	11,776	change confirmed	1.3%
	875,988	**Total area**	

Source: VITO estimates

Though the UASIS raw data is targeted to be harmonized to CORINE data, we can see in the figure above that such harmonization requires further work if the CORINE time-series is to be extended with the UASIS-CORINE map from 2021.

For the ecosystem extent accounting, the application of the dual-proxy binary change approach does clean up a large part of the methodological consistencies and hence is considered valuable to be applied to clean the ecosystem maps. Note however that regional experts need to evaluate if the amount and location of change is considered correct.

The next section explains how to apply this dual-proxy binary change map to harmonize the 2018 and 2021 ecosystem extent maps and reduce the change commission errors.

Cleaning the ecosystem extent maps

Since we only have two time-steps, we first need to decide which will form the base map before cleaning. One option is to take the CLC (Corine map) of 2018 as a base and then imprint the change classes from the UASIS-Corine to generate the cleaned 2021 map, known as the forward cleaning mode. The second option is to use the UASIS-Corine of 2021 as a base and then imprint the change from CLC to generate the cleaned 2018 map, known as the backward cleaning mode.

Both approaches (forward or backward cleaning mode) have their disadvantages and advantages. The CLC is statistically known but has the drawback of not having much detail (MMU is 25 ha) and hence limits the use at regional scale. The UASIS-Corine has a great level of detail (MMU is 0.25 ha) but is a new methodology that is under evaluation and needs statistical approval. Since CLC will be discontinued in the near future (2024 is likely the last step), we propose to further apply the backward cleaning mode during this transition phase (2018–2024). Once more, time-steps are available for the UASIS-Corine map, e.g., yearly maps, and one can better evaluate the full value and potential of detecting the ecosystem changes.

In the remainder of this analysis, we have applied both forward and backward mode. The method is explained here, but the results of the forward mode and its comparison are shown in Annexes 8.3 and 8.4.

Method:

1. Create a binary change map (only confirmed changes) and inverse map (no confirmed changes), through QGIS raster calculator = 3 and (=0 or =1 or =2).
2. In forward mode:
    a. Create temp mask by Tier1_2018_10m (resampled) * binChangeInverse, using QGIS raster calculator.

   b. Create temp mask by Tier2_2021_10m * binChange, using QGIS raster calculator.
   c. Combine both temp layers to create Tier2_2021_cleaned_10m (replace original UASIS_Corine derived ET1 map), using QGIS raster calculator.
3. In backward mode:
   a. Create temp mask by Tier1_2018_10m (resampled) * binChange, using QGIS raster calculator.
   b. Create temp mask by Tier2_2021_10m * binChangeInverse, using QGIS raster calculator.
   c. Combine both layers to create Tier1_2018_cleaned_10m (replace original CLCACC derived ET1 map), using QGIS raster calculator.
4. Create accounts
   a. In forward mode: Tier1_2018_10m * 100 + Tier2_2021_cleaned_10m, then unique values report and put into excel template.
   b. In backward mode: Tier1_2018_cleaned_10m * 100 + Tier2_2021, then unique values report and put into excel template.

Some transitions are related to the difference in spatial resolution as one can see in the images (Figure 38) below at the Ecosystem Accounting Area (EAA) boundaries. They are categorized as unknown.

Figure 38: Ecosystem Accounting Area (EAA) boundary issues

Source: Compiled by VITO

Final Ecosystem Extent accounts – Bolaman

As explained above, we have calculated the ecosystem extent account based on the backward clean method (using UASIS-Corine derived ecosystem extent map as a base). The accounting table for forward clean method and before cleaning can be found in Annexes 8.3 and 8.4.

In the accounting table (Table 19), we can see that Bolaman consists of 60% cropland, 22% forest, and 15% grasslands. From 2018 to 2021, 1,399 ha (0.9% of the area) were converted—mainly grassland into cropland. We can see that due to the higher spatial detail of the UASIS-Corine layer, some sparsely vegetated and Rivers and Canals appear in the accounting table. Further, it should be noted that the coastal mask is not applied in this account, since it will have a very limited impact and the marine ecosystem is not included. Table 20 shows a more detailed view, as is the ecosystem extent transition matrix where one can see that more than 300 ha of grassland is converted to cropland and more than 300 ha to forest and woodland. The 400 ha is of 'Forest and woodland' converted to other ecosystem types refer to forest land cover and does not lead to a change in legal designated forest area. Some changes in the latter forest area could be assigned to silviculture, mining activities, wildfires, construction of energy lines, etc. Note that the methodology is experimental, as explained in section 2.3.1, and further validation is required to confirm the depicted changes.

Table 19: Ecosystem Extent Account Tier-2 for Bolaman 2018-2021

	Ecosystem type (level 1) TUUP Bolaman	Opening area 2018 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2021 (ha)	Closing area 2021 (%)
1	Settlements and other artificial areas	2,335	14	20	- 6	2,328	1.5%
2	Cropland	94,848	822	120	702	95,550	60.4%
3	Grassland	25,227	61	770	- 708	24,518	15.5%
4	Forest and woodland	35,869	475	489	- 13	35,855	22.7%
5	Heathland and shrub	-	-	-	-	-	0.0%
6	Sparsely vegetated ecosystems	-	3	-	3	3	0.0%
7	Inland wetlands	-	-	-	-	-	0.0%
8	Rivers and Canals	-	23	-	23	23	0.0%
9	Lakes and reservoirs	-	0	-	0	0	0.0%
10	Marine inlets and transitional waters	-	-	-	-	-	0.0%
11	Coastal beaches and transitional waters	-	-	-	-	-	0.0%
12	Marine ecosystems	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**158,278**	**1,399**	**1,399**	**- 0**	**158,278**	**ha**
						1,583	km^2

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

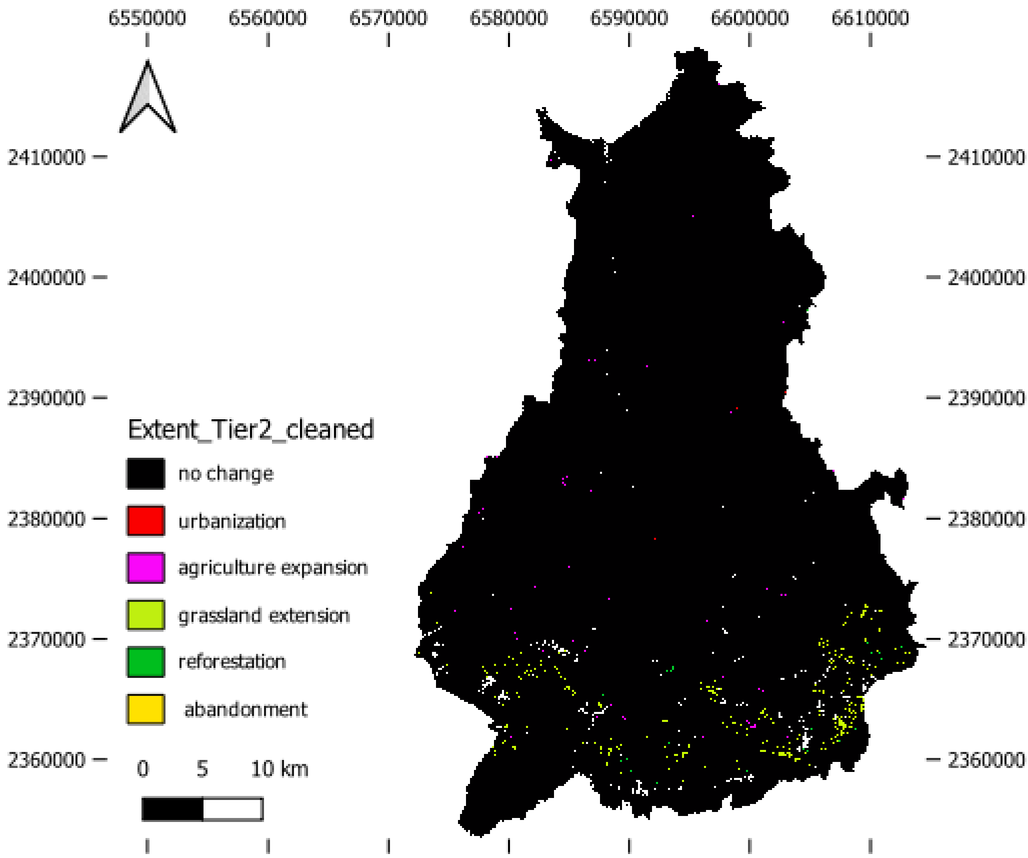
Table 20: Ecosystem Extent Transition Matrix 2018 - 2021 for Bolaman

	2021(closing in ha) → 2018 (opening in ha) ↓	100 Settlements and other artificial areas	200 Cropland	300 Grassland	400 Forest and woodland	500 Heathland and shrub	600 Sparsely vegetated ecosystems	700 Inland wetlands	800 Rivers and Canals	900 Lakes and reservoirs	1000 Marine inlets and transitional waters	1100 Coastal beaches and transitional waters	1200 Marine ecosystems	No-change	Change (reduction)	relative change in%
1	Settlements and other artificial areas	2314.27	14.95		1.1				4.25					2314.27	20.3	0.9%
2	Cropland	11.02	94727.98	1.51	87.53		2.27		17.88					94727.98	120.21	0.1%
3	Grassland	0.94	381.36	24457.04	386.65		0.65			0.01				24457.04	769.61	3.1%
4	Forest and woodland	2.07	426.14	59.69	35380.09				0.73					35380.09	488.63	1.4%
5	Heathland and shrub													0	0	
6	Sparsely vegetated ecosystems													0	0	
7	Inland wetlands													0	0	
8	Rivers and Canals													0	0	
9	Lakes and reservoirs													0	0	
10	Marine inlets and transitional waters													0	0	
11	Coastal beaches and transitional waters													0	0	
12	Marine ecosystems													0	0	0.0%
	No-change	2314.27	94727.98	24457.04	35380.09	0	0	0	0	0	0	0	0	156879.4	1398.75	0.9%
	Change (addition)	14.03	822.45	61.2	475.28	0	2.92	0	22.86	0.01	0	0	0	1398.75		
	relative change in %	1%	0.9%	0.3%	1.3%				#DIV/0!	#DIV/0!			0%	0.9%		

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

Figure 39: Major change fluxes from 2018 to 2021 over Bolaman



Source: Compiled by VITO

Final Ecosystem Extent accounts - Çekerek

As explained above, we have calculated the ecosystem extent account based on the backward clean method (using UASIS-Corine derived ecosystem extent map as a base). The accounting table for forward clean method and before cleaning can be found in the Annex.

In the accounting table (Table 21), we can see that 40% of the area consists of cropland, more than 30% is forest and woodland and more than 20% is grassland ecosystem type. From 2018 to 2021, 11,406 ha (1.3% of the area) has been converted, mainly between cropland and grassland. Table 22 provides a more detailed view on the actual changes. It is seen that more than 800 ha of cropland has changed to grassland, and more than 900 ha into sparsely vegetated (possibly abandoned crop fields). We can also see that more than 3000 ha of grassland has been converted into cropland. The 2000 ha of 'Forest and Woodland' converted to other ecosystem types refer to forest land cover and does not lead to a change in legal designated forest area. Some changes in the latter forest area could be assigned to silviculture, mining activities, wildfires, construction of energy lines, etc. Note also that the methodology is very experimental, as explained in section 2.3.1, and further validation is required to confirm the depicted changes.

Table 21: Ecosystem Extent Account Tier-2 for Çekerek 2018–2021

	Ecosystem type (level 1) TULIP Cekerek, clean backward	Opening area 2018 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2021 (ha)	Closing area 2021 (%)
1	Settlements and other artificial areas	11,640	441	592	- 151	11,489	1.3%
2	Cropland	346,418	6,738	2,565	4,173	350,591	40.2%
3	Grassland	191,723	1,116	5,198	- 4,082	187,641	21.5%
4	Forest and woodland	297,457	895	2,435	- 1,540	295,917	33.9%
5	Heathland and shrub	-	-	-	-	-	0.0%
6	Sparsely vegetated ecosystems	18,307	2,152	175	1,977	20,284	2.3%
7	Inland wetlands	-	-	-	-	-	0.0%
8	Rivers and Canals	-	-	-	-	-	0.0%
9	Lakes and reservoirs	6,900	60	441	- 381	6,519	0.7%
10	Marine inlets and transitional waters	-	4	-	4	4	0.0%
11	Coastal beaches and transitional waters	-	-	-	-	-	0.0%
12	Marine ecosystems	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**872,445**	**11,406**	**11,406**	-	**872,445**	**ha**
						8,724	km^2

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30% of Türkiye (Orman Genel Müdurlügü, 2025)

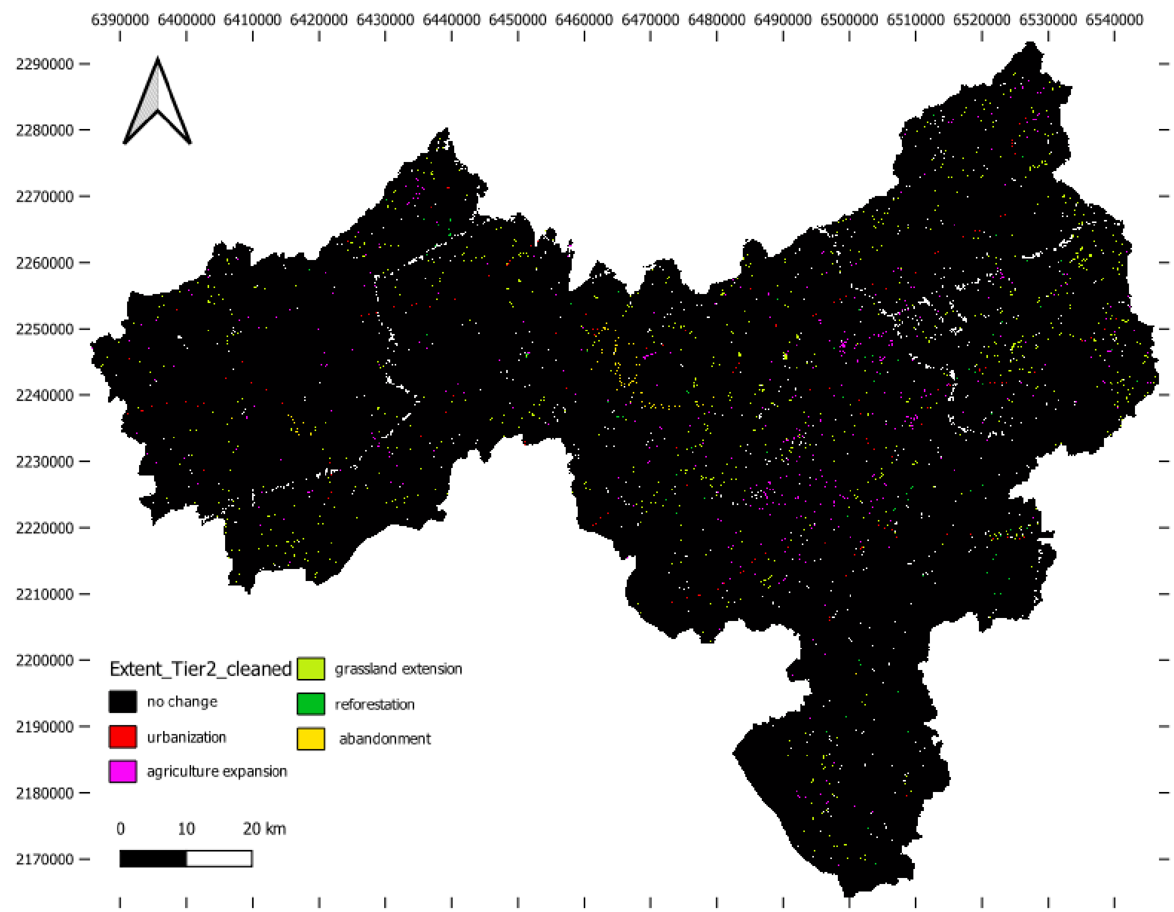
Table 22: Ecosystem Extent Transition Matrix 2018–2021 for Çekerek

	2021 (closing in ha)	100	200	300	400	500	600	700	800	900	1000	1100	1200			
	TULIP Cekerek, clean backward 2018 (opening in ha)	Settlements and other artificial areas	Cropland	Grassland	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and Canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches and transitional waters	Marine ecosystems	No-change	Change (reduction)	relative change in%
1	Settlements and other artificial areas	11048	520	24	14		33			1				11048	592	5.4%
2	Cropland	325	343853	832	428		938			42				343853	2565	0.7%
3	Grassland	94	3777	186525	415		808			10	4			186525	5198	2.8%
4	Forest and woodland	16	2071	160	295022		181			7				295022	2435	0.8%
5	Heathland and shrub													0	0	
6	Sparsely vegetated ecosystems	3	100	62	10		18132							18132	175	1.0%
7	Inland wetlands													0	0	
8	Rivers and Canals													0	0	
9	Lakes and reservoirs	3	270	38	28		102			6459				6459	441	6.8%
10	Marine inlets and transitional waters													0	0	
11	Coastal beaches and transitional waters													0	0	
12	Marine ecosystems													0	0	0.0%
	No-change	11048	343853	186525	295022	0	18132	0	0	6459	0	0	0	861039	11406	1.3%
	Change (addition)	441	6738	1116	895	0	2152	0	0	60	4	0	0	11406		
	relative change in %	4%	2.0%	0.6%	0.3%		11.9%			0.9%			0%	1.3%		

Source: VITO estimates

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30% of Türkiye (Orman Genel Müdurlügü, 2025)

Figure 40: Major change fluxes from 2018 to 2021 over Cekerek



Source: Compiled by VITO

UASIS raw map for EU Tier2 Level-2 accounts

In the sections above, the original classified UASIS (raw) map with 79 classes was not used, but instead the reclassified map according to the Corine typology with 43 classes. This implies that that the generation of the extent maps as earlier described did not exploit the full potential of the UASIS maps, especially at higher levels typology (Level-2 and Level-3).

Since there was no access to the original UASIS raw map, a theoretical cross-reference has been made to check how much detail the UASIS map provides to generate more thematic detailed ecosystem extent maps (Level-2 and Level-3) and identify potential focus areas for future mapping. Note the exercise was limited as no full descriptions of the UASIS classes were provided, neither the involvement of local experts which are both important to finalize the exercise. Despite this limitation, the results show some information which is important for the roadmap.

Table 23 shows a summary of the applicability of UASIS to generate Ecosystem Extent maps as Level-2 or Level-3, depicted in a good (green) or moderate (light green) to a limited (light orange) to no (orange) coverage for both Level-2 and Level-3 European Ecosystem Typology.

We can see that applying a cross-reference from the UASIS (raw) map directly to the Ecosystem Extent typology, hence without going through the intermediate Corine typology, enables the provision of an Ecosystem Extent Level-2 map for most ecosystem types. Some further discussions, and potentially adaptations in the UASIS workflow, are required on the heathland and shrub, and coastal ecosystem types next to the inclusion of the marine ecosystem type. Furthermore, it is recommended to check and refine the anthropogenic classes related to forest (plantations) and agro-forestry areas.

At Level-3 we see that besides the UASIS (raw) maps provide mainly the necessary details for the main croplands as well as most information on settlements and other artificial areas. Decomposing the more natural ecosystem types, as grassland, forest and woodland, heathland and shrub, as well as coastal does require to include habitat maps, preferably based on EUNIS typology, into the extent workflow.

Table 23: Cross-reference UASIS typology to Ecosystem Type typology (direct mode)

	Ecosystem type name	Level2	Level3
1	Settlements and other artificial areas		
1.1	Continuous settlement area		
1.2	Discontinuous settlement area		
1.3	Infrastructure		
1.4	Urban greenspace		
1.5	Other artificial areas		
2	*Cropland*		
2.1	Annual cropland		
2.2	Rice fields		
2.3	Permanent crops		
2.4	Agro forestry areas		
2.5	Mixed farmland		
2.6	Other farmland		
2.7	Hedgerows and tree rows in cropland		
3	*Grassland*		
3.1	Sown pastures and fields (modified grasslands)		
3.2	Natural and semi-natural grasslands		
3.3	Hedgerows and tree rows in grassland		
4	*Forest and woodland*		
4.1	Broadleaved deciduous forest		
4.2	Coniferous forests		
4.3	Broadleaved evergreen forest		
4.4	Mixed forests		
4.5	Transitional forest		
4.6	Plantations		
5	*Heathland and shrub*		
5.1	Tundra		
5.2	Heathland and (sub)alpine shrubs		
5.3	Sclerophyllous vegetation		
6	*Sparsely vegetated ecosystems*		
6.1	Bare rocks		
6.2	Semi-desert, desert and other sparsely vegetation		
6.3	Ice sheets, glaciers and perennial snowfields		

	Ecosystem type name	Level2	Level3
7	*Inland wetlands*		
7.1	Inland marshes on mineral soils		
7.2	Mires, bogs and fens		
8	*Rivers and Canals*		
8.1	Rivers		
8.2	Canals, ditches and drains		
9	*Lakes and reservoirs*		
9.1	Lakes		
9.2	Artificial reservoirs		
9.3	Geothermal pools and wetlands (iceland)		
10	*Marine inlets and transitional waters*		
10.1	Coastal lagoons		
10.2	Estuaries and bays		
10.3	Intertidal flats (e.g., Wadden Sea)		
11	*Coastal beaches, dunes, and wetlands*		
11.1	Artificial shorelines		
11.2	Coastal dunes, beaches and sandy and muddy shores		
11.3	Rocky shores		
11.4	Coastal saltmarshes and salines		
12	Marine ecosystems		
12.1	Marine macrophyte habitats		
12.2	Coral reefs		
12.3	Worm reefs		
12.4	Shellfish beds and reefs		
12.5	Subtidal sand beds and mud plains		
12.6	Subtidal rocky substrates		
12.7	Continental and island slopes		
12.8	Deepwater benthic and pelagic ecosystems		
12.9	Deepwater coastal inlets (fjords)		
12.10	Sea ice		

Legend	
	good replication of ecosystem type at level
	most data available, but no full coverage of ecosystem types at level
	some data available, but limited coverage of ecosystem types at level
	no data available to replicate ecosystem type at level
	not applicable
	to be further discussed

Source: Compiled by VITO

A full cross-reference (or crosswalk) can be found in Annex.

2.3.6 Conclusion and roadmap

A first 2018–2021 ecosystem extent account at EU typology Level-1 has been generated. The UASIS regional maps for 2021, cross walked to Corine, provide a high spatial detail (0.25 ha) and were used as a base map. It is advised that experts further evaluate the accuracy of these maps, and analyze the identified issues (some no values, missing rivers) to further improve the methodology to generate these maps. To detect true changes, a method was developed to use a dual-proxy binary change mask to harmonize the 2018 and 2021 maps given they could not be used directly to detect ecosystem changes given their too large difference in methodologies.

At short term, it is advised to further improve the UASIS-Corine maps and use the existing 'Corine' validation database and validation methodology to quantify the accuracy of these maps, as well as validating the changes. Once known and accepted, statistical validation is to be performed to ensure statistically continued time-series. It is advised to also create a UASIS-Corine extent map for the year 2018 and thereafter subsequent years from 2021 onwards. This will enable support the statistical validation (done for 2018) and to further optimize the change methodology with a larger time-series, introducing some additional techniques to clean individual extent maps. Special attention should also be given to harmonize definitions between different ministries, and where necessary add some specific Level-3 classes for the Anatolian region to the EU typology. Once proven at regional scale on the Bolaman and Çekerek regions, it is required to analyze scaling up to national extent. The cost should be estimated to generate yearly, 2-yearly, or 3-yearly national maps, and the base national map should be generated and validated. The validation should initially be done on some defined regions where sufficient validation data is available to quantify the accuracy of the national maps.

In the longer term, it is advised to further test the direct mapping of the UASIS maps to the ecosystem extent typology, Level-1 and (partly Level-2). This exploration could not be done besides a theoretical exercise, as access to the raw UASIS maps was not granted. To further complement the maps and reach Level-3 ecosystem types, it is advised to create a workflow to generate EUNIS habitat maps. Such workflows are being developed in the scientific community, and priority should be given to create a training database for Türkiye according to the EUNIS2021 typology starting from the Habitats Directive ground-truth collection for Natura 2000 parks and further complementing with specific areas outside the parks. Integrating the EUNIS habitat maps into the ecosystem extent workflow, hence combining with UASIS raw maps, will enable to generate (mostly) Level-3 maps.

2.4 Improvement strategies

Some identified limitations:

- No input data are currently available after 2018, however a new Corine Land Cover data layer is under production and should become available over the next years representing the year 2024.
- Updates of CLCACC is restricted to 6-yearly, which does not fit the 3-yearly accounting requirement.
  - The Minimum Mapping Unit is limited to 25 ha, which would restrict its use for regional use (see 2.3.1).
  - The distinction between rivers and canals (ecosystem type 8) and lakes and reservoirs (ecosystem type 9) cannot be made and requires another input layer. Note that at the given MMU of 25 ha, most rivers and canals will not be detected and hence we assigned all water to lakes and reservoirs.
- Marine ecosystem accounts were not yet developed.

3 ECOSYSTEM CONDITION ACCOUNT

3.1 Forest condition

3.1.1 Definition

EU legislation requires ecosystem condition accounts to be produced every three years. For forest and woodland, this requires reporting the mandatory ecosystem condition variables/indicators 'dead wood' (in m^3/ha) and 'tree cover density' (in %). There are some other recommended variables/indicators to report on, which include 'soil organic carbon content', 'forest productivity', and several more. During the PEOPLE-EA (https://esa-people-ea.org/en) project, a method was developed to create a Forest Condition Index. This method follows the SEEA EA (System for Environmental Economic Accounting – Ecosystem Accounting) framework.

The SEEA EA framework proposes a stepwise approach:

1. Definition and selection of ecosystem condition variables ranging as much as possible Ecosystem Condition Typology (ECT) (overview in Figure 22).
2. Definition of the reference conditions and rescaling of the variables to ecosystem condition indicators which range between 0 and 1.
3. Aggregation of the indicators into a single ecosystem condition index using indicator specific weights.

Figure 41: Ecosystem Condition Typology per group (abiotic, biotic, and landscape level) and per associated classes explained

Group A: **Abiotic ecosystem characteristics**	Class A1. **Physical state characteristics**: physical descriptors of the abiotic components of the ecosystem (e.g. soil structure, water availability)
	Class A2. **Chemical state characteristics**: chemical composition of abiotic ecosystem compartments (e.g. soil nutrient levels, water quality, air pollutant concentrations)
Group B: **Biotic ecosystem characteristics**	Class B1. **Compositional state characteristics**: composition / diversity of ecological communities at a given location and time (e.g. presence/abundance of key species, diversity of relevant species groups)
	Class B2. **Structural state characteristics**: aggregate properties (e.g. mass, density) of the whole ecosystem or its main biotic components (e.g. total biomass, canopy coverage, annual maximum NDVI)
	Class B3. **Functional state characteristics**: summary statistics (e.g. frequency, intensity) of the biological, chemical, and physical interactions between the main ecosystem compartments (e.g. primary productivity, community age, disturbance frequency)
Group C: **Landscape level characteris-tics**	Class C1. **Landscape and seascape characteristics**: metrics describing mosaics of ecosystem types at coarse (landscape, seascape) spatial scales (e.g. landscape diversity, connectivity, fragmentation)

Source: Vallecillo Rodriguez et al. 2022.

In the following section, it will be explained how this approach was applied to create forest condition accounts for the Bolaman and Çekerek region in Türkiye within the period 2016–2022.

3.1.2 Methodology and data sources

Table 24 exhibits a list of proposed forest condition variables covering all ECT classes. First, forest condition variables are identified from this list that will be used to create the final Forest Condition Index (FCI). The indicators composing the index aim to represent comprehensively all the components of ecosystems. The index is usually composed of a single indicator for each ECT class, since the variables belonging to the same ECT class are usually highly correlated. The indicators are selected considering their relevance, their direct relationship to forest conditions and the availability of data for their measurement. The table below gives an overview of these proposed variables, the associated ECT class, and their temporal coverage.

Table 24: Overview of forest condition variables

Forest condition variable	Link to dataset	ECT class	Temporal coverage
Normalized Difference Water Index (NDWI) *Water content index*	GEE Landsat 7 Collection 1 Tier 1 32-Day NDWI Composite GEE Landsat 8 Collection 1 Tier 1 32-Day NDWI Composite	A1 Abiotic: Physical state	2000-2021
Soil Organic Carbon content (SOC) *Organic carbon content in the first 30 cm of the soil (topsoil)*	ISRIC	A2 Abiotic: Chemical state	2003, 2014
Threatened Forest Bird Species Diversity (TFBSD) *Assessment of bird population status (population sizes, trends for breeding and wintering populations, pressures, and threats for Special Protection Area trigger species)*	Population trend of bird species: datasets from Article 12, Birds Directive 2009/147/EC reporting (2008-2012)	B1 Biotic: Compositional state	2000 & 2018
AGB (Above Ground Biomass) *The stock in living or dead biomass aboveground (plant stem, leaves, head, spike, seeds and foliage)*	ESA's Climate Change Initiative Biomass	B2 Biotic: Structural state	2010, 2017–2021
Leaf Area Index (LAI) *The ratio of one-sided leaf is per unit ground area*		B2 Biotic: Structural state	2015-present
Plant Phenology Index (PPI) *Index is linearly related to green leaf area index, is used to track canopy green foliage dynamics (plant phenology)*		B2 Biotic: Structural state	2017–present

Forest condition variable	Link to dataset	ECT class	Temporal coverage
Tree Cover Density (TCD) *Proportional canopy coverage per satellite pixel in a range of 0 to 100%*	Copernicus High Resolution Tree Cover Density	B2 Biotic: Structural state	2012, 2015, 2018
Net Primary Productivity (NPP) *The rate of accumulation of biomass or energy*	Copernicus Dry Matter Productivity and Net Primary Production	B3 Biotic: Functional state	2015–present
Fraction of Green Vegetation Cover (FCOVER) *The fraction of ground covered by green vegetation*		B3 Biotic: Functional state	2015–present
Fraction of Absorbed Photosynthetic Active Radiation (FAPAR) *The fraction of incoming solar radiation in the spectrum 400-700 nm that is absorbed by vegetation canopy*		B3 Biotic: Functional state	2016–present
Drought Severity (SD) *Consecutive occurrences of water deficiency*		B3 Biotic: Functional state	2012–2024
Normalized Difference Vegetation Index (NDVI) *A measure of the amount and vigor of vegetation on the land surface*		B3 Biotic: Functional state	2016–present
Forest Connectivity Percentage (FCP) *The percentage of connected forest patches*		C1 Landscape and seascape at coarse scale	2000, 2006, 2012, 2018
Landscape Naturalness (LN) *The degree of natural characteristics in the landscape (i.e., not human-made structures)*		C1 Landscape and seascape at coarse scale	2000, 2006, 2012, 2018
Forest Fragmentation (FF) *The division of forest into smaller patches*	ESA's Climate Change Initiative Biomass	C1 Landscape and seascape at coarse scale	1992–2020

Source: Compiled by VITO

As can be derived from this table, the Ecosystem Condition Typology (ECT) classes contain variables that are not restricted to describing productivity but also cover biodiversity (e.g. Threatened Forest Bird Species Diversity) and ecosystem integrity (e.g. Forest Connectivity Percentage). Therefore, it is important to realize that the Forest Condition Index (FCI) is not just an index for production but rather an index referring to which degree this forest is containing the capacity to deliver all sort of ecosystem services it could deliver, compared to the reference or optimal condition in which it has the maximal capacity.

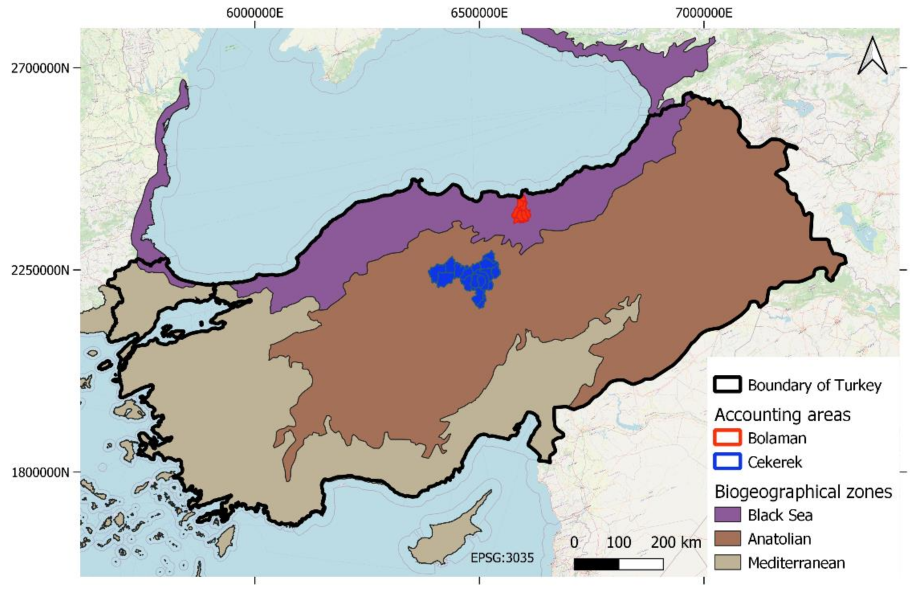
As forest condition variables we selected ‘NDWI’, ‘TFBSD’, ‘AGB’, ‘NPP’, and ‘FCP’ (Table 11). From the set of selected forest condition variables, you might notice that one ECT class is missing, namely ‘A2 Abiotic: chemical state’. In our usual approach, we use the variable ‘Soil Organic Carbon’ (SOC) from the OCTOP (Topsoil Organic Carbon Content for Europe, 2003) and LUCAS (Topsoil Soil Organic Carbon for EU25, 2014) archive. Unfortunately, these datasets do not cover Türkiye and are only available for those specific years. In the SOC account that was created for Bolaman and Çekerek , we worked with data obtained from the ISRIC Soil Database. This data is also not yearly but contains the most updated version. However, soil characteristics do not normally fluctuate much within a short time span (here: 7 years) and could be assumed as stable. But since the same value for the SOC content would be used every year in the metric for the forest condition account, it would not affect or influence the trend over time compared to if it would be left out. Therefore, the SOC content was not considered as a variable in the calculation of the condition index but we simply created a SOC content variable per forest type and biogeographical zone (explained a bit further down).

Originally, Net Primary Productivity (NPP) was derived from Copernicus Land Monitoring Service (CLMS) product ‘Gross Dry Matter Productivity’ (GDMP). This product has a 300 m resolution and is created by PROBA-V data from 2014 until June 2020, and from July 2020 onwards based upon Sentinel-3/OLCI data. When analyzing this dataset, we noticed an abrupt drop in NPP in 2021 that could not be explained by climate or management effects (Figure 52). We concluded that this behavior in NPP for 2020–2021 between CLMS and MODIS is caused by the transition from PROBA-V to Sentinel-3 in mid-2020. Apparently, this transition affected the detection of FAPAR (Fraction of Absorbed Photosynthetically Active Radiation), which is a very important parameter in the derivation of the GDMP. Thus, the GDMP of CLMS is also affected. This effect could have been stronger in Bolaman than in Çekerek since this is a more mountainous region, so specific sensor effects (e.g. BRDF [Bidirectional Reflectance Distribution Function]) could be interfering here. To address this issue, we decided to use the NPP data from the MODIS satellite mission, which has an original resolution of 500 m.

Each variable is rescaled to an indicator ranging from 0 to 1, with values getting closer to 1 as the forest condition improves. The method of rescaling variables to indicators requires identifying the 98th percentile (i.e., Upper Reference) of the variable’s values among forest with ideal condition (i.e., the reference area) and the 2nd percentile (i.e., Lower Reference) of the variable’s values among the remaining forest in the area of interest. The reference areas should contain the desired state of the variable and represent forests in good health. For this study, a shapefile containing ‘Reference Forest Area Sites’ was provided by the national authority as a starting point to define the reference areas. These upper and lower reference values are obtained from the reference year which is normally the first year the data was available (often 2000). However, here we took 2015 as the reference year since the reference sites contain forest under production (as we were informed about), therefore, the current optimal condition of these areas will likely not resemble the same condition back in 2000 if we aim at creating a reliable forest condition account for the period 2016–2022. Lastly, the AGB (Above Ground Biomass) dataset for 2022 is not yet published. Therefore, the data of 2021 was used to create the AGB indicator and Forest Condition Index for 2022. Consequently, the AGB indicator value for 2021 and 2022 are equal in this analysis.

Forest condition accounts were created for two areas: Bolaman and Çekerek. These two areas are not part of the same biogeographical zone; Bolaman is located in the Black Sea zone (BLS) and Çekerek lays more South, in the Anatolian zone (ANA) (Figure 23).

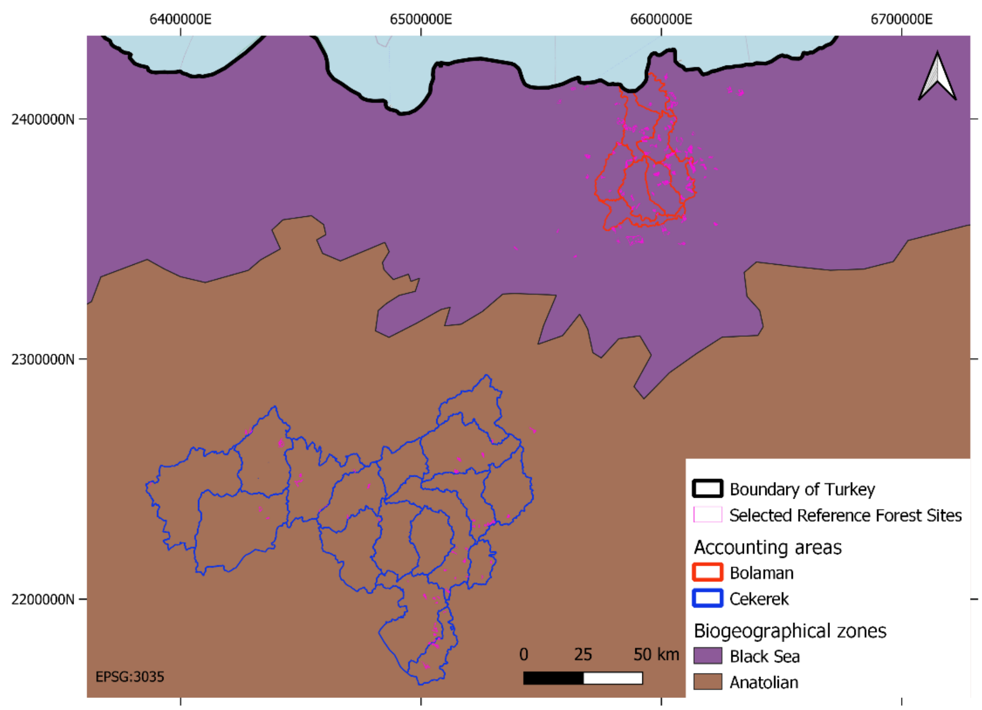
Figure 42: Location of Bolaman (in red) and Çekerek (in blue) within biogeographical zones of Türkiye



Source: European Environment Agency.

Therefore, the condition accounts for the two accounting areas are made with reference to their biogeographical zone. This means that the set of Reference Forest Area Sites is split up in two, with reference sites in the Black Sea zone used for condition accounting of Bolaman and reference sites in the Anatolian zone used for condition accounting of Çekerek (Figure 43).

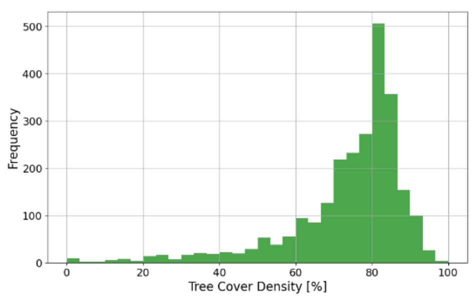
Figure 43: Distribution of Reference Forest Area Sites over biogeographical zones



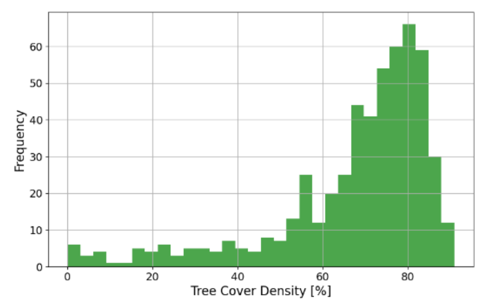
Source: Compiled by VITO

As explained earlier, the ‘selected reference forest sites’ were provided by the national authority. We performed a simple quality check on the indicated reference sites by identifying the tree cover density (TCD) range within these reference forest sites. This is necessary for the following reason: even though the selected forest reference sites may be the desired forest type in the particular biogeographical zone, the variability range between the reference sites should be minimal in order to serve as a decent standard in the approach to calculate the forest condition account. If the range in tree cover density is large, that indicates that there is a high variability in the region. Thus, it is likely that many regions outside of the reference sites will resemble any location inside the reference area. This will lead to a good Forest Condition Index for the whole region which is not considered as a successful and effective forest condition account. For this analysis, we used The High Resolution Layer Tree Cover Density (2015, 100 m) and the CORINE Land Cover map (2018, 100 m) from the Copernicus Land Monitoring Service (CLMS). Our analysis indicated that there is indeed often a wide range of TCD within the selected forest reference sites per forest type per biogeographical zone. *In both Bolaman and* Çekerek*, the Transitional Woodland-Shrub category contains a large spread in TCD percentages, with many pixels containing a value of 0%.*

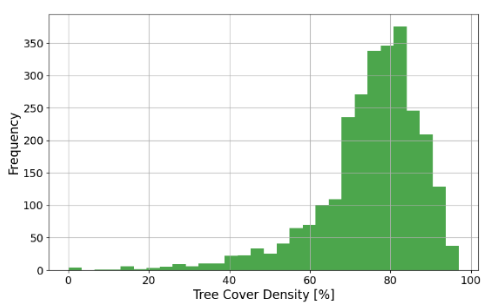
Figure 44: Histogram of Tree Cover Density percentage



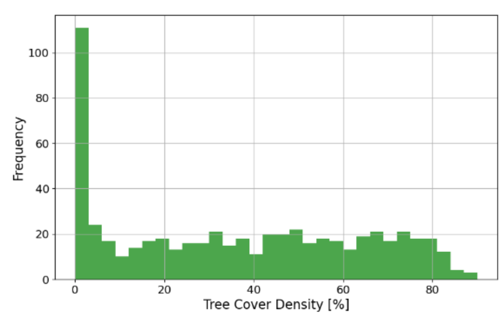
a) Bolaman – Broad-leaved forest



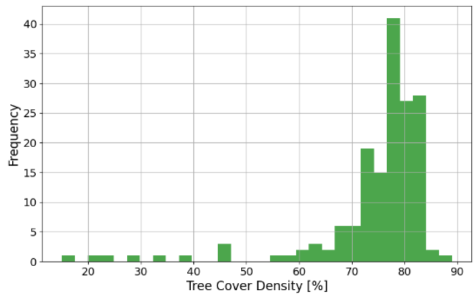
b) Bolaman – Coniferous forest



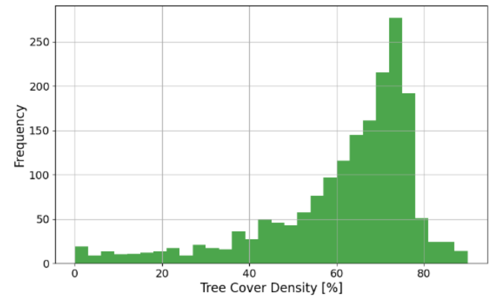
c) Bolaman – Mixed forest



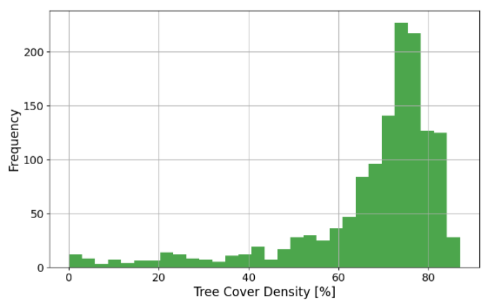
d) Bolaman - Transitional woodland-shrub



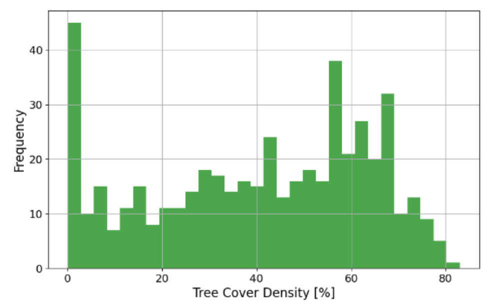
e) Çekerek - Broad-leaved forest



f) Çekerek – Coniferous forest



g) Çekerek – Mixed forest



h) Çekerek – Transitional woodland-shrub

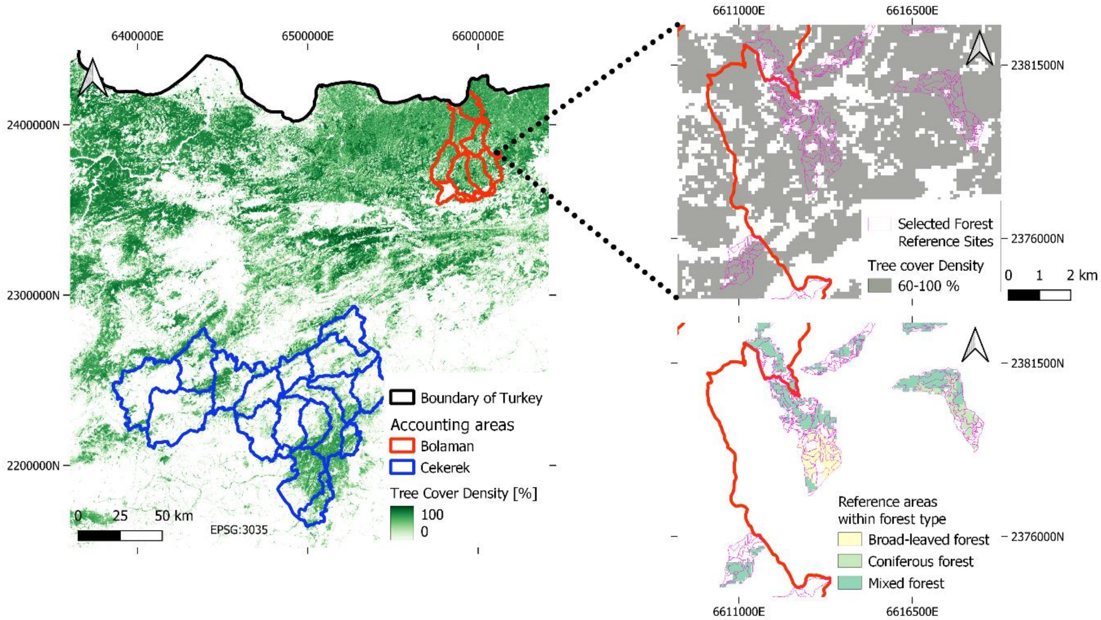
Source: Compiled by VITO

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

To obtain the reference areas per forest type within each biogeographical zone, the approach as depicted in the figure below (Figure 45) was applied. To avoid inaccurate sets of reference conditions, the original tree cover density map of CLMS was filtered to retain the pixels with a tree cover density between 60% and 100% for types broad-leaved forest, coniferous forest, and mixed forest and a tree cover density between 51% and 100% for type transitional woodland-shrub, to secure a more homogeneous set of forest reference sites, see also Table 25. This will make sure that the rescaling of the forest condition variables to indicators creates a more reliable result. Next, only these pixels were filtered to retrieve pixels with the class-related restricted tree cover density only within the Selected Forest Reference Areas. Lastly, these areas were overlaid with the CORINE Land Cover map from CLMS to classify them into one of the four following forest types:

- Broad-leaved forest (BF),
- Coniferous forest (CF),
- Mixed forest (MF) or
- Transitional woodland-shrub (TWS).

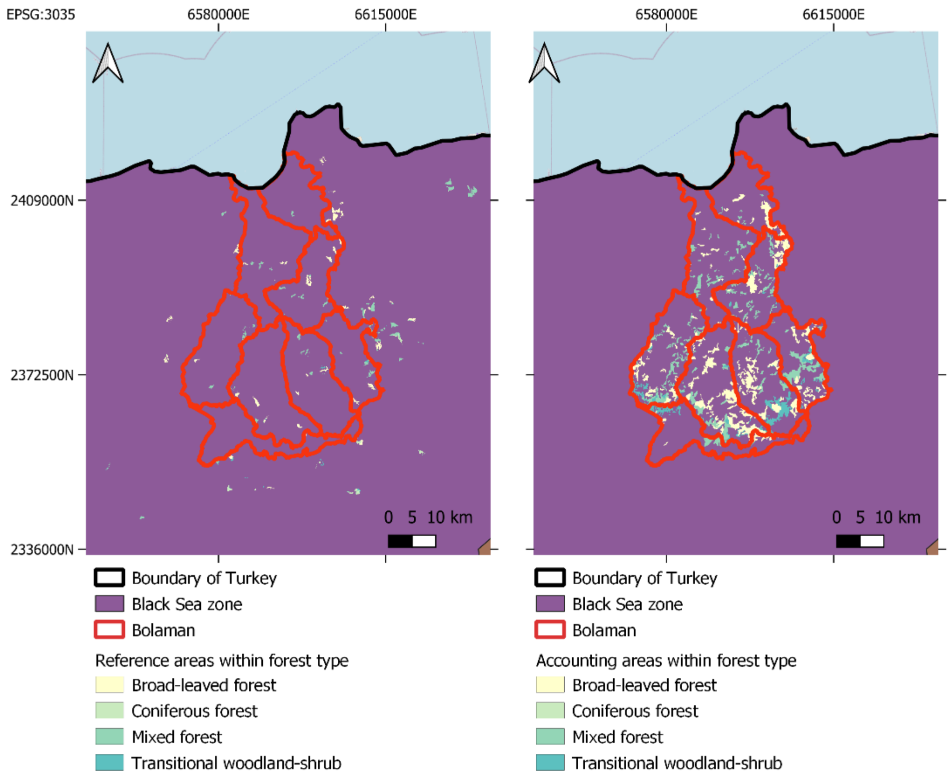
Figure 45: Visualization of method to locate reference areas by identifying pixels within Reference Forest Area Sites with Tree Cover Density between 60% and 100%



Source: Compiled by VITO

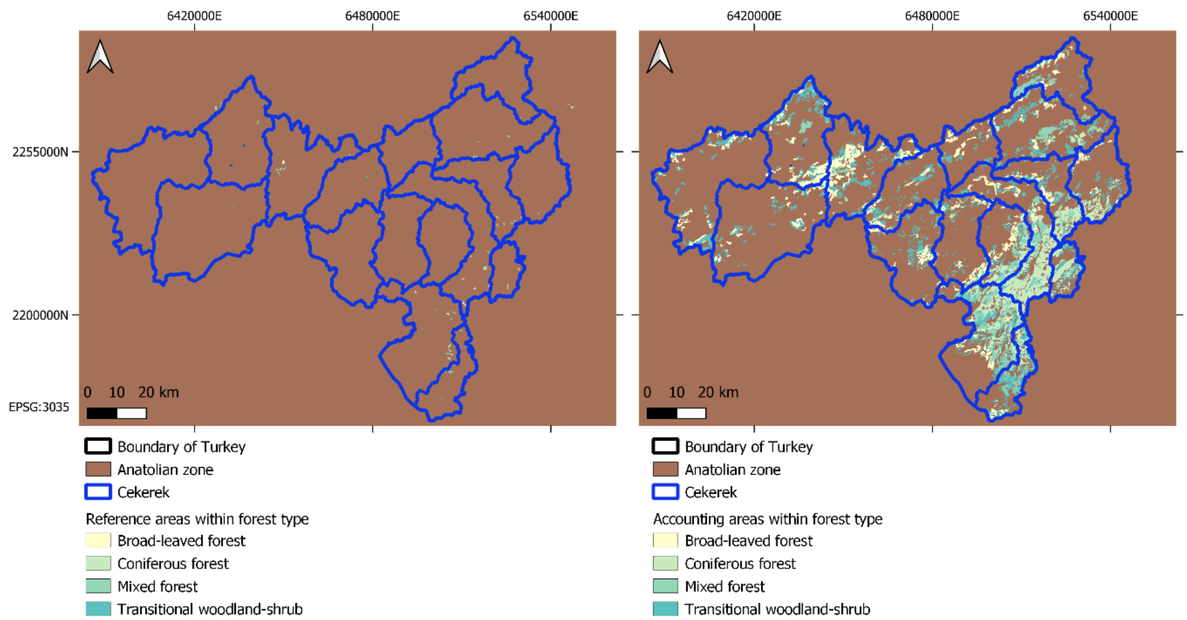
Reference pixels can also be located outside the accounting area but must be in the correct biogeographical zone. These pixels are used to retrieve the 98th percentile of the forest condition variables to rescale them to indicators (Figure 48). As a counterpart of the reference areas, we identified all other forest areas with TCD between 10% and 100%, within the borders of the accounting site and used this to obtain the values of the 2nd percentile for the forest condition variables (Figure 48). The set of reference pixels and the counterpart forest area, both located within the accounting site, form the set of pixels for the full forest condition accounting area.

Figure 46: Distribution of reference areas and all accounting area per forest type within Black Sea biogeographical zone for Bolaman



Source: Compiled by VITO

Figure 47: Distribution of reference areas and all accounting area per forest type within Anatolian biogeographical zone for Çekerek



Source: Compiled by VITO

Table 25: Amount of pixels identified as reference pixels[a] per forest type for Black Sea and Anatolian biogeographical zones

Biogeographical zone	Forest type	Pixel count with TCD between 51% and 100%
Black Sea	Broad-leaved (BF)	2,175
	Coniferous (CF)	413
	Mixed (MF)	2,451
	Transitional woodland-shrub (TWS)	197
Anatolian	Broad-leaved (BF)	152
	Coniferous (CF)	1,219
	Mixed (MF)	1,108
	Transitional woodland-shrub (TWS)	207

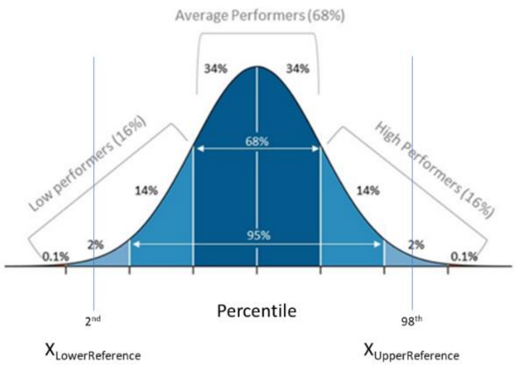
Note: a. Pixels within Reference Forest Area Sites with Tree Cover Density between 60% and 100% for broad-leaved, coniferous and mixed forest and pixels with Reference Forest Area Sites with Tree Cover Density between 51% and 100% for transitional woodland-shrub)

Source: VITO estimates

Rescaling of variables to indicators was done by the following calculation (Figure 28):

$Xi = (X_{observed} – X_{LowerReference}) / (X_{UpperReference} – X_{LowerReference})$

Figure 48: Visualization of extraction of 98th (i.e., Upper Reference) and 2nd percentile (i.e., Lower Reference) per condition variable for rescaling variables to indicators (PEOPLE-EA_ATBD (Deliverable 7))



Source: PEOPLE-EA ATBD (Deliverable 7)

The Forest Condition Index (FCI) quantifies forest health by summarizing the information of several indicator accounts, each representing a different aspect (abiotic, biotic and landscape characteristics) of the forest conditions. The weights for indicator accounts are determined according to the following criteria:

- Their spatial resolution,
- Their temporal resolution,
- Their temporal frequency, and
- The dataset quality (referring to the proximity of the latest year to the present).

Indicator accounts are ranked according to each of these categories based on expert opinion (i.e., a common understanding and not just used in this project only). Larger values of these criteria are associated with a better representation of the ecological conditions and rank in a higher position (Table 26).

Table 26: Forest condition indicators are ranked on 4 criteria (spatial resolution, temporal resolution, temporal frequency, and dataset quality)

Variable	Spatial resolution	Temporal resolution	Temporal frequency	Dataset quality	Total	Final weight
Normalized Difference Water Index (NDWI)	4	5	5	4.5	**18.5**	0.31
Threatened Forest Bird Species Diversity (TFBSD)	1	2.5	2	1	**6.5**	0.11
Above Ground Biomass (AGB)	4	2.5	2	3	**11.5**	0.19
Net Primary Productivity (NPP)	2	4	4	4.5	**14.5**	0.24
Forest Connectivity Percentage (FCP)	4	1	2	2	**9**	0.15
					60	

Note: When data from more than one indicator is considered equal in one criteria, each indicator is attributed to the average of the positions they would represent (e.g. for spatial resolution NDWI, AGB and FCP in the table below). The variable abbreviations are explained in Table 11.

Source: VITO estimates

The overall condition index is calculated by the arithmetic average:

FCI = (NDWI x 0.31) + (TFBSD x 0.11) + (AGB x 0.19) + (NPP x 0.24) + (FCP x 0.15).

The soil organic carbon (SOC) indicator was created based on data from the ISRIC – World Soil Information SoilGrids database. From here, raster data of SOC content (tonne C ha^{-1}) is downloaded in EPSG:4326 with spatial resolution of 250 meters. The exact temporal coverage of the data from SoilGrids is not specified but is considered as 'the latest up-to-date' data. This map was reprojected to EPSG:3035 and resampled to a 100 meters spatial resolution. The map was then filtered to obtain all the pixels per forest type and biogeographical zone. We derived the mean and median SOC content variable (kg C ha^{-1}) for the reference sites and the remaining forest per forest type and biogeographical zone separately.

3.1.3 Results

The table below (Table 27) shows the evolution of the mean Forest Condition Index during the period 2016–2022 per forest type and biogeographical zone. Figure 49 gives a visual representation of how the mean and standard deviation of the FCI evolve over time per forest type and biogeographical zone. In the Bolaman region, we notice a small drop in FCI in 2017, which is also visible in Çekerek but less pronounced. After 2018, we see a slightly decreasing trend in FCI in Bolaman but the standard deviations indicate the uncertainty of that trend. In Çekerek, the trend can be considered as good as stable. The forest types in the Anatolian zone experience a less negative trend in FCI between 2016 and 2022 than the ones in the Black Sea zone, and the maximum drop in FCI contains only 0.0324. In Bolaman, the highest drop in condition index between 2016 and 2022 contains a value of 0.1941 for the 'coniferous forest' type, and 'transitional woodland-shrub' exhibits the lowest drop with a value of 0.12.

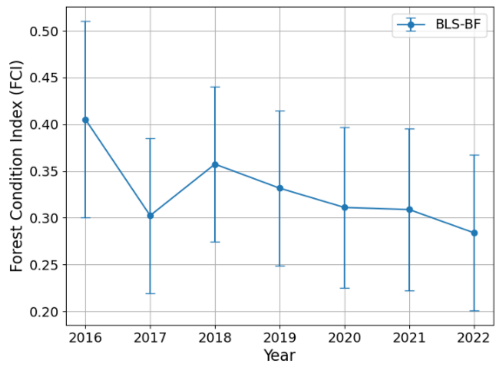
Table 27: Forest Condition account (in terms of Forest Condition Index) per combination of biogeographical zone and forest type, for the period 2018–2021

FCI	BLS-BF	BLS-CF	BLS-MF	BLS-TWS	ANA-BF	ANA-CF	ANA-MF	ANA-TWS
2016	0.4053	0.5364	0.3736	0.467	0.4851	0.5139	0.4695	0.4552
2017	0.3024	0.3938	0.2643	0.3277	0.4123	0.4395	0.4077	0.3983
2018	0.3574	0.4061	0.3147	0.4499	0.451	0.4818	0.4414	0.4319
2019	0.3317	0.4246	0.2873	0.4147	0.4649	0.5038	0.4662	0.4473
2020	0.3111	0.3427	0.2692	0.397	0.4276	0.4678	0.4295	0.4175
2021	0.3088	0.4078	0.2686	0.3648	0.4434	0.4830	0.4378	0.4219
2022	0.2839	0.3423	0.2486	0.347	0.4527	0.4832	0.4417	0.4309

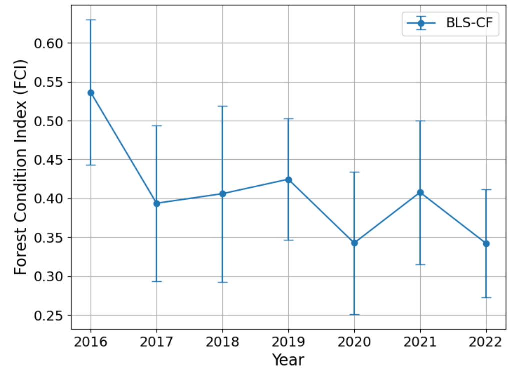
Note: BLS-BF: Black Sea – Broad-leaved Forest. BLS-CF: Black Sea – Coniferous Forest. BLS-MF: Black Sea – Mixed Forest. BLS-TWS: Black Sea – Transitional Woodland-Shrub. ANA-BF: Anatolia – Broad-leaved Forest. ANA-CF: Anatolia – Coniferous Forest. ANA-MF: Anatolia – Mixed Forest.

Source: VITO estimates

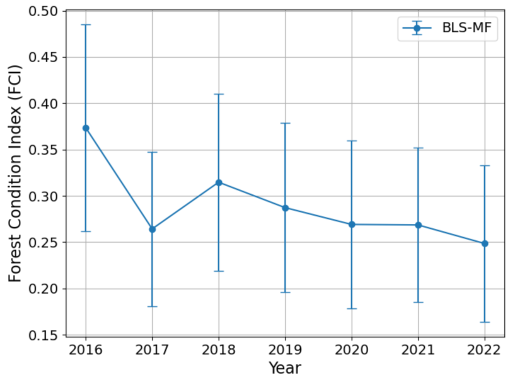
Figure 49: Graphical image of the forest condition account through time (2016–2022) per forest type in Bolaman and Çekerek



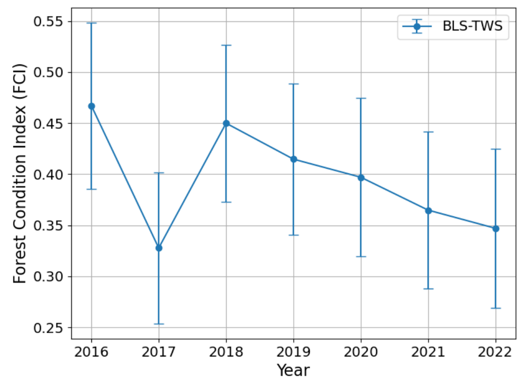
a) Black Sea – Broad-leaved Forest



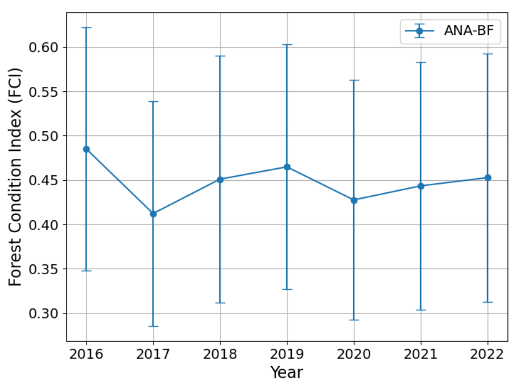
b) Black Sea – Coniferous Forest

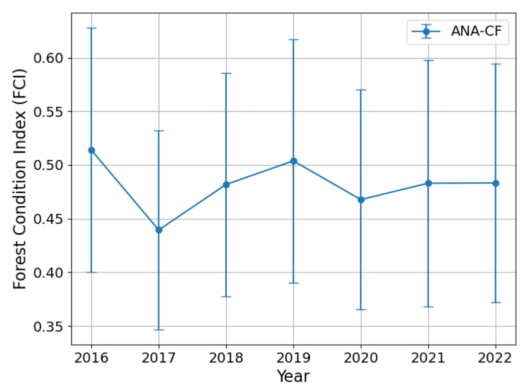


c) Black Sea – Mixed Forest

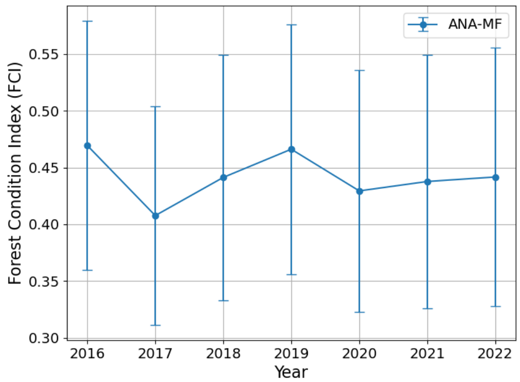


d) Black Sea – Transitional Woodland-Shrub

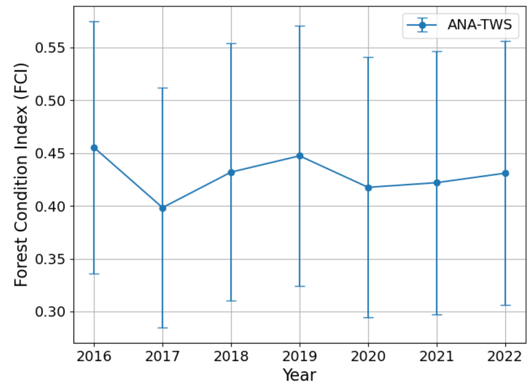




e) Anatolia – Broad-leaved Forest. f) Anatolia – Coniferous Forest



g) : Anatolia – Mixed Forest



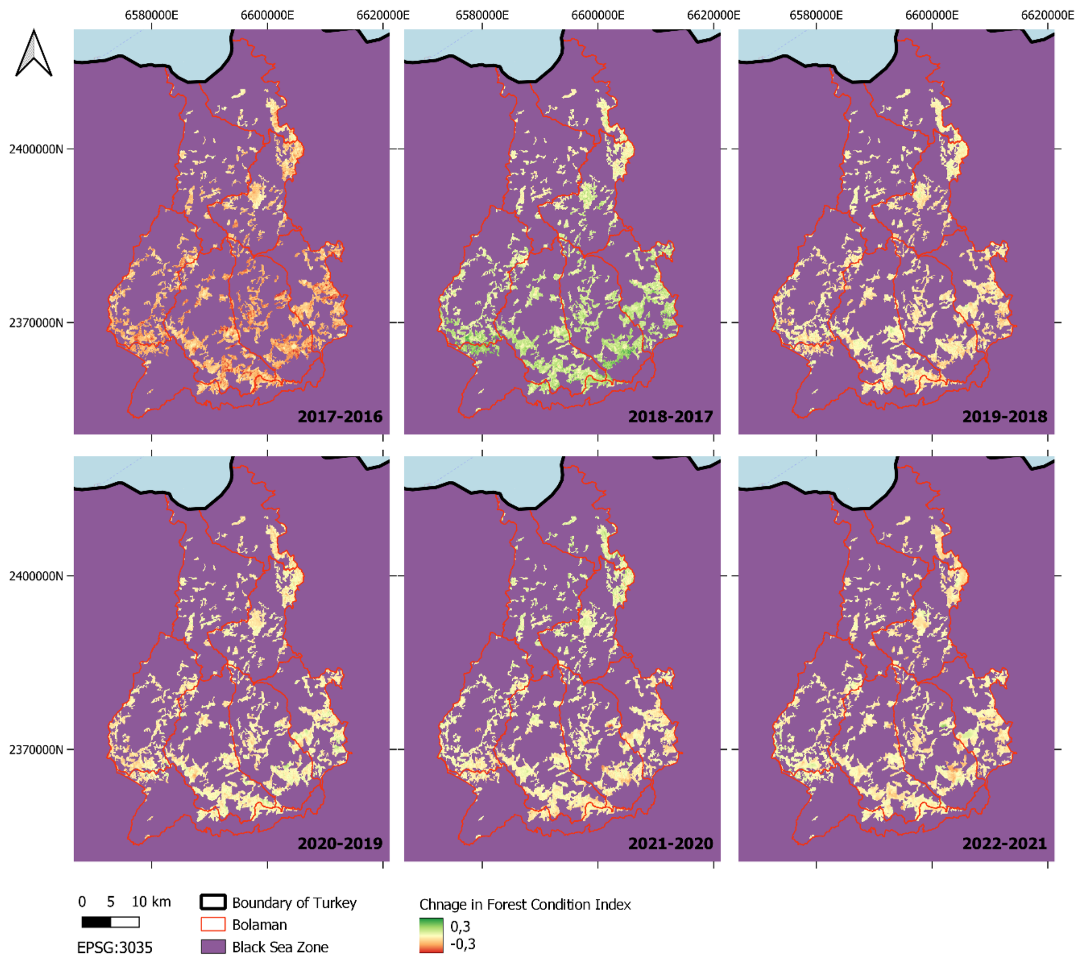
h) Anatolia – Transitional Woodland-Shrub

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

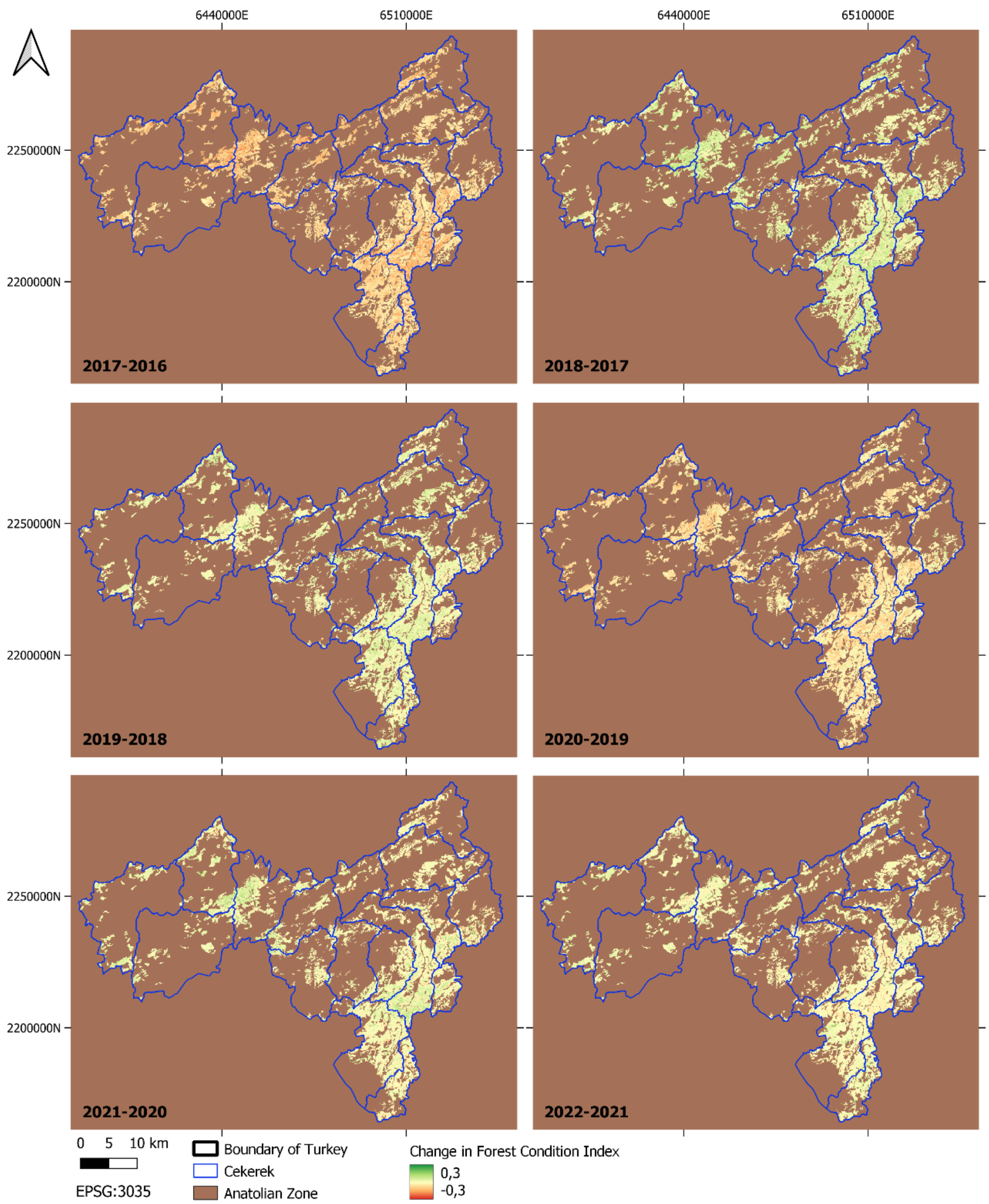
A visualization of the change in forest condition at a one-year time interval is depicted in Figure 50 and Figure 51. They clearly indicate that Bolaman has undergone a higher decrease in FCI for 2017–2016 than Çekerek, but a relatively stronger increase during 2018–2017.

Figure 50: Change in Forest Condition Index in a one-year time interval for Bolaman



Source: Compiled by VITO

Figure 51: Change in Forest Condition Index in a one-year time interval for Çekerek



Source: Compiled by VITO

The tables below provide a more detailed overview of the condition indicator values per combination of biogeographical zone and forest type for the period 2016–2022.

For each combination of biogeographical zone and forest type, a decrease in NDWI between 2016 and 2022 is discovered (Table 28). This decrease is more pronounced in forest areas in Bolaman than in Çekerek.

Table 28: Normalized Difference Water Index indicator account per year and per combination of biogeographical zone and forest type

NDWI	BLS-BF	BLS-CF	BLS-MF	BLS-TWS	ANA-BF	ANA-CF	ANA-MF	ANA-TWS
2016	0.2225	0.3472	0.2615	0.1872	0.5562	0.3312	0.4359	0.6166
2017	0.1287	0.2217	0.1428	0.1487	0.5298	0.3096	0.4226	0.5989
2018	0.0544	0.0895	0.0578	0.0973	0.4572	0.2376	0.3463	0.5427
2019	0.0563	0.0894	0.0729	0.1040	0.4709	0.2525	0.3659	0.5474
2020	0.0590	0.0813	0.0852	0.0980	0.4918	0.2603	0.3707	0.5659
2021	0.0625	0.0848	0.0868	0.1052	0.4953	0.2832	0.3784	0.5674
2022	0.0633	0.0749	0.0794	0.1028	0.4632	0.2661	0.3434	0.5310

Source: VITO estimates

The NPP varies quite extensively over time (Table 29). We observe a decrease in 2017 compared to 2016 for all categories. In the Black Sea zone, the NPP further undergoes a decreasing pattern compared to the reference condition between 2018 and 2022 while in Anatolia all forest types recover in NPP between 2020 and 2021.

Table 29: Net Primary Productivity indicator account per year and per combination of biogeographical zone and forest type

NPP	BLS-BF	BLS-CF	BLS-MF	BLS-TWS	ANA-BF	ANA-CF	ANA-MF	ANA-TWS
2016	0.5564	0.7716	0.5004	0.8586	0.4814	0.5486	0.4675	0.4539
2017	0.2513	0.3729	0.2106	0.3191	0.2277	0.2657	0.2307	0.2408
2018	0.5778	0.6470	0.5140	0.8964	0.4716	0.5476	0.4705	0.4567
2019	0.5019	0.7097	0.4420	0.7573	0.4960	0.5803	0.5016	0.4821
2020	0.4100	0.4284	0.3386	0.6942	0.2906	0.4368	0.3464	0.3206
2021	0.4012	0.7204	0.3412	0.5512	0.3620	0.4706	0.3762	0.3454
2022	0.2947	0.4603	0.2644	0.4800	0.4422	0.4938	0.4380	0.4300

Source: VITO estimates

The AGB remains more or less stable but undergoes a small decrease from 2016 to 2022, except for the Broad-leaved forest and transitional woodland-shrub in Anatolia (Table 30).

Table 30: Above Ground Biomass indicator account per year and per combination of biogeographical zone and forest type

AGB	BLS-BF	BLS-CF	BLS-MF	BLS-TWS	ANA-BF	ANA-CF	ANA-MF	ANA-TWS
2016	0.4213	0.5548	0.3969	0.2298	0.1933	0.4611	0.3258	0.1182
2017	0.4114	0.5125	0.3689	0.2389	0.1732	0.4620	0.3214	0.1166
2018	0.4169	0.4466	0.4028	0.2388	0.1878	0.4465	0.3199	0.1125
2019	0.3990	0.4348	0.3759	0.2273	0.1800	0.4320	0.3299	0.1161
2020	0.4005	0.3720	0.3866	0.2237	0.2092	0.4105	0.3246	0.1330
2021	0.3938	0.3404	0.3780	0.2224	0.1964	0.4107	0.3182	0.1224
2022	0.3938	0.3404	0.3780	0.2224	0.1964	0.4107	0.3182	0.1224

Source: VITO estimates

The behavior of the TFBSD indicator does not show a similar pattern for all categories (Table 31). The indicator increases in Anatolia between 2016 and 2022 for all forest types while this increase is only observable for forest type ‘coniferous forest’ in the Black Sea zone.

Table 31: Threatened Forest Bird Species Diversity indicator account per year and per combination of biogeographical zone and forest type

TFBSD	BLS-BF	BLS-CF	BLS-MF	BLS-TWS	ANA-BF	ANA-CF	ANA-MF	ANA-TWS
2016	0.5603	0.3166	0.4813	0.7897	0.6801	0.7438	0.5950	0.5097
2017	0.5603	0.3166	0.4813	0.7897	0.6801	0.7438	0.5949	0.5097
2018	0.5603	0.3166	0.4813	0.7897	0.6802	0.7438	0.5949	0.5097
2019	0.5167	0.3693	0.3910	0.7783	0.7286	0.8561	0.6816	0.5757
2020	0.5167	0.3693	0.3910	0.7783	0.7286	0.8561	0.6816	0.5757
2021	0.5167	0.3693	0.3910	0.7783	0.7286	0.8561	0.6816	0.5757
2022	0.5167	0.3693	0.3910	0.7783	0.7286	0.8561	0.6816	0.5757

Source: VITO estimates

The forest connectivity does not show significant change over time for any of the categories (Table 32).

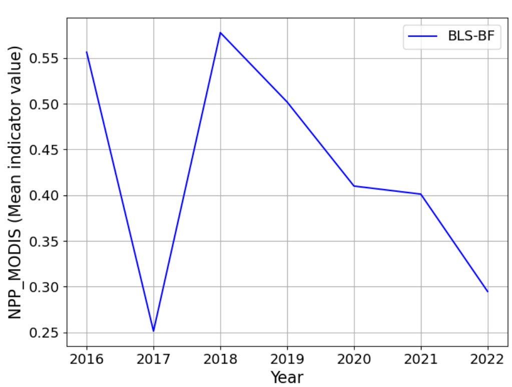
Table 32: Forest connectivity indicator account per year and per combination of biogeographical zone and forest type

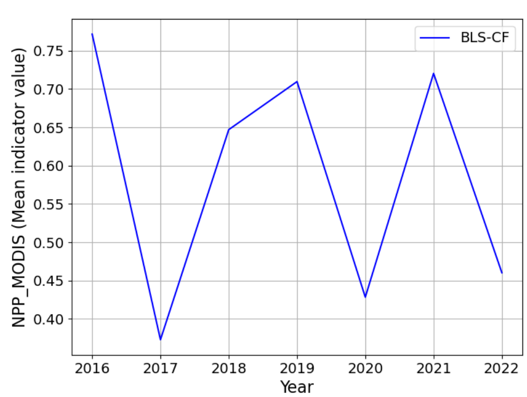
FCP	BLS-BF	BLS-CF	BLS-MF	BLS-TWS	ANA-BF	ANA-CF	ANA-MF	ANA-TWS
2016	0.4226	0.689	0.3213	0.4861	0.5713	0.7344	0.6323	0.5111
2017	0.4226	0.689	0.3213	0.4861	0.5713	0.7344	0.6325	0.5112
2018	0.4226	0.689	0.3213	0.4861	0.5713	0.7344	0.6325	0.5112
2019	0.4209	0.689	0.3190	0.4824	0.5707	0.7339	0.6317	0.5106
2020	0.4208	0.689	0.3188	0.4824	0.5707	0.7339	0.6319	0.5107
2021	0.4209	0.689	0.3190	0.4824	0.5707	0.7339	0.6319	0.5107
2022	0.4209	0.689	0.3190	0.4824	0.5707	0.7339	0.6317	0.5106

Source: VITO estimates

The biggest influence in the FCI pattern is caused by the NPP indicator, which also contains the second highest weight in the calculation of the FCI. The NPP indicator decreased abruptly in 2017 compared to 2016 in both the Black Sea zone as the Anatolian zone. After a recovery in 2018, the NPP decreases further from the reference condition in Bolaman, only for forest type 'coniferous forest' the NPP has showed recovery in 2021. In Çekerek, all forest types contain improvement in NPP from 2021 onwards. The NPP indicator is the main cause for the large drop in FCI during 2017 for both Bolaman and Çekerek.

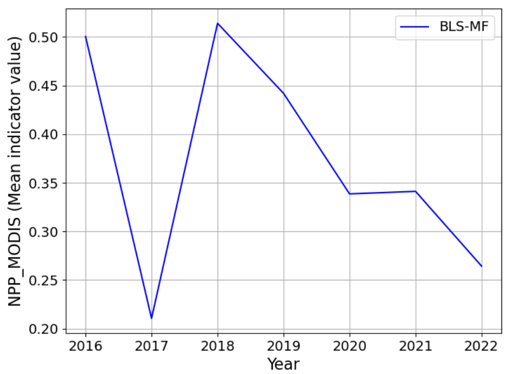
Figure 52: Evolution of the Net Primary Productivity indicator (based on MODIS dataset) per forest type and biogeographical zone between 2016 and 2022

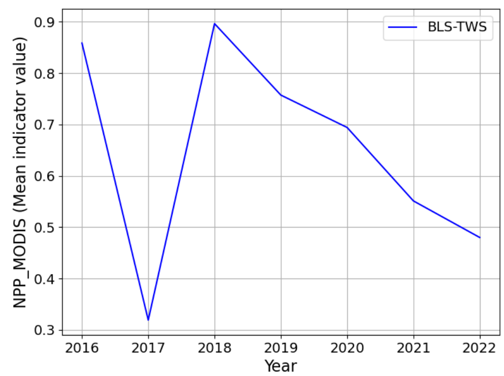




a) Black Sea – Broad-leaved Forest

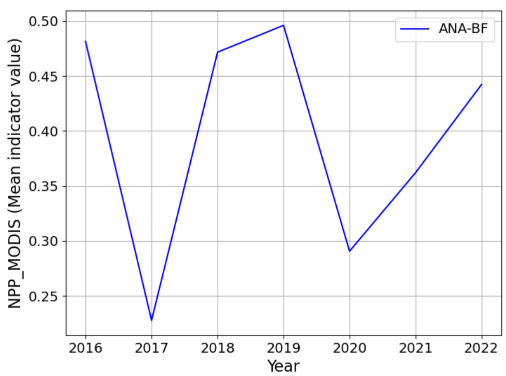
b) Black Sea – Coniferous Forest

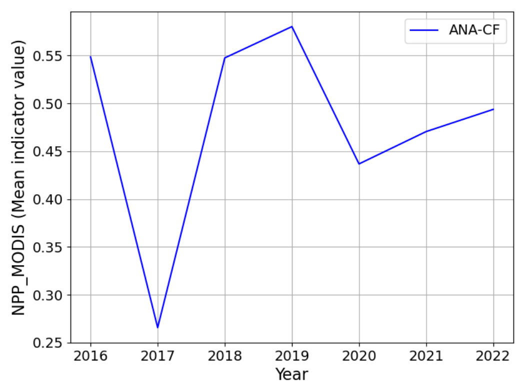




c) Black Sea – Mixed Forest. BLS-TWS

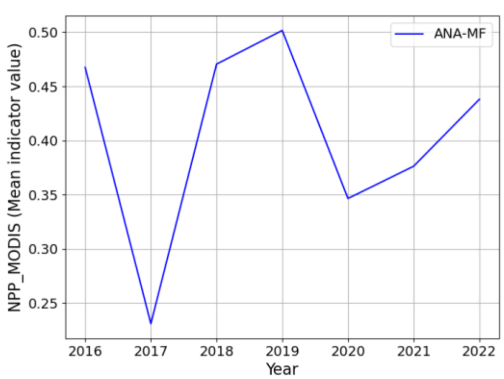
d) Black Sea – Transitional Woodland-Shrub

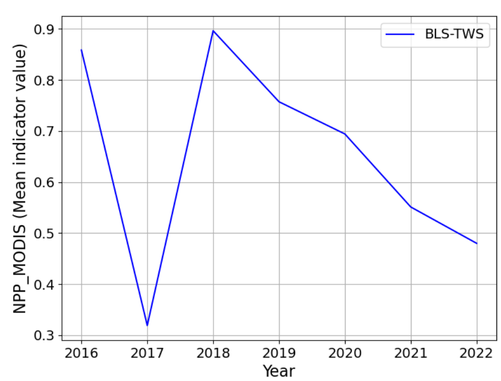




e) Anatolia – Broad-leaved Forest

f) Anatolia – Coniferous Forest





g) Anatolia – Mixed Forest

h) Anatolia – Transitional Woodland-Shrub

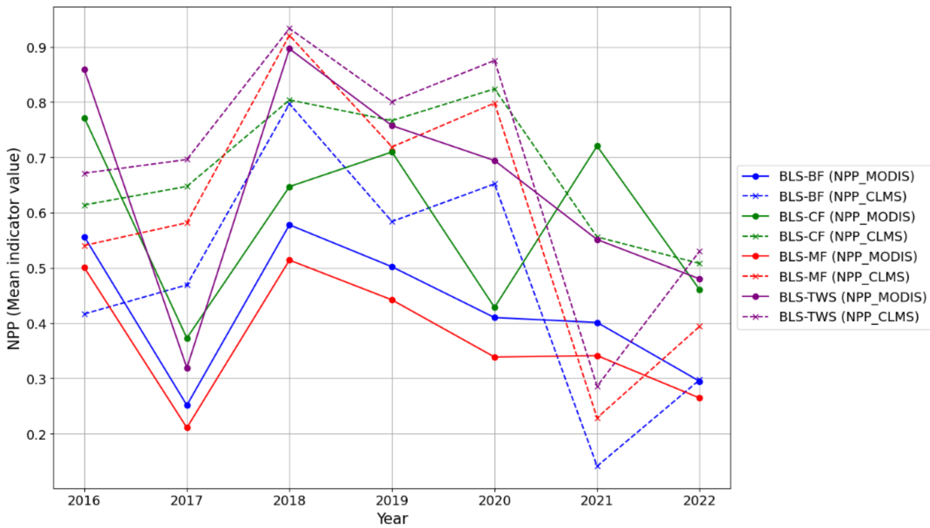
Source: Compiled by VITO

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

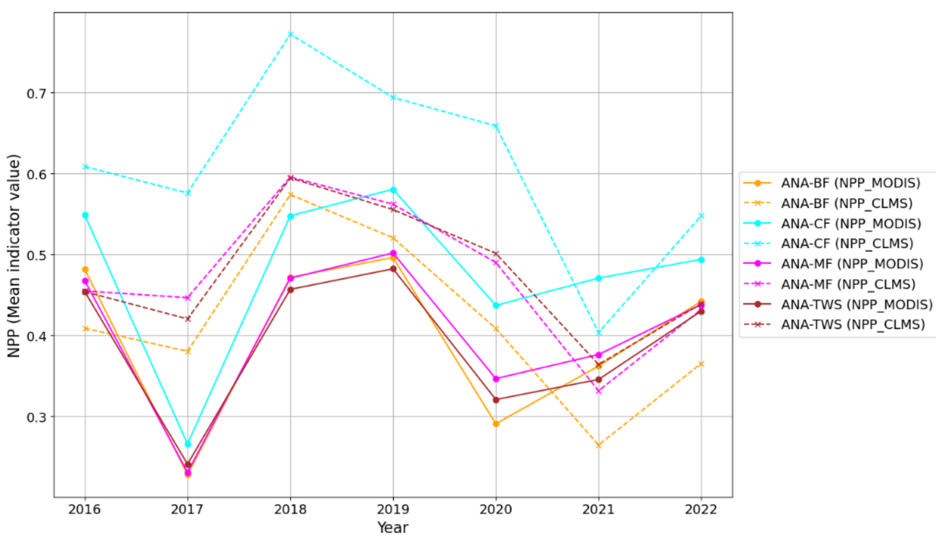
Regarding the NPP dataset, we explained earlier that MODIS was used and not CLMS. Comparing the NPP indicator derived from both CLMS and MODIS indicates that the MODIS NPP undergoes a larger decrease in 2017 than the NPP of CLMS. Therefore, the NPP indicator for 2017 should be considered with some uncertainty.

In the next paragraph, we tried to explain this uncertainty and variance with climate data. The remote sensing derived indicator has likely not experienced such a large drop from 2016 to 2017 in reality. Thus, the Forest Condition Index for 2017 in reality can be considered to not have dropped so abruptly.

Figure 53: Comparison between NPP indicator derived from MODIS and NPP indicator derived from CLMS (Copernicus Land Monitoring Service) for all forest types within a) the Black Sea zone, and b) the Anatolian zone



(a)



(b)

Note: BLS-BF: Black Sea – Broad-leaved Forest. BLS-CF: Black Sea – Coniferous Forest. BLS-MF: Black Sea – Mixed Forest. BLS-TWS: Black Sea – Transitional Woodland-Shrub. ANA-BF: Anatolia – Broad-leaved Forest. ANA-CF: Anatolia – Coniferous Forest. ANA-MF: Anatolia – Mixed Forest. ANA-TWS: Anatolia – Transitional Woodland-Shrub

Source: Compiled by VITO

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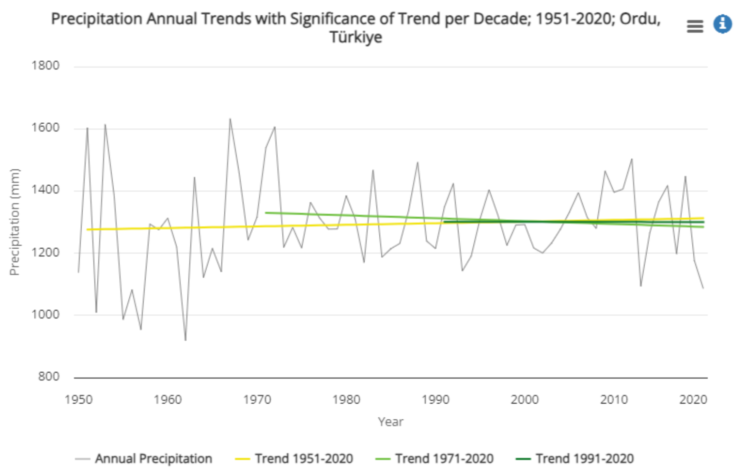
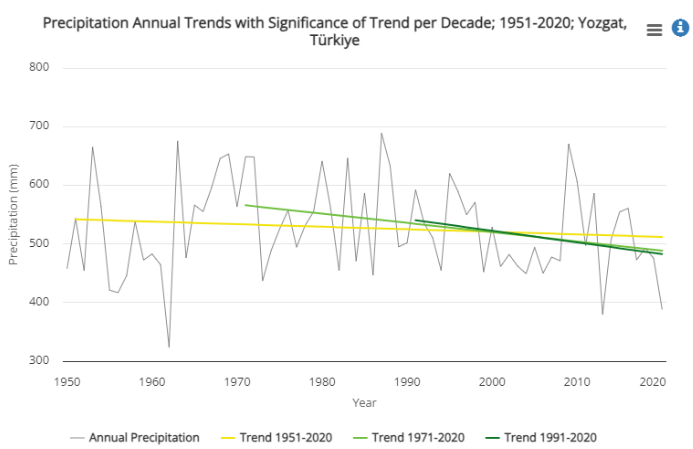
A study by Erşahin et al. (2016) found that monthly precipitation and monthly maximum temperature are the most common variables contributing to the NPP of Anatolian forest study sites. Precipitation pattern analysis on the Climate Change Knowledge Portal shows that precipitation both in the Black Sea zone and the Anatolian zone was below normal in 2019 and 2020 (Figure 54). This lack in precipitation and water availability might have influenced the NPP in the next years (2021–2022) to be further from the reference NPP. This effect was higher in the Bolaman region as we see a larger decreasing NDWI indicator trend between 2016 and 2022 compared to Çekerek (Table 28). Hence, this resulted in a slight decreasing trend in Forest Condition Index in Bolaman.

Figure 54: Precipitation Annual Trends derived from the Climate Change Knowledge Portal for a) the Black Sea zone (Ordu), and b) the Anatolian zone (Yozgat)



(a)



(b)

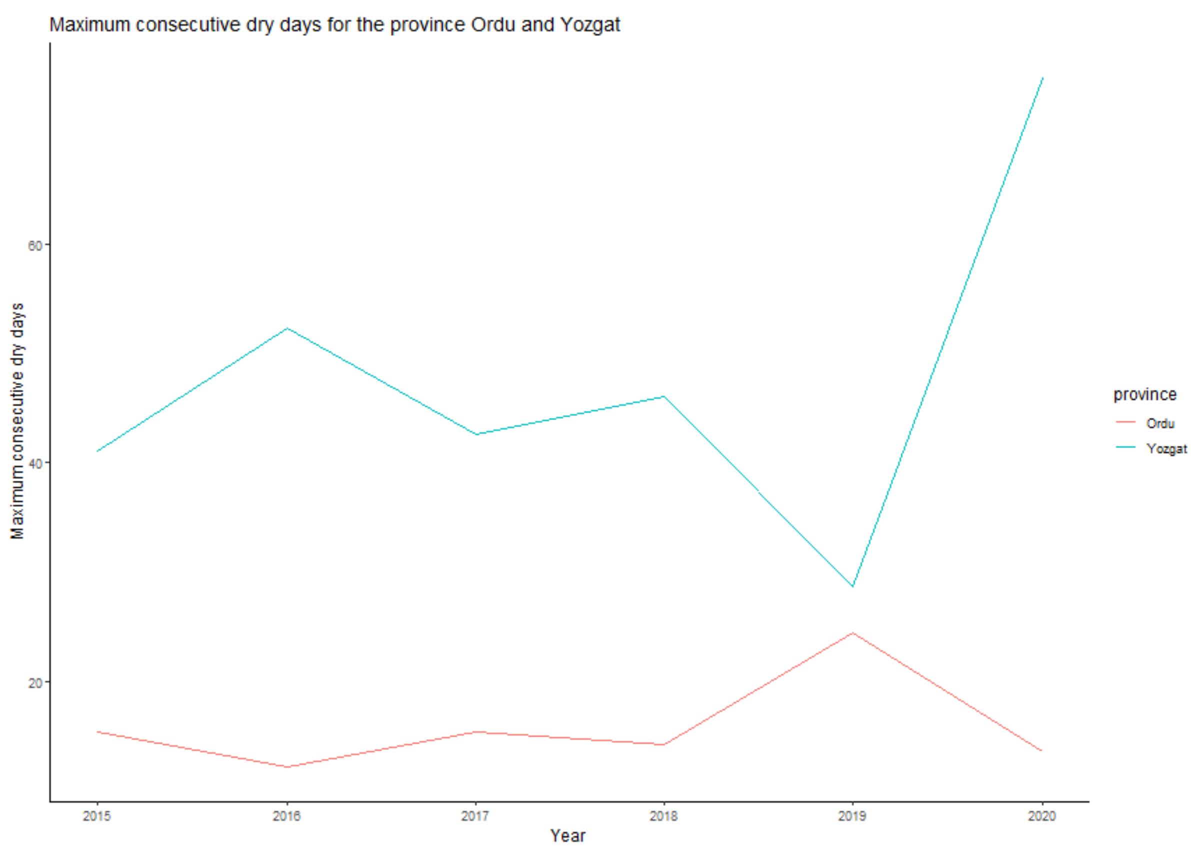
Source: Compiled by VITO adapted from Climate Change Knowledge Portal

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

For crops and forest, lengths of consecutive drought can be of importance as well. This variable is reported in the Climate Change Knowledge portal as the annual maximum number of consecutive dry days. There was an increase in consecutive dry days in 2017 for Ordu and a larger peak of dry days in 2019. For Yozgat, there is mainly a large peak in 2020 which reached almost 80 consecutive dry days (Figure 55). When investigating this indicator, a visual correlation is discovered with the NPP and the NDWI. There is no data for the two pilot regions but there is data concerning the dry days on provincial level. In Figure 56, the NPP and the NDWI are overlayed with the scaled number of consecutive dry days. It is scaled by dividing it by the average consecutive dry days. If it is higher than 1, then it means that the dry spells are longer than average that year. The decrease of the NPP and the NDWI follows the increase in dry days in 2017. After that there is some recovery but in 2019 there is a decrease in NPP and NDWI again combined with a peak in consecutive dry days. are taken to compare the variables. In Figure 56, the NPP and NDWI are compared with the scaled consecutive dry days. In Yozgat, the correlation is less pronounced but following the wet years of 2018 and 2019, there seems to be an increase in NPP and NDWI. The dry day peak of 2020 corresponds with the decrease in NPP and NDWI.

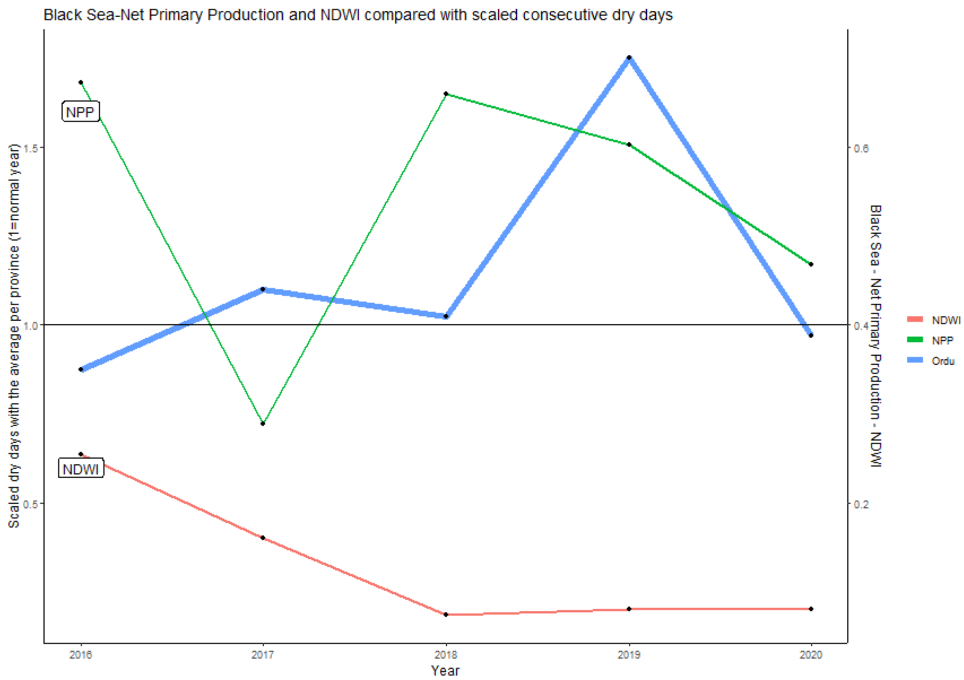
The relation between consecutive dry days and the NPP and to a lesser extent NDWI can be a reason for explaining the variance in the Forest Condition Index and it is recommended to investigate it further.

Figure 55: Maximum amount of consecutive dry days for the province of Ordu and Yozgat



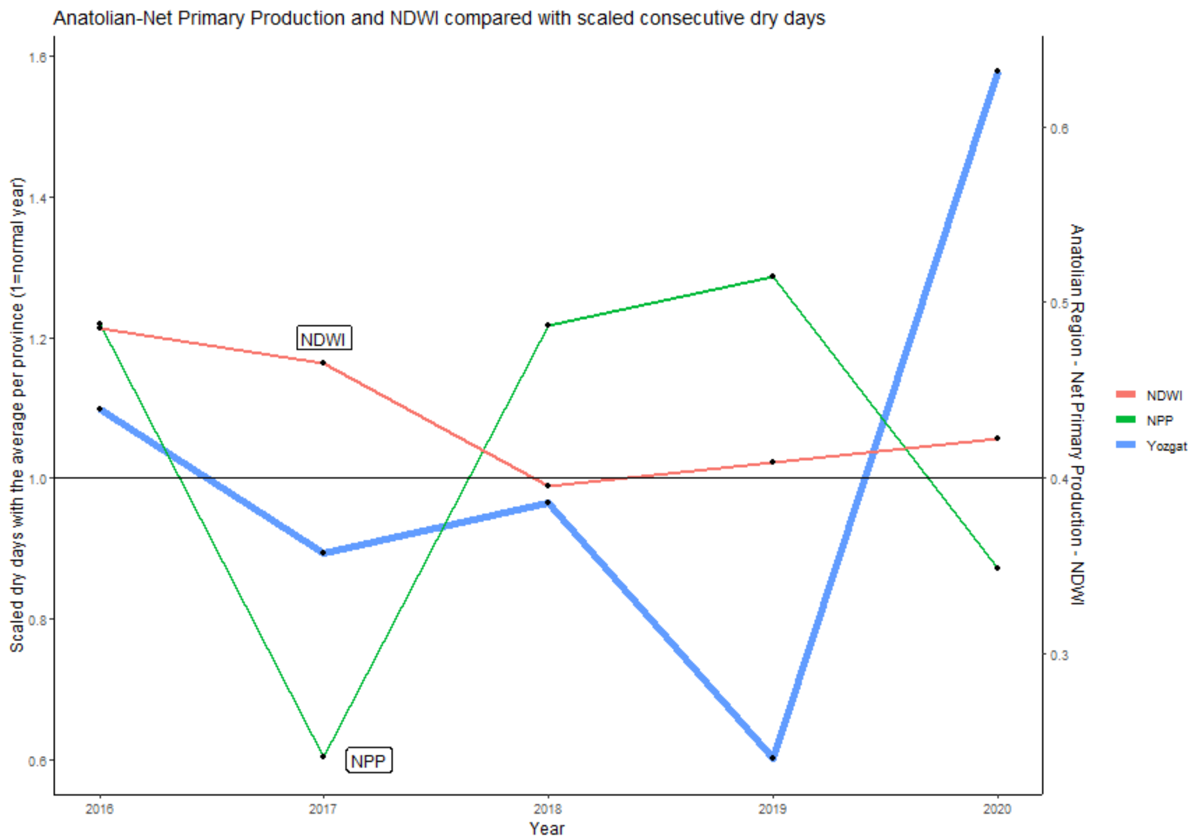
Source: Compiled by VITO adapted from Climate Change Knowledge Portal

Figure 56: Black Sea-Net Primary Production and NDWI compared with scaled consecutive dry days



Source: Compiled by VITO adapted from Climate Change Knowledge Portal

Figure 57: Anatolian region-Net Primary Production and NDWI compared with scaled consecutive dry days



Source: Compiled by VITO adapted from Climate Change Knowledge Portal

3.1.4 Improvement strategy

Since we evaluated the Forest Condition Index for only a short period (7 years), the trend in FCI could lead to biased conclusions. Ideally, we should work with larger forest condition variable time series to retrieve a more trustworthy and realistic trend, but the process is hindered by the attempt to create a forest condition account for a forest under production. Therefore, this forest is obviously experiencing some change over time and the reference condition could not be assumed to resemble the condition in 2000.

As seen previously, years with extreme climatic events (temperature or precipitation) have a large influence on the behavior of several forest condition variables. If these variables are linked to a large weight in the FCI calculation, a big effect of the extreme event can be expected in the final FCI. Therefore, it might also be interesting to discuss or explore different weighting methods in collaboration with local authorities.

Furthermore, the selection of the condition variables is a decisive step that needs to be considered with caution. First, be aware that the spatial resolution of the original forest condition variables' datasets varies. To align all datasets, a resampling of the resolution had to be performed and this step increases the uncertainty of the resulting raster (in terms of potential pixel shifts). Currently, methods on recording the error propagation are not optimal. Be aware that the Forest Condition Index is created of mainly remote sensing derived products and sensor artifacts could play a role at times (as discovered in the NPP dataset of CLMS, see above). On-site observations can validate the results. Second, ideally all classes of the ECT should be covered. However, in this study we did not take Soil Organic Carbon content and the Abiotic Chemical State characteristic into account due to lack of coverage of the dataset in Türkiye and due to lack of yearly detailed datasets. In order to still cover this ECT class, a possible solution could be to incorporate a different abiotic chemical state characteristic with yearly records such as particulate matter concentrations. However, the single year relative (mean/median) SOC variable account could be used as a base to present to field experts for evaluation if the SOC would have been stable during 2016–2022 or not, to estimate its effect on the current Forest Condition Index. The condition variable on forest fire or wildfire is not incorporated yet as there is little previous work done by the literature on how a good indicator would look like and in which ECT class it fits. Local expertise on wildfire and its relation to the condition and health of forest is needed. Forest fires do have a large impact on the capabilities of delivering ecosystems services by forest ecosystems and forest fire occur frequently in all Mediterranean countries like Türkiye.

Besides, it is crucial to stress the importance of the selection of the reference areas. The reference areas should represent the ideal state of a healthy forest that you want to use to benchmark all other surrounding forest of the same type. In this case, we received a shapefile containing Reference Forest Area Sites polygons and we performed a short analysis that indicated that the tree cover density within these polygons per forest type and biogeographical zone often contained a range too wide to be considered suitable as a standard to which other forest areas of the same type can be compared. Therefore, we filtered these polygons for the pixels with a TCD between 60% and 100% for broad-leaved, coniferous and mixed forest and a TCD between 51% and 100% for transitional woodland-shrub to create a more homogenous set of reference sites that can serve as a decent upper standard in the rescaling step. This decision does not imply that forest areas with lower tree cover densities cannot be suitable reference sites or the desired forest condition. However, in these particular cases it is necessary to classify the reference polygons further into different categories that each contain a narrow tree cover density range.

Lastly, we would like to bring your attention back to the overall purpose of the Forest Condition Index. The FCI should give information how forests are exhibiting characteristics that are important in terms of delivering essential ecosystem services, compared to the ideal condition. Besides, a condition variable does not support solemnly one service but rather a broader collection of services. A decreasing trend in forest condition indicator does not mean that the ecosystem services are not delivered, it just means that for these particular years the forest condition was further away from the reference forest condition in order to support the ecosystem services. The results also show that the indicators can recover quite easily so a decreasing trend does not have to be permanent, nor does the derived Forest Condition Index have to influence the services (e.g., wood provision or bird's habitat suitability) to a large extent. That is because the index takes many condition variables into account that range from productivity to biodiversity. A drop in Net Primary Productivity (NPP) indicator does not mean there was no forest growth, it rather says that this year experienced relatively less production than the previous, when both years are compared to the reference production. Considering forests, this is a completely normal result as there are many elements to consider (e.g., competition between trees, climate/soil influence). It is the combination of all important condition variables that should give an overall indication of the capability of the forests to support the big range of ecosystem services and the trend should indicate how sustainable this support is when looking at the future. Since the study area in Bolaman and Çekerek contains mainly forest under production, it is important to place the results of the forest condition account into perspective and not only consider the condition index to support the forest productivity.

3.2 Coastal zone condition

3.2.1 Definition

Coastal zones rank among the most productive regions, offering a diverse array of valuable habitats and ecosystem services that have consistently drawn human presence and activities. Their beauty and richness have made them popular for settlements, tourism, business, and transport. This intensive use places significant pressure on coastal ecosystems, leading to biodiversity loss, habitat destruction, and space congestion. To compute the accounts, the coastal zone is defined by a 1 km buffer landwards of those Corine Land Cover (CLC) classes that are characterized as being under the influence of sea water (either as sea water bodies or areas regularly flooded in tidal environments, up to the high-tide line). These CLC classes include 521 Coastal lagoon, 522 Estuaries, 423 Intertidal flats, 523 Sea and ocean, and selected pixels from 421 Salt marshes and 422 Salines (isolated polygons inland are excluded). The coastal area includes ecosystem types of coastal beaches, dunes, and wetlands.

For the coastal ecosystems, the focus is on the only mandatory condition indicator from the EU Legislation: *the share of artificial impervious area cover*, in %, as a national average for the reporting period. The substitution of the original (semi-) natural land cover or water surface in coastal areas with an artificial, impervious cover is an indicator for ecosystem condition degradation, reflecting the encroachment of built-up land in the coastal zone (e.g., roads, residential development, holiday houses).

This mandatory indicator represents the *Abiotic / Physical state* condition type and should be complemented with other indicators representing other condition types to represent a true condition index. Some potential other indicators are beach litter (Abiotic/physical), percentage of coastal wetland species with good population status (biotic/compositional), percentage of coastal wetland birds with increasing or stable population trends (biotic/compositional), percentage of beaches with water quality for swimming (biotic/compositional).

3.2.2 Methodology and data sources

In the framework of ESA's PEOPLE for EA project, a workflow was developed to produce yearly imperviousness density maps using features derived from Sentinel-1 and Sentinel-2, with the existing 2018 Copernicus Land Monitoring Service (CLMS) HRL Imperviousness Density (IMD) map serving as the baseline and reference. The workflow (Figure 58) closely mirrors that of the CLMS HRL IMD 2018 and involves two primary steps. First, a binary classification based on Sentinel-1 and Sentinel-2 data is performed to create a sealed surfaces mask. Then, within this mask, the imperviousness density (1-100%) is estimated using Sentinel-2 features.

The reference dataset for training and validation was collected through stratified random sampling of the 2018 CLMS HRL IMD product. Image collection, preprocessing, and feature calculations were conducted using openEO. Input features for binary classification and imperviousness density estimation included yearly median composites of Sentinel-2 spectral bands (blue, NIR, and SWIR1), normalized built-up area index (NBAI, equation 1), the 90th percentile normalized difference vegetation index (NDVI, equation 2), and median Sentinel-1 VV and VH sigma0 backscatter.

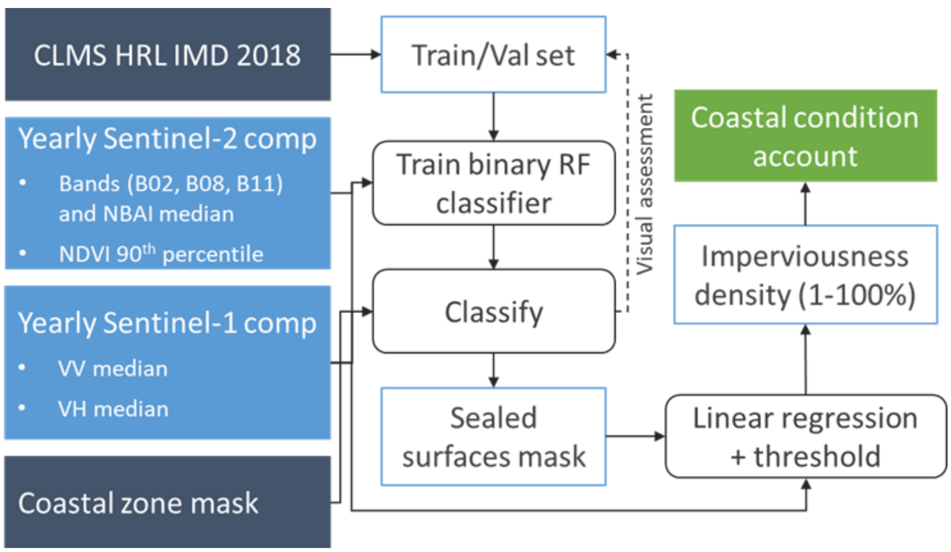
$$NBAI = \frac{(SWIR2 - SWIR1)/Green}{(SWIR2 + SWIR1)/Green} \quad (1)$$

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad (2)$$

To create the binary sealed surfaces mask, a random forest classifier was iteratively trained for each region. A first model is trained and applied to generate a mask, which is then visually evaluated. Additional training points are added in areas of confusion, and a new classifier is trained with the enhanced dataset. This cycle continues until no notable improvements are observed.

Sealed surface pixels were further differentiated by imperviousness density using the 90th percentile NDVI and median NBAI. First, a threshold 90th percentile NDVI (0,25) value was established to identify 100% impervious pixels. The imperviousness density for the remaining pixels (1–99%) was determined through linear regression of the 90th percentile NDVI and median NBAI.

Figure 58: Workflow for a yearly imperviousness density map



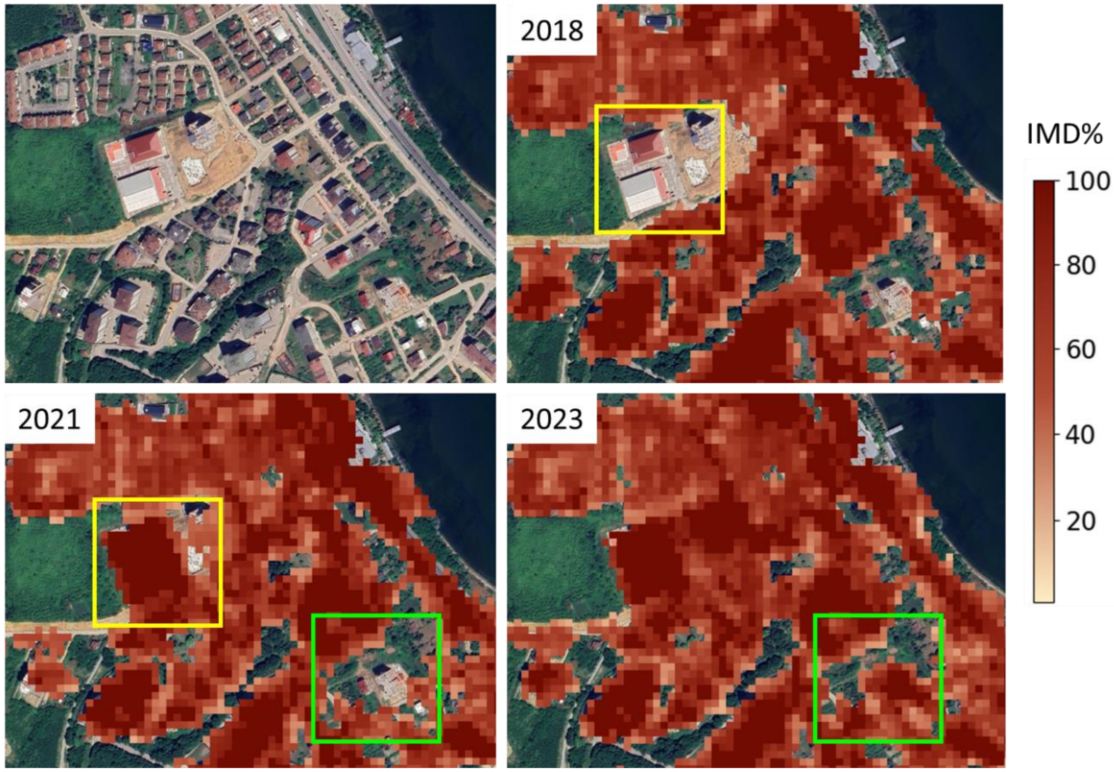
Source: Compiled by VITO

3.2.3 Results

The workflow described above was applied to generate a yearly imperviousness degree layer covering the coastal area of the Bolaman basin from 2018 to 2023. Çekerek contains no coastal area. Overall, most artificial impervious surfaces are well detected by the IMD layers and changes in soil sealing are captured accurately, as shown in Figure 59. The main drawback is the confusion with bare soil and rocks, which might cause an overestimation of the fraction of artificially sealed area. This however does not represent a significant issue in the Bolaman basin.

Based on the imperviousness density layers, a coastal condition index was calculated for each year (Table 33). The index is given based on two different calculation methods, namely the fraction of sealed pixels (IMD>0%) and the aggregated mean IMD of Bolaman's coastal area. Both versions of the index show an overall increasing trend in the share of artificial area cover from 2018 to 2023, illustrating a decrease in coastal ecosystems condition.

Figure 59 Illustration of the imperviousness density layer capturing soil sealing due to the construction of new buildings in Fasta, Ordu



Source: Compiled by VITO

Table 33: Annual coastal condition account for the Bolaman basin

Index	*2018*	*2019*	*2020*	*2021*	*2022*	2023
Sealed %	32.5%	32.6%	32.2%	32.4%	33.7%	34.4%
Average IMD	25.3%	25.1%	25.3%	24.8%	25.8%	26.2%

Note: The account is given based on two calculation methods: the fraction of sealed pixels (IMD > 0%) and the aggregated mean IMD%.

Source: VITO estimates

3.3 Other ecosystem types

This section contains the following condition accounts:

- Soil organic carbon (SOC) stock in topsoil in kg C ha^{-1} for cropland and grassland,
- Concentration of particulate matter (PM10 and PM2.5) in annual average µg m^{-3} in settlement and other artificial areas, and
- Green area in cities and adjacent towns and suburbs in % of total area in settlement and other artificial areas.

These accounts are generated for the Bolaman and Çekerek region within Türkiye for 2018.

3.3.1 Definition

The three accounts are considered as *condition* accounts since they are important variables describing the state and functioning of the ecosystems in question.

- Soil organic carbon (SOC) stock in topsoil is a carbon sink, capturing atmospheric carbon dioxide and storing it in the soil. This process is contributing crucially to the mitigation of climate change effects by reducing greenhouse gas emissions. Grasslands and croplands both have a high potential to store SOC (grasslands by their extensive root systems and croplands through practices like reduced tillage). Levels of SOC also indicate soil fertility, soil health and ecosystem resilience. SOC forms soil aggregates and improves the soil structure. These aggregates bind with important elements in the soil and therefore SOC stock serves as a reservoir of nutrients. This is beneficial for crop yields and healthy plant communities. The improved structure of the soil by the SOC aggregates also enhances the soil's ability to retain water and improve aeration. Soil erosion and SOC affect each other cyclically where high soil eroision reduce the SOC and a high SOC reduces soil erosion. SOC also functions as an important binding factor for soil particles, which makes the soil more resistant to erosion by wind and water. Lastly, high SOC levels support biodiversity of soil organisms which are essential for soil health (e.g. nutrient cycling). (Source: Vargas-Rojas et al. 2019).
    - PM2.5 is particulate matter (PM) that has a diameter of 2.5 micrometers (µm) or lower. PM10 is particulate matter that has a diameter of 10 µm or lower. Monitoring the concentrations of PM in the air is crucial due to their significant impacts on human health and the environment. Understanding the concentrations of these particles helps in assessing air quality and informing public health policies. PM2.5 and PM10 differ in their sources: PM2.5 typically results from combustion processes, secondary aerosols and chemical reactions in the atmosphere while PM10 often comes from larger particles such as dust, soil, pollen, and construction debris. Both can have huge health impacts when respired but PM2.5 is considered with a higher risk and therefore the threshold of PM2.5 concentrations in the air is set much lower than for PM10. Both PM2.5 and PM10 can penetrate the respiratory system, but since PM2.5 has a smaller size, it can reach deeper into the lungs and even enter the bloodstream. It can lead to respiratory issues and cardiovascular diseases. Heart disease and lung cancer in consequence of the PM impacts can result in mortality, with PM10 being less harmful compared to PM2.5. Besides the health impacts, PM concentrations can damage ecosystems by settling in ground or water bodies and leading to soil and water pollution. This can affect plant life, aquatic ecosystems and often leads to acidification. Besides, some components of PM, such as black carbon (which is a part of PM2.5), can contain reflected sunlight from the Earth's surface and therefore have a warming effect on the atmosphere (i.e., contributing to the greenhouse gas effect of climate change). (Source: WHO 2005).
- In relation to the previous, it is important to monitor green area in cities, in the context of urban air quality and human health. Green areas (such as parks, trees, urban forests) act as natural air filters. Vegetation can trap and absorb particulate matter, reducing the concentrations of these pollutants in the air. This significantly diminishes the risk of these airborne particles being inhaled by residents, polluting ground or water bodies or contributing to global warming. An important asset of green area in cities is the reduction of the so-called 'urban heat island' effect, where cities become significantly warmer than surrounding rural areas due to human activities and dense infrastructure. Besides the cooling effect, green spaces help manage heavy rainfall events by

allowing water take-up, reducing runoff and preventing flooding. Lastly, green area within cities positively influence mental health of citizens. The presence of greenery and natural environments promotes physical activity, social interaction, and a sense of well-being. (Source: WHO 2016).

3.3.2 Methodology and data sources

The accounts were calculated within the applicable area (cropland, grassland and settlements, and other artificial area) based on the generated level-1 Ecosystem Extent map for this project. The extent map had a CRS in EPSG:3035 and an original spatial resolution of 100 m. The map was resampled to 10 m spatial resolution to match the spatial resolution of the HRVPP parameter. All steps were carried out in python and QGIS.

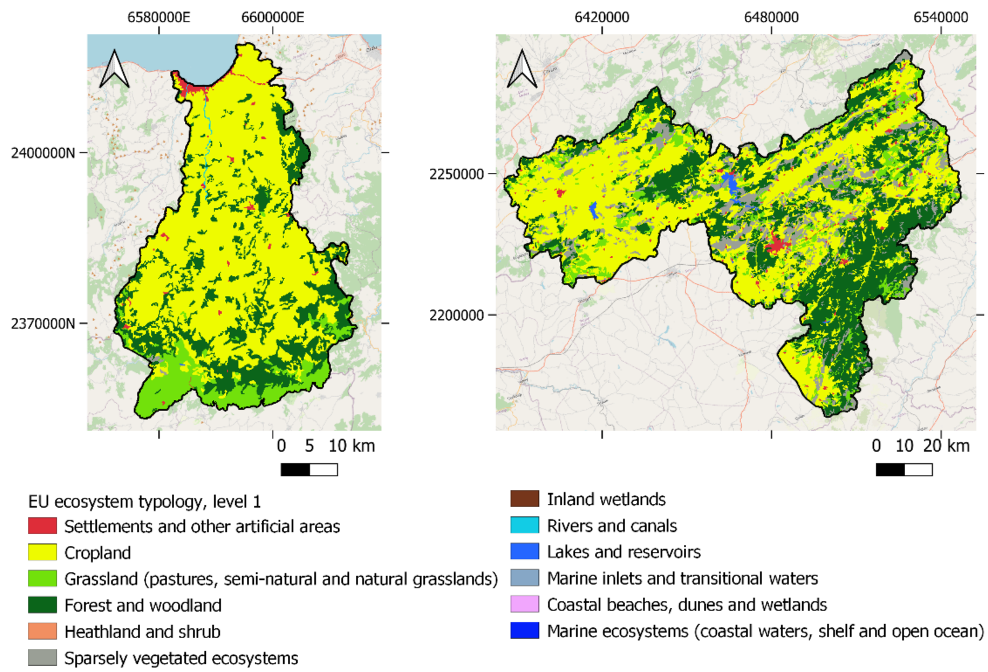
Table 34: Associated data sources, original CRS and spatial resolution and year of data collection per condition account of interest

Condition account	Datasource	Years
SOC stock in topsoil	ISRIC – World Soil Information, SoilGrids database (https://soilgrids.org/), unit in tonne C ha^{-1}	Around 2018
Concentration of particulate matter (PM10 and PM2.5)	Copernicus Atmosphere Monitoring Service (CAMS), European air quality reanalyzes, unit in µg m^{-3}	2018
Green area in cities and adjacent towns and suburbs	Copernicus Land Monitoring Service (CLMS), High Resolution Vegetation Phenology and Productivity (HRVPP) - Season Amplitude 2018, unit in Plant Phenology Index (PPI)	2018

Source: Compiled by VITO

The accounts were calculated within the applicable area (cropland, grassland and settlements and other artificial area) based on the generated Level-1 Ecosystem Extent map for this project. The extent map had a CRS in EPSG:3035 and an original spatial resolution of 100m. The map was resampled to 10 m spatial resolution to match the spatial resolution of the HRVPP parameter.

Figure 60: Ecosystem extent maps on Level-1 for Bolaman (left) and Çekerek (right)



Source: Compiled by VITO

Table 35: Area of EU ecosystem class Level-1 of interest for Bolaman and Çekerek region

EU ecosystem class Level-1	Area in Bolaman (ha)	Area in Çekerek (ha)
Settlements and other artificial areas	1,838	13,170
Cropland	103,638	417,141
Grassland (pastures, semi-natural and natural grasslands)	15,910	78,720

Source: VITO estimates

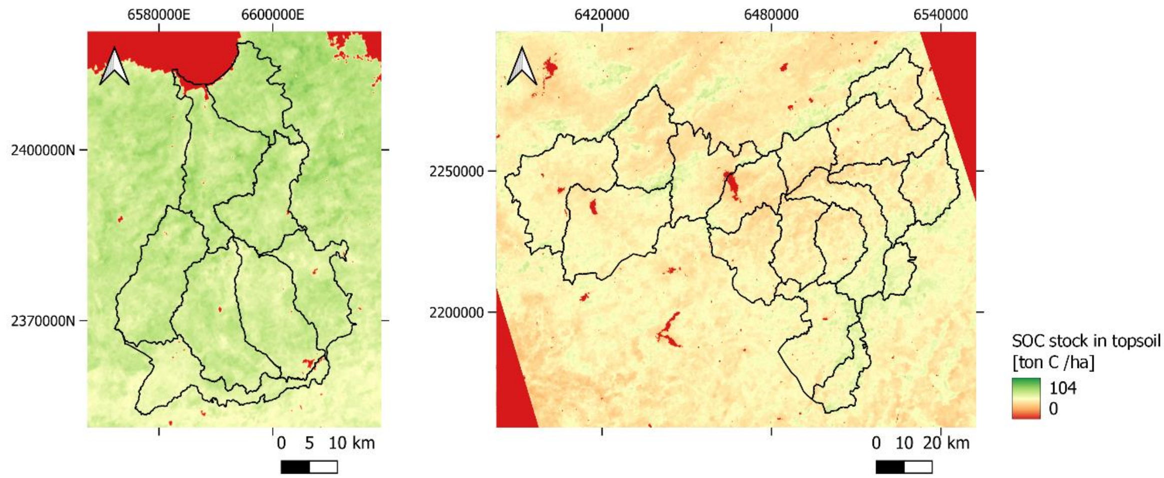
The condition account 'Common farmland birds index' in combined extent of cropland and grasslands could not be calculated as no data sources are currently available or retrievable for Türkiye. Most of the data layers on the EBCC (European Bird Census Council) platform do not cover Turkish land. The EBBA2 (European Breeding Bird Atlas version 2) does cover the breeding distribution of all European bird species and has included Türkiye in comparison to EBBA1. However, this data is not free of charge and the desired data (Multi-species maps per habitat: EBBA 2[15] – Richness in Agricultural and Grassland area) could not be requested. Therefore, we decided to leave this condition account out of the report for now.

3.3.3 SOC stock in topsoil

The downloaded data layer from SoilGrids was reprojected to CRS EPSG:3035 and resampled to 10 m spatial resolution.

[15] https://ebba2.info/maps/.

Figure 61: Distribution of soil organic carbon stock in topsoil for Bolaman (left) and Çekerek (right)



Source: Compiled by VITO

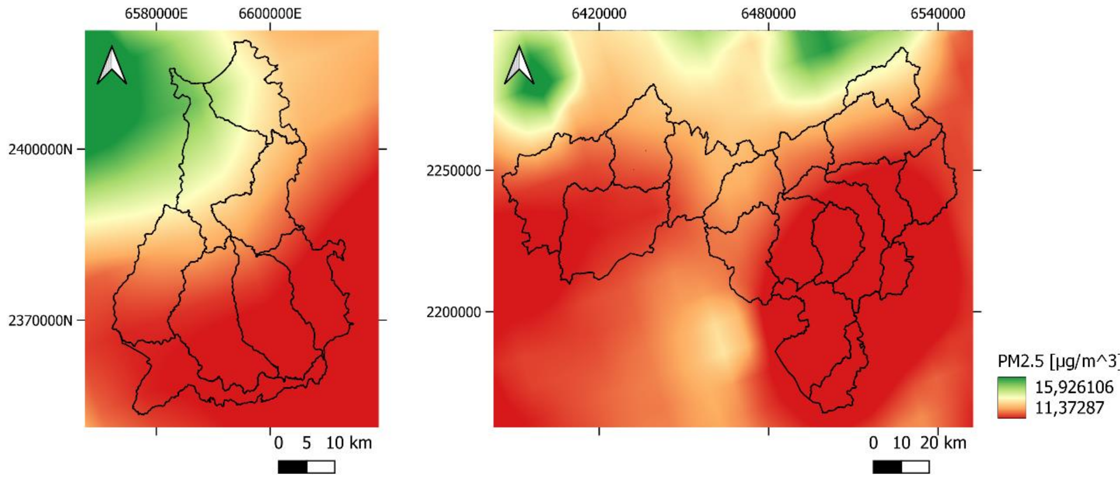
In general, Bolaman contains per pixel larger values for SOC stock in the topsoil compared to Çekerek (Figure 61). In Bolaman, the grasslands in the South seem to have lower values of SOC stock than the cropland more to the North (Figure 61). In Çekerek, the highest values of SOC stock are obtained in forest and woodland areas, and settlements and sparsely vegetated ecosystems around the center store the least of SOC (Figure 61).

The SOC maps of Bolaman and Çekerek were filtered twice to the pixels classified as respectively ‘cropland’ or ‘grassland’ in the ecosystem extent map Level-1. These pixels were used to calculate the total SOC stock in the topsoil. The pixel values were divided by 100 to retrieve the absolute value of SOC in tonne (since pixel area contains 100 m^2 so extra factor of 100 is necessary to bring ton C ha^{-1} to tonne C). The absolute SOC stock in topsoil was calculated by taking the sum of the pixel values in tonne C. The relative SOC stock in topsoil was retrieved by dividing the absolute SOC stock by respectively the area of ‘cropland’ and ‘grassland’ in Table 35.

3.3.4 Concentration of particulate matter (PM10 and PM2.5)

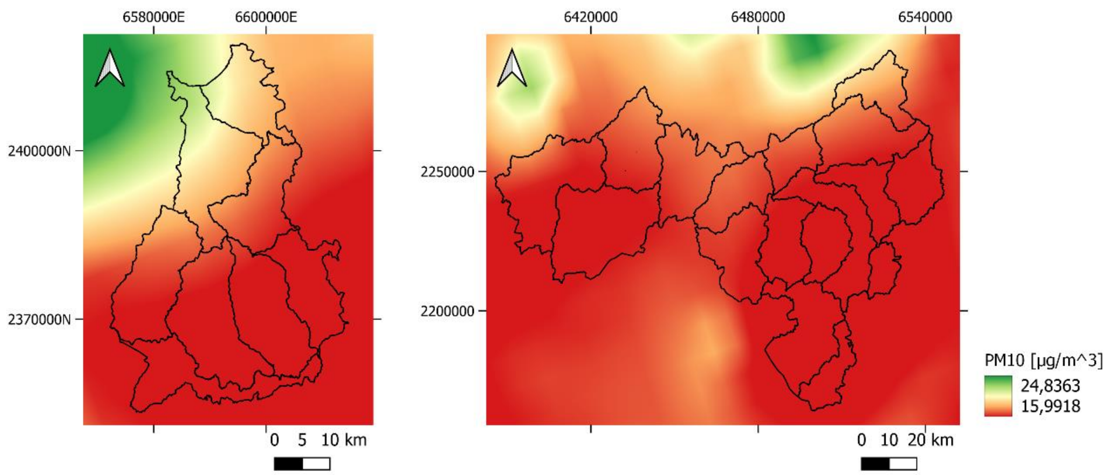
The downloaded data from Copernicus Atmosphere Monitoring Service (CAMS) is in netcdf format, containing monthly files by 1-hour analyses. Thus, one year contains 365×24 datapoints per pixel. Yearly averages are obtained by summing up the 365×24 values per pixel and dividing it by 365×24 observations. The resulting map was reprojected to CRS EPSG:3035 and resampled to 10m spatial resolution.

Figure 62: Concentration particulate matter smaller than 2.5 µm in Bolaman (left) and Çekerek (right) in 2018



Source: Compiled by VITO

Figure 63: Concentration particulate matter smaller than 10 µm in Bolaman (left) and Çekerek (right) in 2018



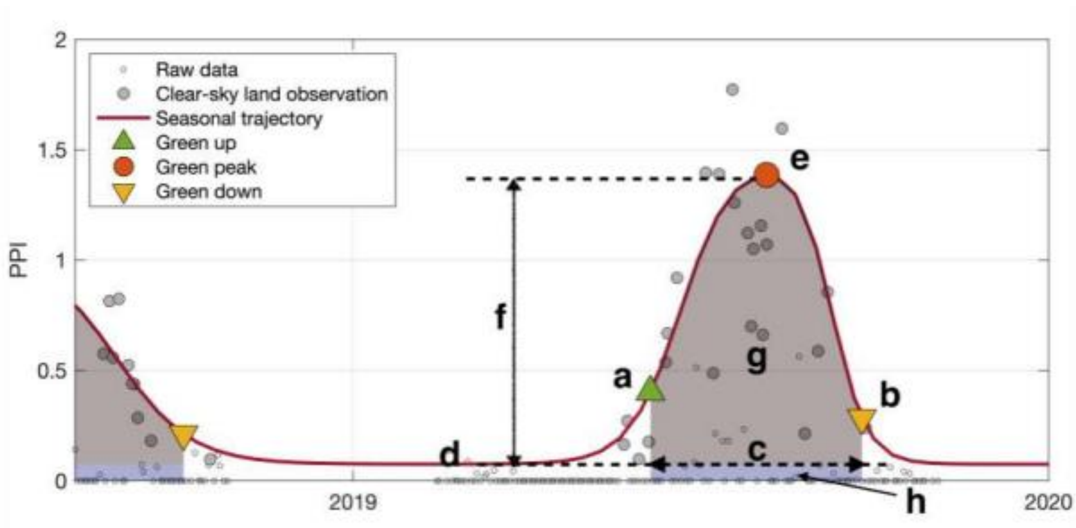
Source: Compiled by VITO

The PM maps of Bolaman and Çekerek were filtered to the pixels classified as 'settlements and other artificial area' in the ecosystem extent map Level-1. Since the pixel values are relative in µg m^{-3}, it does not make sense to calculate absolute concentrations. Consequently, neither does it make sense to derive the relative total concentrations in µg m^{-3}. This is because the original spatial resolution was 10 km and we resampled to 10 m. During this resampling, we cannot rely any longer on similar measurement conditions of PM concentrations within a certain air cube (in m^3). Therefore, the mean concentration of particulate matter (PM2.5 and PM10) are the best indication for the condition account, since the relative unit (µg m^{-3}) can be contained during the calculation of the average.

3.3.5 Green area in cities and adjacent towns and suburbs

The downloaded HRVPP raster layer from CLMS was reprojected to CRS EPSG:3035. To calculate this account, we applied a method based on using one of the HRVPP parameters of CLMS. The HRVPP parameters are produced by independent growing season per year, with a maximum of two seasons occurring throughout the year. We checked for one parameter, Season Amplitude (unit in PPI [Plant Phenology Index], ranging between 0 and 3) if pixel values within ecosystem category 'settlements and other artificial area' contained a value higher than 1.5 PPI (PPI value right in the middle between average vegetation index value of minima on left and right sides of each season and the vegetation index value at day of maximum-of-season, see Figure 64), for both the season 1 raster map and the season 2 raster map. A value higher than 1.5 makes a clear distinction between pixels that contain a valid green area that experiences a growth season and pixels where adjacency effects are at stake. In case a pixel contained a value higher than 1.5 PPI for either the season 1 or season 2 map, we considered the pixel as valid for containing green area. The total amount of valid pixels was calculated and divided by the total amount of pixels classified as 'settlements and other artificial area' to obtain the percentage of green area in cities and adjacent towns and suburbs.

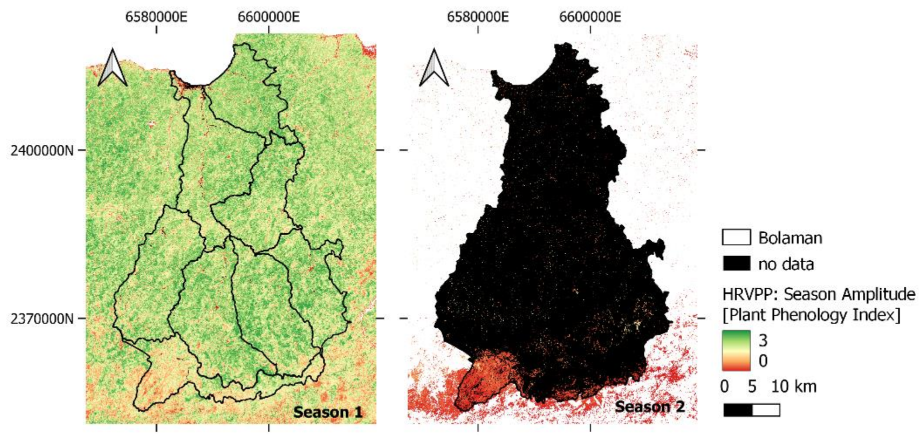
Figure 64: Vegetation Phenology and Productivity Parameters (VPPs)



Note: (a) start of season (date, PPI value and slope), (b) end of season (date, PPI value and slope), (c) length of season, (d) minimum-of-season, (e) peak of the season (date and PPI value), (f) amplitude, (g) small integrated value, (g+h) large integrated value.

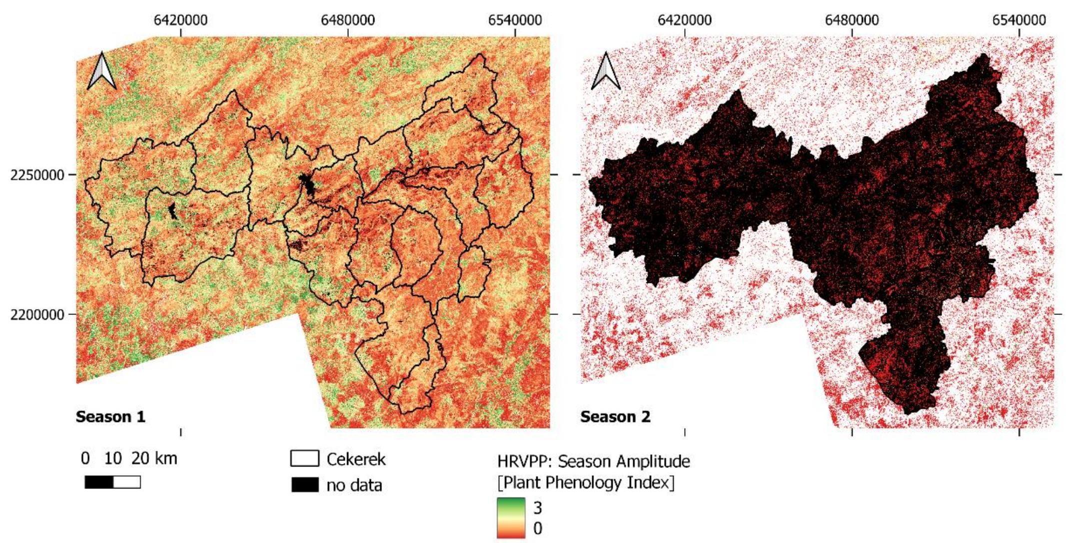
Source: Compiled by VITO adapted from Product User Manual HRVPP ST-VPP

Figure 65: High Resolution Vegetation Phenology and Productivity parameter 'Season Amplitude' for season 1 and season 2 in Bolaman



Source: Compiled by VITO

Figure 66: High Resolution Vegetation Phenology and Productivity parameter 'Season Amplitude' for season 1 and season 2 in Çekerek



Source: Compiled by VITO

Figure 65 and Figure 66 clearly indicate that most areas contain only one season. Comparing with the ecosystem extent categories in Figure 1 for Bolaman, it is mainly the 'grassland' class that has a second growing season. The Season Amplitude seems to be highest in cropland area.

3.3.6 Results

The relative SOC stock values in kg C ha^{-1} indicate that although Çekerek contains much larger areas cropland and grassland than Bolaman, the land in Bolaman stores more SOC in the topsoil and that amount is per hectare significantly larger than for Çekerek (Table 36). The SOC stocks for cropland and grassland within the same region (either Bolaman or Çekerek) cannot be compared since they don't have a similar extent. Grassland store more organic carbon when compared per hectare. This demonstrates the high potential of carbon sequestration of grasslands.

The account of concentration of particulate matter is not a sum but an average. Therefore, we can compare the values between Bolaman and Çekerek, despite the different extents of their built-up area (i.e. settlements and other artificial areas). A lower mean concentration of PM2.5 in Çekerek compared to Bolaman matches with patterns (Figure 62). The built-up area in Bolaman is mainly located nearby the coast and in this region, we also see the highest relative concentrations of PM2.5 (Figure 62). In Çekerek, the built-up area is distributed more unevenly over the region but these areas do not contain peaks in relative PM2.5 concentration (Figure 62). Logically, the mean concentration of PM10 is higher than the mean concentration of PM2.5 since PM2.5 is a subset within PM10. However, mean PM2.5 stock takes up around 70% of the mean PM10 stock, which is a large part. That is because PM2.5 originates from mainly anthropogenic sources (e.g. fossil fuels, industrial emissions, vehicle exhaust, residential heating) that are very prevalent and constant in cities, while other PM10 sources (e.g. dust, soil, pollen) are less frequent or concentrated in urban areas. Moreover, since PM10 in general retains also particles with a higher diameter than PM2.5, it is also larger and heavier and therefore will travel shorter distances through the air than PM2.5, which can stay suspended in the air for longer periods and distances. This phenomenon can also be seen in Figure 62 and Figure 63: the high PM10 concentration North-West from Bolaman reaches less deep into Bolaman than the PM2.5 concentration.

Mean concentrations PM2.5 and PM10 are lower in Çekerek than in Bolaman. Settlements and artificial area in Çekerek contain more than ten times the area of settlements and artificial area in Bolaman. However, the percentage of green area in cities and adjacent towns and suburbs is not very different (almost a factor 2). Vegetation plays a role in filtering particulate matter in the air by taking up particles. Since Çekerek still consists of relatively many green spaces in the built-up area and the cities are found deeper toward the central - Çekerek surrounded by forests in comparison to Bolaman (where cities mainly are found at the coast), the mean concentration of PM2.5 and PM10 could be lower in Çekerek than in Bolaman. Air quality guidelines by WHO (2021) state that the annual average air pollution levels of PM2.5 should not exceed 5 µg m^{-3} and the annual average PM10 concentration should not exceed 15 µg m^{-3}. EU standards differ from the WHO guidelines and consider risky exposure of PM to urban population for PM2.5 at 25 µg m^{-3} and for PM10 at 50 µg m^{-3}. That means that the mean annual concentrations of PM2.5 and PM10 do not exceed the EU standards but they do when compared to the WHO guidelines. In 2030, a revised ambient air quality directive is proposed to come into force and will introduce more ambitious EU air quality standards than the current ones.

Table 36: Ecosystem condition accounts in 2018, Bolaman and Çekerek

Ecosystem condition account – 2018	Bolaman	Çekerek
Absolute SOC stock in topsoil – cropland [kg C]	66.62×10^{8}	192.66×10^{8}
Relative SOC stock in topsoil – cropland [kg C ha^{-1}]	64,281	46,186
Absolute SOC stock in topsoil – grassland [kg C]	14.15×10^{8}	49.23×10^{8}
Relative SOC stock in topsoil – grassland [kg C ha^{-1}]	88,940	62,540
Mean concentration of particulate matter (PM2.5) in cities and adjacent towns and suburbs [µg m^{-3}]	13.90	11.69
Mean concentration of particulate matter (PM10) in cities and adjacent towns and suburbs [µg m^{-3}]	20.07	16.08
Green area in cities and adjacent towns and suburbs [%]	23.85	12.20

Source: Compiled by VITO

4 ECOSYSTEM SERVICES ACCOUNTS

4.1 Crop provision

4.1.1 Definition

In the proposed amendment of Regulation (EU) 691/2011, crop provision is defined as 'the ecosystem contributions to plant growth as approximated by the amount of harvested crops for different uses. This includes food and fiber production, fodder and energy and grazed biomass, as set out under Annex III [of Regulation (EU) 691/2011 on European environmental economic accounts], Table A, Section 1.1 and Section 1.2'.

Since the material flow account (MFA) will be mostly the main source of data for the crop provision account, the concepts and scope are aligned with the SEEA EA framework. In MFA the domestic flow is measured in extraction of biomass and uses the 'harvest approach'. The harvest approach records the flow from the environment to the economy at the point of harvest which is described in the Economy-wide Material Flow accounts handbook, paragraph 74. (European Commission, 2018)(Eurostat, 2018. This approach includes quantities directly consumed on the farm but also all losses on the farm or during transport, storage and packaging. The harvest approach is a proxy indicator for the ecosystem contribution, as it is assumed that the ecosystem contribution is 100% of the crops provided.

A distinction can be made between crop provision services and grazed biomass provision services. This is reflected in the reporting of outcome where per default the supply of fodder is allocated to the ecosystems under grasslands while other crops are allocated to croplands.

All material flows are recorded in cultivated contexts, this excludes gathering of wild-growing mushrooms, berries, nuts, etc.

The EU guidance notes define the harvest approach thus as an approximate for the ecosystems contribution and recognizes it shortcomings with this approach. The method to estimate the monetary value of crop provision proposed by SEEA-EA is calculating the resource rent but the monetary valuation performed in this project is by using market prices for each crop type and multiplying it by the harvested quantity. This is a simplified approach adopted from the EU KIP INCA project. Agro-economic statistics like gross and net value added are available to calculate the resource rent but sometimes even negative they are not crop specific meaning the differentiation between crops is lost. The currently applied monetary value can be considered as an overestimation, as no distinction is made on the ecosystem contribution and the contribution from other inputs such as labor, capital, seeds, etc. Prices are expressed in nominal values, using market prices of the same year and real values; real values are estimated by adjusting the market prices for inflation between 2018 and 2021. The ratio to correct for inflation between 2018 and 2021 is 1.6921 (World Bank 2024). This is calculated by dividing the GDP deflator index of 2021 by the deflator index of 2018.

4.1.2 Methodology and data sources

Table 37 describes the datasets that are used for this service.

The calculation of crop provision is based on the material flow account in Türkiye.

The supply and use of the ecosystem service is calculated by spatially disaggregating crop production statistics from the MFA within the administrative boundaries. The material flow account is available for provinces.

The spatial disaggregation of crop statistics is based on dry mater productivity. This spatial disaggregation allows to estimate the amount of crops produced in the Çekerek and Boloman basins based on provincial statistics. The disadvantage of the spatial (dis)aggregation and not using the same administrative boundaries as the MFA statistics itself is that the crop statistics become aggregated, and the detail is lost. In the annex in Table 125 it is shown when using province boundaries one can keep the crop specific yields.

Table 37: Crop provision datasets

Dataset	Description	Source	Scale	Years
Crop material flow (MFA)	The amount of crops produced per MFA crop type. Expressed in tonne.	Turkstat	Province	2018, 2021
Crop prices	The market price per tonne per MFA crop type.	Turkstat	Province	2018, 2021
Spatial Proxy	Dry matter productivity as a suitable proxy for distributing the amount of crops produced in each location.	Copernicus	100×100m	2018, 2021
Ecosystem Extent	**Corine Land Cover map 2018**	**Corine**	**100×100m**	**2018, 2021**

Source: Compiled by VITO

4.1.3 Results

4.1.3.1 Results for 2018

Table 38 and Table 40 present the use of crop provision account for the areas Bolaman and Çekerek in physical and monetary terms. Although the area of Çekerek is producing in quantity much more than Bolaman, 877,265 tonne versus 211,706 tonne, the value for both ecosystem services is almost equal with 729 million TRY and 764 million TRY. This is because relatively more high value crops such as hazelnuts are produced in Bolaman. In the annex in Table 125 is the crop provision for the province Ordu per specific crop since agricultural statistics are on province level, the distinction can be made. The results show that the province of Ordu produces over 100,000 tonne of nuts.

In Table 40 and Table 41, the supply table is represented with the two crop producing ecosystems, cropland and grasslands expressed in tonne and million TRY.

Table 38: Use table crop provision in tonne in 2018, Bolaman and Çekerek

	Intermediate consumption by industries	Total
Bolaman	211,706	**211,706**
Çekerek	877,265	**877,265**
All regions	**1,088,971**	**1,088,971**

Source: VITO estimates

Table 39: Supply table crop provision in tonne in 2018, Bolaman and Çekerek

	Cropland	Grassland (pastures, semi-natural and natural grassland)	Total
Bolaman	83,279	128,427	**211,706**
Çekerek	546,925	330,340	**877,265**
All regions	**630,204**	**458,767**	**1,088,971**

Source: VITO estimates

Table 40: Use table crop provision in million TRY in 2018, Bolaman and Çekerek

	Intermediate consumption by industries	Total
Bolaman	729	729
Çekerek	764	764
All regions	**1,493**	**1,493**

Source: VITO estimates

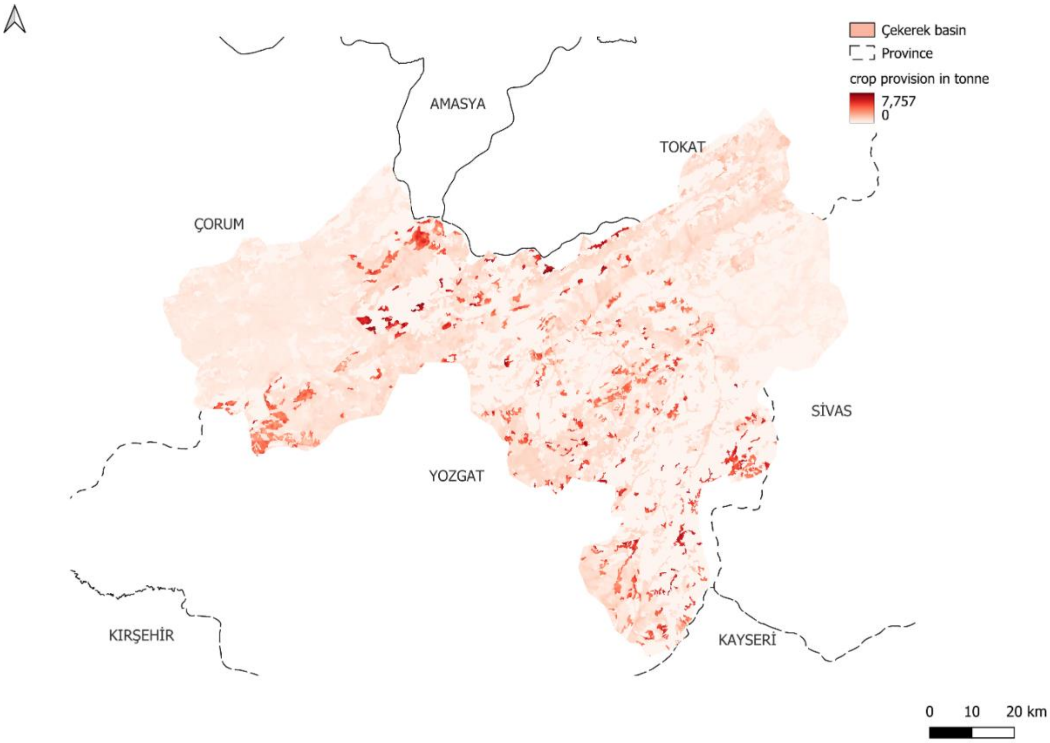
Table 41: Supply table crop provision in million TRY in 2018, Bolaman and Çekerek

	Cropland	Grassland (pastures, semi-natural and natural grassland)	Total
Bolaman	620	109	**729**
Çekerek	483	281	**764**
All regions	**1,103**	**390**	**1,493**

Source: VITO estimates

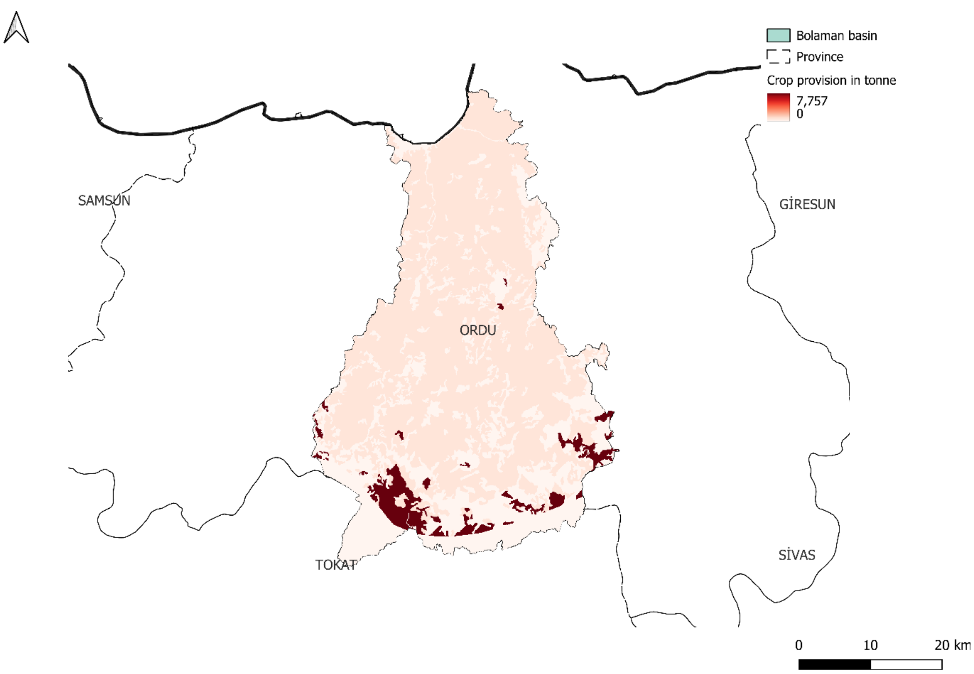
Figure 67 and Figure 68 are reflecting the spatial distribution of crop provision in both pilot areas.

Figure 67: Crop provision in tonne in 2018, Çekerek



Source: Compiled by VITO

Figure 68: Crop provision in tonne in 2018, Bolaman



Source: Compiled by VITO

4.1.3.2 Results for 2021

Table 42 and Table 44 present the use table for crop provision for the areas Bolaman and Çekerek in physical and monetary terms. Although the area of Çekerek is producing in quantity much more than Bolaman, 863,211 tonne versus 261,421 tonne, the value for both ecosystem services is almost equal with TRY 1,417 million TRY and TRY 1,497 million like in 2018.

In Table 43 and Table 45, the supply table is represented with the two crop producing ecosystems, cropland and grasslands expressed in tonne and million TRY. In Table 46 and Table 47 the value of crop provision is adjusted for inflation between 2018 and 2021. When comparing the monetary account of 2021 with 2018 there is an increase in value from 1,493 million TRY to 1,729 million TRY, following the physical account where an increase of the amount of crops in tonne is being observed.

Table 42: Use table crop provision in tonne in 2021, Bolaman and Çekerek

	Intermediate consumption by industries	**Total**
Bolaman	216,421	**261,421**
Çekerek	863,211	**863,211**
All regions	**1,079,632**	**1,079,632**

Source: VITO estimates

Table 43: Supply table crop provision in tonne in 2021, Bolaman and Çekerek

	Cropland	**Grassland (pastures, semi-natural and natural grassland)**	**Total**
Bolaman	86,992	129,429	**261,421**
Çekerek	509,311	353,900	**863,211**
All regions	**596,303**	**483,329**	**1,079,632**

Source: VITO estimates

Table 44: Use table crop provision in nominal million TRY in 2021, Bolaman and Çekerek

	Intermediate consumption by industries	**Total**
Bolaman	1,417	**1,417**
Çekerek	1,497	**1,497**
All regions	**2,913**	**2,913**

Source: VITO estimates

Table 45: Supply table crop provision in nominal million TRY in 2021, Bolaman and Çekerek

	Cropland	**Grassland (pastures, semi-natural and natural grassland)**	**Total**
Bolaman	1,192	225	**1,4167**
Çekerek	1,216	281	**1,497**
All regions	**2,408**	**508**	**2,913**

Source: VITO estimates

Table 46: Use table crop provision in real million TRY in 2021, Bolaman and Çekerek

	Intermediate consumption by industries	Total
Bolaman	838	**838**
Çekerek	886	**886**
All regions	**1,724**	**1,724**

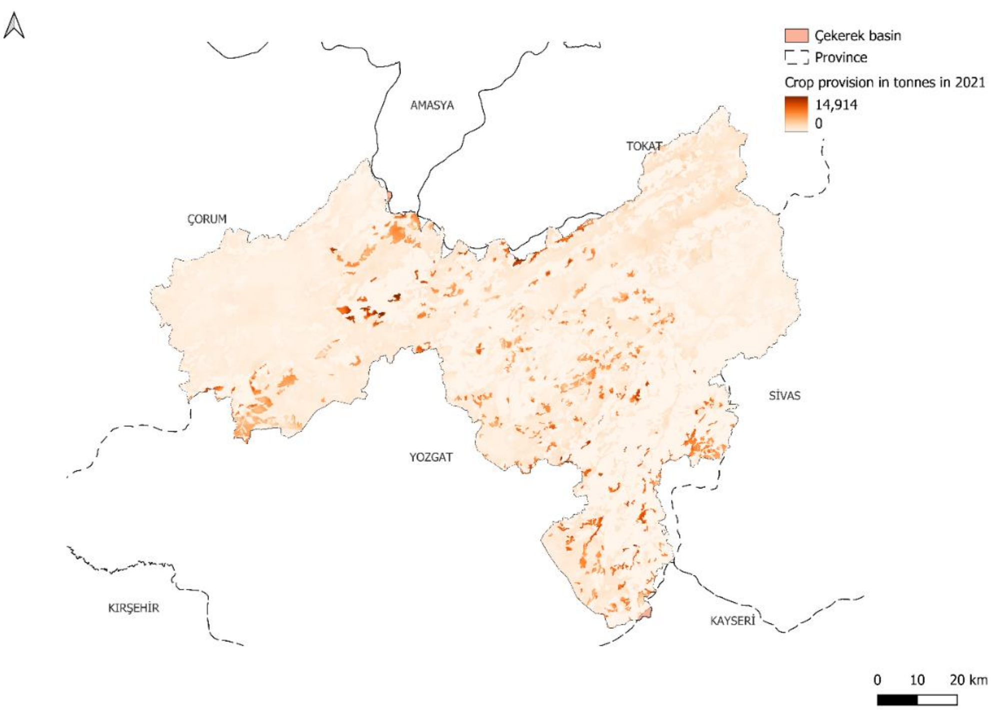
Source: VITO estimates

Table 47: Supply table crop provision in real million TRY in 2021, Bolaman and Çekerek

	Cropland	Grassland (pastures, semi-natural and natural grassland)	Total
Bolaman	705	133	**838**
Çekerek	719	166	**886**
All regions	**1,425**	**299**	**1,724**

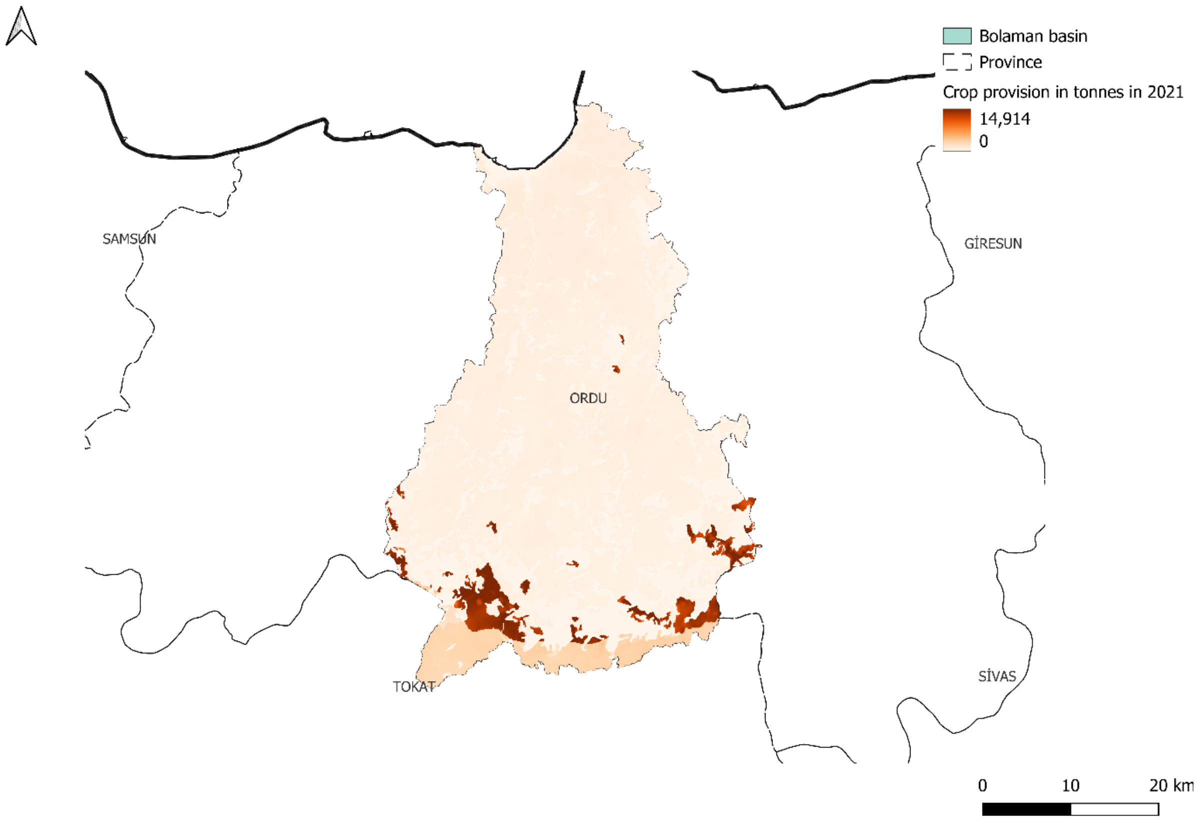
Source: VITO estimates

Figure 69: Crop provision in tonne in 2021, Bolaman



Source: Compiled by VITO

Figure 70: Crop provision in tonne in 2021, Çekerek



Source: Compiled by VITO

4.1.4 Improvement strategies

The spatial disaggregation of crop provision is based on dry matter productivity. Crop type maps or crop yield maps provide a more accurate methodology to perform this spatial disaggregation. Crop type maps indicate which crops are grown in specific areas and allow to redistribute crop specific production statistics. Crop yield maps indicate not only the crop type but also the quantities which areas are producing and allow for the most accurate redistribution of the crop production statistic within the administrative boundaries.

Detailed agricultural statistics on the cultivation of vegetables under greenhouses can be used to improve the crop provision account in combination with a crop type map. In the material flow account information on crops produced under greenhouses is not available.

Crop provision is defined as 'the ecosystem contributions to plant growth, which means that outputs are corrected for the contribution of other production factors such as labor and capital. However, based on the default method applied within the INCA project, production statistics are multiplied by market prices which means that total revenues are being considered. This leads to an overestimation of this service as a correction for other production factors is not performed. To correct monetary values for other production factors, alternative methods include the use of land rental data, the econometric estimation of production functions distinguishing the ecosystem contribution in the physical outputs of agricultural production or the resource rent approach where the contribution of land can be deduced as a residual from the value of the crops when payments to all other production factors are subtracted (NCAVES and MAIA 2022).

4.2 Wood provision

4.2.1 Definition

In the proposed amendment of Regulation (EU) 691/2011, wood provision is defined as "the ecosystem contributions to the growth of trees and other biomass." It shall be reported as net increment in thousand m³ over bark and it refers to Annex VII of the proposed Forest accounts legal module. This legal module defines net annual increment of timber as the average annual volume growth of live trees, calculated from the stock of live trees (growing stock) available at the start of the year less the average annual mortality.[16]

Based on the SEEA EA principles provisioning services are recorded in both cultivated and uncultivated contexts. This leads to the distinction for wood provisioning in:

- Forests available for wood supply (FAWS) where forest areas have no environmental, social, or economic restrictions that have a significant impact on the current or potential supply of wood.
- Forest not available for wood supply (FNAWS) which are assumed to be the non-cultivated forests (for wood). In the proposed Forest accounts module FNAWS is defined as '*All forests where environmental, social, economic or legal restrictions prevent any significant wood supply. It includes (a) forests with legal restrictions or restrictions resulting from other political decisions that totally exclude or severely limit wood supply for reasons such as environmental or biodiversity conservation (protection forest, national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest); (b) forests where physical productivity or wood quality is too low or harvesting and transport costs are too high to justify wood harvesting, apart from occasional cuttings for auto-consumption*'.
- This distinction is relevant for the measurement of service flow: according to national accounts, output is recorded when produced (ESA 2010, paragraph 1.102) and ecosystem accounts follow this rule. This means that, for both FAWS and FNAWS, wood provision is measured at the point when the service is provided. However, this point represents ecosystem contribution to different types of products, as follows:
  - For FAWS, the service '*should be recorded progressively as the timber resources grow in line with the recording of the growth of this resource in the national accounts as a work in progress*' (SEEA EA 6.92). The growth of cultivated wood is an economic product. As a result, wood provision from FAWS is measured using net increment as indicator of service flow and not removals. The same applies to other types of wooded land AWS (see further sections for types of land).
  - For FNAWS, wood provision is measured using removals as indicator of service flow, which is when resources from uncultivated context enter the production boundary. The same applies to other types of wooded land NAWS.

Turkish forests have a long tradition in silviculture. Many of the forests are under control of governmental or forestry agencies, consequently the majority of wood provision flows from FAWS. Therefore, reporting on the indicator for the ecosystem service flow originating from FNAWS is voluntary. In Türkiye, almost (>99%) all forests are under public management and can be considered as FAWS. Wood provision from FNAWS in Türkiye is not included in the assessment, due to a lack of data and the small contribution in the total amount.

[16] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/2. Wood provision ecosystem service – guidance note.

Like the crop provisioning service, in wood provisioning the wood harvest is fully contributed to ecosystems. This is of course an overestimation since timber provision is also partially driven by human interactions. An advised, the method is to use forestry inputs recorded in the national accounts, but this method is out of scope. And the EU guidance notes are followed to be compliant.

For monetary valuation we use the stumpage price per volume of timber. The stumpage price is the market value of standing trees (on the stump) prior to felling and removal. This means that selling prices are corrected for costs for felling and removal. Ideally, this price is also corrected for the costs of managing the cultivated lands (NCAVES and MAIA, 2022) or a calculation of resource rent based on standard SNA measures of gross operating surplus; by deduction subsidies, adding back specific taxes and deducting user costs of produced assets, composed of consumption of fixed capital and the return to produced assets (Vallecillo et al. 2019). Due to lack of data, such corrections and calculations are not performed. These datasets should be covered in the future Turkish European forestry accounts but previous tests with existing data from EU members states learned that using those economic forestry statistics tend to give inconsistent monetary valuation estimates and sometimes even a negative rent (Vallecillo et al. 2019).

4.2.2 Methodology and data sources

The EU guidance note heavily relies on the use of European Forest account data (questionnaires) where member states are asked to record annual increment for forest available or not available for wood supply. Türkiye recently adopted the use of the European Forest Account questionnaire. For the accounting year 2018 this is however unavailable. The statistic produced timber in logs is used instead. This statistic originates from the forestry statistics from the Ministry of Agriculture and Forestry[17].

The INCA tool is used to produce the ecosystem accounts (SUT and maps). Wood statistics by province are distributed to each pixel in the province weighted by dry matter productivity (spatial proxy) and corrected for specific zones which are not available for wood supply (proxy weights). In this account for the two pilot basins only honey forest production areas are excluded but for other regions it should not be limited to that type. In Table 48 the wood provision specific datasets are listed.

Due to the limited scope of the project and the data availability, the same simplified monetary valuation methodology as currently proposed by Eurostat and JRC is used. The biophysical amount is multiplied by the unit price to derive the monetary account. This probably leads to an overestimation of the value.

Table 48: Wood provision datasets

Dataset	Description	Source	Scale	Years
Timber volume over bark (m^3)	Volume of timber over bark. Wood in the rough production, logs of wood (2018).	OGM	Province	2018, 2021
Unit price (TRY/m^3)	The average selling price of coniferous roundwood logs	OGM	National	2018, 2021
Spatial Proxy	Dry matter productivity as a suitable proxy for distributing the amount of wood produced in each location.	Copernicus	100×100m	2018, 2021

[17] https://www.ogm.gov.tr/en/e-library/official-statistics

Dataset	Description	Source	Scale	Years
Proxy weights	Forests that have a special status which exclude them from wood harvest. Honey forests areas received a weight of 0 and are excluded from wood provision. Other forests are included.	OGM	100×100m	2023
Ecosystem Extent	Corine Land Cover map 2018	Corine	100×100m	2018, 2021

Source: Compiled by VITO

4.2.3 Results

4.2.3.1 Çekerek, 2018

Wood provision in Çekerek amounts up to 143.51 thousand m³ and the monetary valuation estimates the flow as TRY 58.98 million. The biophysical supply/use is displayed in Table 49 and Table 50. The monetary supply/use is displayed in Table 51 and Table 52.

In the East and North of Çekerek, the highest production of timber is recorded. This is shown in Figure 71.

Table 49: Supply table wood provision in 1,000 m³ overbark in 2018, Çekerek

1,000 m³	Forest and woodland	Total supply
Wood provision – increment in FAWS	143.51	**143.51**

Source: VITO estimates

Table 50: Use table wood provision in 1,000 m³ overbark in 2018, Çekerek

1,000 m³	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total use
Wood provision – increment in FAWS	143.51	-	-	-	-	**143.51**

Source: VITO estimates

Table 51: Supply table wood provision in million TRY in 2018, Çekerek

Million Turkish Lira (TRY)	Forest and woodland	Total supply
Wood provision – increment in FAWS	58.98	**58.98**

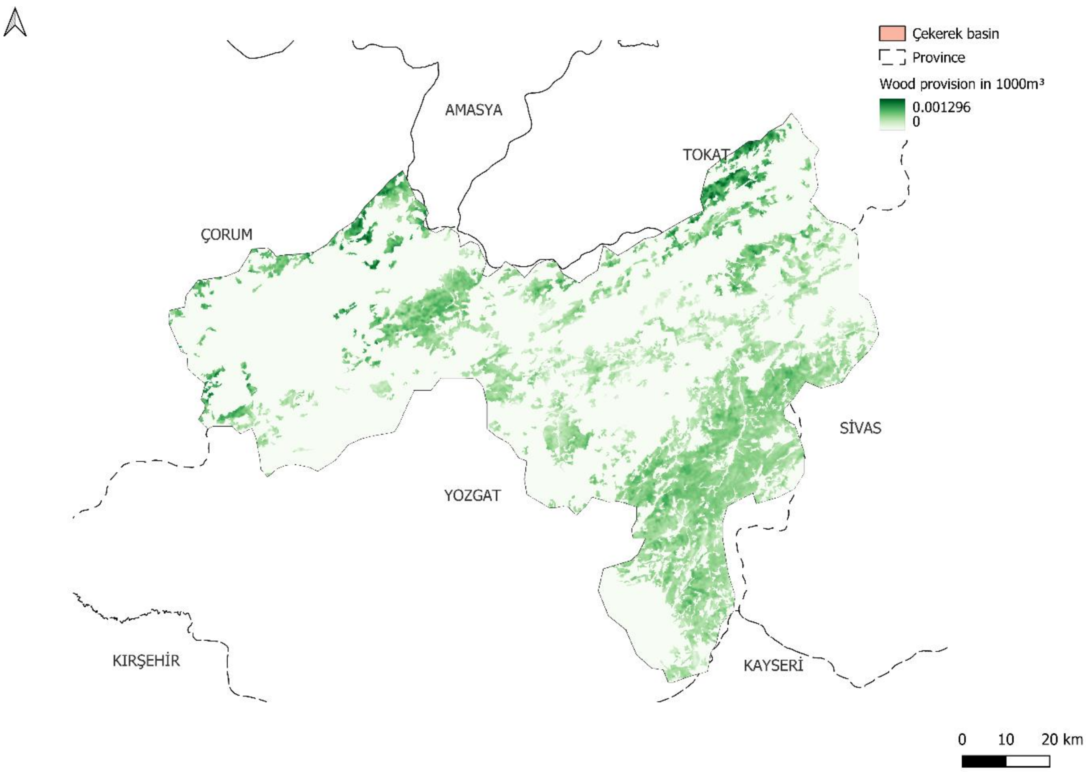
Source: VITO estimates

Table 52: Use table wood provision in million TRY in 2018, Çekerek

Million Turkish Lira (TRY)	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total use
Wood provision – increment in FAWS	58.98	-	-	-	-	**58.98**

Source: VITO estimates

Figure 71: Wood provision in m³ in 2018, Çekerek



Source: Compiled by VITO

4.2.3.2 Çekerek, 2021

Wood provision in Çekerek amounts up to 207.97 thousand m³ and the monetary valuation estimates the flow on 231.91 million Turkish lira. The biophysical supply/use is displayed in Table 53 and Table 54. The nominal monetary supply/use is displayed in Table 54 and Table 55 and Table 56 while the values adjusted for inflation is in and Table 57.

In the East and North of Çekerek, the highest production of timber is recorded. This is shown in Figure 72.

There is an increase in wood provision in tonne and in nominal and real value. The difference between 2018 and 2021 is that a different data source has been used and this can explain the increase.

Table 53: Supply table wood provision in 1,000 m³ in 2021, Çekerek

1,000 m³	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS	207.97	**207.97**

Source: VITO estimates

Table 54: Use table wood provision in 1,000 m³ in 2021, Çekerek

1,000 m³	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**

Wood provision – increment in FAWS	207.97	-	-	-	-	**207.97**

Source: VITO estimates

Table 55: Supply table wood provision in nominal million TRY in 2021, Çekerek

Million Turkish Lira (TRY)	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS	231.91	**231.91**

Source: VITO estimates

Table 56: Use table wood provision in nominal million TRY in 2021, Çekerek

Million Turkish Lira (TRY)	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**
Wood provision – increment in FAWS	231.91	-	-	-	-	**231.91**

Source: VITO estimates

Table 57: Supply table wood provision in real million TRY in 2021, Çekerek

Million Turkish Lira (TRY)	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS	137.22	**137.22**

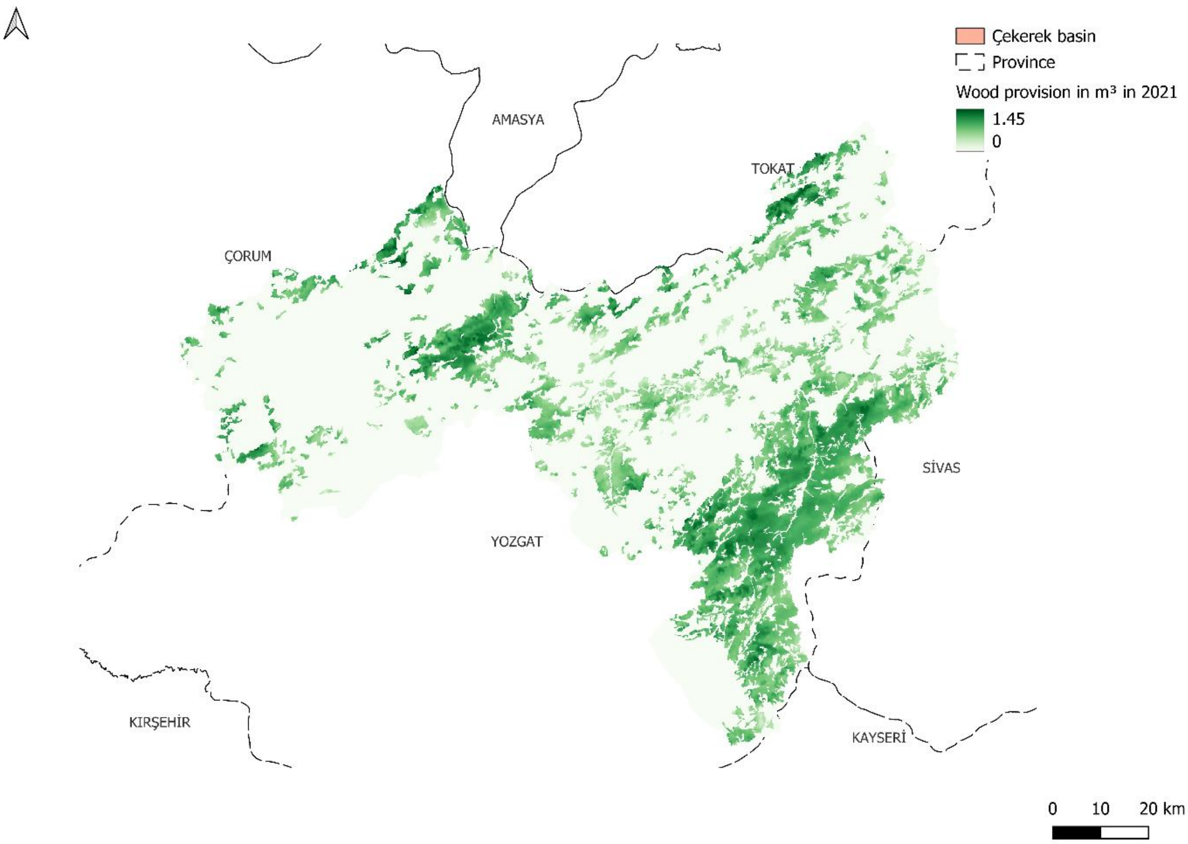
Source: VITO estimates

Table 58: Use table wood provision in real million TRY in 2021, Çekerek

Million Turkish Lira (TRY)	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**
Wood provision – increment in FAWS	137.22	-	-	-	-	**137.22**

Source: VITO estimates

Figure 72: Wood provision in m³ in 2021, Çekerek



Source: Compiled by VITO

4.2.3.3 Bolaman, 2018

Wood provision in Bolaman amounts up to 55.38 thousand m³ and the monetary valuation estimates the flow on TRY 22.76 million. The biophysical supply/use is presented in Table 59 and Table 60. The monetary supply/use is presented in Table 61 and Table 62.

In the South- and North-East of Bolaman, the highest production of timber is recorded. This is presented in Figure 73.

Table 59: Supply table wood provision in 1,000 m³ in 2018, Bolaman

1,000 m³	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS (mandatory)	55.38	**55.38**

Source: VITO estimates

Table 60: Use table wood provision in 1,000 m³ in 2018, Bolaman

1,000 m³	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**
Wood provision – increment in	55.38	-	-	-	-	**55.38**

FAWS (mandatory)						

Source: VITO estimates

Table 61: Supply table wood provision in million TRY in 2018, Bolaman

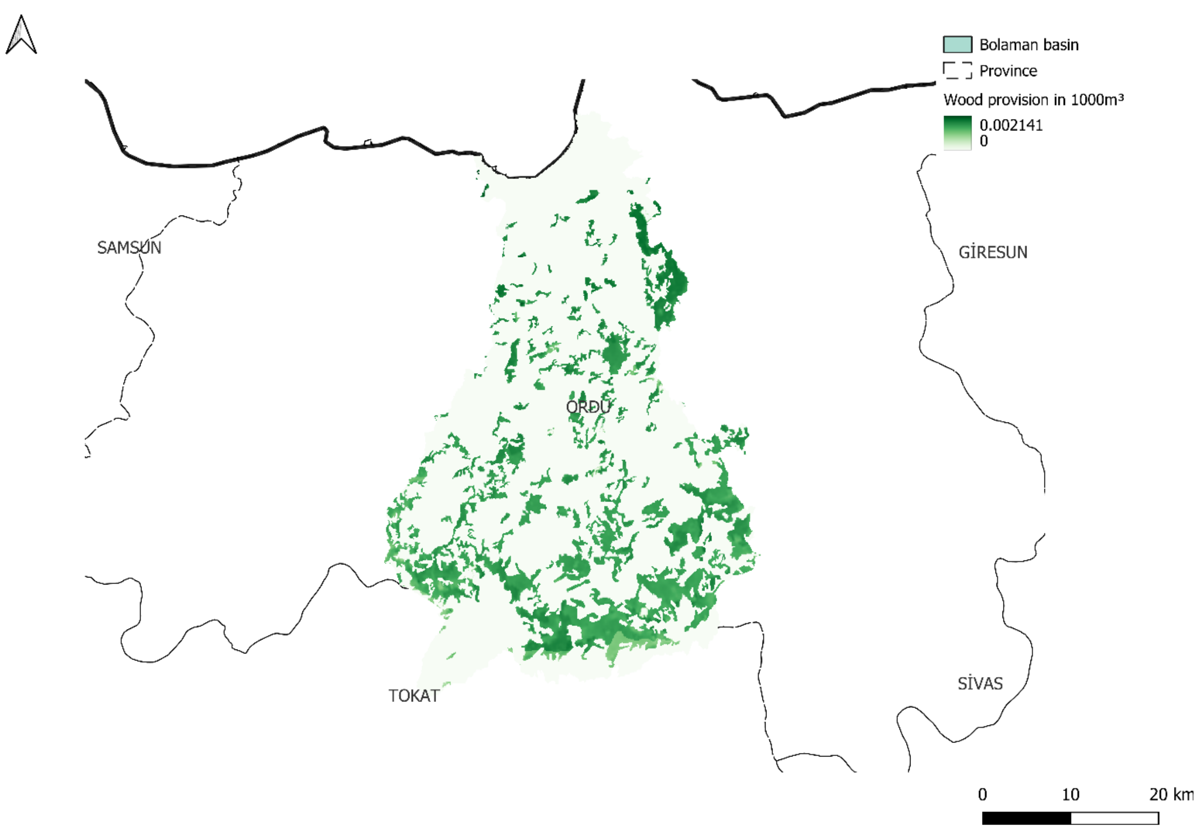
Million Turkish Lira (TRY)	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS (mandatory)	22.76	**22.76**

Source: VITO estimates

Table 62: Use table wood provision in million TRY in 2018, Bolaman

Million Turkish Lira (TRY)	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**
Wood provision – increment in FAWS (mandatory)	22.76	-	-	-	-	**22.76**

Figure 73: Wood provision in m³ in 2018, Bolaman



Source: Compiled by VITO

4.2.3.4 Bolaman, 2021

Wood provision in Bolaman amounts up to 43.72 thousand m³ and the monetary valuation estimates the flow on 46.52 million. The biophysical supply/use is displayed in Table 63 and Table 64. The nominal monetary supply/use is displayed in Table 65 and Table 66. The real monetary supply/use is displayed in Table 67 and Table 68.

In the South- and North-East of Bolaman, the highest production of timber is recorded. This is projected in Figure 74.

For Bolaman, there seems to be a decrease in production and total value compared to 2018. Different datasets are used and this can cause a discrepancy.

Table 63: Supply table wood provision in 1,000 m³ in 2021, Bolaman

1,000 m³	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS (mandatory)	43.72	**43.72**

Source: VITO estimates

Table 64: Use table wood provision in 1000m³ in 2021, Bolaman

1,000 m³	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**
Wood provision – increment in FAWS (mandatory)	43.72	-	-	-	-	**43.72**

Source: VITO estimates

Table 65: Supply table wood provision in nominal prices (million TRY) in 2021, Bolaman

Million Turkish Lira (TRY)	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS (mandatory)	46.52	**46.52**

Source: VITO estimates

Table 66: Use table wood provision in nominal prices (million TRY) in 2021, Bolaman

Million Turkish Lira (TRY)	**Intermediate consumption by industries**	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total use**
Wood provision – increment in FAWS (mandatory)	46.52	-	-	-	-	**46.52**

Source: VITO estimates

Table 67: Supply table wood provision in real prices (million TRY) in 2021, Bolaman

Million Turkish Lira (TRY)	**Forest and woodland**	**Total supply**
Wood provision – increment in FAWS (mandatory)	27.53	**27.53**

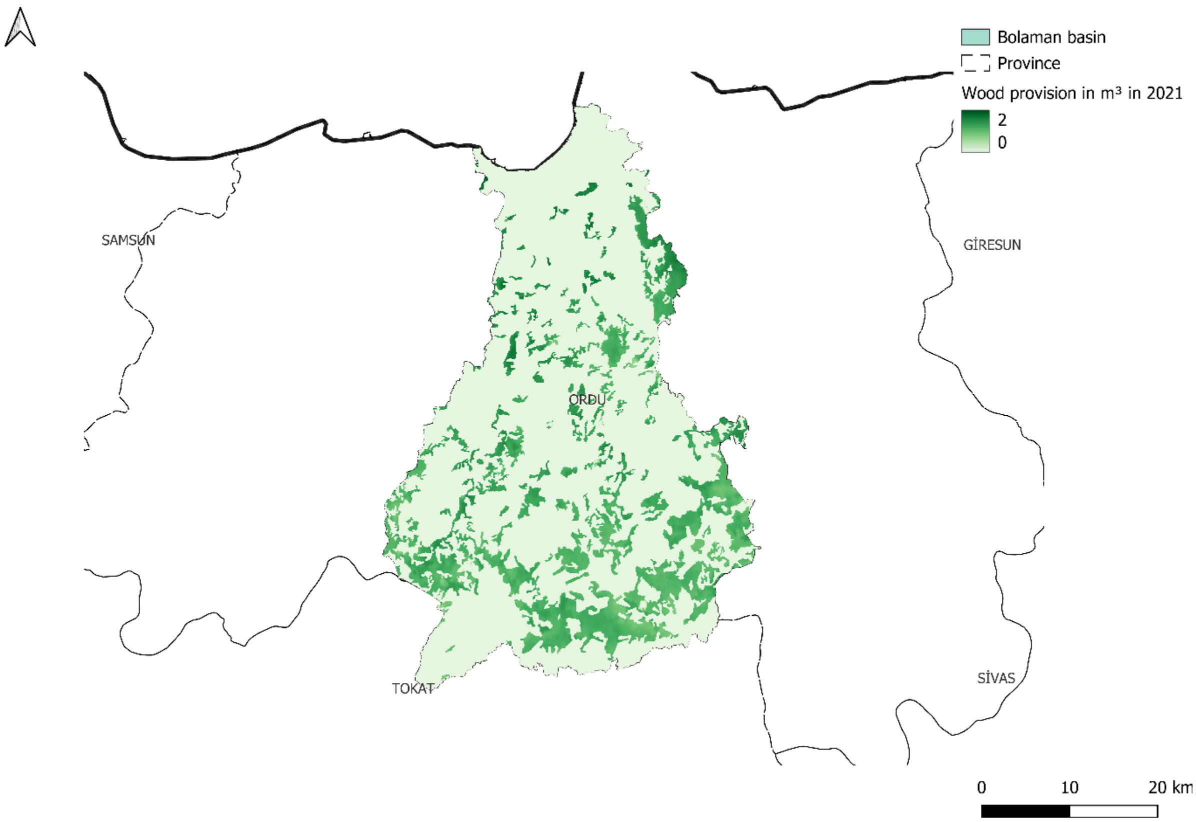
Source: VITO estimates

Table 68: Use table wood provision in real prices (million TRY) in 2021, Bolaman

Million Turkish Lira (TRY)	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total use
Wood provision – increment in FAWS (mandatory)	27.53	-	-	-	-	**27.53**

Source: VITO estimates

Figure 74: Wood provision in m³ in 2021, Bolaman



Source: Compiled by VITO

4.2.4 Improvement strategies

When the European Forest Accounts (EFA) are available, it should be used as the data source for the wood provisioning account. For the wood harvest, only harvested wood is taken into account. In the EFA, the net annual increment of forest will be available which is more closely related to the ecosystem contribution and its nature of sustainability. This also corresponds with the methodologies as described in EU guidance notes.

The dataset '*proxy weights'* can be expanded with other areas not available for wood supply such as Natura 2000 areas, forest nurseries, touristic forest areas or observation centers. For the two pilot basins only the exclusion of honey forest was considered.

The price for timber is a national price which is not corrected for incurred governmental costs for managing the forests lands for wood supply. Consequently, the ecosystem's contribution to monetary valuation of timber is overestimated. It is advisable to calculate the resource rent of timber instead of the total value calculated by multiplying the harvest and the unit price of logs. To calculate the resource rent, the costs made by the forestry industry should be subtracted from the unit price.

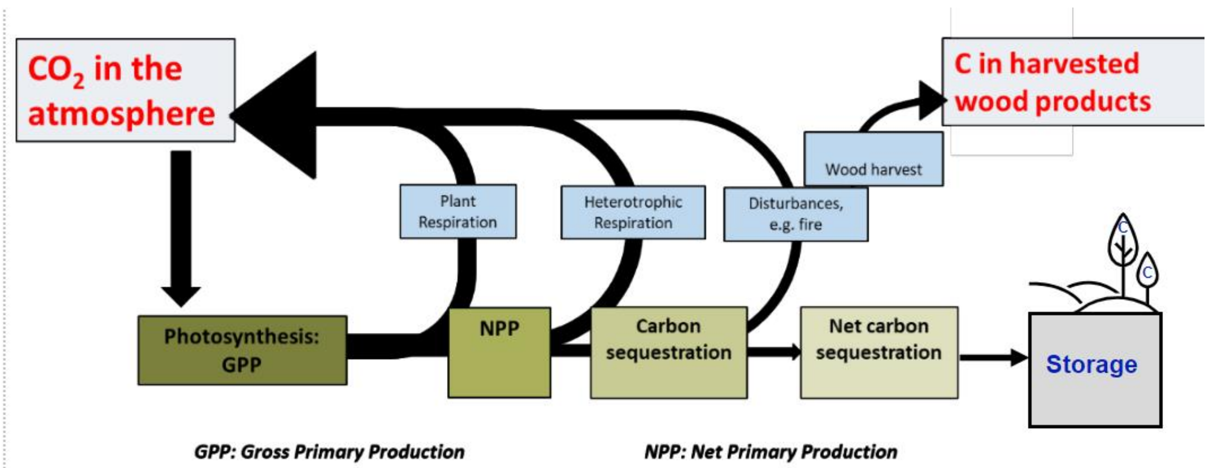
4.3 Global climate regulation

4.3.1 Definition

Global climate regulation is defined as 'the ecosystem contributions to reducing concentrations of greenhouse gases in the atmosphere through the removal (net sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems' in the proposed amendment of Regulation (EU) 691/2011. The contributions are reported in terms of tonne of net sequestration of carbon and tonne of organic carbon stored in terrestrial ecosystems including above ground and below ground in the first 0.3 meters of the soil (including peatlands).

The scope of global climate regulation services is restricted to biocarbon, and the storage of carbon in harvested wood and non-wood biological products is not considered an ecosystem service.

Figure 75: Overview Global Climate Regulation biophysical components

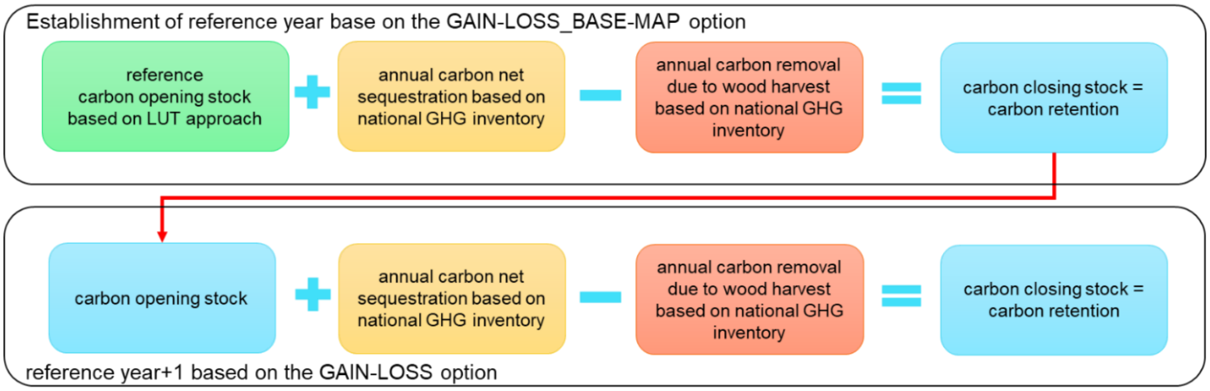


Source: Compiled by VITO

4.3.2 Methodology and data sources

The service was run annually for the years 2000 to 2021. The main reason is that carbon retention stocks are only available for the year 2000. Therefore, the INCA model was run for the year 2000 in '**base'** mode for the carbon retention to establish a carbon retention opening stock for the year 2000. The model creates the closing stock for the year 2000 taking into account the carbon sequestration and harvest which then becomes the opening stock for the carbon retention account for the year 2001. Therefore, the years 2001 to 2021 were run in the '**gain-loss'** mode as described in the INCA tool user manual. The figure below illustrates this process.

Figure 76: Carbon retention model to create consistent annual accounts



Source: Compiled by VITO adapted from INCA user manual

Table 69 below provides an overview of the datasets used to run the model.

Table 69: Global Climate Regulation datasets

Dataset	Description	Source	Scale	Years
Ecosystem extent: CORINE CLCACC layers by EEA	Corine Land cover maps 2000, 2006, 2012, 2018	Corine	100×100 m	2018–2021
Copernicus annual DMP	Productivity proxy Maps (yearly from 2000 – 2021)	Copernicus	1×1 km or 300×300 m	2018–2021
Wood harvest proxy map	There is no full map of wood harvest for the whole of Türkiye. Carbon removal due to wood harvest is uniformly spread out over all forest areas.	Not Available	Not Available	/
GHG statistics	Greenhouse Gas Emission statistics from the different CRF categories	Turkstat	National	2018–2021
Carbon retention stock	Opening stock base values for the year 2000	Gibbs and Ruesch (2008) and isric SoilGrids250m 2.0	100×100 m	2000
Annual carbon prices	Average price per ton of CO2 uptake	Average EU ETS prices	National	2018–2021

Source: Compiled by VITO

Ecosystem extent: The Corine Land Cover maps for 2000, 2006, 2012, and 2018 were used (CORINE CLC ACC layers), as provided by the EEA. For 2021, the 2018 map was used.

The **productivity proxy (Copernicus annual DMP)** is used to spatially distribute the national GHG statistics over the country. Copernicus annual Dry Matter Productivity (DMP) represents the overall growth rate or dry biomass increase of the vegetation and is directly related to ecosystem Net Primary Production (NPP).

Areas with higher production are assigned a larger portion of the sequestration listed in the GHG statistics, and vice versa.

The **GHG statistics** were provided by TURKSTAT, they list the annual emissions (or sequestration) from different sources. The following components are considered:

Table 70: CRF categories considered in the GHG statistics

CRF	Label emitter
CRF4A	Forest
CRF4B	Cropland
CRF4C	Grassland
CRF4D	Wetlands
CRF4E	Artificial land
CRF4F	Other lands
CRF4G	Carbon removal due to wood harvest

Source: Compiled by VITO

The reporting of non-CO2 GHGs originating in ecosystems under human influence (in particular CH4 and N2O) is not considered for this calculation. An important note to make is that Turkstat reported a change in methodology over the years. From 2018 onwards, GHG statistics cannot be directly compared to the previous years. Since there are no GHG statistics for the Bolaman and Çekerek basins, we start from national GHG statistics, and then distribute the results spatially using the DMP proxy maps.

Carbon retention: To calculate Global Climate Regulation in 2018 and 2021, a starting point of carbon stock is needed. From the opening stock of 2000, each year we add the gains (sequestration) and remove the losses (wood harvest), to arrive at the final values in the years needed. Since literature-based carbon stock estimations were mainly based on 2000, we start the calculations from this year.

Annual carbon prices: Market prices for carbon were derived from (the annual average ETS prices. The EU-ETS envisions to limit GHG emissions from polluting installations by putting a price on carbon, encouraging organizations to reduce their emissions. The ETS price of 2018 was used for both 2018 and 2021 to derive the real prices. To come to prices in TRY, we did use the exchange rates from 2018 and 2021.

4.3.3 Results

4.3.3.1 Retention

Supply and Use[18] are 5 times higher in Çekerek compared to Bolaman, which is to be expected since Çekerek is a much larger basin and more forest is present. In Çekerek, most carbon retention is supplied by forest and woodland, in Bolaman most of the carbon retention is present in cropland. Retention by forests and woodland increased between 2018 and 2021, albeit only slightly.

[18] By convention, under SEEA EA framework the use of global climate regulation as an ecosystem service is allocated to ‘government’s final consumption’

Table 71: Use table Global Climate Regulation Retention in 1,000 tonne in 2018 (closing stock)

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	13,139	-	-	-	13,139
Çekerek	-	71,812	-	-	-	71,812
All regions	**-**	**84,951**	**-**	**-**	**-**	**84,951**

Source: VITO estimates

Table 72: Use table Global Climate Regulation Retention in 1000 tonne in 2021 (closing stock)

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	13,199	-	-	-	13,199
Çekerek	-	72,050	-	-	-	72,050
All regions	**-**	**85,249**	**-**	**-**	**-**	**85,249**

Source: VITO estimates

Table 73: Supply table Global Climate Regulation Retention in 1,000 tonne in 2018 (closing stock)

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	99	7,249	1,403	4,366	-	22	-	-	-	-	-	-	**13,139**
Çekerek	719	25,831	6,910	29,334	-	9,014	-	-	-	-	-	-	**71,812**
All regions	**818**	**33,080**	**8,313**	**33,700**	**-**	**9,036**	**-**	**-**	**-**	**-**	**-**	**-**	**84,951**

Source: VITO estimates

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Table 74: Supply table Global Climate Regulation Retention in 1,000 tonne in 2021 (closing stock)

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	98	7,248	1,402	4,429	-	22	-	-	-	-	-	-	**13,199**
Çekerek	715	25,828	6,906	29,586	-	9,013	-	-	-	-	-	-	**72,051**
All regions	**814**	**33,077**	**8,309**	**33,952**	**-**	**9,035**	**-**	**-**	**-**	**-**	**-**	**-**	**85,190**

Source: VITO estimates

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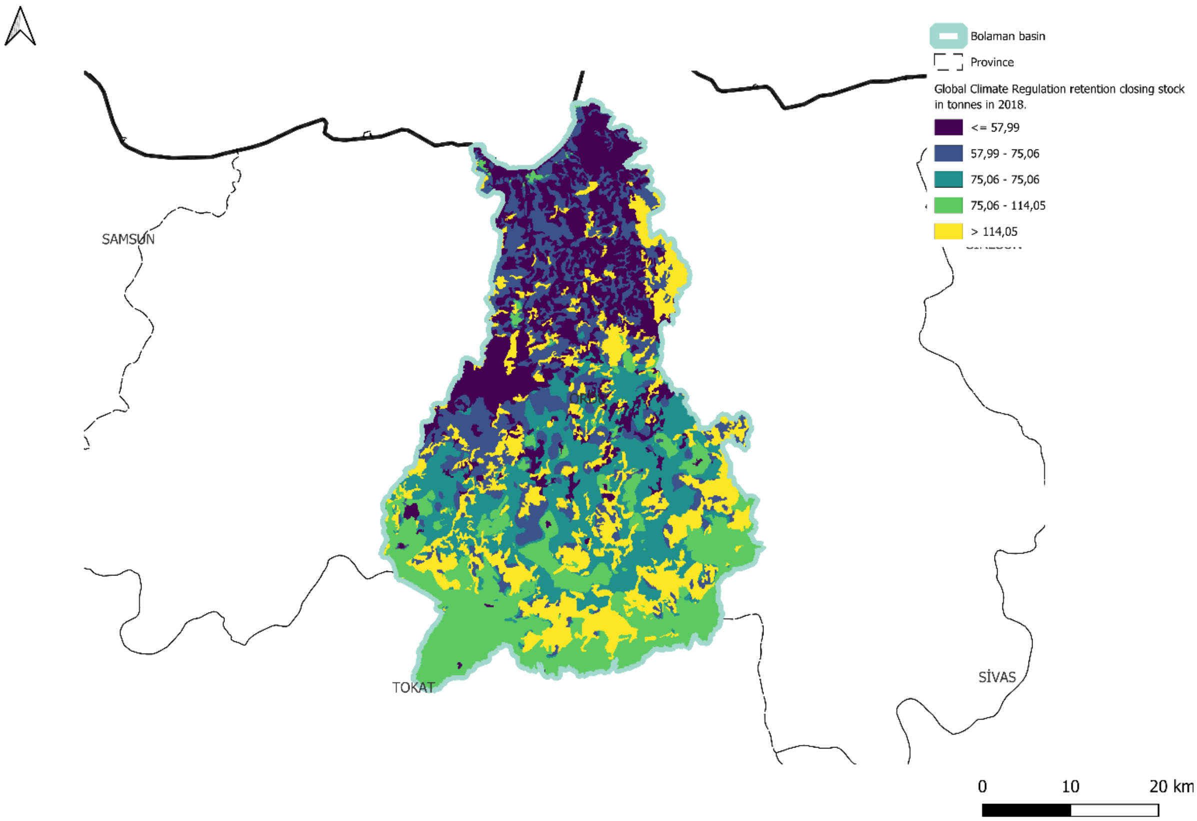
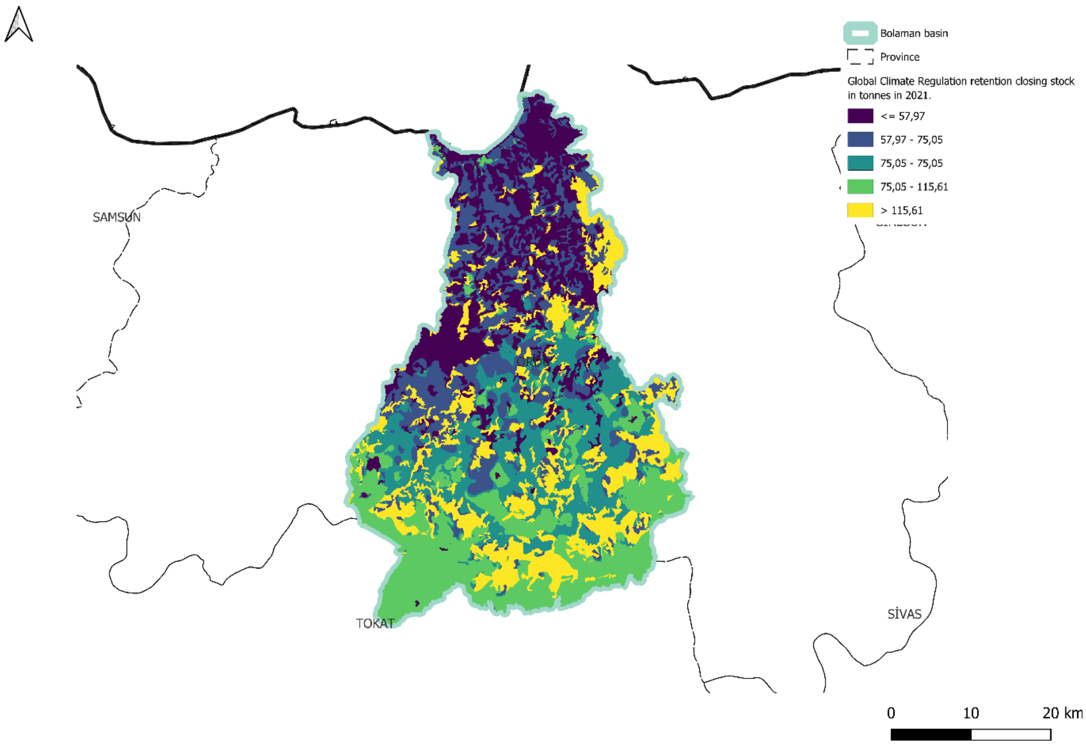
Figure 77: Global Climate Regulation retention closing stock in tonne in 2018, Bolaman



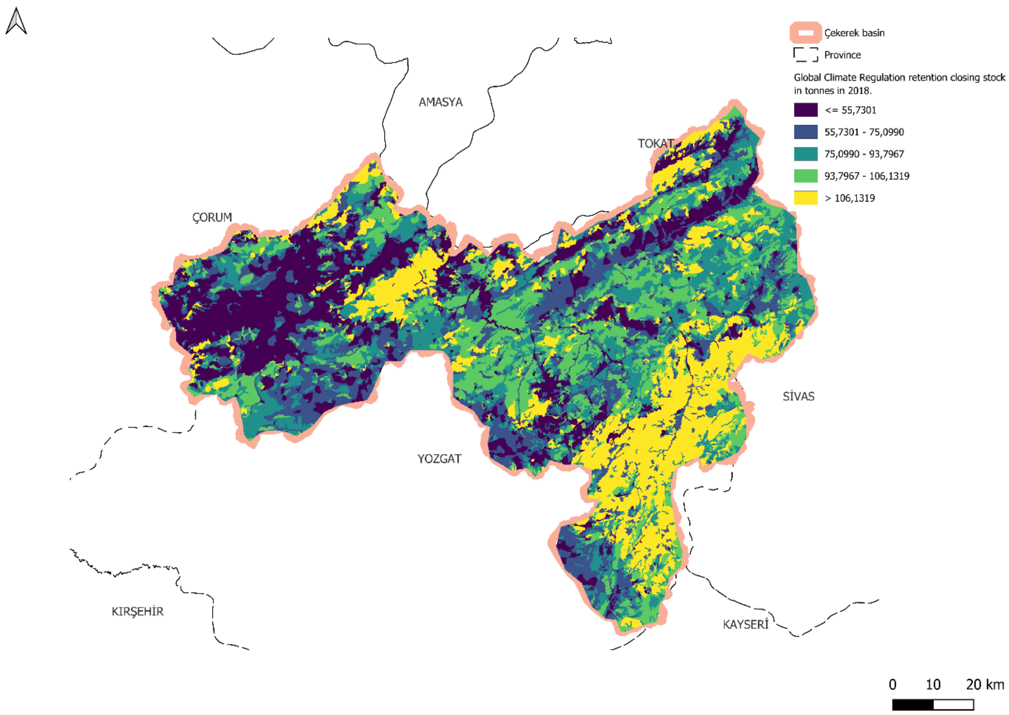
Source: Compiled by VITO

Figure 78: Global Climate Regulation retention closing stock in tonne in 2021, Bolaman



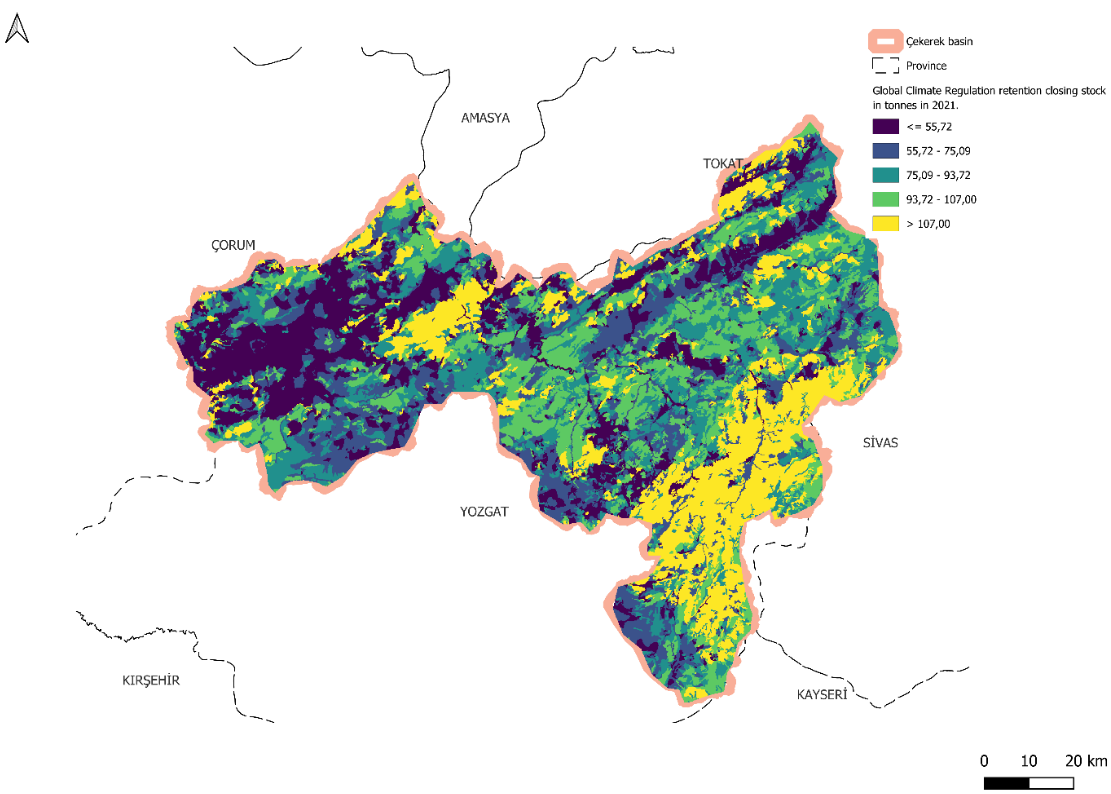
Source: Compiled by VITO

Figure 79: Global Climate Regulation retention closing stock in tonne in 2018, Çekerek



Source: Compiled by VITO

Figure 80: Global Climate Regulation retention closing stock in tonne in 2021, Çekerek



Source: Compiled by VITO

4.3.3.2 Sequestration

Forest and woodland are the only ecosystem type with a value for sequestration. It must be noted, that only net positive sequestration is taken into account. When an ecosystem loses carbon, this is not considered in the tables as a “negative” sequestration. Comparable to the retention statistics, also carbon sequestration in Çekerek is 5 times higher compared to Bolaman. The calculated carbon sequestration is all provided by the Forest & Woodland ecosystem type. Sequestration almost halves between 2018 and 2021. This reflects the CRF4A GHG trend, present in the input data. When the real price value of carbon sequestration in 2021 is compared with 2018 a decrease from 8.16 million TRY to 4.63 million TRY is calculated.

The LULUCF report (https://unfccc.int/documents/644387) provides the reasons.

It is important to note that statistics were only made available for the whole of Türkiye. Turkish national data are extrapolated to the basins based on land cover data and the Dry Matter Productivity. This might have the consequence that national trends are not observed in Bolaman and Çekerek specifically, but the methodology and the available data do not allow us to find a solution for the discrepancy between the level at which the data is collected, and the level for which we need to do the analysis.

Table 75: Use table Global Climate Regulation Sequestration in 1,000 tonne in 2018

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	39.70	-	-	-	39.70
Çekerek	-	187.00	-	-	-	187.00
All regions	**-**	**226.70**	**-**	**-**	**-**	**226.70**

Source: VITO estimates

Table 76: Use table Global Climate Regulation Sequestration in 1000 tonne in 2021

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	19.94	-	-	-	19.94
Çekerek	-	98.00	-	-	-	98.00
All regions	**-**	**117.94**	**-**	**-**	**-**	**117.94**

Source: VITO estimates

Table 77: Supply table Global Climate Regulation Sequestration in 1,000 tonne in 2018

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	-	-	39.70	-	-	-	-	-	-	-	-	**39.70**
Çekerek	-	-	-	187.00	-	-	-	-	-	-	-	-	**187.00**
All regions	-	-	-	**226.70**	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**226.70**

Source: VITO estimates

Table 78: Supply table Global Climate Regulation Sequestration in 1,000 tonne in 2021.

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	-	-	19.94	-	-	-	-	-	-	-	-	**19.94**
Çekerek	-	-	-	98.00	-	-	-	-	-	-	-	-	**98.00**
All regions	-	-	-	**117.94**	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**117.94**

Source: VITO estimates

Table 79: Use table Global Climate Regulation Sequestration in nominal prices in million TRY in 2018

	Intermediate consumption by industries	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total**
Bolaman	-	1.43	-	-	-	**1.43**
Çekerek	-	6.73	-	-	-	6.73
All regions	**-**	**8.16**	**-**	**-**	**-**	**8.16**

Source: VITO estimates

Table 80: Use table Global Climate Regulation Sequestration in nominal prices in million TRY in 2021

	Intermediate consumption by industries	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total**
Bolaman	-	1.32	-	-	-	**1.32**
Çekerek	-	6.50	-	-	-	**6.50**
All regions	**-**	**7.83**	**-**	**-**	**-**	**7.83**

Source: VITO estimates

Table 81: Use table Global Climate Regulation Sequestration in real prices in million TRY in 2021

	Intermediate consumption by industries	**Government final consumption**	**Households final consumption**	**Gross capital formation**	**Exports**	**Total**
Bolaman	-	0.78	-	-	-	**0.78**
Çekerek	-	3.85	-	-	-	**3.85**
All regions	**-**	**4.63**	**-**	**-**	**-**	**4.63**

Source: VITO estimates

Table 82: Supply table Global Climate Regulation Sequestration in nominal prices in million TRY in 2018.

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	-	-	1.43	-	-	-	-	-	-	-	-	1.43
Çekerek	-	-	-	6.73	-	-	-	-	-	-	-	-	6.73
All regions	-	-	-	**8.16**	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**8.16**

Source: VITO estimates

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Table 83:Supply table Global Climate Regulation Sequestration in nominal prices in million TRY in 2021

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	-	-	1.32	-	-	-	-	-	-	-	-	**1.32**
Çekerek	-	-	-	6.50	-	-	-	-	-	-	-	-	**6.50**

All regions	-	-	-	**7.83**	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**7.83**

Source: VITO estimates

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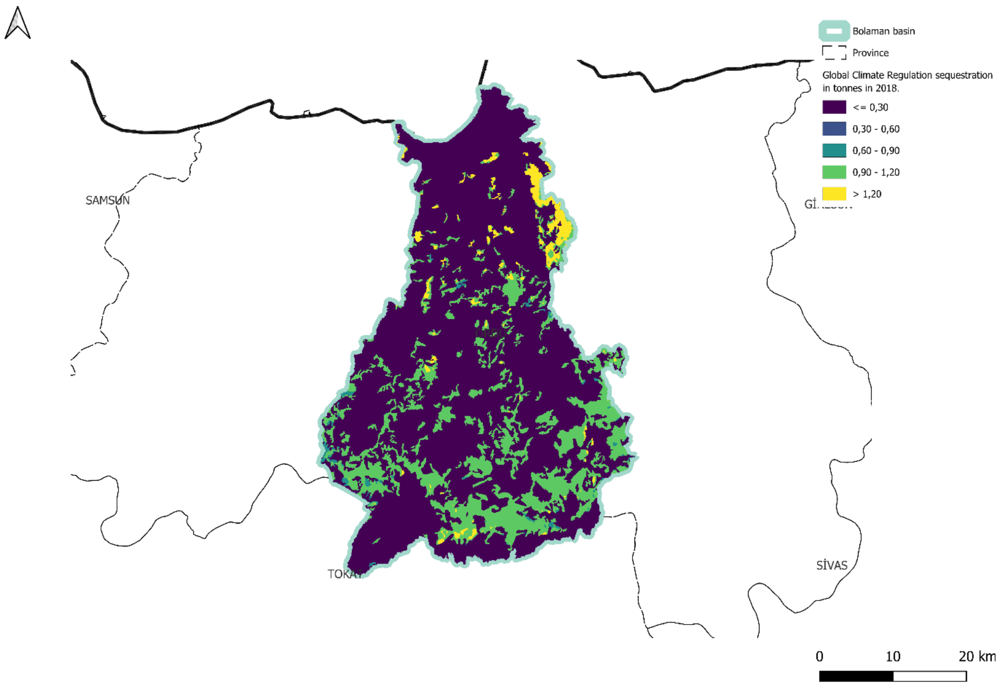
Table 84: Supply table Global Climate Regulation Sequestration in real prices in million TRY in 2021

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	-	-	0.78	-	-	-	-	-	-	-	-	0.78
Çekerek	-	-	-	3.85	-	-	-	-	-	-	-	-	3.85
All regions	-	-	-	**4.63**	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**4.63**

Source: VITO estimates

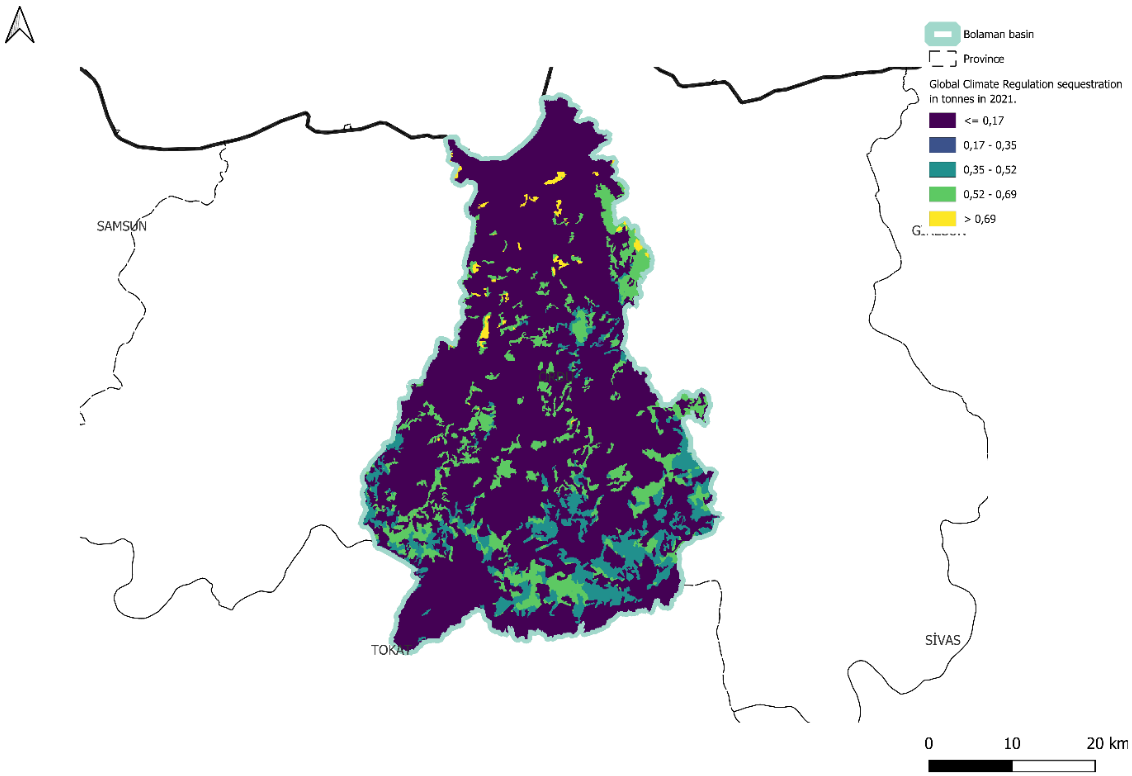
Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Figure 81: Global Climate Regulation sequestration in tonne in 2018, Bolaman



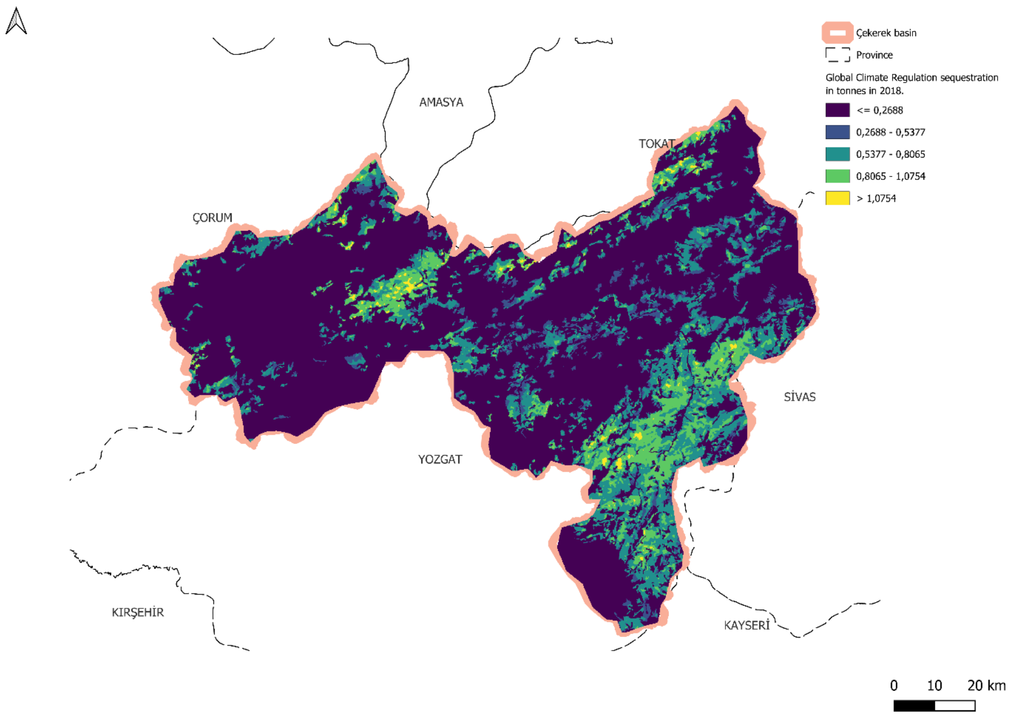
Source: VITO estimates

Figure 82: Global Climate Regulation sequestration in tonne in 2021, Bolaman



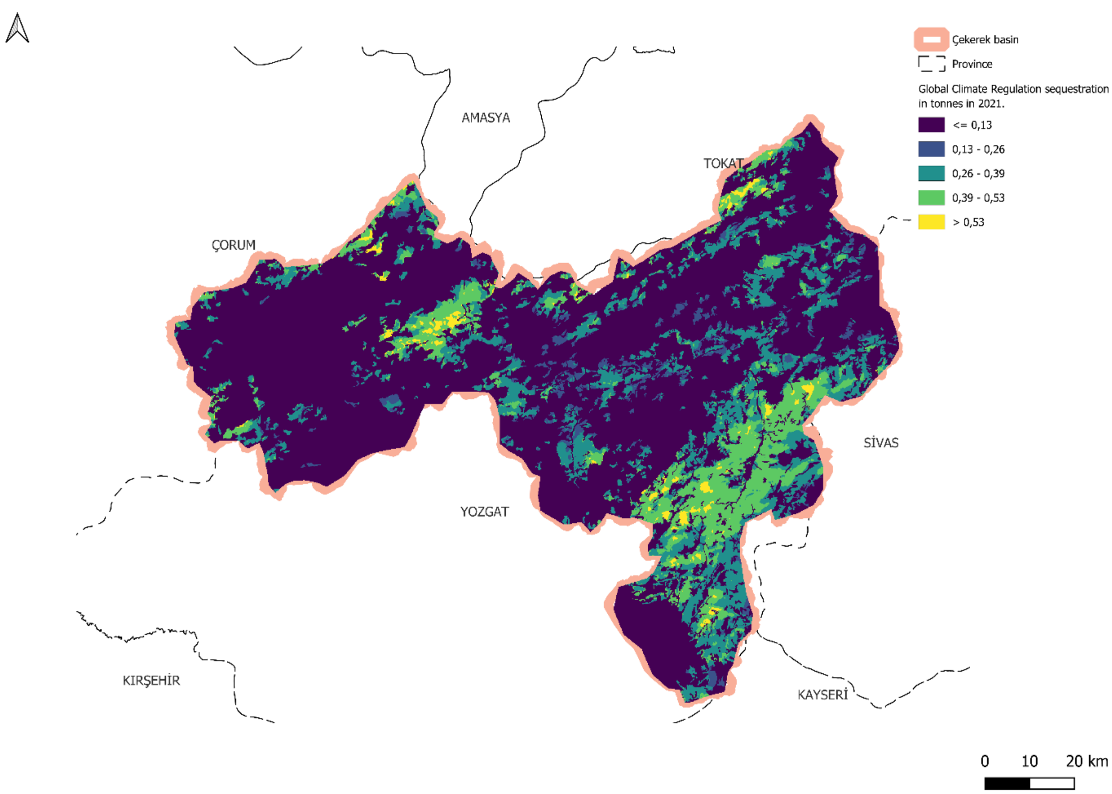
Source: Compiled by VITO

Figure 83: Global Climate Regulation sequestration in tonne in 2018, Çekerek



Source: Compiled by VITO

Figure 84: Global Climate Regulation sequestration in tonne in 2021, Çekerek

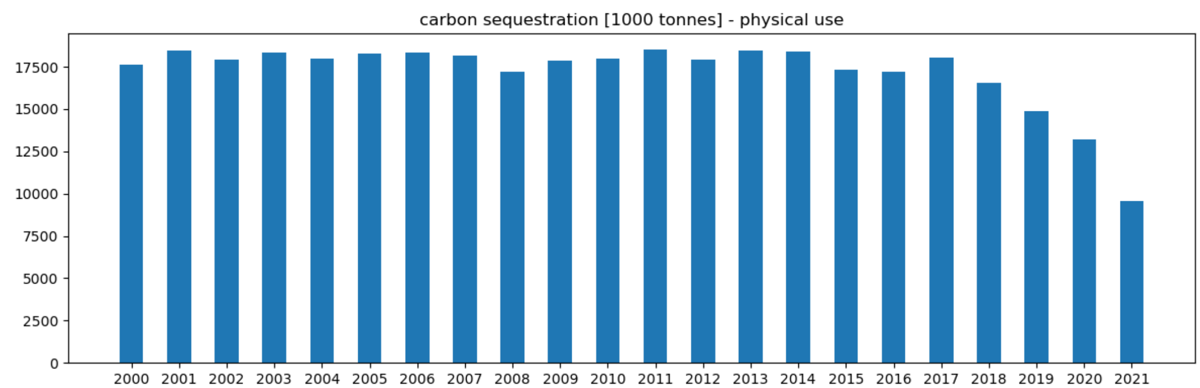


Source: Compiled by VITO

4.3.4 Improvement strategies

The Global Climate Regulation account, especially sequestration, depends heavily on reported GHG Statistics. Turkstat reported a change in methodology of GHG statistics from 2018 onwards. The figure below represents carbon sequestration statistics that were derived from the GHG Statistics. The values stay rather constant over the years but start to decrease from 2018 onwards. The sequestration values of 2021 are approximately half the values of 2018, which is inconsistent with the stable extent of forest and woodland present in Türkiye. Moving forward, this should be investigated, in order to create reliable time series.

Figure 85: Carbon sequestration in 1,000 tonne based on GHG Statistics, Türkiye



Source: Compiled by VITO

To be able to create consistent time series for carbon retention, either this change in methodology is retrospectively corrected, or an account is made starting from an opening stock in the year where the new methodology starts. Currently, we can only produce a 2000 starting stock.

Wood harvest statistics was not available for all provinces in Türkiye. Consequently, they were not used as a proxy to distribute sequestration statistics. Instead, carbon removal due to wood harvest is uniformly distributed over all forest areas, which is a less reliable method than the use of wood harvest statistics.

National GHG statistics are used and distributed spatially to derive values for the pilot sites (a top-down approach). Ideally, bottom-up approaches are applied that build on local monitoring data to estimate local GHG statistics for carbon sequestration. However, as discussed with TWG, this would be highly time consuming. Using national GHG statistics and combining it with a spatial disaggregation based on the DMP layer was seen as a suitable alternative but it results in unreliable local results.

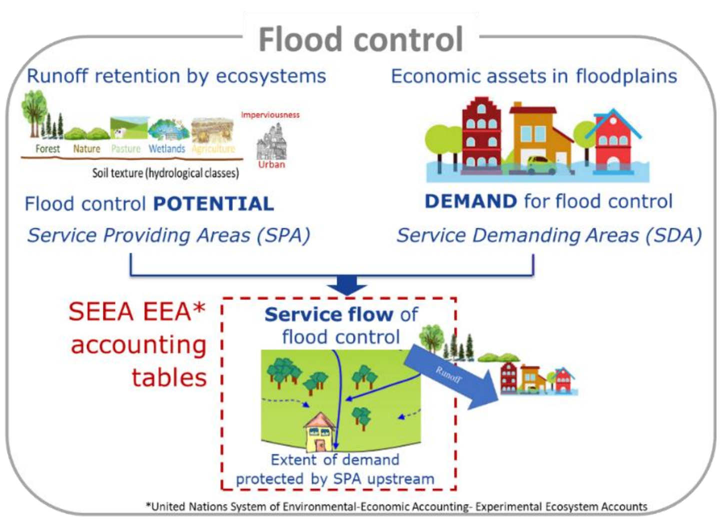
4.4 Flood control

4.4.1 Definition

The ecosystem service of flood control (peak flow mitigation) can be defined as the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and hence mitigate the effects of flood and other extreme water-related events (UN 2021). Ecosystems provide flood protection services by reducing (peak) runoff, retaining water from rainfall and storing it locally in the soil or aquifers and thus slowing down the water flow. The physical account is measured in ha of settlements and cropland in floodplains protected by upstream ecosystems.

To estimate this service, the modelling approach from Vallecillo et al. (2020) was applied. This approach is integrated in the KIP INCA tool. Figure 86 describes the different components of this model. The model distinguishes upper basin areas that provide flood protection as service providing areas (SPA) and the lower basin areas with economic assets that need protection as service demanding areas (SDA). The model estimates the amount of SDA's protected by SPA's upstream. The flood control potential is the total amount of protection, ecosystems can potentially provide independently whether it is needed or not. The amount of protected SDA's supplied by the SPA's is called the '*met*' demand expressed in hectare, which is the service flow reported in the accounting tables. When the demand is higher than the ecosystems' flood control potential and SDA's are currently unprotected, it is called '*unmet'* demand.

Figure 86: Overview methodology Flood Control



Source: INCA user manual, 2024

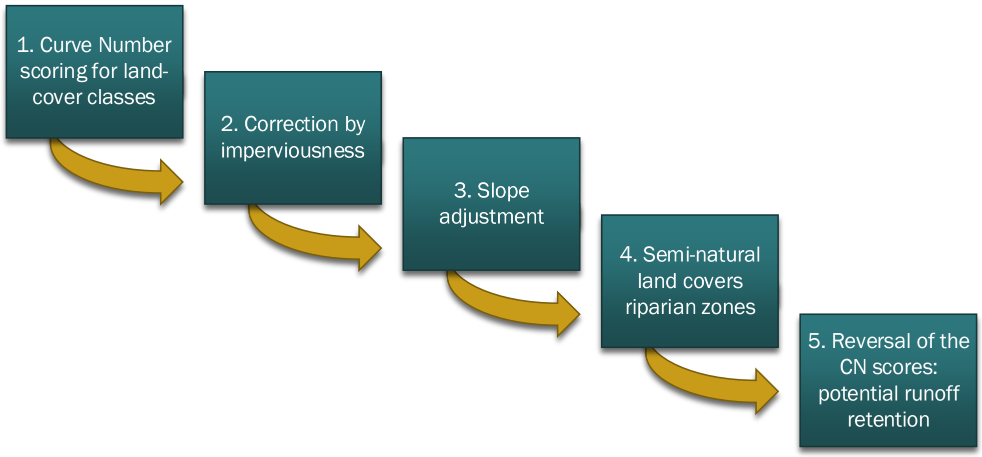
Moreover, in this model two important principles apply:

- Flood control is assessed on an annual basis, independently of the number of flood events derived from the precipitation patterns taking place in the specific accounting year. As explained above, the suggested approach is more suitable for ecosystem accounts than other models such as those quantifying the attenuation of peak discharges;
- The service flow of flood control is quantified independently of the role of defence measures against floods already in place (e.g. dykes, dams, and other infrastructure to control water flows). Ecosystems provide flood control by themselves, but they also provide support to defence measures already in

place. Without the protective function of upstream ecosystems, more investments in defence measures would be needed to maintain the same or higher level of protection.

4.4.2 Methodology and data sources

The first calculation is the **potential flood control** by ecosystems and is based on the quantification of the potential runoff retention as proxy for the identification of the SPA. The estimate of the potential runoff retention indicator includes five steps.



*Source: INCA user manual,2024*Estimate the amount of runoff generated for different land cover types and their underlying hydraulic soil properties. This estimate is based on the Curve Number (CN) method.

1. Correction of CN values by the imperviousness. Imperviousness level directly determines the ability of soil to retain and infiltrate water.
2. Adjustment of the CN value by slope. The original CN method was created for flat areas, hence to consider this important factor determining runoff, we applied the slope-modified CN method.

– Integration of natural and semi-natural land covers with vegetation in riparian zones. This step is necessary to guarantee that natural and semi-natural land covers relevant for the flood protection in riparian zones[19] are considered as key SPA given their important role retaining and absorbing runoff.

3. Reversal of the CN values into the indicator of potential runoff retention. CN values show higher values when there is higher runoff, inversersly related to the runoff retention indicator. Therefore, the difference is calculated between the maximum CN score of the baseline year chosen and the CN score in the accounting year. The difference is change in the runoff retention.

The second calculation is the **quantification of the service demanding area** or economic assets located in floodplains based on floods with a 500-year return period. The location of the relevant economic assets is mapped out and crosschecked whether they are situated in the flood-prone areas. The selection of the economic assets is based on Corine land cover class (see Annex Table 122: Corine land cover classes and economic activities).

[19] Transitional areas between terrestrial and aquatic ecosystems (waterways).

The last calculation uses spatial functions to overlay supply and demand and the direction of water flow to find the spatial relationship between the supply and demand to determine the actual flow or met demand. The datasets are listed in Table 85.

The monetary valuation is based on the avoided damages method and calculated by estimating the damage of certain economic assets exposed under different water depths. For a range of the depths and different land covers, damage values are calculated which results in a damage function. A sum is taken for all the damages on the economic assets in the administrative boundaries using the flood risks maps and the damage function. The damage function for Türkiye is the European average weighted by its GDP per capita according to the method described in Huizinga (2007).

Changes in the results of flood control are mainly driven by changes in land cover and flood risks. Since for this exercise the 2018 Corine land cover is used for both 2018 and 2021 and flood risk maps are also only available for one reference year, the 2021 flood control account is not estimated separately.

Table 85: Flood control datasets

Dataset	Description	Source	Scale	Years
Curve Number table	A measure of precipitation runoff, depending on land cover type and hydrological soil type.	JRC	/	2018
Slope map	A map with terrain slope expressed as a percentage	JRC	Europe	2018
Hydrological soil type map	A map with hydrological soil types	JRC	Europe	2018
Imperviousness density map	A map with imperviousness density expressed as a percentage	JRC	Europe	2018
Riparian zones map	A map indicating where riparian zones are located.	JRC	Europe	2018
DEM	Digital Elevation Model	JRC	Europe	2018
Floodplains	A raster file describing the extent of floodings in a 500-year event	JRC	Europe	2018
Flood maps	A set of flood risk maps describing the extent of floodings and water depth for different return periods	JRC	Europe	2018
Damage function	A table describing the damage in euro for different water depths and land cover types.	JRC	Europe	2018
Land cover economic sector	A table translating land cover types into economic assets.	JRC	/	2018
Catchment outlines	A shapefile containing the water catchment to produce results per catchment.	HydroSHEDS	Europe	2018
Population	A worldwide population grid.	JRC	World	2018
Hydro basins	A shapefile containing hydro basins or other basins levels.	HydroSHEDS	World	2018
Ecosystem Extent	Corine Land Cover map 2018	Corine	100x100m	2018

Source: VITO estimates

4.4.3 Results

In Table 86, the use of flood protection is summarized for the Bolaman and Çekerek basins. In Bolaman there is a lower flood protection than in Çekerek, but relatively more households are protected. In Table 87, flood protection is expressed in million TRY which is estimated by multiplying the values in euro produced by the INCA tool with the 2018 exchange rate (0.1783). As stated before, the damage function for Türkiye is derived from the European average and weighted by the GDP per capita.

Table 86: Use table flood protection in ha in 2018, Bolaman and Çekerek

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	1,442	0	149	0	0	**1,591**
Çekerek	11,108	0	29	0	0	**11,137**
All regions	**12,545**	**0**	**178**	**0**	**0**	**12,728**

Source: VITO estimates

Table 87: Use table flood protection in million TRY in 2018, Bolaman and Çekerek

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	20.85	0	89.76			**110.62**
Çekerek	28.68	0	30.54			**59.22**
All regions	**49.53**	**0**	**120.31**			**169.84**

Source: VITO estimates

In Table 88, the supply of flood protection for each pilot site is summarized. The ecosystem types that provide the most flood protection are croplands and forests and woodlands. Both ecosystem types are holding a large share of land in both the pilot basins. They are often situated upstream as well in comparison with the users of flood protection.

Table 88: Supply table flood protection in ha in 2018, Bolaman and Çekerek

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	19	1,012	4	555	0	0	0	0	0	0	0	0	**1,591**
Çekerek	0	5,259	841	5,037	0	0	1	0	0	0	0	0	**11,137**
All regions	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**12,728**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

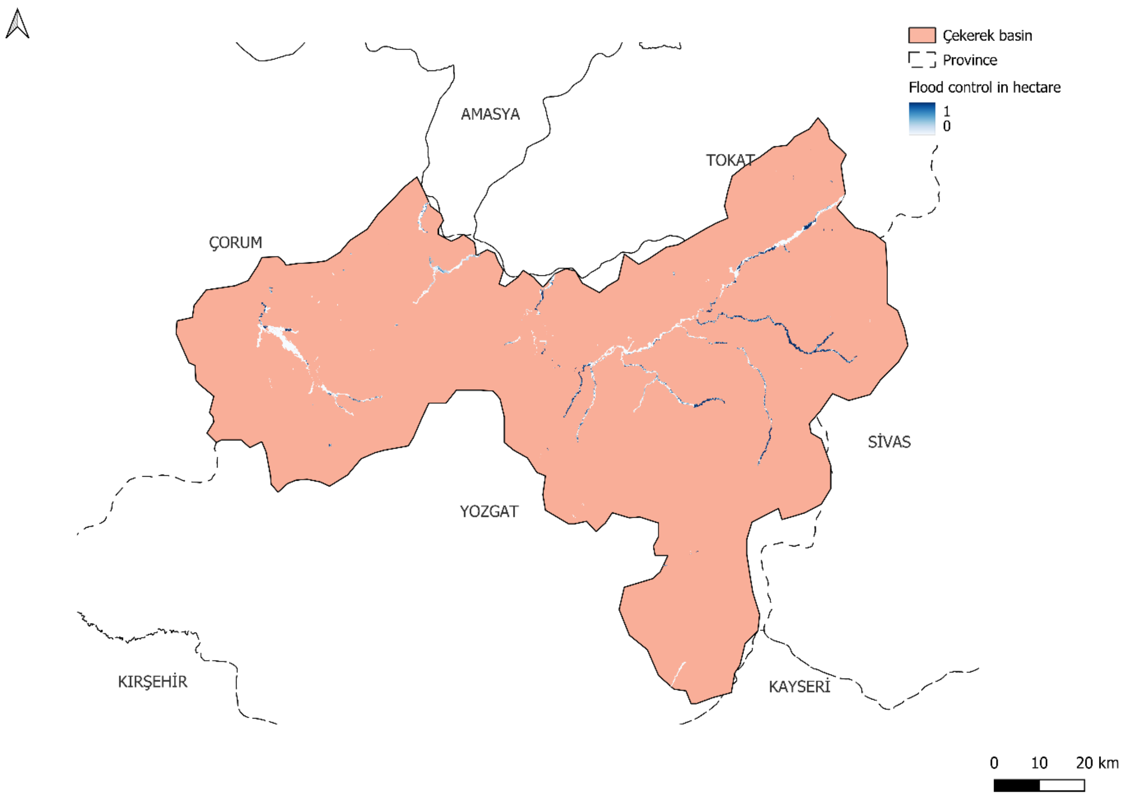
Table 89: Supply table flood protection in million TRY in 2018, Bolaman and Çekerek

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	1.3	70.36	0.28	38.59	0	0	0	0	0	0	0	0	**110.62**
Çekerek	0	27.96	4.47	26.78	0	0	0	0	0	0	0	0	**59.22**
All regions	**1.3**	**98.32**	**4.75**	**65.37**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**169.84**

Source: VITO estimates

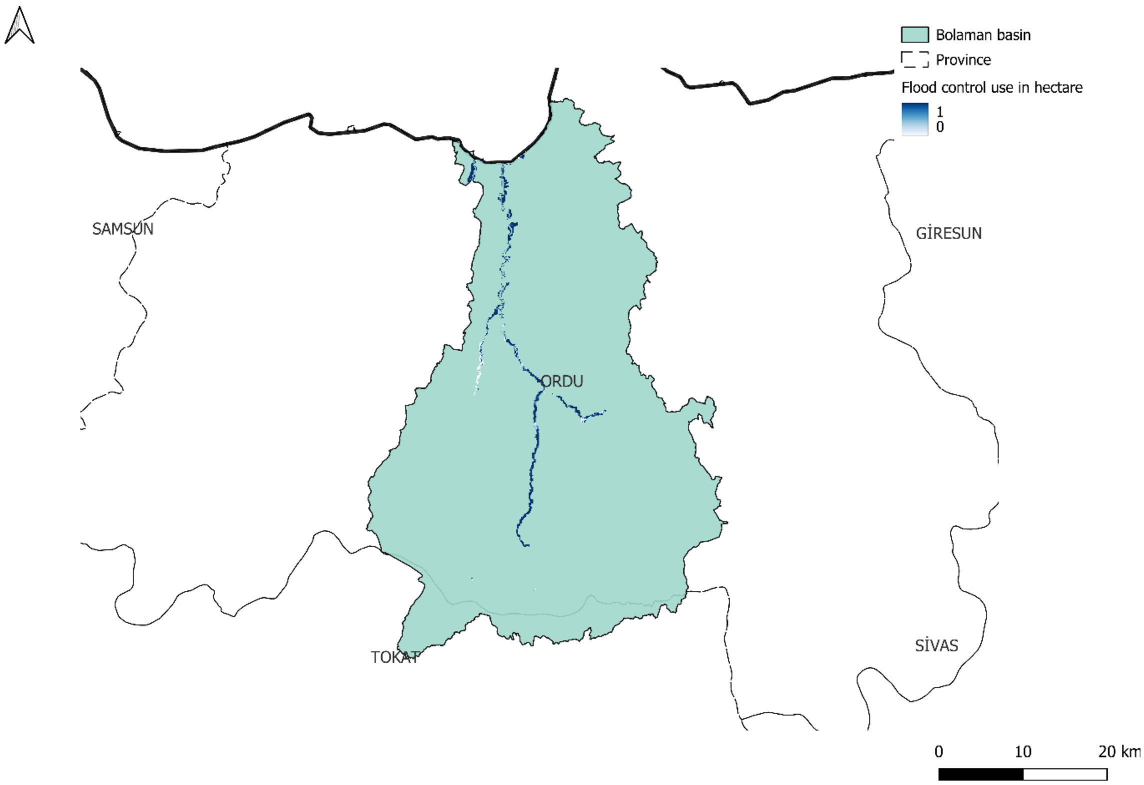
Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Figure 87: Flood control service demanding areas in hectare in 2018, Çekerek



Source: Compiled by VITO

Figure 88: Flood control service demanding areas in hectare in 2018, Bolaman



Source: VITO estimates

4.4.4 Improvement strategies

The calculation of flood control as an ecosystem service can be improved by using local datasets instead of the national, low resolution European datasets that are used now. Local flood risk maps are preferred to increase the detail and accuracy of economic assets that are under risk of flooding.

4.5 Nature-based tourism

4.5.1 Definition

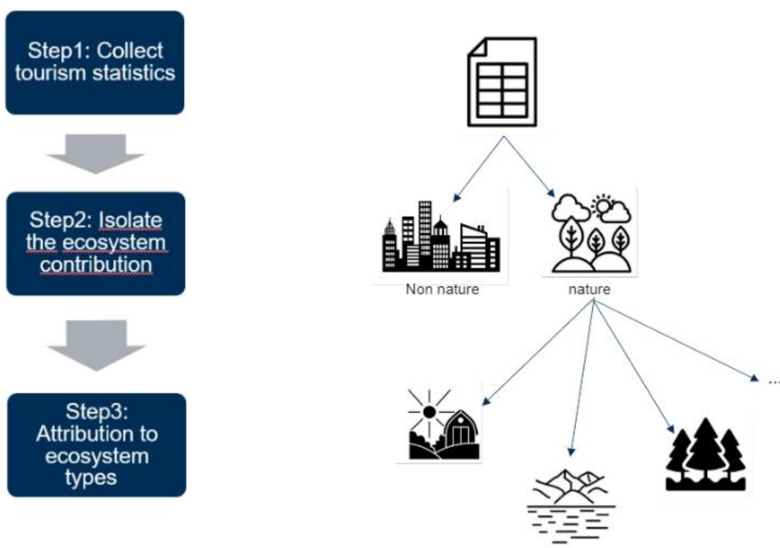
Nature-based tourism is defined as the ecosystem contribution, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in situ, physical, and experiential interactions with the environment. These contributions are reported in the number of overnight stays in hotels, hostels, camping grounds, etc. that can be attributed to visits to ecosystems.

4.5.2 Methodology and data sources

The accounting tables for nature-based tourism are calculated with the INCA tool. This section gives an overview of the methodology used in the INCA tool to calculate the nature-based tourism (NBT) service. The calculation can be summarized in 3 main steps:

- Step 1: Collection of tourism statistics.
- Step 2: Isolating the ecosystem contribution.
- Step 3: Attribution to ecosystem types.

Figure 89: Overview methodology Nature Based Tourism



Source: Compiled by VITO

NBT step 1: Tourism statistics

Step 1 of the NBT service consists of collecting annual data on overnight stays. For Türkiye, data at district level is available for the Çekerek and Bolaman basins.

NBT step 2: Ecosystem contribution

In step 2, the ecosystem contribution or percentage of overnight stays per district that we can consider "nature-based" is determined. There are different ways to split up the overnight stays from step 1 into nature-based and non-nature-based visits. The applied method is based on fixed percentages per district depending on their Degree of Urbanization (cities, towns and suburbs, rural areas). We assumed a contribution percentage of nature-based stays for cities of 30%, for towns and suburbs of 60% and rural areas of 90%, based on the default values of European guidance notes. The higher this fraction, the more visits are labeled as nature-based visits.

NBT step 3: Attribution to ecosystem types

In step 3, we assign the nature-based visits from step 3 to specific ecosystem types that can be considered “responsible” for attracting the nature-based visits. For this, we use a Recreation Potential map. Each pixel on the map is given a weight to how much it contributed to the nature-based visits. Depending on different characteristics (ecosystem type, accessibility, landscape diversity, facilities, etc.), each pixel is given an attractiveness weight. Overnight stays are spatially distributed proportionally in a district according to the weight of a pixel. By summing up all stays attributed to the pixels of a certain ecosystem type the total supply per ecosystem type can be determined.

Recreation Potential Map

A critical aspect of the methodology, both in step 2 and step 3, is the use of the Recreation Potential Map (RP map). For this study, based on the discussions in the TWGs, VITO created 2 new RP maps: one derived from the CLC map, one derived from Open street Map (OSM) data. Only the results from the CLC based RP map are presented in the integrated summary report.

Input data

The table below gives an overview of the used datasets.

Table 90: Nature-Based Tourism datasets

Dataset	Description	Source	Scale	Years
Ecosystem extent: CORINE CLCACC layers by EEA	Land cover map 2018	Corine	100×100m	2018
Tourism statistics	Overnight stays – local data from the 2 basins.	Turkstat	District level	2019, 2022
RP map	2 types of recreation potential maps were used. One based on the CLC map, and the one based on the OSM data.	VITO	100×100m	2018
Urbanization type	See column “TypeOfArea” in overnight_stays_<basin>.csv	Turkstat	Village level	/
Average Expenditure per night ($)	Average expenditures per night for each year for the whole of Türkiye	Turkstat	National	2019, 2022

Source: Compiled by VITO

For step 1, tourism statistics were delivered by Turkstat. For step 2, we used the Degree of Urbanization to get the distinction between nature and non-nature visits (urban, suburb and rural). For step 3 we used the CLC based RP map, that was developed specifically for this project.

The monetary valuation is based on tourism expenditures. We used statistics from Turkstat (average expenditure per night [$]) for each year for Türkiye. These expenditures are multiplied with the number of overnight stays. A conversion from USD to TRY for each year was based on the average exchange rate for that year.

Data was provided for 2019 until 2022. 2022 was exceptionally chosen as the 2nd reference year to decrease the effect of the COVID pandemic in the tourism statistics. It is important to note that the inflation rate between 2019 and 2022 is much higher compared to 2018 versus 2021. This has an influence on exchange rates and deflators that were applied, leading to much higher monetary nominal values in 2022 but comparable real values in 2019.

4.5.3 Results

Forest is the largest provider of nature-based visits, followed by cropland, grassland, and finally SVE Çekerek receives almost 4 times as many nature-based visits compared to the Bolaman basin. Most overnight stays are related to domestic visits, only a fraction of overnight stays[20] is from international travelers. Both Bolaman and Çekerek saw an increase in visits, which contrasts with the global trend of 2023 being the first year to surpass pre-pandemic levels (UN tourism 2024).

Table 91: Use table Nature-Based Tourism in overnight stays in 2019

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	-	76,497	-	1,185	**77,682**
Çekerek	-	-	282,966	-	2,343	**285,309**
All regions	**-**	**-**	**359,463**	**-**	**3,528**	**362,991**

Source: VITO estimates

Table 92: Use table Nature-Based Tourism in overnight stays in 2022

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	-	99,908	-	1,521	**101,429**
Çekerek	-	-	278,395	-	8,611	**287,006**
All regions	**-**	**-**	**378,303**	**-**	**10,132**	**388,435**

Source: VITO estimates

Table 93: Use table Nature-Based Tourism in nominal prices in million TRY in 2019

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	-	34.28	-	0.53	**34.81**
Çekerek	-	-	126.81	-	1.05	**127.86**
All regions	**-**	**-**	**161.01**	**-**	**1.58**	**162.67**

[20] Daily visits without accommodation in forest areas are excluded.

Source: VITO estimates

Table 94: Use table Nature-Based Tourism in nominal prices in million TRY in 2022

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	-	141.25	-	2.15	**143.40**
Çekerek	-	-	393.61	-	12.17	**405.78**
All regions	**-**	**-**	**534.86**	**-**	**14.33**	**549.19**

Source: VITO estimates

Table 95: Nature-Based Tourism in real prices in million TRY in 2022

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	-	-	48.67	-	0.74	49.41
Çekerek	-	-	135.62	-	4.19	139.82
All regions	**-**	**-**	**184.29**	**-**	**4.94**	**189.23**

Source: VITO estimates

Table 96: Supply table Nature-based tourism in overnight stays in 2019

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	1,509	29,531	370	43,737	-	-	-	2,532	-	-	-	-	77,679
Çekerek	3,315	57,089	61,138	111,749	-	49,069	-	-	2,951	-	-	-	**285,309**
All regions	**4,824**	**86,620**	**61,508**	**155,486**	**-**	**49,069**	**-**	**2,532**	**2,951**	**-**	**-**	**-**	**362,988**

Source: VITO estimates

Table 97: Supply table Nature-based tourism in overnight stays in 2022

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	2,000	38,972	375	56,723	-	-	-	3,357	-	-	-	-	**101,428**
Çekerek	3,312	55,215	62,168	114,186	-	48,800	-	-	3,324	-	-	-	**287,005**
All regions	**5,312**	**94,187**	**62,543**	**170,909**	**-**	**48,800**	**-**	**3,357**	**3,324**	**-**	**-**	**-**	**388,433**

Source: VITO estimates

Table 98: Nature-based tourism in nominal prices in million TRY in 2019

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	0.68	13.23	0.17	19.60	-	-	-	1.13	-	-	-	-	**34.81**
Çekerek	1.49	25.58	27.40	50.08	-	21.99	-	-	1.32	-	-	-	**127.86**
All regions	**2.16**	**38.82**	**27.56**	**69.68**	**-**	**21.99**	**-**	**1.13**	**1.32**	**-**	**-**	**-**	**162.67**

Source: VITO estimates

Table 99: Nature-based tourism in nominal prices in million TRY in 2022

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	2.83	55.10	0.53	80.20	-	-	-	4.75	-	-	-	-	**143.40**
Çekerek	4.68	78.07	87.90	161.44	-	69.00	-	-	4.70	-	-	-	**405.78**
All regions	**7.51**	**133.17**	**88.43**	**241.64**	**-**	**69.00**	**-**	**4.75**	**4.70**	**-**	**-**	**-**	**549.18**

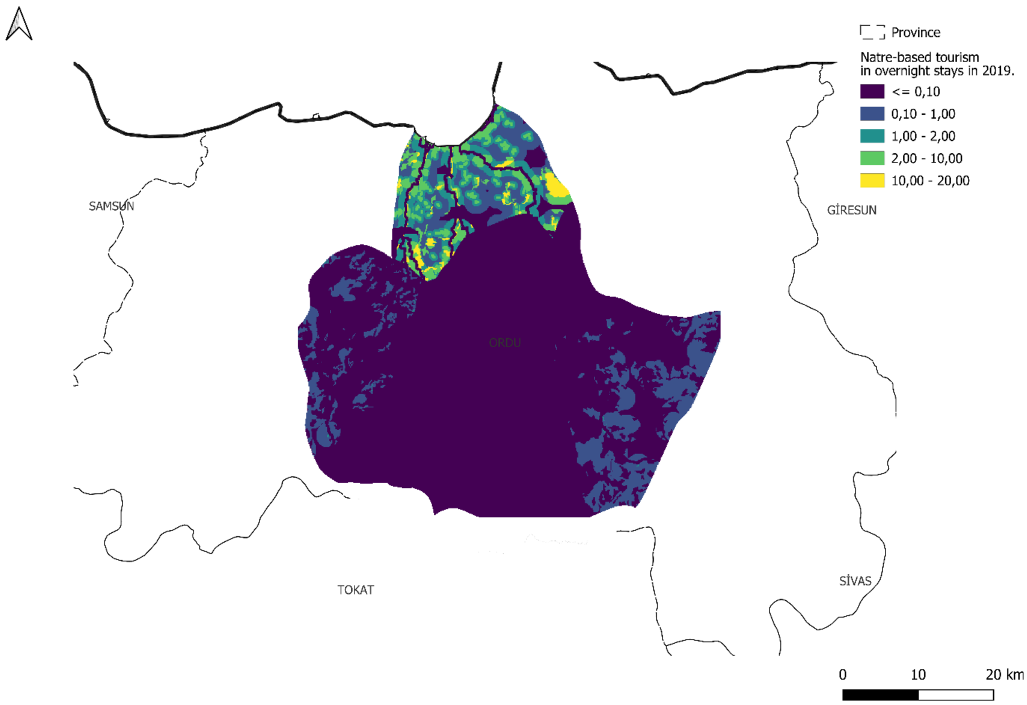
Source: VITO estimates

Table 100: Nature-based tourism in real prices in million TRY in 2022

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	0.97	18.99	0.18	27.63	-	-	-	1.64	-	-	-	-	49.41
Çekerek	1.61	26.90	30.29	55.63	-	23.77	-	-	1.62	-	-	-	139.82
All regions	**2.59**	**45.88**	**30.47**	**83.26**	**-**	**23.77**	**-**	**1.64**	**1.62**	**-**	**-**	**-**	**189.23**

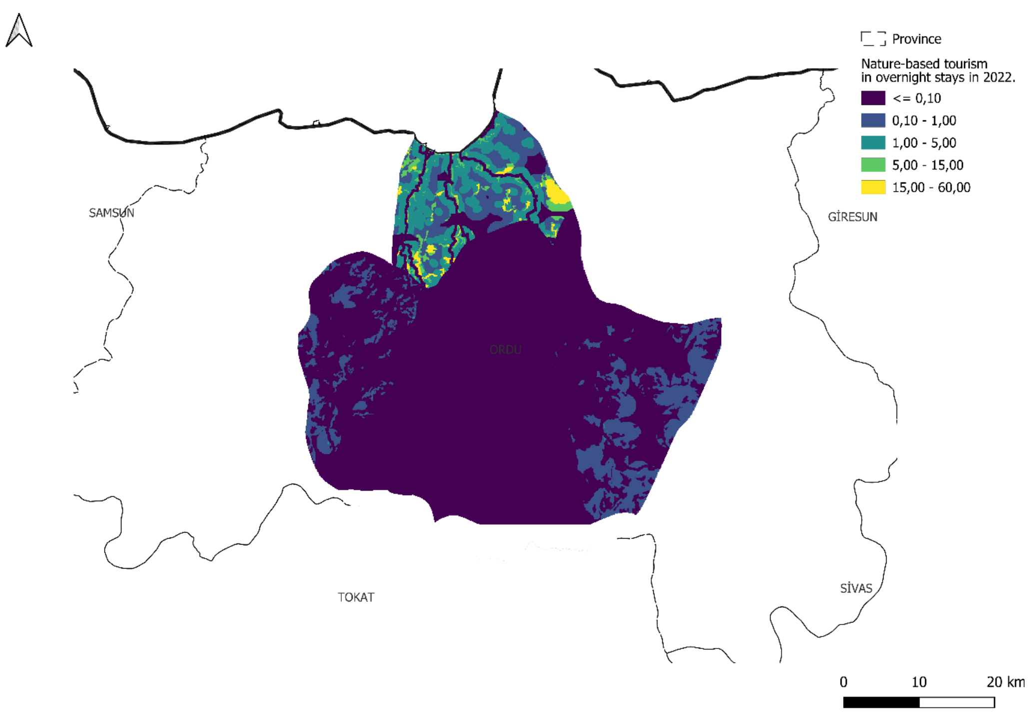
Source: VITO estimates

Figure 90: Nature-based tourism in overnight stays in 2019, Bolaman



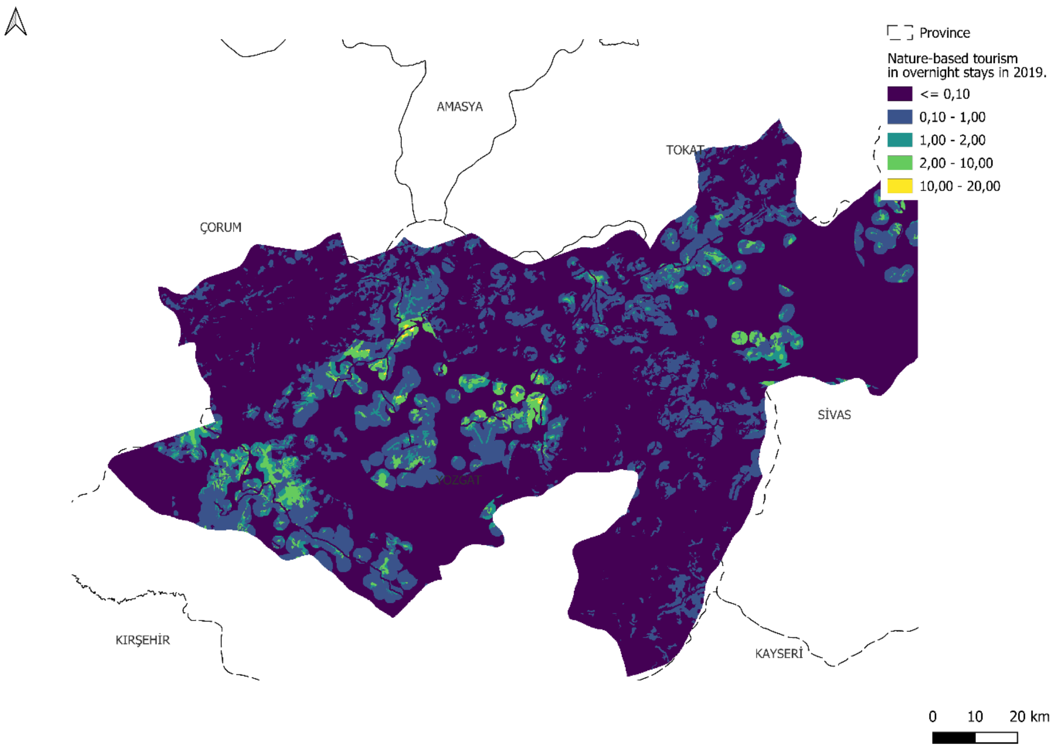
Source: Compiled by VITO

Figure 91: Nature-based tourism in overnight stays in 2022, Bolaman



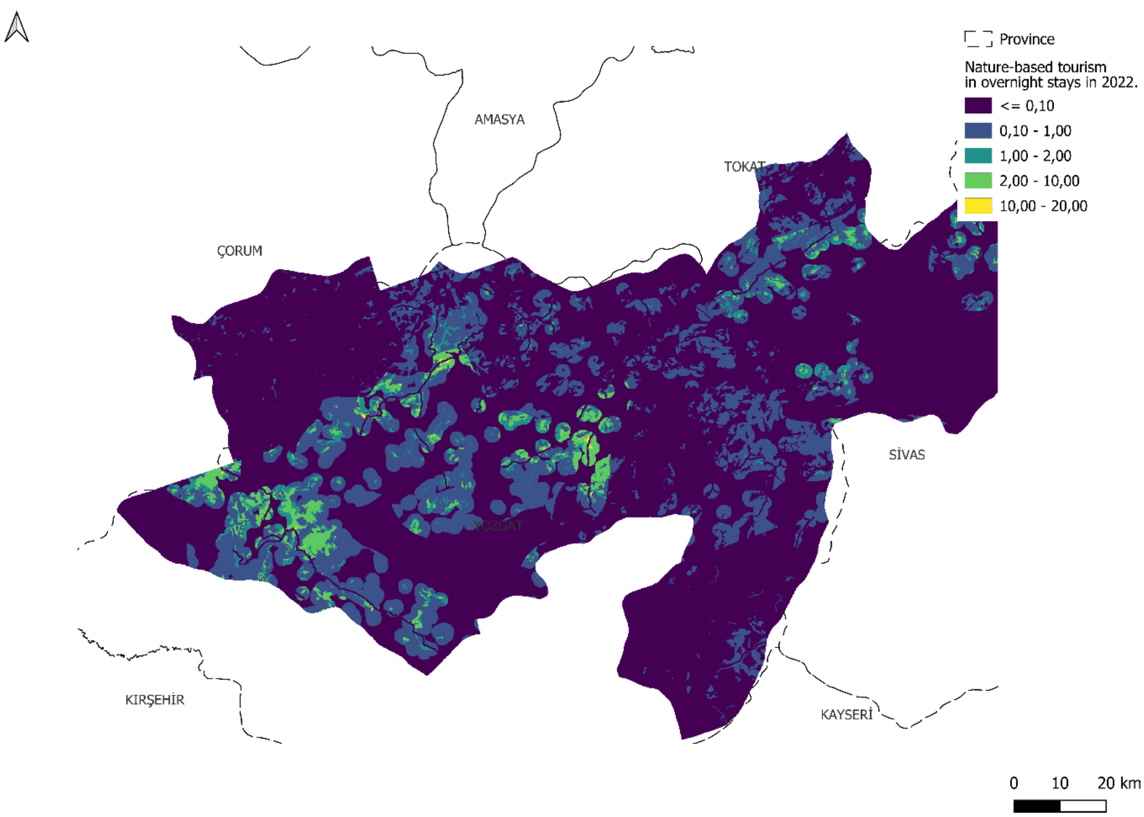
Source: Compiled by VITO

Figure 92: Nature-based tourism in overnight stays in 2019, Çekerek



Source: Compiled by VITO

Figure 93: Nature-based tourism in overnight stays in 2022, Çekerek



Source: Compiled by VITO

4.5.4 Improvement strategies

The method applied for this service relies heavily on the INCA tool and default parameters that were already integrated in the tool. Assumption made to identify the ecosystem contribution depending on the Degree Of Urbanization and create the Recreation Potential Map are discussed with a Technical Working Group. However, this deserves more attention and requires local surveys on trip purposes, data collection, expert consultation, and validation to make this a more robust method. Also, the monetary valuation is based on total tourism expenditure data, which does not make a difference between the ecosystem contribution of expenditures and the contribution from other inputs such as human and produced capital. This is the so-called tier 1 approach as mentioned in NCAVES and MAIA 2022. More advanced methods which allow to better disentangle the ecosystem contribution are travel cost methods and simulated exchange values.

An alternative recreation potential map was developed based on OSM data, but it needs further finetuning to become a robust method to apply for an account. There are many decisions to be made on which features influence the attractiveness, how these features should be mapped, and how weights for all features need to be determined. For every choice, an expert or literature reference should be consulted, which is time consuming. It does provide more flexibility and goes beyond the rather simplistic approach in the CLC based method. Although the TWG decided that the weights as presented in this document suffice, they should be revised in the future. Especially the weights of cropland should be discussed.

The identification of beneficiaries (households and exports) is based on the current state of EU guidance notes for nature-based tourism. It is in line with the SEEA EA approach. One could argue that the beneficiaries of tourism are not only households but also the hotel accommodation sector, the restaurants, etc. (income generated through NBT). The SEEA EA guidelines (UN 2021) state that the use should be assigned to households and recorded in this way irrespective of the degree to which there is involvement of businesses in facilitating or supporting the activity. In addition, a supplementary row to the use of ecosystem services can be recorded showing the connection between the ecosystem and relevant businesses. This is not performed in this study.

A conceptual improvement comes from the discussion around the carrying capacity of a natural location. When more visits equal a better service of nature to society, one might forget that too many visits can also have a detrimental effect on nature itself. This feedback loop is currently not included in the service, but it is an important element to consider moving forward. A potential way to approach this is to monitor ecosystem condition over time. If forests over time degrade, an evaluation might be needed to check whether excessive visits may have been the cause of the degradation. Another way is to involve experts for the different natural parks and consult them to provide insight on what a good threshold of number of visits.

It is important to note the limited scope of the current service. It is limited to tourism (overnight stays). Daily recreation and visits, which are often the majority of nature-based visits, are not considered in this project. It was also mentioned during technical working group meetings that day-visits to recreational areas also are an important source of (domestic) visits in Türkiye.

4.6 Soil Retention

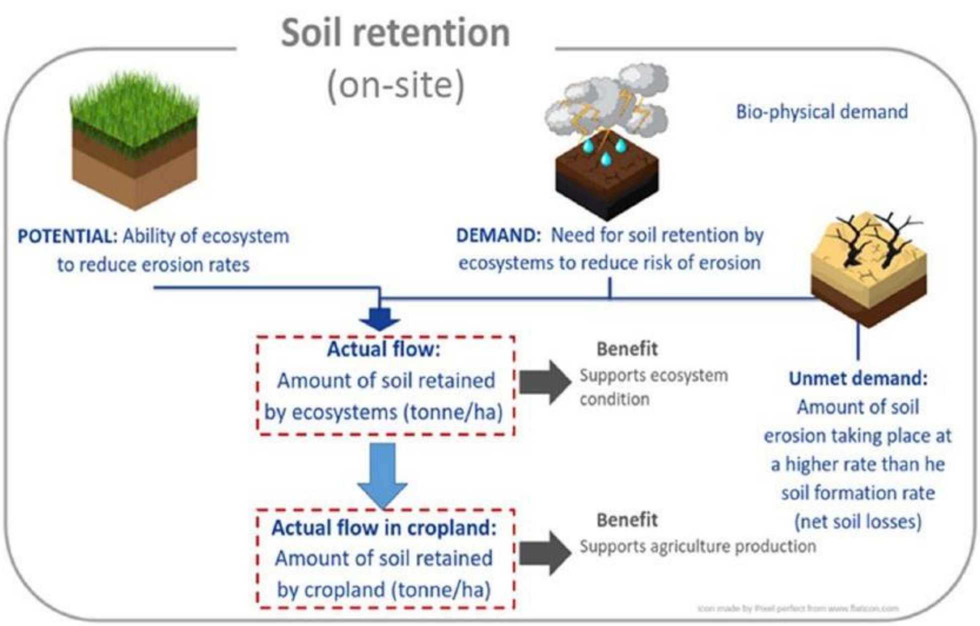
4.6.1 Definition

Soil retention services are the ecosystem contributions, particularly the stabilizing effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). It is reported in terms of thousand tonne of soil retained (UN 2021). Soil retention as an ecosystem service refers to the ability of ecosystems to reduce on-site erosion rates resulting from rainfall.

4.6.2 Methodology and data sources

Figure 94 gives an overview of the soil retention service components.

Figure 94: Visual simplification of soil retention flows from different ecosystem types



Source: Compiled by VITO

A crucial component in the calculation is the RUSLE equation. It calculates the annual soil loss per acre based on a multiplication of the following factors:

- R = rainfall erosivity
- L = slope length
- S = slope steepness
- C = cover-management factor
- P = erosion control practices
- K = soil erodibility.

The soil retention **potential** is calculated by comparing a given C-factor with the maximum and minimum C-factor. By default, the C-factor map for arable land is made up out of 2 components: the crop component and the management component. However, due to difficulties in collecting information on tillage, residues, and crop cover, the simplification was made to have the C-factor map only depend on the type of vegetation on the fields. Since land use is a very important factor for soil loss in Türkiye, we acknowledge data on this will be useful and would contribute to better estimates of soil retention. For non-arable land, a correction of the C-factor is made with vegetation density (F-cover). **Demand** is defined as the RUSLE worst case scenario, which can be calculated by setting the C-factor to burnt areas without vegetative cover (C=0.55). Soil retention, or the **flow** is defined as the Demand – the RUSLE calculated current erosion. Finally, **Unmet demand** is defined as the demand for soil erosion – the RUSLE calculated soil erosion, minus the soil formation. Soil formation is considered a constant of 1.4 tonne/ha/year.

For the monetary valuation, the model assesses the amount of N, P, and soil lost and combines this with replacement costs. Replacement costs were retrieved for each year from the EU-series (2018, 2021 in €). To derive prices in TRY from EU average data, a correction using Purchasing Power Parity (PPP) was done. We used the following formula:

$Vp = Vs (Yp/Ys)$,

where Y is the purchasing power adjusted income per capita, V is the value estimate for a given service, p is the policy site for which an estimate is required, and s the study site for which a value already exists. Values for Yp and Ys were retrieved from the EOCD databases. For s, an average for all EU member states in 2018 and 2021 was made.

The table below gives an overview of the used datasets.

Table 101: Soil retention datasets

Dataset	Description	Source	Scale	Years
Ecosystem extent: CORINE CLCACC layers by EEA	Land cover maps 2000, 2006, 2012, 2018	Corine	100×100 m	2018
C-factor map	RUSLE C-factor map, accounting for the effects of land cover	ARIES for PEOPLE-EA explorer	2×2 km (resampled to 100×100 km)	2018
K-factor map	RUSLE K-factor map, accounting for the effects of soil erodibility	ARIES for PEOPLE-EA explorer	2×2 km (resampled to 100×100 km)	2018
LS factor maps	Slope and length-factor map, accounting for the effects of slope and slope length	ARIES for PEOPLE-EA explorer	2×2 km (resampled to 100×100 km)	2018
R-factor map	RUSLE R-factor map, accounting for the effects of rainfall erosivity	ARIES for PEOPLE-EA explorer	2×2 km (resampled to 100×100 km)	2018
Topsoil N content	Topsoil N content (0–30cm)	Isric World Soil Information: SoilGrids	2×2 km (resampled to 100×100 km)	2018
Topsoil P content	Topsoil P content (0–30cm)	Global patterns and drivers of soil total phosphorus concentration	2×2 km (resampled to 100×100 km)	2018
Retention ratio	Factor that describes how much more nutrients need to be added to compensate nutrient loss due to soil erosion	EU 2021 series	National	2018

Dataset	Description	Source	Scale	Years
Nutrient and bulk soil prices	Replacement cost for nutrients (N, P) and bulk soil, corrected for purchasing power parity (PPP).	EU 2021 series, OECD	National	2018, 2021

Source: Compiled by VITO

4.6.3 Results

In Table 86, the use of soil retention is summarized for Bolaman and Çekerek basins. In Bolaman, soil retention is almost a factor of 3 higher compared to Çekerek. This is because of the more mountainous character of the landscape in Bolaman: the protective cover of vegetation is more important here. All use is allocated to the intermediate consumption by industries since we consider agricultural fields as the users of soil retention. The only change in input data between 2018 and 2021 is the land cover and the resulting C-factor map. But since the CLC map of 2018 had to be used for 2021, there are no actual changes between 2018 and 2021 in biophysical terms. The monetary valuations did change since prices changed between 2018 and 2021 but when looking at the prices corrected for inflation the difference is almost (due to rounding factors) reduced to 0.

Table 102: Use table soil retention in 1,000 tonne in 2018

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	32,827	-	-	-	-	**32,827**
Çekerek	14,333	-	-	-	-	**14,333**
All regions	**47,159**	**-**	**-**	**-**	**-**	**47,159**

Source: VITO estimates

Table 103: Use table soil retention in 1,000 tonne in 2021

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	32,827	-	-	-	-	**32,827**
Çekerek	14,333	-	-	-	-	**14,333**
All regions	**47,159**	**-**	**-**	**-**	**-**	**47,159**

Source: VITO estimates

Table 104: Use table soil retention in nominal prices in million TRY in 2018

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	684	-	-	-	-	**684**
Çekerek	297	-	-	-	-	**297**
All regions	**981**	-	-	-	-	**981**

Source: VITO estimates

Table 105: Use table soil retention in nominal prices in million TRY in 2021

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	1,116	-	-	-	-	**1,116**

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Çekerek	502	-	-	-	-	**502**
All regions	**1,618**	-	-	-	-	**1,618**

Source: VITO estimates

Table 106: Use table soil retention in real prices in million TRY in 2021

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total
Bolaman	686	-	-	-	-	**686**
Çekerek	298	-	-	-	-	**298**
all regions	**984**	-	-	-	-	**984**

Source: VITO estimates

In Table 88, the supply of soil retention for each pilot site is summarized. The ecosystem types that provide the most soil retention are forests and woodland, followed by cropland and then grassland.

Table 107: Supply table soil retention in 1,000 ton in 2018

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	385	32,827	4,337	16,987	-	65	-	102	3	-	-	-	**54,707**
Çekerek	552	14,333	6,620	38,144	-	8,555	-	-	207	-	-	-	**68,411**
All regions	**937**	**47,159**	**10,957**	**55,132**	-	**8,620**	-	**102**	**210**	-	-	-	**123,118**

Source: VITO estimates

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Table 108: Supply table soil retention in 1,000 ton in 2021

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	385	32,827	4,337	16,987	-	65	-	102	3	-	-	-	**54,707**
Çekerek	552	14,333	6,620	38,144	-	8,555	-	-	207	-	-	-	**68,411**
all regions	**937**	**47,159**	**10,957**	**55,132**	-	**8,620**	-	**102**	**210**	-	-	-	**123,118**

Source: VITO estimates

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Table 109: Supply table soil retention in nominal prices in million TRY in 2018.

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	684	-	-	-	-	-	-	-	-	-	-	684
Çekerek	-	297	-	-	-	-	-	-	-	-	-	-	297
All regions	-	**981**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**981**

Source: VITO estimates

Table 110: Supply table roil retention in nominal prices in million TRY in 2021.

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	1,156	-	-	-	-	-	-	-	-	-	-	1,156
Çekerek	-	502	-	-	-	-	-	-	-	-	-	-	502
All regions	-	**1,658**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1,658**

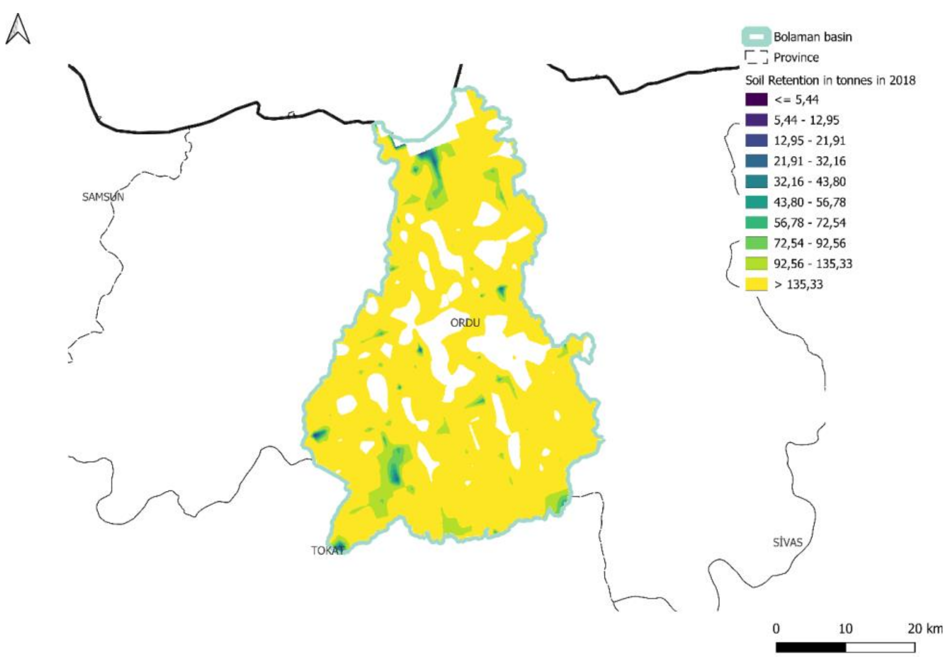
Source: VITO estimates

Table 111: Soil retention in real prices in million TRY in 2021.

	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)	**Total**
Bolaman	-	686	-	-	-	-	-	-	-	-	-	-	686
Çekerek	-	298	-	-	-	-	-	-	-	-	-	-	298
All regions	-	**984**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**984**

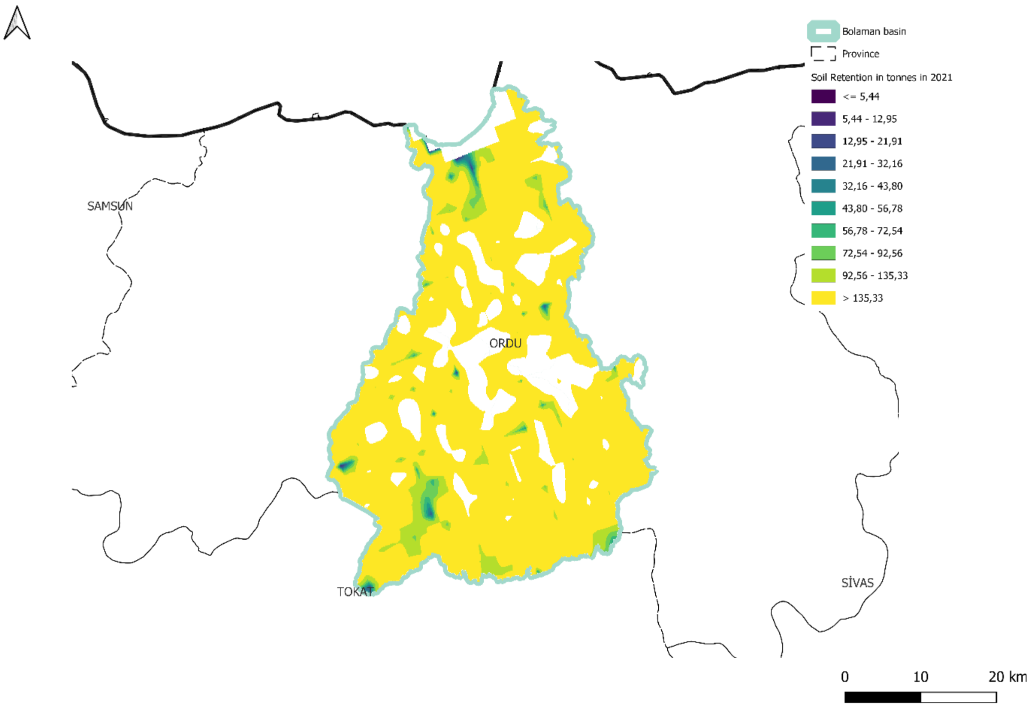
Source: VITO estimates

Figure 95: Soil Retention in tonne in 2018, Bolaman



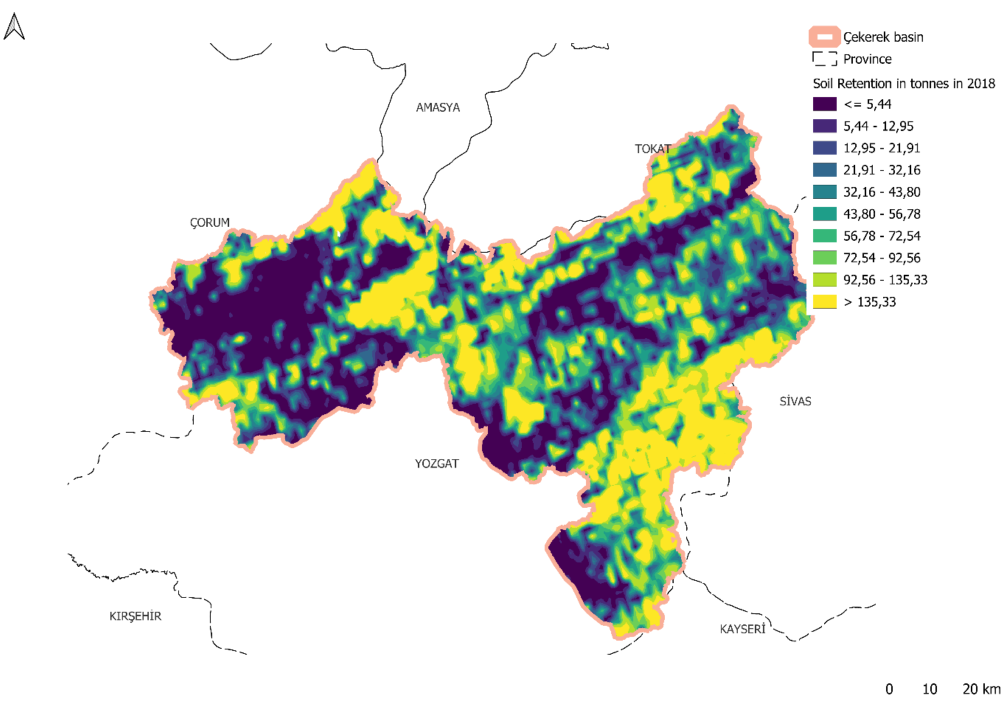
Source: Compiled by VITO

Figure 96: Soil Retention in tonne in 2021, Bolaman



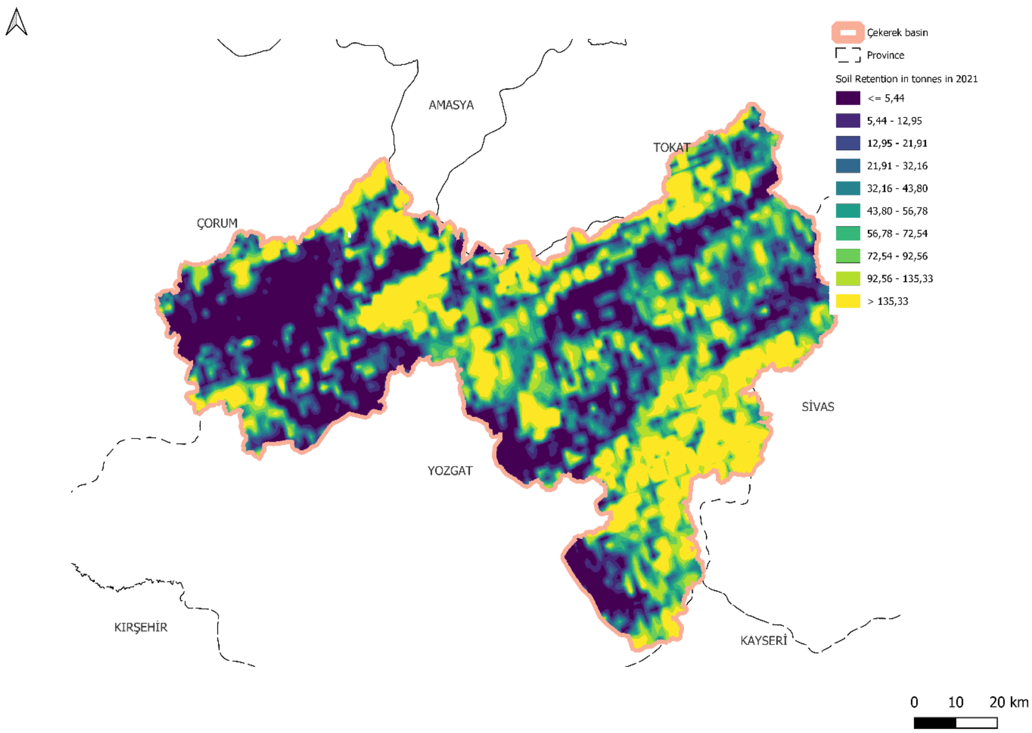
Source: Compiled by VITO

Figure 97: Soil Retention in tonne in 2018, Çekerek



Source: Compiled by VITO

Figure 98: Soil Retention in tonne in 2021, Çekerek



Source: Compiled by VITO

4.6.4 Improvement strategies

The quantification of this service relies heavily on RUSLE maps.

RUSLE maps were retrieved from the ARIES for PEOPLE-EA explorer. These are global gridded datasets, and do not give the spatial detail as when performed with national generated maps. We would highly recommend collecting and rerunning the service with these national datasets when they are made available.

A similar recommendation goes for the topsoil N and P maps. They were also retrieved from global gridded datasets. For the EU, we can see a significant difference in topsoil nutrient concentrations when comparing these global datasets with maps generated at a higher spatial detail (500 by 500 m). Such maps were generated in the EU by Ballabio et al. (2016). The monetary valuation, which relies on topsoil N and P content, will be significantly impacted by this. In Europe, reliable topsoil N and P maps were generated by collecting a large dataset of topsoil samples (n= 22,000) and performing a spatial regression analysis. To achieve similar topsoil nutrient maps for Türkiye, we would recommend setting up similar soil sampling campaigns or aligning with the directorates who might already have collected such data.

Currently, only on-site effects of erosion were considered making the monetary valuation. For this, by far the most relevant ecosystem type is cropland, since soil loss will lead to a reduced crop productivity. For other ecosystem types, this is less impactful.

However, a future improvement would be to also quantify the off-site effects of soil erosion, for example, soil that ends up in rivers or canals. This would result in additional dredging costs, that can be reduced through soil retention. This analysis becomes more complicated, however, since not all soil lost from the hillslopes ends up in canals or rivers, since redeposition of soil material may occur along the way to those soil sinks. Hence, the soil erosion quantification through the RUSLE equation would not suffice. Software programs such as WaTEM/SeDEM also take into account deposition and might serve as a further improvement.

4.7 Integrated monetary ecosystem account

In this section, you can find for each pilot basin the integrated monetary ecosystem accounts, both the supply and use tables.

The integrated monetary accounts demonstrate the relevant importance of individual ecosystem services and the degree in which ecosystem types contribute to the delivery of ecosystem services. Bolaman and Çekerek are low populated areas where crop provision plays a major role. This is confirmed in the integrated monetary account where crop provision is the most important service, expressed in monetary units. Soil retention is the second most valued service in the table. This service also has a close connection to crop provision and the potential loss of fertile soils due to erosion. Especially in Bolaman, this service is very important as this is an erosion-sensitive area. The safeguarding of ecosystems like forests is in that sense important for the supply of crucial services like soil or water retention. The local challenges due to a strong relief, rainfall or climate change vulnerability will stress the value of these regulating services even more. Expressed in monetary terms, nature-based tourism is of less importance. Tourism in general in these two pilot sites is of less importance compared to other areas in Türkiye.

The ecosystem type cropland delivers the most services according to the integrated account. Grassland and forests are other important ecosystem types.

It is important to note that only a limited set of ecosystem services are modeled. When considering a wider range, results might change heavily.

The main user is "Intermediate consumption by industries" before households. Especially provisioning services which in first instance serve industry (and agriculture) play a dominating role in this. Other services where the major users are households or government are not dominant when expressed in monetary terms.

Table 112: Monetary account overview of supply in 2018, Bolaman

Supply table 2018 **Bolaman** **in Million TRY**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**Total**
Crop provision		620	109							**729**
Wood provision				23						**23**
Global climate reg.				1						**1**
Flood control	1	70	0	39	0	0	0	0	0	**111**
Soil retention	-	684	-	-	-	-	-	-	-	**684**
Nature-based tourism	1	13	0	20	-	-	-	1	-	**35**
Total in million TRY	**2**	**1,387**	**109**	**83**	**0**	**0**	**0**	**1**	**0**	**1,584**

Source: VITO estimates

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Table 113: Monetary account overview of supply in 2021 in real prices, Bolaman

Supply table 2018 **Bolaman** **in Million TRY**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**Total**
Crop provision		705	133							838
Wood provision				28						28
Global climate reg.				1						**1**
Flood control	1	70	0	39	0	0	0	0	0	**111**
Soil retention	-	684	-	-	-	-	-	-	-	**684**
Nature-based tourism	1	19	0	28	-	-	-	2	-	-
Total in million TRY	**2**	**1,480**	**133**	**95**	**0**	**0**	**0**	**2**	**0**	**1,712**

Source: VITO estimates
Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Table 114: Monetary account overview supply in 2018, Çekerek

Supply table 2018 **Çekerek** **in Million TRY**	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**total**
Crop provision		483	281							**764**
Wood provision				59						**59**
Global climate reg.				7						**7**
Flood control	0	28	4	27	0	0		0	0	**59**
Soil retention	-	297	-	-	-	-	-	-	-	**297**
Nature-based tourism	1	26	27	50	-	22	-	-	1	**128**
Total in million TRY	**1**	**834**	**312**	**143**	**0**	**22**	**0**	**0**	**1**	**1,314**

Source: VITO estimates

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Table 115: Monetary account overview supply in real prices 2021, Çekerek

Supply table 2021 Çekerek in Million TRY	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	**total**
Crop provision		719	166							**885**
Wood provision				137						**137**
Global climate				4						**4**
Flood control	0	28	4	27	0	0	0	0	0	**59**
Soil retention		297								**297**
Nature-based tourism	2	27	30	56		24			2	**140**
Total in million TRY	**2**	**1,072**	**201**	**223**	**0**	**24**	**0**	**0**	**2**	**1,523**

Source: VITO estimates
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Table 116: Monetary account overview use in 2018, Bolaman

Use table 2018 Bolaman in Million TRY	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	total
Crop provision	729	-	-	-	-	**729**
Wood provision	23					**-**
Global climate regulation		1				**1**
Flood control	21	-	90			**111**
Soil retention	684	-	-	-	-	**684**
Nature-based tourism	-	-	34	-	1	**35**
Total in million TRY	**1,457**	**1**	**124**	**-**	**1**	**1,560**

Source: VITO estimates
Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Table 117: Monetary account overview use in real prices in 2021, Bolaman

Use table 2021 **Bolaman** **in Million TRY**	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	**Total**
Crop provision	838					**838**
Wood provision	28					**28**
Non-wood provision (kg)						**0**
Global climate regulation		1				**1**
Flood control	21	0	90			**111**
Soil retention	686					**686**
Nature-based tourism			49		1	**50**
Total	**1,572**	**1**	**139**	**0**	**1**	**1,713**

Source: VITO estimates

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Table 118: Monetary account overview use in 2018, Çekerek

Use table 2018 **Cekerek** **in Million TRY**	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	**Total**
Crop provision	764					**764**
Wood provision	59					**59**
Global climate regulation		7				**7**
Flood control	29	0	31			**60**
Soil retention	297					**297**
Nature-based tourism			127		1	**128**
Total	**1,149**	**7**	**158**	**0**	**1**	**1,315**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Table 119: Monetary account overview use in real prices in 2021, Çekerek

Use table 2021 **Cekerek** **in Million TRY**	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	**Total**
Crop provision	885					**885**
Wood provision	137					**137**
Global climate regulation		4				**4**
Flood control	29	0	31			**60**
Soil retention	297					**297**
Nature-based tourism			136		4	**140**
Total	**1,348**	**4**	**167**	**0**	**4**	**1,523**

Source: VITO estimates

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5 CAPACITY BUILDING

5.1 Training program

Besides the production of accounts, a training program was provided for capacity building. The overall objective of these trainings was to provide technical staff from the ministries of planning, economy, statistical agencies, and allied sectoral/regional offices with the basic knowledge, essential technical skills, methodologies, and tools they need to implement a System of Economic and Environmental Accounting (SEEA EA) at the national level for forest ecosystems. A second objective was to facilitate the sharing of experience between the 2 pilot sites and the national level.

The training program was a combination of face-to-face sessions with trainers, online sessions (webinars), and self-paced e-learnings. The program was split in three phases: (i) introduction of methodologies, tools, and datasets; (ii) supervised self-study to deepen the knowledge; (iii) hands-on training to ensure reproducibility of generating the accounts.

The training courses were accompanied by a Training Manual, in which the training schedule is described, as well as useful links and tools to be put in place in order to develop a national SEEA EA system. The e-learnings (in English) used the available materials from UNSD (see https://seea.un.org/content/seea-e-learning-resources), ARIES (upcoming end 2023) and INCA (upcoming end 2023). The SEEA EA e-learning is comprised of 8 modules, taking about 20 hours and recommended to follow on average one module per week. A zoom link was provided by VITO. Two webinars were organized during the e-learnings. The purpose of the webinars was to follow up progress and provide additional feedback.

The hands-on trainings were set up for Turkstat and other relevant agencies to compile the accounts for Türkiye' at national scale or lower tiers. It focused on reproducing accounts, and how new, future data sources could be introduced.

The table below shows the schedule for the training modules.

Module 1 aimed to establish a good understanding of SEEA EA and its terminology. After this module, local partners were able to interpret ecosystem accounts and to see how the methodology and tools fit in the SEEA EA framework.

Module 2 aimed to train statistical officers basic GIS knowledge in case they need it and introduced common NCA datasets and tools. After this training, Turkstat (and its GIS office) and OGM were able to load land cover maps, extent maps in the GIS and to start producing basic maps. They were able to do basic manipulation with the tools, INCA for ecosystem services accounts and SEEA 4 Aries for compiling condition extents.

Module 3 aimed to train the producers of extent accounts the details of compiling them. After this module, local partners were independently able to start producing extent accounts and to think on the method's shortcomings and possible improvements.

Module 4 aimed to train the producers of accounts on the details of condition accounts. The workflow from measuring the ecosystem' condition, translating them into indicators and aggregating with weights into indices was explained. At the end, they were able to make new condition accounts, introduce new condition metrics.

Module 5 aimed to train the producers of accounts and relevant governmental agencies on the production of the discussed ecosystem services. Attention was given to the terminology of the supply and use of ecosystem services. The biophysical modelling and its use in the INCA tool were also explained. After this training, they were able to produce ecosystem services accounts and use the modelling framework to make suggestion and additions to future accounts.

Module 6 aimed to train the producers of accounts and relevant governmental agencies on the monetary valuation of ecosystem services. The methods used in the INCA tool were explained but also other possible monetary valuation techniques and key challenges, e.g., the monetary valuation of nature-based tourism. After this module, users were able to produce ecosystem accounts with a monetary valuation in the INCA tool. They also gathered knowledge on possible monetary valuation methods.

Module 7 aimed to guide the producers of accounts with reproducing the extent account for a certain year. It aimed to train the technical experts of the governmental agencies on compiling and reporting extent accounts. After this module, they were able to reproduce an exact copy of the original extent account independently.

Module 8 aimed to guide the producers of accounts with reproducing the condition account for a certain year. It aimed to train the technical experience of the governmental agencies on compiling and reporting condition accounts. After this module, they were able to reproduce an exact copy of the original condition account independently.

Module 9 aimed to guide the producers of accounts with reproducing the ecosystem services account for a certain year. It aimed to train the technical experience of the governmental agencies on compiling and reporting ecosystem services accounts. After this module they were able to reproduce an exact copy of the ecosystem services condition account independently.

In Table 3, an overview of the timing of the training modules is given. Modules 1 and 2 on the introduction of methodologies, tools and datasets are foreseen at the end of February. Modules 3 to 6 are organized between March and May to allow participants to perform the e-courses and to plan webinars between VITO and the Turkish partners to facilitate the trainings. Modules 7 to 9 with the focus on ensuring reproducing the accounts independently are organized in May.

After the first training (modules 1 and 2), a meeting will be held or a part of the technical workgroup meeting will be used to discuss on which topics Türkiye wants to focus. Based on these insights, an EU member state will be selected and VITO will organize an exchange visit if the selected member state has the ability to cooperate.

Table 120: Overview training modules

Training module	Format	Audience
Module 1: SEEA EA introduction Overview of concepts and methodology Description of SEEA EA ecosystem core accounts SEEA EA vs. national accounts (SNA): differences and consistencies	Face to face #1	Producers and Consumers of accounts (Turkstat, OGM, SBB)
Module 2: Introduction to data needs, GIS spatial analysis and map production Core datasets for the production of ecosystem extent and some ecosystem services accounts GIS: Data loading, integration of different data sets (e.g. raster and vector) using GIS tools, production of maps INCA Tool: Introduction SEEA 4 ARIES Tool: Introduction	Face to face #1	Producers of accounts (Turkstat, OGM)
Kick-off: Introduction of the e-learning courses	Face to face #1 / Webinar	
Module 3: Accounting for Ecosystem extent Ecosystem extent account – overview	E-learning (+ self-assessment)	Producers of accounts (Turkstat, OGM)

Training module	Format	Audience
Spatial units in SEEA EA Ecosystem type classifications (IUCN GET) How to build ecosystem extent accounts: data extraction from GIS, building accounts from extracted datasets		
Module 4: Accounting for Ecosystem condition How to measure ecosystem condition - SEEA Ecosystem Condition Typology Reference condition, reference levels, and rescale ecosystem variables to ecosystem condition indicators Aggregate the indicators to a single ecosystem condition index.	E-learning (+ self-assessment)	Producers of accounts (Turkstat, OGM)
Mid-course webinar on Modules 1/2/3/4: Q&A	Webinar	
Module 5: Spatial modelling for compiling Ecosystem Services biophysical accounts Spatial aspects of ecosystem services supply and use (SPA, SBA, SCA) Methods to map and assess spatial aspects of ecosystem services. Challenges of spatial modelling of selected ES Exercises on Spatial modelling [face to face]	E-learning (+ self-assessment)	Producers of accounts (Turkstat, OGM, relevant departments by interest)
Module 6: Monetization of ecosystem service accounts Monetary valuation for ecosystem services in the SEEA Key challenges in monetary valuation	E-learning (+ self-assessment)	Producers of accounts (Turkstat, OGM, relevant departments)
Final e-learning webinar **Q&A and preparation for the face-to-face session**	Webinar	
Module 7: Hands-on exercise Ecosystem Extent Ecosystem extent account – recap theory SEEA4ARIES tool for extent accounting Exercise: generation of Tier-1 national account	Face to face #2	Producers of accounts (Turkstat, OGM,)
Module 8: Hands-on exercise Ecosystem Condition Ecosystem condition accounts – recap theory SEEA4ARIES tool for condition accounting Exercise: generation of condition accounts at Watershed	Face to face #2	Producers of accounts (Turkstat, OGM)
Module 9: Hands-on exercise Ecosystem Services Ecosystem service biophysical accounts – recap theory Ecosystem service monetary accounts – recap theory INCA tool for service accounting Exercise: generation of service accounts	Face to face #2	Producers of accounts (Turkstat, OGM, relevant departments by interest)
Face-to-face session **for modules 3 to 6 (quick review of module content, Q&A) and for modules 7 to 9 (practical exercises)**	Face to face#2	

5.2 Knowledge exchange with EU-member state – Germany

With the purpose of introducing Turkish stakeholders on how to create a roadmap for NCA and how NCA can be used in further policy application, a knowledge exchange meeting was set up with the German statistical office (Deutsche Statistisches Bundesamt - Destatis).

The meeting was attended by four experts from Destatis that are working on ecosystem accounts. Destatis is responsible for creating the extent and services accounts; the (forest) condition account is managed by the Thünen research institute. From the Turkish partners, Turkstat's ecosystem accounts team and representatives of the Ministry of Agriculture and Forestry were attending this meeting. VITO and World Bank representatives also participated.

Destatis started the presentation by showing a timeline of their ecosystem accounting trajectory. They started in 2020 on the extent account and were able to have a first publication in 2021. They explained that it was very important to spend a lot of time to create a high-quality extent map, as this is the starting point for many accounts. They faced some challenges during this process which are also relevant for the future Turkish roadmap. One challenge was aligning and harmonizing a suitable national ecosystem extent classification with international standards and reporting systems. It is important to map the national classes to their corresponding EU classes. The second challenge was to get the extent account consistent over time to derive trends, meaning that the extent maps need to be updated in each reporting cycle with validated input data such as earth observation data and cadastral data sources. This requires a trade-off between quality/validation and the length of the reporting cycles. They gradually expanded the publication of these maps and accounts by disclosing the data on an online portal (https://oekosystematlas-ugr.destatis.de/), providing factsheets and producing other ways of visualization and communication.

Destatis and the Thünen research institute monitor and report the ecosystem condition accounts with 44 variables which are collected with remote sensing or with existing monitoring programs. The main challenge was to decide which condition variables are relevant and how to aggregate them. The first account was published in 2023.

Destatis closely follows the EU legislation and guidance on the ecosystem services accounts, and they are also present in the member state task force meetings. They stressed that each service needs specific expertise and the involvement of specific stakeholders. They are aware of the INCA tool and know its use, but they adapted the methodology (by still being compliant), so that results better fit the local context and policy needs. They mainly work in a python/ESRI environment while the INCA tool is built for the open-source system of python/Qgis. They work currently on local and global climate regulation, air filtration and nature-based tourism. The latter was discussed more in detail. The key take-aways are that official overnight stays datasets are combined with platform data like Airbnb. Business trips were excluded. They developed an own recreation potential map (landscape aesthetic quality map) similar to the potential map needed in the INCA tool. No work on monetary valuation is done. The first published version is planned for 2025.

In the future, they want to harmonize and align with other official statistics like the European Forest Accounts, LULUCF/GHG Inventories, National Accounts. They want to expand the services with wood provision, crop provision, soil erosion and flood protection. They want to mainstream the accounts by looking at different user perspectives, other reporting levels. Also securing funding/resources for further developments is important.

By 2026, they are obliged to report ecosystem accounts to Eurostat.

Destatis confirms that monetary valuation is challenging due to stakeholders' interests and misinterpretation of results. Framing the right messages is important. Therefore, only by 2026, they aim to have a first concept for the monetary ecosystem service accounts.

6 ROADMAP TOWARD DEVELOPING AND INSTITUTIONALIZING NATURAL CAPITAL ACCOUNTING IN TURKIYE

6.1 Objective

The objective of this chapter is to set up recommendations for a roadmap with steps to be taken for upscaling natural capital accounting toward the whole of Türkiye.

These recommendations are based on experiences and stakeholder contacts during the project and the development of the pilot accounts. Specifically, workshops were organized to discuss the content of the roadmap, and a knowledge exchange session was organized with the German Statistical Office.

The technical working group meetings and the knowledge exchange revealed that there will be work and steps to take in setting up the right organizational settings.

We can mention that the procedure for the inclusion of ecosystem accounts in the Official Statistics Program (RIP) has begun and that it will take a series of high-level approvals until legislation.

The roadmap should be calibrated with the specific goals Türkiye wants to achieve by developing and using the three different accounts. The next section on potential policy objectives can serve as an inspiration or a direction.

6.2 Potential policy objectives of NCA

Since 2021, the SEEA EA has been accepted as the standard by the UN, EC, OESO, World Bank, and other large organizations (de Jongh 2021). With national data on NCA becoming more and more accessible, it seems a matter of time before NCA becomes widespread in policies. To develop a roadmap, it is essential to consider possible policy objectives as this also has an important influence on the priority of accounts and the methods applied to compose them.

Besides NCA, there are several international agreements that relate to natural capital in some way or other. The Global Biodiversity Framework stipulates that further loss of biodiversity must be prevented, and the European Natura 2000 guidelines indicate that the quality of habitats and species richness in Natura 2000 areas must not deteriorate. Both rely on ecosystem condition calculations (de Jongh 2021). Furthermore, there is the Paris climate agreement and the Sustainable Development Goals (SDGs), in which ecosystem services accounts can play a crucial role.

Trying to capture every service that the ecosystem delivers seems a daunting task but what can help is implementing services step by step. It also helps to divide ecosystem accounting goals according to their administrative levels, uses, and beneficiaries. The benefits of climate regulation are global and are linked to government objectives on reducing carbon emission. Non-wood provisioning often supports local households. Soil retention prevents environmental damages and degradation. In the Netherlands strategic plans for the management of the environment exists at several levels (national, provincial, municipal). They address the interconnections between space for housing and economic activities, water, the environment, nature, landscape, and cultural heritage. NCA is used here to quantify the progress in several of these topics (de Jongh 2021).

A last important message is about decreasing or increasing the value of ecosystem services. Decreasing values of natural assets does not mean that there is ecosystem degradation or less biophysical use. It can mean that the exchange value of the products of the service is decreasing, for example for crop or timber. This holds true in the other direction as well—it is possible to have more degraded ecosystems and less of an ecosystem service (for example, forest delivering flood protection) while the value of the flow is higher (the real estate in the flood risk areas is valued much higher due to development). At this moment, natural capital accounts do not explicitly reflect that message and local expertise is needed.

6.3 Methodological improvements / potential modelling approaches

6.3.1 Ecosystem extent account

Extent or land use maps form the solid foundation of ecosystem accounting but without a validated map supported by local partners, all ecosystem accounts results will suffer from a strong distrust and will always be up for debate. Therefore, it should receive the highest priority in the roadmap. It is important to note that international datasets such as Corine land cover are not sufficiently accurate to monitor the extent of different ecosystem types in Türkiye and how they evolve over time. A more regional approach, using country specific datasets and classification methods, is required. However, a crosswalk with international classification systems remains important.

In this study, an example ‘regional approach’ to develop extent maps is discussed and demonstrated. The regional approach with the UASIS land cover map as basis provides a possible starting point for future work on the extent account. This was confirmed by the members of the technical working group. The short-term recommendations for extent are:

  - Statistical validation of 2021 UASIS-Corine maps (Level-2)
  - Creation of 2018 UASIS-Corine maps (Level-2) and protocol spatial-temporal statistical validation
  - Need detection of Level-3 ecosystem classes (especially in the Anatolian region)
- Start process to scale up to the national scale and to validate based on sampling
- Standardize and formalize the process of making national maps.

The long-term recommendations are:

  - Direct mapping of the UASIS maps to the EU ecosystem extent typology, Level-1 and partly Level-2
- Adaptation of workflow to generate EUNIS habitat maps
  - Ground-truth collection of ecosystem types for Natura 2000 parks (complemented with specific areas outside those parks).

6.3.2 Ecosystem condition accounts

The forest condition account is the most developed condition account in this study. It is also the only condition account with an aggregated condition index. The other condition accounts presented here are in fact only measured variables. Forest ecosystems provide a range of ecosystems services and managing them sustainably is crucial to the steady (future) supply of those services. A Forest Condition Index (FCI) helps to monitor this. The following recommendation should be considered in creating the roadmap:

- Extend time series data: Current FCI trends are based on a limited 7-year period, which may not fully capture long-term trends. Aim to integrate extended time series data to enhance the reliability of FCI evaluations.
- Refine weighting for climate sensitivity: Extreme weather events strongly influence forest condition variables, especially those heavily weighted in the FCI. Collaborate with local authorities to explore alternative weighting strategies to minimize event-driven bias.
- Optimize condition variable selection:

    - Address spatial inconsistencies in condition datasets by improving resampling techniques and error propagation tracking.
    - Expand variables, particularly for unrepresented areas like soil organic carbon, possibly using particulate matter as a proxy, to capture a more complete forest condition profile.
- Enhance reference site criteria: Ensure reference areas represent stable, ideal conditions by refining criteria for tree cover density. Filter reference sites to a narrow Tree Cover Density range, allowing consistent benchmarking against ideal forest states.
- Contextualize FCI results for ecosystem service assessment: Recognize that FCI scores reflect proximity to ideal conditions but do not directly measure ecosystem service delivery. Use FCI trends as an indicator of long-term sustainability, not just immediate productivity, especially in production forests.
- Include the forest fire indicator in the Forest Condition Index in the future. This should be based on OGM's expertise of forests affected by wildfires.

This roadmap for the ecosystem forest condition targets increased data accuracy, improved resilience to environmental extremes, and a more holistic approach to forest condition evaluation, supporting both sustainable management and robust ecosystem services.

6.3.3 Ecosystem services accounts

The service accounts benefit a lot from an increase in spatial granularity and in localizing the datasets that are used for the calculations. It would improve the integration into the economic accounts on the one side and measures from local authorities or governments. And thus, it should receive priority over finetuning modelling approaches. By using the two basins as a pilot instead of an administrative unit like a province, crop provision and wood statistics are aggregated and then spatially distributed again. This results in a loss of detail.

There was a first attempt to collect data for calculating non-wood provisioning. It is believed that non-wood provisioning provides many benefits to local households, authorities, and industry but that it is underexposed. The definition for **non-wood provisioning** falls under the ecosystem service category of biomass provisioning services. According to the SEEA framework, it is defined as '*Wild animals, plants and other biomass provisioning services are the ecosystem contributions to the growth of wild animals, plants and other biomass that are captured and harvested in uncultivated production contexts by economic units for various uses. The scope includes non-wood forest products (NWFP) and services related to hunting, trapping and bio-prospecting activities; but excludes wild fish and other natural aquatic biomass (included in previous class). This is a final ecosystem service.*'

In Türkiye, forest villagers sell these products and pay a foraging fee to the local government. The biophysical ecosystems contribution is the entire supply of collected non-wood products.

Major sources of non-wood products are rosehips, chestnuts, and mushrooms, for example. Monetary valuation for non-wood products is done by using exchange values for the products. Often, this is measured by direct observation like local market prices for the non-wood products. Opposed to the monetary valuation of timber, SEEA EA does not advice the correction of the price with incurred costs for land management. It states that this will be marginal to the exchange price of the product (NCAVES and MAIA 2022). Developing the non-wood accounts is important to capture a better picture of Turkish forests and their relation to sustaining and improving resilient rural forest communities.

The most important recommendations for **crop provision** are as follows:

- Include a crop type and crop yield map in the methodology.
- Distinguish the ecosystem contribution in the monetary valuation.

The most important recommendations for **wood provision** are:

- Changing the harvested wood data source to the net annual increment originating form the European Forest Accounts.

The most important recommendations for **non-wood provision** in the compilation of accounts are as follows:

- Include data on the foraging of non-wood products.
- Include data on the location of the foraging.
- Include data on the exchange value of the non-wood products.

The most important recommendations for **global climate regulation** revolve around two improvements:

- Investigate the decrease in sequestration caused by the change in the methodology of reporting the GHG statistics.
    - Use jointly with OGM the wood harvest statistics for Türkiye to improve the spatial distribution of carbon sequestration.

The most important recommendations for **flood control** are as follows:

- Develop local flood risk datasets.
- Use a suitable ecosystem extent map with a proper mapping unit to detect changes or nature based solutions against flooding.
- Replace global datasets for damages with local datasets.

The most important recommendations for **nature-based tourism** are as follows:

- Conduct surveys on the reason of overnight stays (visits to which ecosystem type; beach, hiking in the forests and woodlands, etc, how much time they spent in ecosystem type x) to identify the ecosystem contribution and improve the development of recreation potential maps.
- Investigate other more touristic regions.

The most important recommendations for **soil retention** are as follows:

- Align with the department ÇEM on the modelling approach.
- Align with the department ÇEM on the use of local datasets.
- Invest in new field campaigns to collect soil information.

The table below lists the global or European datasets that are used in this study and which are priority datasets to be replaced by local data.

Table 121: Datasets eligible changing to a local dataset.

Service	Variable	Current data source	Local data source
Crop provision	Crop yield		Crop Yield map
Crop provision	Crop type		Crop type map
Wood provision	Net annual increment	Forest production statistics	European Forest Accounts
Flood control	Flood risk water depth	Joint Research Centre (EU)	Local flood risk maps
Flood control	Monetary damage by water depth	European average adjusted with GDP per capita	Local damage function on avoided costs
Nature-based tourism	Allocation weights	Literature	Turkish survey data
Soil retention	RUSLE datasets	Global dataset	Turkish soil data
Soil retention	Annual nutrient and bulk soil prices	EU averages	Turkish prices for nutrients and bulk soils

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8 ANNEX: ADDITIONAL INFORMATION EXTENT ACCOUNT

8.1 Classification

Table 122: Corine land cover classes and economic activities

Broad demand types	CLC classes (LABEL 3)	Economic activities NACE classification*
Artificial land	Continuous urban fabric	Other tertiary and households
	Discontinuous urban fabric	Other tertiary and households
	Green urban areas	Other tertiary and households
	Sport and leisure facilities	Other tertiary and households
	Road and rail networks and associated land (main roads from TeleAtlas are also added)	Transportation
	Port areas	Transportation
	Airports	Transportation
	Industrial or commercial units	Manufacturing and mining
	Mineral extraction sites	Manufacturing and mining
	Dump sites	Waste management
	Construction sites	Construction
Agricultural land	Non-irrigated arable land	Agriculture
	Permanently irrigated land	Agriculture
	Vineyards	Agriculture
	Fruit trees and berry plantations	Agriculture
	Olive groves	Agriculture
	Pastures	Agriculture
	Annual crops associated with permanent crops	Agriculture
	Complex cultivation patterns	Agriculture
	Land principally occupied by agriculture, with significant areas of natural vegetation	Agriculture
	Agro-forestry areas	Agriculture

Source: Corine Land Cover, COPERNICUS

Table 123. Crosswalk UASIS+ to CORINE

	UASIS+ code	UASIS+ class (TR)	UASIS + class (EN)	Corine1 code
Yapılaşmış Alanlar; Built-up	1	Yerleşim Yerleri	Settlement locations	111
	2	Sanayi ve Ticari Alanlar	Industrial and Commercial Areas	121

	UASIS+ code	UASIS+ class (TR)	UASIS + class (EN)	Corine1 code
	3	Turizm Alanları	Tourism Areas	142
	4	Enerji Tesisleri	Energy Facilities	121
	5	Arıtma Tesisleri	Treatment Plants	121
	6	Kamu Alanları	Public Spaces	111
	7	Karayolları ve İlgili Alanlar	Highways and Related Areas	122
	8	Demiryolları ve İlgili Alanlar	Railways and Related Areas	122
	9	Limanlar	Ports	123
	10	Havaalanları	Airports	124
	11	Maden Çıkartma Alanları	Mineral Extraction Areas	131
	12	Boşaltım Alanları	Dump Areas	132
	13	İnşaat Alanları	Construction Areas	133
	14	Kentsel Yeşil Alanlar	Urban Green Areas	141
	15	Spor ve Dinlence Alanları	Sports and Recreation Areas	142
Orman ve Yarı Doğal Alanlar; Forest and Semi-Natural Areas	31	Meralar	Pastures	231
	32	Geniş Yapraklı Ormanlar	Broad-leaved forests	311
	33	İğne Yapraklı Ormanlar	Coniferous forests	312
	34	Karışık Ormanlar	Mixed forests	313
	35	Ot ve Çayır Vejetasyonu	Grass and grassland vegetation	321
	36	Makilikler ve Diğer Çalılıklar	Maquis and Other shrublands	323
	37	Orman Gençleştirme, Ağaçlandırma, Rehabilitasyon	Forest Rejuvenation, afforestation, rehabilitation	324
	38	Karasal Kumul	Terrestrial Dune	331
	39	Kumsal ve Kıyı Kumulları	Beach and Coastal Dunes	331
	40	Çıplak Kayalıklar	Naked Cliffs	332
	41	Tuz İçeriği Yüksek Çıplak Topraklar	Bare soils with high salt content	332
	42	Seyrek Bitkili ve Bozkır Alanlar	Sparsely Planted and Steppe Areas	333
	43	Yanmış Alanlar	Burnt Areas	334
	44	Buzul ve Kalıcı Kar	Glacier and Permanent Snow	335
Sulak Alanlar	45	Sazlık İçermeyen Karasal Bataklıklar	Terrestrial marshes without reeds	411

	UASIS+ code	UASIS+ class (TR)	UASIS + class (EN)	Corine1 code
	46	Sazlıklar	Reeds	411
	47	Turbalıklar	Peatlands	412
	48	Tuz Bataklıkları	Salt Marshes	421
	49	Tuzlalar	Tuzlalar	422
Su Yolları ve Kütleleri; Waterways and water bodies	50	Doğal Su Yolları	Natural Waterways	511
	51	Yapay Su Yolları	Artificial Waterways	511
	52	Doğal Su Kütleleri	Natural Water Bodies	512
	53	Yapay Su Kütleleri	Artificial Water Bodies	512
	54	Kıyı Lagünleri	Coastal Lagoons	521
	55	Nehir Ağızları	River Mouths	522
	56	Deniz Ve Okyanus	Sea and Ocean	523
Tarım; Agriculture	101	Tahıl	Grain	211
	102	Tahıl-Mısır	Grain-corn	211
	103	Tahıl-Pamuk	Grain-cotton	211
	104	Fasülye	Bean	211
	105	Nohut	Chickpea	211
	106	Mercimek	Lentil	211
	107	Fiğ	Vetch	211
	108	Yonca	Clover	211
	109	Kolza	Rapeseed	211
	110	Fiğ-Mısır	Vetch-corn	211
	111	Fiğ-Pamuk	Vetch-cotton	211
	112	Ayçiçeği	Sunflower	211
	113	Mısır	Egypt	211
	114	Pamuk	Cotton	211
	115	Şeker Pancarı	Sugar Beet	211
	116	Susam	Sesame	211
	117	Tütün	Tobacco	211
	118	Çeltik	Paddy	213
	119	Nadas	Fallow	211
	120	Patates	Potato	211
	121	Domates	Tomato	211
	122	Biber	Pepper	211
	123	Diğer Sebzeler	Other Vegetatbles	211
	124	Sera	Greenhouse	211
	125	Üzüm	Grape	221
	126	Çay	Tea	222
	127	Antep Fıstığı	Pistachio	222

	UASIS+ code	UASIS+ class (TR)	UASIS + class (EN)	Corine1 code
	128	Fındık	Hazelnut	222
	129	Zeytin	Olive	223
	130	Turunçgiller	Citrus fruits	222
	131	Badem	Almond	222
	132	Elma	Apple	222
	133	İncir	Fig	222
	134	Kayısı	Apricot	222
	135	Kiraz	Cherry	222
	136	Şeftali	Peach	222
	137	Vişne	Cherry	222
	138	Diğer Meyve Ağaçları	Other Fruit Trees	222
	171	Mezarlıklar	Cementeries	141

Source: Compiled by VITO

Table 124. Number of UASIS+ classes mapped per CORINE class

Corine Code	Corine class (TR)	Corine class (EN)	Count UASIS+
111	Sürekli Şehir Yapısı,	Continuous urban fabric	2
112	Kesikli-Süreksiz şehir yapısı,	Discontinuous urban fabric	0
121	Sanayi Ticaret alanları,	Industrial or commercial units	3
122	Karayolları,demiryolları ve ilgili alanlar,	Road and rail networks and associated land	2
123	Limanlar,	Port areas	1
124	Havaalanları,	Airports	1
131	Maden çıkarma alanları,	Mineral extraction sites	1
132	Boşaltım Sahaları,	Dump sites	1
133	İnşaat sahaları,	Construction sites	1
141	Yeşil Şehir Alanları,	Green urban areas	2
142	Spor ve Eğlence Alanları,	Sport and leasure facilities	2
211	Sulanmayan tarım alanları,	Non-irrigated arable land	23
212	Sürekli sulanan alanlar,	Permanently irrigated land	0
213	Pirinç Tarlaları,	Rice fields	1
221	Üzüm bağları,	Vineyards	1
222	Meyve bahçeleri,	Fruit trees and berry plantations	12
223	Zeytinlikler,	Olive groves	1

Corine Code	Corine class (TR)	Corine class (EN)	Count UASIS+
231	Çayır ve meralar,	Pastures	1
241	Sürekli Ürünlerle Birlikte Bulunan Senelik Ürünler,	Annual crops associated with permanent crops	0
242	Karışık tarım alanları,	Complex cultivation patterns	0
243	Doğal bitki örtüsü ile birlikte bulunan tarım alanları,	Land principally occupied by agriculture with significant areas of natural vegetation	0
244	Ormanla Karışık Tarım Alanları,	Agro-forestry areas	0
311	Geniş yapraklı ormanlar,	Broad-leaved forest	1
312	İğne yapraklı ormanlar,	Coniferous forest	1
313	Karışık Ormanlar,	Mixed forest	1
321	Doğal otlak alanları,	Natural grasslands	1
322	Fundalıklar,	Moors and heathland	0
323	Skierofil bitki örtüsü,	Sclerophyllous vegetation	1
324	Bitki Değişim Alanları,	Transitional woodland-shrub	1
331	Sahiller, Kumsallar ve Kumluklar,	Beaches - dunes – sands	2
332	Çıplak kayalıklar,	Bare rocks	2
333	Seyrek bitki örtüsü ile Kaplı alanlar,	Sparsely vegetated areas	1
334	Yanmış Alanlar,	Burnt areas	1
335	Buzul ve Kalıcı Kar,	Glaciers and perceptual snow	1
411	Karasal Bataklıklar,	Inland marshes	2
412	Turbalıklar,	Peat bogs	1
421	Tuz Bataklığı,	Salt marshes	1
422	Tuzlalar,	Salines	1
423	Gelgit Olayı ile Oluşan Düzlükler,	Intertidal flats	0
511	Su Yolları,	Water courses	2
512	Su kütleleri,	Water bodies	2
521	Kıyı Lagünleri,	Coastal lagoons	1
522	Nehir Ağızları,Deltalar,	Estuaries	1
523	Deniz ve Okyanus,	Sea and ocean	1

Source: Compiled by VITO

Table 125: Supply for crop provision in 2021, Ordu

In 1,000 tonne	Cropland	Grassland (pastures, semi-natural and natural grassland)
MF1.1.1 cereals	7,886	0
MF1.1.2 roots and tubers	15,357	0
MF1.1.3 sugar crops	0	0
MF1.1.4 pulses	37	0
MF1.1.5 nuts	100,817	0
MF1.1.6 oil-bearing crops	147	0
MF1.1.7 vegetables	8,407	0
MF1.1.8 fruits	12,285	0
MF1.1.9 fibres	0	0
MF1.1.A other crops (excluding fodder crops) n.e.c.	100,003	0
MF1.2.1.1 Straw	7,065	0
MF1.2.1.2 Other crop residues (sugar and fodder beet leaves and other)	0	0
MF1.2.2.1 Fodder crops (including biomass harvest from grassland)	31,884	0
MF1.2.2.2 Grazed biomass	0	509,531
All regions	**283,888**	**509,531**

Source: Compiled by VITO

8.2 CLC+ Backbone change analysis

Since there are no Tier-2 extent maps available, neither for Türkiye nor for the regional zones (Bolaman or Çekerek), the CLC+ backbone layer was used to identify the amount of land cover change in the two regional zones from 2018 to 2021 at high spatial resolution (10 m).

Table 126 shows the overview of potential change (expressed in ha) between 2018 and 2021. Note the change is named potential as it does not reflect necessarily ecosystem extent changes since the data source is a land cover characteristics dataset. It is assumed the actual change is slightly lower, as some land cover characteristic changes (e.g., periodic to permanent herbaceous) will not result in an ecosystem change. Figure 99 shows the locations of potential change.

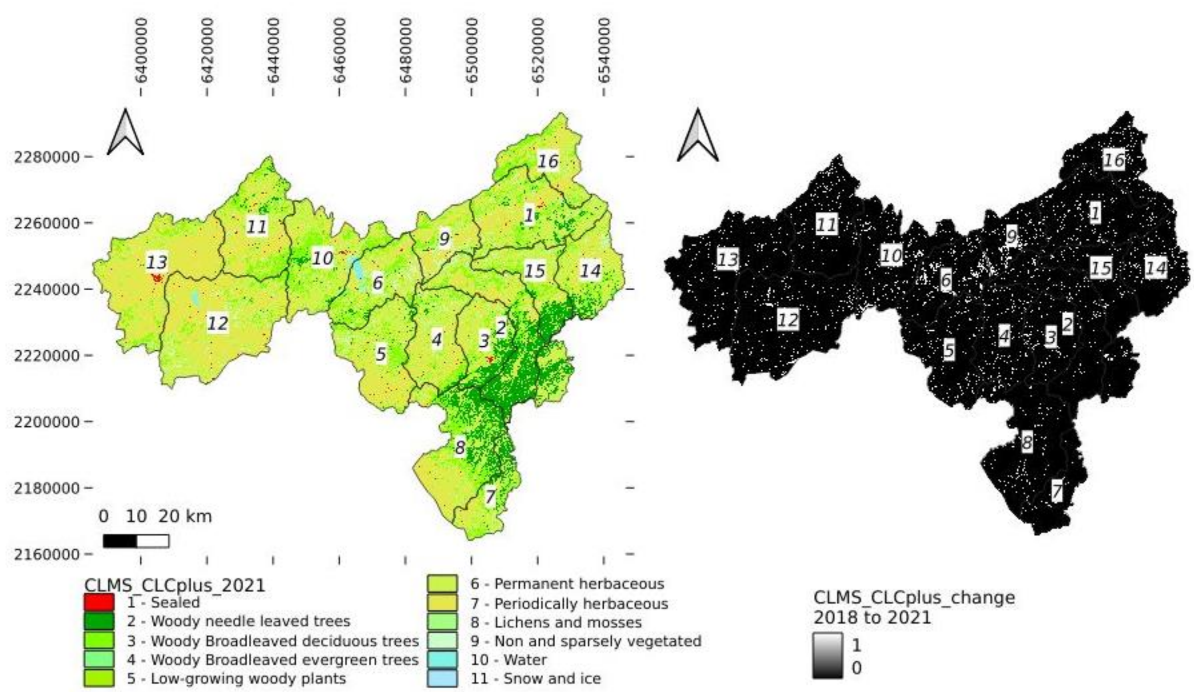
Table 126. Potential land cover change in Çekerek from 2018 to 2021

Sub-region ID	Bolaman sub-region	Potential change (ha)
1		314
2		188
3		159
4		276
5		221
6		449
7		82
8		183
9		296
10		389
11		216
12		359
13		277
14		229
15		137
16		208
	Total	3,983 ha (0.5%)

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Figure 99. Copernicus CLCplus backbone land cover. Left image: 2021 layer, Right image: change from 2018 to 2021



Source: Compiled by VITO

A change matrix was developed to identify the from-to class changes, hence the change flow.

Table 127: Overview of potential change (expressed in ha) in Bolaman between 2018 and 2021.

			2021											Formation		
			Sealed	Needle leaved trees	Broadleaved deciduous trees	Broadleaved evergreen trees	Low-growing woody plants	Permanent herbaceous	Periodically herbaceous	Lichens and mosses	Non and sparsely vegetated	Water	Snow and ice	Change	No change	Relative change
			1	2	3	4	5	6	7	8	9	10	11			
2018	**Sealed**	100	552410					23	68			2		93	552410	0.02%
2018	**Needle leaved trees**	200		7844824			38	11232			790	65		12125	7844824	0.15%
2018	**Broadleaved deciduous trees**	300	15		11458793			68770	752		1463			71000	11458793	0.62%
2018	**Broadleaved evergreen trees**	400												0	0	0.00%
2018	**Low-growing woody plants**	500		6025	46873		1173062	54	2825		211	141		56129	1173062	4.78%
2018	**Permanent herbaceous**	600	2170	1416	64312		3061	34979735	1812914		142865	1152		2027890	34979735	5.80%
2018	**Periodically herbaceous**	700	2315		119		1	1153343	25180391		500595	1638		1658011	25180391	6.58%
2018	**Lichens and mosses**	800												0	0	0.00%
2018	**Non and sparsely vegetated**	900	90	1	270		297	3079	1887		2080707	1875		7499	2080707	0.36%
2018	**Water**	1000	2042		291		23	27172	63193		67035	336787		159756	336787	47.44%
2018	**Snow and ice**	1100												0	0	0.00%
Consumption	Change		6632	7442	111865	0	3420	1263673	1881639	0	712959	4873	0	**87,601,248**	**are**	
Consumption	No change		552410	7844824	11458793	0	1173062	34979735	25180391	0	2080707	336787	0	**876,012**	**ha**	
Consumption	Relative change		1.20%	0.09%	0.98%	0.00%	0.29%	3.61%	7.47%	0.00%	34.27%	1.45%	0.00%			

Source: Compiled by VITO

Disclaimer: Numbers differ from the official 2024 activity report of the General Directorate of Forestry due to limitation of the source data, European Corine Land Cover maps. Forests cover around 30 percent of Türkiye (Orman Genel Müdurlügü, 2025)

Note the change is named potential as it does not necessarily reflect ecosystem extent changes since the data source is a land cover characteristics dataset. It is assumed the actual change is slightly lower, as some land cover characteristic changes (e.g., periodic to permanent herbaceous) will not result in an ecosystem change. Figure 100 shows the locations of potential change.

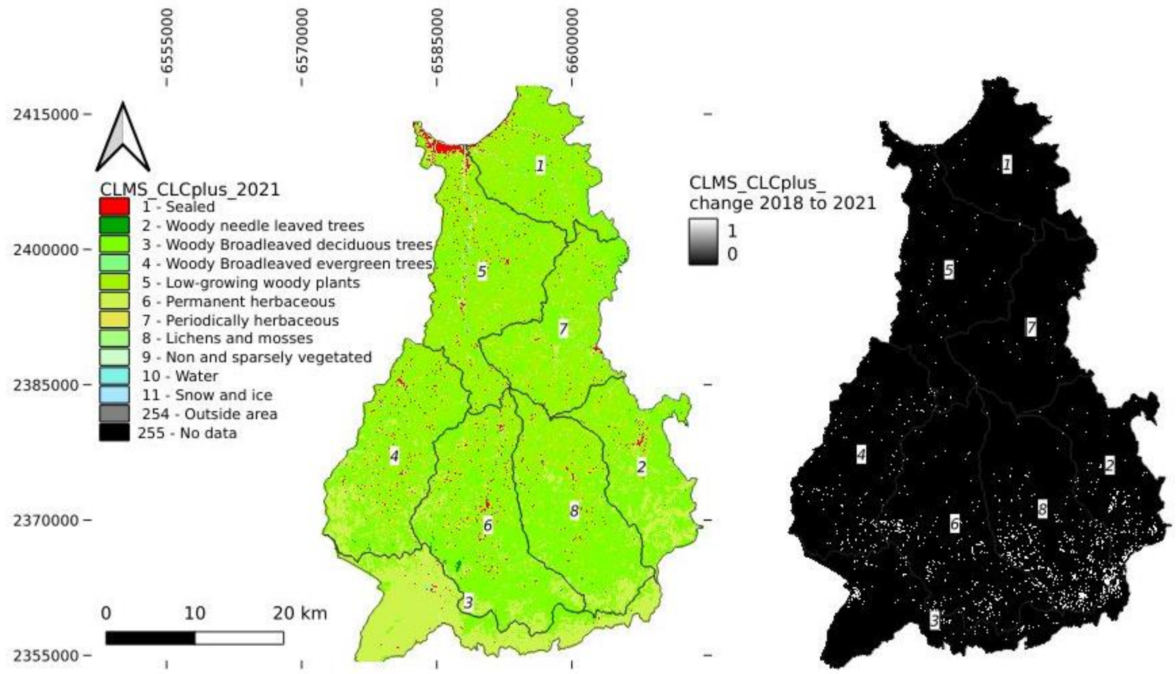
Table 128. Potential land cover change in Bolaman from 2018 to 2021

Sub-region ID	Bolaman sub-region	Potential change (ha)
1	Ilica çayi	36
2	Medrese çayi	409
3	Gokcebayir çayi	387
4	Kes çayi	258
5	Bolaman çayi	147
6	Eceli çayi	648
7	Sahsene çayi	58
8	Direkli çayi	107
	Total	2050 (1.2%)

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Figure 100. Copernicus CLCplus backbone land cover. Left image: 2021 layer, Right image: change from 2018 to 2021



Source: Compiled by VITO

Figure 95: Extent table cleaned for Bolaman

			2021											Formation		
			Sealed	Needle leaved trees	Broadleaved deciduous trees	Broadleaved evergreen trees	Low-growing woody plants	Permanent herbaceous	Periodically herbaceous	Lichens and mosses	Non and sparsely vegetated	Water	Snow and ice	Change	No change	Relative change
			1	2	3	4	5	6	7	8	9	10	11			
2018	**Sealed**	100	234895		10		3	111				1		125	234895	0.05%
	Needle leaved trees	200		26896			1	94			4	20		119	26896	0.44%
	Broadleaved deciduous trees	300	54		7439935		6271	35320	135		2015	186		43981	7439935	0.59%
	Broadleaved evergreen trees	400												0	0	0.00%
	Low-growing woody plants	500	246		3229		4650141	1355	59		1468	17		6374	4650141	0.14%
	Permanent herbaceous	600	42	1849	202745		2985	3087225	4689		4971	580		217861	3087225	7.06%
	Periodically herbaceous	700		18	20		15	25016	23783		79	5		25153	23783	105.76%
	Lichens and mosses	800												0	0	0.00%
	Non and sparsely vegetated	900	25		293		106	4982			101912	2461		7867	101912	7.72%
	Water	1000	2		83			225	1		551	18788		862	18788	4.59%
	Snow and ice	1100												0	0	0.00%
Consumptio	Change		369	1867	206380	0	9381	67103	4884	0	9088	3270	0	**15,885,917**	**are**	
	No change		234895	26896	7439935	0	4650141	3087225	23783	0	101912	18788	0	**158,859**	**ha**	
	Relative change		0.16%	6.94%	2.77%	0.00%	0.20%	2.17%	20.54%	0.00%	8.92%	17.40%	0.00%			

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

8.3 Alternative cleaning using CLCACC as base map, Bolaman

Applying the forward cleaning mode.

Figure 96: Extent table forward cleaned for Bolaman

	Ecosystem type (level 1) TULIP Bolaman	Opening area 2018 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2021 (ha)	Closing area 2021 (%)
1	**Settlements and other artificial areas**	1,806	20	14	6	1,813	1.1%
2	**Cropland**	103,510	120	822	- 702	102,807	64.7%
3	**Grassland**	15,808	770	61	708	16,517	10.4%
4	**Forest and woodland**	36,728	489	475	13	36,741	23.1%
5	**Heathland and shrub**	-	-	-	-	-	0.0%
6	**Sparsely vegetated ecosystems**	234	-	3	- 3	231	0.1%
7	**Inland wetlands**	-	-	-	-	-	0.0%
8	**Rivers and Canals**	375	-	23	- 23	352	0.2%
9	**Lakes and reservoirs**	25	-	0	- 0	25	0.0%
10	**Marine inlets and transitional waters**	-	-	-	-	-	0.0%
11	**Coastal beaches and transitional waters**	-	-	-	-	-	0.0%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown	340				340	
	Total	**158,826**	**1,399**	**1,399**	**0**	**158,826**	**ha**
						1,588	km^2

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Comparing the accounting results before and after (both methods) cleaning. Note the totals differ slightly due to some boundary issues at Ecosystem Accounting Area which were not solved for the forward mode.

Figure 97: Difference Extent table Bolaman

	Before cleaning operation			Backward cleaning			Forward cleaning		
Ecosystem type (level 1) TULIP Bolaman	**Tier-1 2018 (opening stock)**	**net change**	**Tier-2 2021 (closing stock)**	**Tier-1 2018 (opening stock)**	**net change**	**Tier-2 2021 (closing stock)**	**Tier-1 2018 (opening stock)**	**net change**	**Tier-2 2021 (closing stock)**
Settlements and other artificial areas	1,838	516	2,354	2,335	- 6	2,328	1,806	6	1,813
Cropland	103,284	- 8,364	94,920	94,848	702	95,550	103,510	- 702	102,807
Grassland	15,910	9,393	25,303	25,227	- 708	24,518	15,808	708	16,517
Forest and woodland	36,828	- 908	35,920	35,869	- 13	35,855	36,728	13	36,741
Heathland and shrub		-		-	-	-	-	-	-
Sparsely vegetated ecosystems	235	- 235		-	3	3	234	- 3	231
Inland wetlands		-		-	-	-	-	-	-
Rivers and Canals	377	- 377		-	23	23	375	- 23	352
Lakes and reservoirs	25	- 25		-	0	0	25	- 0	25
Marine inlets and transitional waters		-		-	-	-	-	-	-
Coastal beaches and transitional waters		-		-	-	-	-	-	-
Marine ecosystems		-		-	-	-	-	-	-
Totals	**158,497**	**-**	**158,497**	**158,278**	**- 0**	**158,278**	**158,486**	**0**	**158,486**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

8.4 Alternative cleaning using CLCACC as base map, Çekerek

Applying the forward cleaning mode.

Figure 96: Extent table forward cleaned for Çekerek

	Ecosystem type (level 1) TULIP Cekerek, clean forward	Opening area 2018 (ha)	Additions	Reductions	*Net changes (voluntary)*	Closing area 2021 (ha)	Closing area 2021 (%)
1	**Settlements and other artificial areas**	13,170	592	441	- 151	13,321	1.5%
2	**Cropland**	416,989	2,565	6,738	4,173	412,816	47.1%
3	**Grassland**	78,697	5,198	1,116	- 4,082	82,779	9.5%
4	**Forest and woodland**	266,053	2,435	895	- 1,540	267,593	30.6%
5	**Heathland and shrub**	-	-	-	-	-	0.0%
6	**Sparsely vegetated ecosystems**	96,182	175	2,152	1,977	94,205	10.8%
7	**Inland wetlands**	-	-	-	-	-	0.0%
8	**Rivers and Canals**	-	-	-	-	-	0.0%
9	**Lakes and reservoirs**	4,614	441	60	- 381	4,995	0.6%
10	**Marine inlets and transitional waters**	10	-	4	4	6	0.0%
11	**Coastal beaches and transitional waters**	-	-	-	-	-	0.0%
12	**Marine ecosystems**	-	-	-	-	-	0.0%
	Unknown (to be investigated)						
	Total	**875,715**	**11,406**	**11,406**	**-**	**875,715**	**ha**
						8,757	km^2

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

Comparing the accounting results before and after (both methods) cleaning. Note the Totals slightly differ due to some boundary issues at Ecosystem Accounting Area which were not solved for the forward mode.

Figure 97: Difference extent table for Çekerek

	Before cleaning operation			Backward cleaning			Forward cleaning		
Ecosystem type (level 1) TULIP Bolaman	**Tier-1 2018 (opening stock)**	**net change**	**Tier-2 2021 (closing stock)**	**Tier-1 2018 (opening stock)**	**net change**	**Tier-2 2021 (closing stock)**	**Tier-1 2018 (opening stock)**	**net change**	**Tier-2 2021 (closing stock)**
Settlements and other artificial areas	13,170	- 1,500	11,670	11,640	- 151	11,489	13,170	151	13,321
Cropland	413,218	- 66,728	346,490	346,418	4,173	350,591	416,989	- 4,173	412,816
Grassland	78,720	113,125	191,845	191,723	- 4,082	187,641	78,697	4,082	82,779
Forest and woodland	266,084	31,654	297,738	297,457	- 1,540	295,917	266,053	1,540	267,593
Heathland and shrub		-		-	-	-	-	-	-
Sparsely vegetated ecosystems	96,210	- 77,853	18357	18,307	1,977	20,284	96,182	- 1,977	94,205
Inland wetlands		-		-	-	-	-	-	-
Rivers and Canals		-		-	-	-	-	-	-
Lakes and reservoirs	4,614	2,302	6916	6,900	- 381	6,519	4,614	381	4,995
Marine inlets and transitional waters	1000	- 1,000		-	4	4	10	- 4	6
Coastal beaches and transitional waters		-		-	-	-	-	-	-
Marine ecosystems		-		-	-	-	-	-	-
Totals	**873,016**	**-**	**873,016**	**872,445**	**-**	**872,445**	**875,715**	**-**	**875,715**

Source: VITO estimates

Disclaimer: See the official 2024 activity report of the General Directorate of Forestry page 8

8.5 Crosswalk UASIS typology to EU ecosystem typology

Figure 97: USASIS typology mapping with CORINE land cover typology

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
1		Settlements and other artificial area				
1.1	1.1.1	Continuous residential area	1, 6	Yerleşim Yerleri, Kamu Alanları	Settlement locations, Public spaces	
	1.1.2	Continuous commercial and industrial area				Need Corine protocol
1.2	1.2.1	Discontinuous residential area	2, 4, 5	Sanayi ve Ticari Alanlar, Arıtma Tesisleri Enerji Tesisleri	Industrial and Commercial Areas, Energy facilities, Treatment plants	
	1.2.2	Discontinuous commercial and industrial area				Need Corine protocol
1.3	1.3.1	Road and rail networks and associated land	7, 8	Karayolları ve İlgili Alanlar, Demiryolları ve İlgili Alanlar	Highways and Related Areas, Railways and Related Areas	
	1.3.2	Port areas	9	Limanlar	Ports	
	1.3.3	Airports	10	Havaalanları	Airports	
	1.3.4	Other infrastructure				
	1.3.5	Mineral extraction sites (excluding peat extraction sites, see 7.3.1)	11	Maden Çıkartma Alanları	Mineral Extraction Areas	
	1.3.6	Dump areas				
	1.3.7	Construction sites	13	İnşaat Alanları	Construction Areas	
1.4	1.4.1	Parks (including Zoos and botanical gardens)				
	1.4.2	Sports and recreation sites	3, 15	Spor ve Dinlence Alanları, Turizm Alanları	Sports and Recreation Areas, Tourism Areas	
	1.4.3	Other urban green	14	Kentsel Yeşil Alanlar	Urgan Green Areas	
	1.4.4	Urban blue				Extract from lake?
1.5	1.5.1	Permanent Greenhouses	124	Sera	Greenhouse	Check: are these permanent only?
	1.5.2	Cemeteries	171	Mezarlıklar	Cementeries	
	1.5.3	Archaeological sites				
2		Cropland				
2.1	2.1.1	Cereals excluding rice (C1000) excluding maize (C1500)	101,102,103	Tahil, Tahil-Misir, Tahil-Pamuk	Grain, Grain-corn, Grain-cotton	

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
	2.1.2	Maize (C1500 + G3000)	*			Several classes existing
	2.1.3	Dry pulses and protein crops (P0000)	*			Several classes existing
	2.1.4	Root crops, like sugar beet and potatoes (R0000)	115 120	Şeker Pancarı, Patates	Suger Beet, Potato	
	2.1.5	Vegetables (including melons) and strawberries (V0000_S0000)	121, 122, 123	Domates, Biber, Diğer Sebzeler	Tomato, Pepper, Other vegetables	
	2.1.6	Industrial crops including annual bioenergy crops (I0000)	*			Several classes existing
	2.1.7	Flowers and ornamental plants (N0000)				
	2.1.8	Fallow land (Q0000)	119	Nadas	Fallow	
	2.1.9	Temporary grasses (G1000)				
	2.1.10	Other crops (further categories may be added by Member States, depending upon nationally important crop types).				
	2.1.11	Semi-natural elements associated with agricultural land use in annual cropland				
2.2	2.2.1	Rice fields (C2000)	118	Çeltik	Paddy	
2.3	2.3.1	Olives (O1000)	129	Zeytin	Olive	
	2.3.2	Grapes (W1000)	125	Üzüm	Grape	
	2.3.3	Pome fruits (F1100)	132, 133	Elma, Incir	Apple, Fig	
	2.3.4	Stone fruits (F1200)	134, 135, 136, 137	Kayısı, Kiraz, Seftali, Visne	Apricot, Cherry, Peach, Cherry	
	2.3.5	Berries excluding strawberries (F3000)				
	2.3.6	Citrus fruits (T1000)	130	Turunçgiller	Citrus fruits	
	2.3.7	Nuts (F4000)	131	Badem	Almond	
	2.3.8	Hazelnut	128	Fındık	Hazelnut	
	2.3.9	Chestnut				
	2.3.10	Other perennial crops and orchards	138	Diğer Meyve Ağaçları	Other Fruit Trees	
	2.3.11	Semi-natural elements associated with agricultural land use in in permanent crops				
2.4	2.4.1	Holm and cork oak stands with arable crop understorey				
	2.4.2	Other agro-forestry area with arable crop understorey				
2.5	2.5.1	Mosaic farmland (comprising cropland, grassland and (semi-)natural components)				
2.6	2.6.1	Nurseries				
	2.6.2	Christmas tree plantations				
	2.6.3	Perennial bioenergy crops				

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
	2.6.4	Semi-natural elements associated with agricultural land use in other farmland				
3		Grassland				
3.1	3.1.1	Sown pastures used for grazing	31	Meralar	Pastures	
	3.1.2	Sown grassland mown frequently for fodder or silage				Need mowing events
	3.1.3	Semi-natural elements associated with agricultural land use in modified grassland				
3.2	3.2.1	Mesic grassland	35	Ot ve Çayır Vejetasyonu	Grass and grassland vegetation	Need EUNIS
	3.2.2	Dry grassland				Need EUNIS
	3.2.3	Seasonally wet and wet grassland				Need EUNIS
	3.2.4	Alpine and subalpine grasslands				Need EUNIS
	3.2.5	Woodland fringes and clearings and tall forb stands				Need EUNIS
	3.2.6	Inland salt steppes				Need EUNIS
	3.2.7	Holm and cork oak stands with grassy understorey				Need EUNIS
	3.2.8	Wooded pastures				Need EUNIS
	3.2.9	Semi-natural elements associated with agricultural land use in (semi-) natural grassland				
4		Forest and woodlands				
4.1	4.1.1	Riparian forest and woodland	32	Geniş Yapraklı Ormanlar	Broad-leaved forests	Need EUNIS
	4.1.2	Broad-leaved swamp forest on non-acid and acid peat				Need EUNIS
	4.1.3	Fagus dominated forest				Need EUNIS
	4.1.4	Temperate, Submediterranean and Mediterranean thermophilous deciduous forest				Need EUNIS
	4.1.5	Acidophilous [*Quercus*]- dominated forests				Need EUNIS
	4.1.6	Temperate and boreal and Southern European *Betula* and *Populus tremula* forest on mineral soils				Need EUNIS
	4.1.7	Other Broad-leaved deciduous forest, excluding highly modified plantations				Need EUNIS
4.2	4.2.1	Boreal and temperate fir and spruce forest	33	İğne Yapraklı Ormanlar	Coniferous forests	Need EUNIS
	4.2.2	Mediterranean mountain fir and spruce forest				need EUNIS
	4.2.3	Temperate subalpine Larix, *Pinus cembra* and *Pinus uncinata* forest				Need EUNIS

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
	4.2.4	Pine forest, excluding mires, non-thermophilous				Need EUNIS
	4.2.5	Mediterranean thermophilous lowland pine forest				Need EUNIS
	4.2.6	Spruce, pine and larch mire forest				Need EUNIS
	4.2.7	Taiga forests				need EUNIS
	4.2.8	Other coniferous forests, excluding plantations				Need EUNIS
	4.2.9	Highly modified coniferous forests including stands of non-native trees species that have long been established in European ecosystems stands				Need EUNIS
4.3	4.3.1	Mediterranean evergreen Quercus forest				Need EUNIS
	4.3.2	Mainland laurophyllous forest				Need EUNIS
	4.3.3	Macaronesian laurophyllous forest				Need EUNIS
	4.3.4	Olea europaea-Ceratonia siliqua forest				Need EUNIS
	4.3.5	Palm groves				Need EUNIS
	4.3.6	Other Broad-leaved evergreen forests				Need EUNIS
	4.3.7	Highly modified Broad-leaved evergreen forests including stands of non-native trees species that have long been established in European ecosystems stands				Need EUNIS
4.4	4.4.1	Mixed forests dominated by coniferous species	34	Karışık Ormanlar	Mixed forests	
	4.4.2	Mixed forests dominated by Broad-leaved species				
	4.4.3	Other mixed forests including stands of non-native trees species that have long been established in European ecosystems stands				
4.5	4.5.1	Transitional woodland/forest land including recently felled or clear-cut, burnt, replanted or newly afforested	37	Orman Gençleştirme, Ağaçlandırma, Rehabilitasyon	Forest Rejuvenation, afforestation, rehabilitation	
4.6	4.6.1	Monoculture plantations of non-native tree species (note: forest stands of single or mixed species consisting of native and/or non-native trees species that have long been established in European ecosystems and have diverse undergrowth typical for forest ecosystems should be classified as part of types 4.1 to 4.4)				
	4.6.2	Mixed plantations of a few species of non-European coniferous and Broad-leaved trees with				

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
		underdeveloped undergrowth. Forest stands of single or mixed species consisting of native and/or non-native trees species that have long been established in European ecosystems and have diverse undergrowth typical for forest ecosystems should be classified as part of types 4.1 to 4.4)				
5		Heathlands and shrub				
5.1	5.1.1	Tundra				
5.2	5.2.1	Arctic, alpine and subalpine scrub				
	5.2.2	Temperate and Mediterranean montane scrub				
	5.2.3	Temperate shrub heathland				
5.3	5.3.1	Maquis, arborescent matorral and thermo-Mediterranean scrub				Need EUNIS
	5.3.2	Garrigue				Need EUNIS
	5.3.3	Spiny Mediterranean heaths (phrygana, hedgehog-heaths & coastal cliff vegetation)				Need EUNIS
	5.3.4	Thermo-Atlantic xerophytic shrub (Madeira and Canary Islands)	36	Makilikler ve Diğer Çalılıklar	Maquis and Other shrublands	Need EUNIS
6		Sparsely vegetated ecosystems				
6.1	6.1.1	Rocky pavements, outcrops, and screes	40	Çıplak Kayalıklar	Naked Cliffs	
	6.1.2	Lava flows				Not applicable?
6.2	6.2.1	Semi-desert steppes	41, 42	Tuz İçeriği Yüksek Çıplak Topraklar, Seyrek Bitkili ve Bozkır Alanlar	Bare soils with high salt content, Sparsely Planted and Steppe Areas	
	6.2.2	Cool deserts and semi-desert steppes	42			
	6.2.3	Other sparsely vegetated areas	38	Karasal Kumul	Terrestrial Dune	Probably requires other types
6.3	6.3.1	Ice sheets, glaciers and perennial snowfields	44	Buzul ve Kalıcı Kar	Glacier and Permanent Snow	
7		Inland wetlands				
7.1	7.1.1	Inland marshes	45	Sazlık İçermeyen Karasal Bataklıklar	Terrestrial marshes without reeds	
	7.1.2	Inland salt marshes	48, 49	Tuz Bataklıkları, Tuzlalar	Salt Marshes, Salt flats	
	7.1.3	Reedbeds	46	Sazlıklar	Reeds	
	7.1.4	Springs				
7.2	7.2.1	Raised bogs				Need EUNIS

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
	7.2.2	Blanket bogs				Need EUNIS
	7.2.3	Valley mires, poor fens and transition mires				Need EUNIS
	7.2.4	Aapa, palsa and polygon mires				Need EUNIS
	7.2.5	Base-rich fens and calcareous spring mires				Need EUNIS
	7.2.6	Peat extraction sites	47	Turbalıklar	Peatlands	
8		Rivers and canals				
8.1	8.1.1	Permanent, non-tidal, fast, turbulent water courses	50	Doğal Su Yolları	Natural Waterways	Need EUNIS
	8.1.2	Permanent non-tidal, smooth-flowing watercourses				Need EUNIS
8.2	8.2.1	Canals	51	Yapay Su Yolları	Artificial Waterways	Need cadaster informatio n
	8.2.2	Ditches and drains				Need cadaster informatio n
9		Lakes and reservoirs				
9.1	9.1.1	Lakes	52	Doğal Su Kütleleri	Natural Water Bodies	
	9.1.2	Inland saline or brackish lakes and pools				Need EUNIS
	9.1.3	Ponds and natural small standing water bodies				Need cadaster informatio n
9.2	9.2.1	Artificial reservoirs	53	Yapay Su Kütleleri	Artificial Water Bodies	
9.3	9.3.1	Geothermal pools and wetlands (Iceland)				Not applicable
10		Marine inlets and transitional waters				
10.1	10.1.1	Coastal lagoons	54	Kıyı Lagünleri	Coastal Lagoons	
10.2	10.2.1	Estuaries and bays	55	Nehir Ağızları	River Mouths	
10.3	10.3.1	Intertidal flats (e.g., Wadden Sea)				Not applicable ?
11		Coastal beaches, dunes, and wetlands				
11.1	11.1.1	Artificial shorelines				
11.2	11.2.1	Coastal dunes	39	Kumsal ve Kıyı Kumulları	Beach and Coastal Dunes	Need EUNIS
	11.2.2	Beaches and sandy shores				Need EUNIS
	11.2.3	Muddy shores				Need EUNIS
11.3	11.3.1	Coastal shingle				Need EUNIS
	11.3.2	Rock cliffs, ledges and shores				Need EUNIS

Level1/2	Level-3	Ecosystem type Level-3	UASIS code	UASIS name (TR)	UASIS name (EN)	Remarks
11.4	11.4.1	Coastal saltmarshes	48, 49	Tuz Bataklıkları & Tuzlalar	Salt Marshes	Split from Inland Terrestrial
	11.4.2	Salines				Need EUNIS
12		Marine ecosystems				
12.1	12.1.1	Kelp forests				
	12.1.2	Coastal macrophyte beds				
	12.1.3	Seagrass meadows				
12.2	12.2.1	Coral reefs				
12.3	12.3.1	Worm reefs				
12.4	12.4.1	Shellfish beds and reefs				
12.5	12.5.1	Subtidal sand beds and mud plains				
12.6	12.6.1	Subtidal rocky substrates				
12.7	12.7.1	Continental and island slopes				
12.8	12.8.1	Deepwater benthic and pelagic ecosystems				
12.9	12.9.1	Deepwater coastal inlets (fjords)				
12.1	12.10.1	Sea ice				

Source: Compiled by VITO