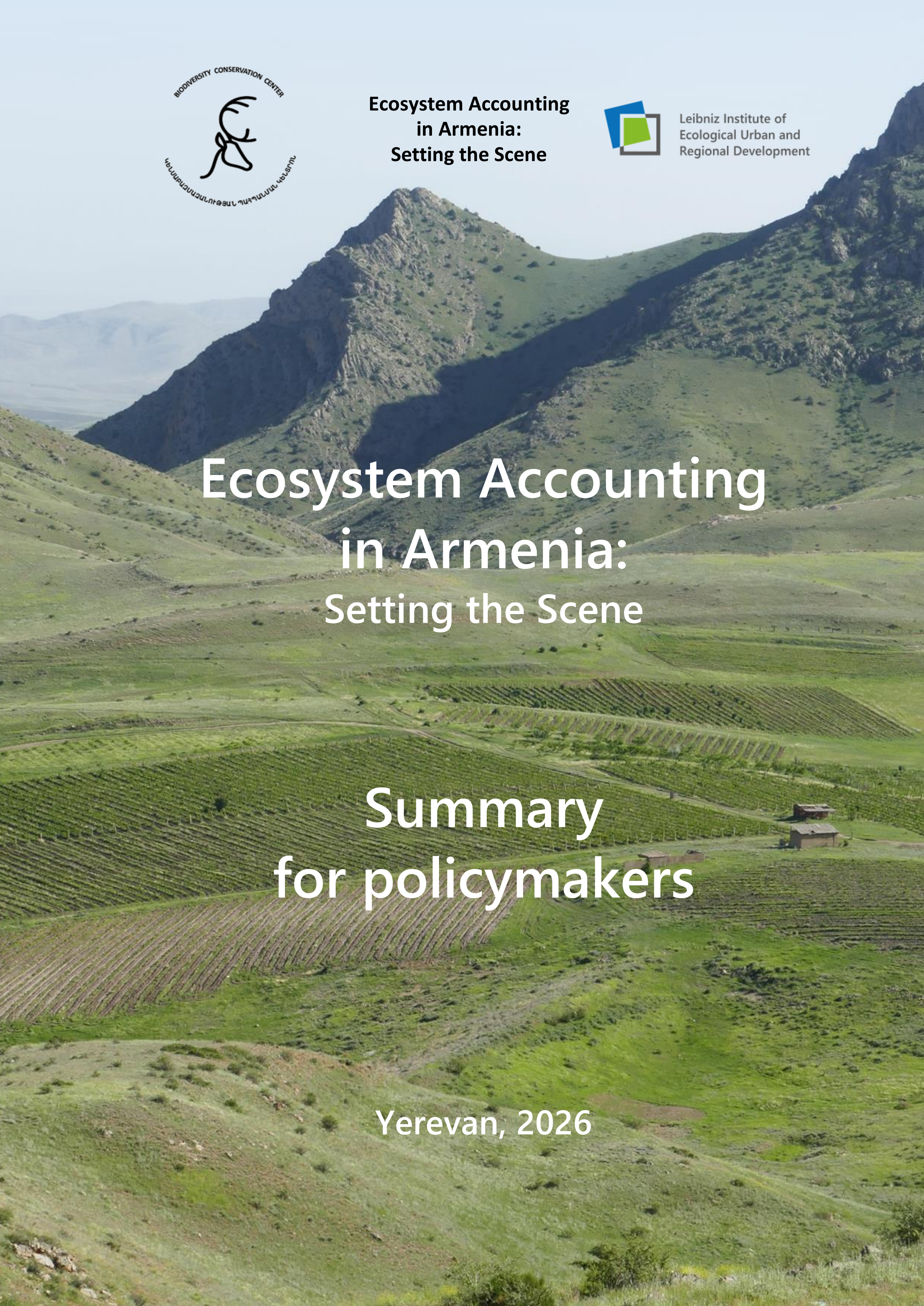

Biodiversity Conservation Center

Leibniz Institute of Ecological Urban and Regional Development

Ecosystem Accounting in Armenia: Setting the Scene

Ecosystem Accounting in Armenia:

Setting the Scene

Summary for policymakers

Yerevan, 2026

Ecosystem Accounting in Armenia: Setting the Scene

The project is being implemented by the Biodiversity Conservation Center (BCC Armenia) in collaboration with the Leibniz Institute of Ecological Urban and Regional Development (IOER, Germany) as well as the participation of experts from leading scientific organizations in Armenia.

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Highlights

Ecosystem accounting (EA) is a statistical framework for organizing data on ecosystems and ecosystem services with the aim of tracking changes.

The **Governmental Decision on the classification of land cover** in Armenia (2019) initiated the first step towards ecosystem accounting aligned with the UN System of Environmental-Economic **Accounting – Ecosystem Accounting (SEEA-EA)** by establishing extent accounts for land-cover classes.

An **Ecosystem Accounting Prototype** was created as part of an Armenian-German research project with the aim of:

- demonstrating the value of EA as a tool for integrating information on ecosystem extent, condition and services into policy and management decisions;
- defining the initial technical and data steps required for developing EA in Armenia.

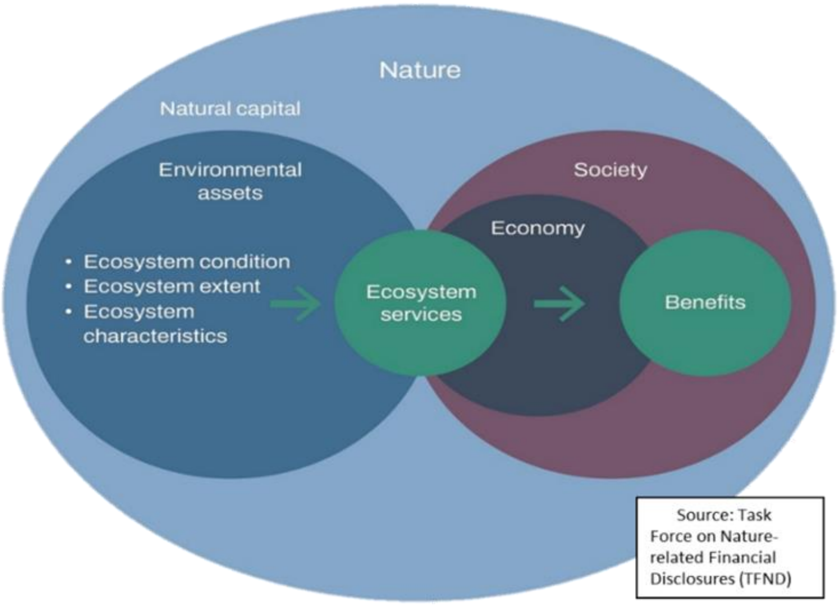


Figure 1. Ecosystem services as a bridge between nature and society

Six policy-relevant key findings are as follows (detailed information is provided on a project website biodiversity-armenia.am and in a Technical Report at https://biodiversity-armenia.am/en/full-report/):

1) The value of Armenian ecosystems in numbers;
2) Ecosystem maps as a basis for decision-making in biodiversity conservation;
3) Sustainable ecosystem use to maintain ecosystem services;
4) Land-use planning for climate change mitigation;
5) Land-use planning for risk reduction;
6) Changes in ecosystem services as result of changes in land cover.

At the end of this summary, we outline limitations, reporting usability and the next steps.

1 The value of Armenia's ecosystems

The total value of ecosystem services demonstrates their key importance for the economy and population of Armenia, as well as for assessing the country's contribution to mitigating global and regional environmental problems, including climate change and water crisis.

- Natural grasslands provide fodder for one million livestock units
- Wild insects can potentially pollinate almost the entire area of agricultural crops
- Total carbon stock in soils and tree biomass has been calculated at 151 MtC
- Forests cool the land surface in summer due to water evaporation, increasing cooling capacity by 21%
- Ecosystems prevent more than 90% of soil erosion by water and over 95% of sediment wash-off into streams and water bodies, ensuring good water quality
- Terrestrial ecosystems provide 93% of riverine baseflow, ensuring water availability in summer and during droughts, which is critically important for Armenia
- Ecosystems reduce spring and early summer flood risk by increasing runoff retention by 11% and decreasing quick flow by 32%

Table 1. Total estimated potential/capacity of ecosystem services in Armenia

Ecosystem service	**Indicators of ES potential/capacity**	**Indicator values**
Production of forage and fodder by natural grasslands	Maximum allowable stocking rate (all grasslands)	0.54 LU/ha* 1,111,000 LU
	Maximum allowable stocking rate (non-degraded grasslands)	0.44 LU/ha 913,000 LU
Storage of carbon in ecosystems in soil and tree biomass	Carbon content	53 tC/ha
	Carbon stock	151 MtC
Ecosystem effect on surface temperature	Ecosystem effect on cooling capacity	0.04
Prevention of soil erosion by water	Avoided erosion	46.4 t/ha/year 140.4 Mt/year
Prevention of sediment export to streams	Avoided sediment export	4.3 t/ha/year 13.0 Mt/year
Baseflow maintenance	Baseflow provided by ecosystems	47.8 mm 2212 millions of m^3
Flood risk mitigation	Ecosystem effect on quick runoff	- 4.1 mm
	Runoff retention provided by ecosystems	0.4 mm 119 million of m^3

*LU – livestock unit

2 Ecosystem maps as a basis for decision-making in biodiversity conservation

Accounting for ecosystem extent is based on vegetation types. This approach:

- captures the full diversity of terrestrial ecosystems when the ecosystem map has an optimal level of detail;
- assesses ecosystem rarity;
- tracks changes in ecosystem area by combining vegetation maps with updated land-cover data;
- evaluates the contribution of different marzes (provinces) to the conservation of ecosystem diversity in Armenia.

Ecosystem rarity and trends in extent are the two main indicators used to compile the Red List of Ecosystems of Armenia.

The most widespread natural ecosystems in Armenia are steppe and subalpine meadows, followed by forests and grasslands in forests. The smallest zones are marshes and juniper woodlands as well as the extremely small desert zone.

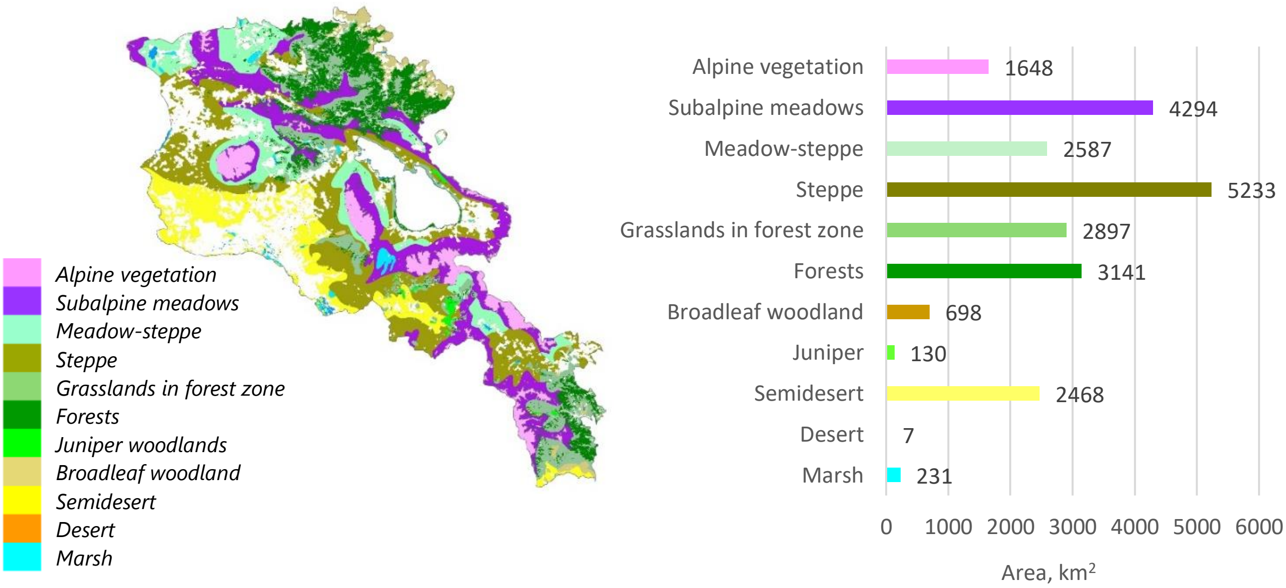


Figure 2. Assessed ecosystem types (left) and their total area in Armenia (right)

Data on changes in ecosystem extent from 2017 to 2023 highlights the most strongly transformed ecosystem types in Armenia (meadow-steppe, steppes, forests) and the affected *marzes* (Shirak, Lori, Gegharkunik). The total area of natural ecosystems in Armenia decreased by 578.9 km² (-2.5%), most of which became croplands.

Transition matrices between land-cover classes and natural ecosystems show which processes drive changes in ecosystem extent and make it possible to account for the area of unchanged and recently transformed ecosystems.

Tracking not only the net changes to ecosystem extent but also the transitions between natural ecosystems and anthropogenic areas and vice versa is **crucial for conserving biodiversity and maintaining ecosystem services.**

3 Land-use planning and sustainable ecosystem use to maintain ecosystem services

The contribution of different ecosystem types to the delivery of ecosystem services (ES) in Armenia and across *marzes*/watersheds forms an information basis for territorial planning aimed at maintaining key ES, helping decision-makers determine the ecosystem types that are most valuable for delivering ES, identify priority areas for ecosystem conservation/restoration and optimize land-use allocations.

➨ Example: Provision of biomass and nectar by wild plants

The three provisioning ES supplied by wild plants – the benefits from edible/culinary, medicinal and nectar-producing (honey) plants – were assessed as scores based on the number of plant species in these groups. The largest total number of species across all three groups is found in the forest and steppe vegetation zones, while the smallest number occurs in the desert and alpine zones. The largest ES potential is found in *marzes* with extensive areas of forest and steppe zones (Syunik, Lori, Tavush). The high ES value in the Gegharkunik *marz* is due to the large area of subalpine meadows, which, along with forests and steppes, also hosts a considerable number of useful plant species.

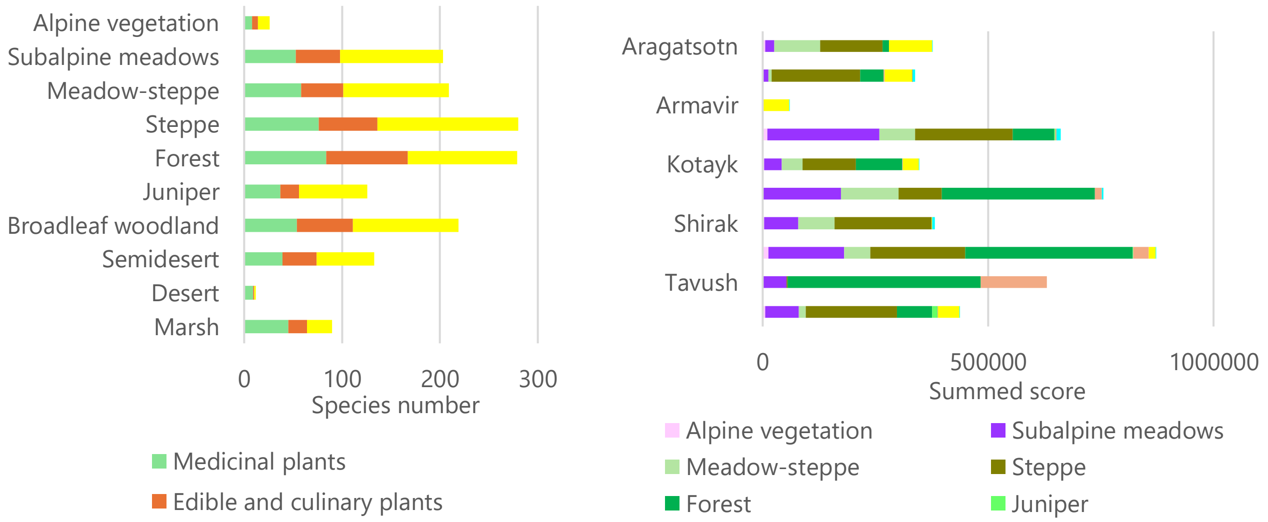


Figure 3. Potential provision of ecosystem services across ecosystem types (left) and marzes (right)

The balance between ES potential, the demand for ES and current ES use allows us to identify areas where ecosystems are sufficient to meet current and future ES needs, areas of ES overuse or under-use, and supports informed decisions on whether ES use may be increased or should be decreased.

➨ Example: ES of baseflow provisioning

Water consumption exceeds baseflow volume provided by ecosystems in two watersheds: Metsamor and Hrazdan. The largest share of total water use is from the agriculture, forestry and fish-breeding sectors, underscoring the importance of baseflow to ensure water availability during the dry season.

In the Metsamor and Hrazdan watersheds, baseflow provides 63% and 54% of agricultural water consumption, respectively. In the other watersheds, baseflow exceeds water consumption many times over. However, water use nowhere exceeds total river flow. In the Arpa, Debed and Vorotan watersheds, there is a substantial unused potential of baseflow, whereas the ecosystems of the Hrazdan and Metsamor watersheds do not meet the demand for water consumption.

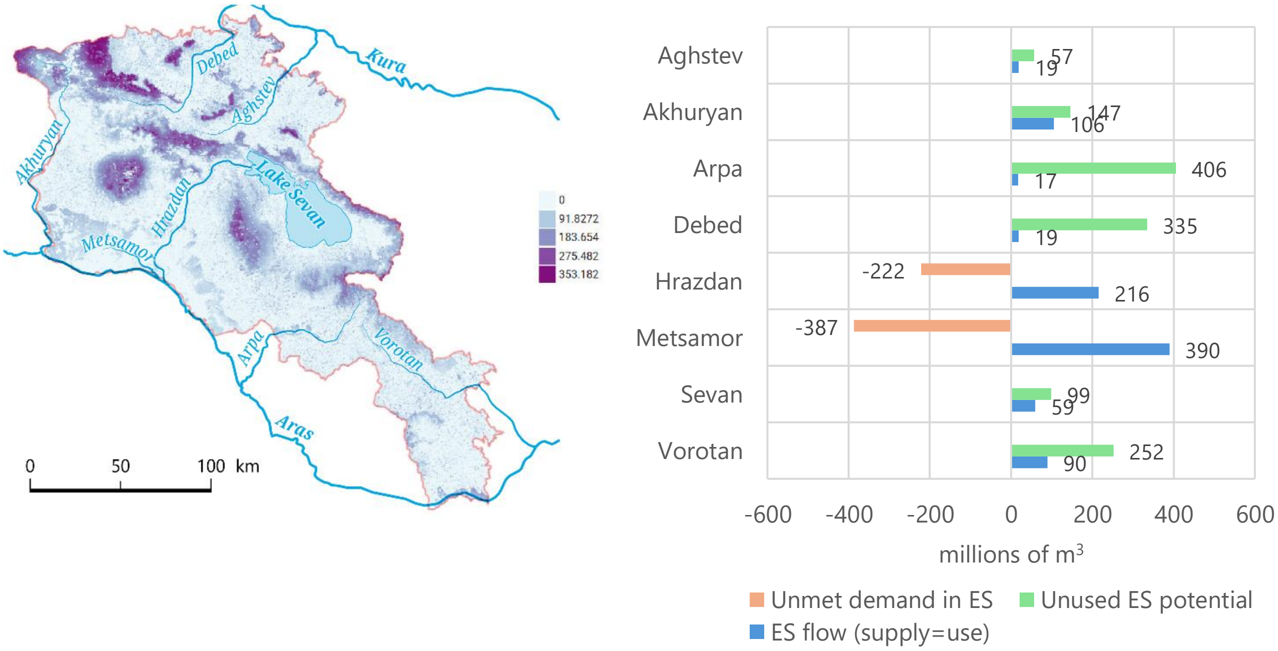


Figure 4. Map of the ecosystem services baseflow provisioning (left) and assessment of base flow use (right)

4 Land-use planning for climate change mitigation

ES accounting for carbon storage and the ecosystem cooling effect helps identify priority ecosystems/areas and guides land-use planning to mitigate climate change at global and local scales. It shows which territories contribute most to climate regulation and therefore require special conservation or sustainable management. It also helps planners to avoid decisions that could reduce ecosystem carbon stocks or increase local heat stress.

In Armenia, the main carbon stock (90%) is stored in soils, highlighting the importance of soil protection programmes and ecosystem services that prevent carbon emissions into the atmosphere (Fig. 5). These are particularly important in regions and natural zones where ecosystems contain large amounts of soil carbon, including all mountain grassland ecosystems, steppe, grasslands in forest zones and forests, which store around 60 tC/ha. Considering the ecosystem area, the largest carbon stocks are found in forest, steppe and subalpine ecosystems.

Across *marzes*, average C-content generally varies at around 60 tC/ha, except in Armavir and Ararat, which have lower C-content (33 and 48 tC/ha, respectively) due to their carbon-poor semi-desert soils. The total carbon stock is highest in *marzes* Syunik and Lori (24 and 21 MtC), and lowest in Armavir *marz* (1.5 MtC) because of low carbon content in the soil and the small area of ecosystems. The carbon stock in tree biomass makes a noticeable addition to soil carbon only in the *marzes* Tavush and Lori. Across vegetation types, total carbon stock is highest in forests with a large level of C in wood, followed by steppe and subalpine zones. The absolute C stock is lowest in juniper woodlands, marshes and desert only due to their limited extent (Fig. 5).

Figure 5. Absolute carbon stocks, MtC (left), and relative carbon content in soil, tC/ha (right)

5 Land-use planning for risk reduction

ES accounting for flood mitigation and erosion prevention provides useful information for territorial planning aimed at reducing risks associated with soil erosion and flooding. It helps identify ecosystems that naturally protect infrastructure, agricultural land and settlements from water-related hazards. It also enables planners to prioritize conservation or restoration measures in areas where the loss of ecosystem functions could lead to increased damage, higher public costs or greater risks to local communities.

➡ ***Example: ES of flood risk mitigation***

Ecosystems reduce quick runoff by an average of 4 mm (-32%) and increase runoff retention by 0.4 m^3/pix (+11%) during extreme spring rainfall. If this ES was greatly reduced, e.g. by replacing natural vegetation with bare ground, there would be a noticeable decrease in runoff retention and an increase in quick runoff.

The total runoff retention volume is highest in the *marzes* Syunik and Gegharkunik, where mountain grasslands make a substantial contribution in both cases, and lowest in Armavir *marz*. Among vegetation types, steppe and subalpine meadows make the largest total contribution. The smallest contribution comes from open juniper woodlands, deserts and marshes due to their limited area (Fig. 6).

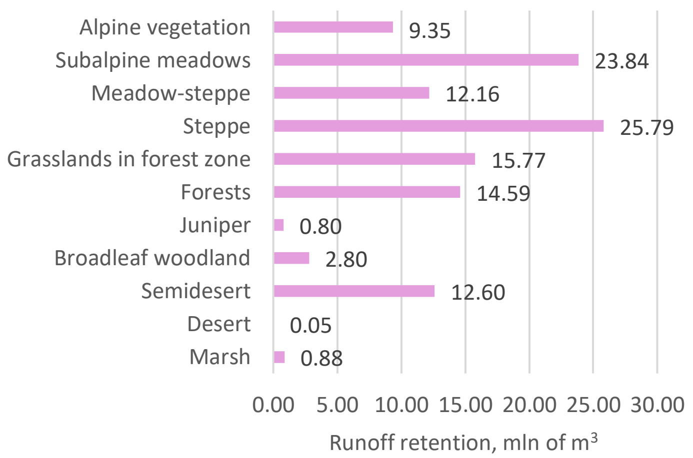


Figure 6. Total runoff retention provided by different vegetation types in millions of m^3

6 Changes in ecosystem services due to land cover changes

Estimates were made of changed ES capacity as a result of land-cover changes. The overall 2.5% reduction in the extent of natural ecosystems from 2017 to 2023 caused a 0.5-2.7% reduction in the potential of all assessed ES. This data clearly shows how changes in ecosystem extent directly affect both the overall supply of ES and their spatial distribution. Such information is essential for planning and prioritizing measures that maintain or enhance ecosystem benefits for communities and sectors across Armenia.

EA Prototype V1 considers changes in ES only resulting from land-cover changes that occurred according to ESRI data between 2017 and 2023. Climate change and changes in ecosystem condition were not considered at this stage. Changes in all ES are sporadic and multidirectional across locations, as illustrated by the example of erosion prevention. The potential of all assessed ES decreased, albeit slightly, by 0.5% to 2.7% for Armenia as a whole. This is consistent with the relatively small magnitude of natural ecosystem area loss. Below, we present examples of the ES of erosion prevention, although analogous data are available in the Technical Report for all assessed ES (Tab. 2).

Table 2. Total changes in ecosystem services from 2017 to 2023

Ecosystem service	Indicator	Absolute changes	Changes relative to 2017
Baseflow provisioning	Baseflow volume provided by ecosystems	-49.1 million of m^3	-2.2%
Prevention of soil erosion	Avoided erosion	-1.18 Mt	-0.9%
Prevention of sediment export	Avoided sediment export	-0.06 Mt	-0.5%
Flood mitigation	Runoff retention provided by ecosystems	-2.79 million of m^3	-2.3%
Ecosystem effect on surface temperature	Cooling capacity	-0.002	-1%
Carbon storage	Carbon stock in ecosystems	-4.26 Mt	-2.7%
Fodder production	Carrying capacity of grasslands	-23,600 LU	-2.1%

Relative changes in ES capacity for erosion prevention are 0.1-5% for *marzes* and 0.6-7% for vegetation types. However, for certain vegetation types within *marzes*, the rate of change goes up to 71% for erosion prevention and 88% for avoided sediment export (forests in Armavir). In absolute terms, the most noticeable changes occurred in the *marzes* of Syunik, Lori and Shirak. In Syunik, the ES capacity of forests decreased while the capacity of grasslands within the forest zone increased, apparently due to the replacement of some forests by grasslands. In Lori, the opposite pattern was observed: ES capacity increased for forests and decreased for forest grasslands and steppes. However, these opposing changes were not able to fully offset each other, and the overall change was negative.

Limitations and identified data gaps

Absence of an accurate, regularly updated land-cover dataset

Currently, Armenia does not have a refined national land-cover dataset that is regularly updated. Therefore, for the methodological demonstration of ecosystem services (ES), we had to rely on one of the publicly available global datasets. Testing of the four datasets most closely representing Armenia's land cover (Dynamic World; ESRI; ESA; GLAD) showed a total discrepancy with Government-reported land-cover class areas across *marzes* ranging from 19.4% to 20.9% of Armenia's total area. For use in EA Prototype, the ESRI dataset was selected, as it is sufficiently accurate and allows us to demonstrate changes in ecosystem extent and ES between 2017 and 2023. However, global land-cover datasets inevitably contain errors. Among the most evident land-cover errors are the misclassification of croplands and built-up areas in high-elevation regions. Such errors have the strongest impact on EA results for small accounting units, such as PAs (protected areas) and natural monuments.

Accounting by land-cover classes delineated in accordance with the "Government of the Republic of Armenia's Decision on Land-cover Classification" can be carried out on the basis of Government-reported data. However, this data does not include digital land-cover maps, so they cannot be used for ES modelling and mapping. The absence of maps also prevents the construction of a land-cover transition matrix and the assessment of additions and reductions by land-cover classes over the reporting period, as recommended by the SEEA-EA.

Ecosystem map

A national ecosystem map is essential for biodiversity conservation, as it provides a consistent spatial basis for identifying rare, threatened and priority ecosystems. EA Prototype uses a generalized vegetation map developed by the project experts on the basis of previous long-term studies by Armenian geobotanists. To enable more accurate ecosystem accounting for biodiversity conservation purposes, as well as a more precise assessment of the role of ecosystems in providing ES, we need a detailed ecosystem map based on the conceptual approach of Ecological Land Units (ELU) and which defines the correspondence between vegetation community types and environmental factors, i.e. topography, climate (precipitation, temperature, seasonality), soils and geology.

Lack and inaccuracy of data for ES assessments

In the scoping phase, certain data for ES assessment was obtained from global databases, between which accuracy may vary at national scale. We recommend that ES modelling for national ecosystem accounting is based on data verified using *in situ* measurements from Armenia's hydro-meteorological, geodesy and cartography services.

The absence of publicly available data on forestry and hunting management prevented us from assessing the corresponding ES. The ES "recreation" was assessed using data provided by the project's experts. The lack of recent scientific studies on the productivity and exploitable stocks of wild, edible and medicinal plants, as well as the absence of data on harvesting intensity, meant that we could not assess the level of use of the corresponding ES.

Use of scoping-level ES models

At the scoping stage, the InVEST models used for water-related ES modelling proved useful for demonstrating general approaches to integrating ES assessments and maps into Armenia's ecosystem accounting. However, the InVEST tool does not reflect the diversity of natural conditions in Armenia.

Conclusion

Ecosystem accounting for national and international reporting

It is vital that public and corporate reporting systems take account of natural assets and ecosystem services as this is the only way to ensure that they get sufficient consideration in political and economic decision-making processes. The explicit recognition of nature and its services is the basis for holistic corporate reporting, management and financing.

EA Prototype supports Armenia's integration into the main global and international processes in the fields of ecosystem accounting and biodiversity protection:

Global and international Initiatives	**Related sections of EA Prototype V1 (Technical Report)**
System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA-EA)	Ecosystem extent accounting (Section 2) Ecosystem service accounting (Section 3)
Integrated Natural Capital Accounting in the European Union (EU INCA)	Ecosystem service accounting (Section 3), subsections about ES potential-use balance
International Union for Conservation of Nature (IUCN) Red List of Ecosystems (RLE)	Extent of ecosystems (Section 2.3)
Global Ecosystem Atlas (GEA)	Section 2.7
Global Biodiversity Framework (GBF)	Section 4

Main initial steps for launching ecosystem accounting in Armenia

As impacts on biodiversity and ecosystems, as well as interdependencies between ES, can be highly specific to the relevant sector, company activity and location, sectoral-based information will be needed in the future – ideally also from national accounting.

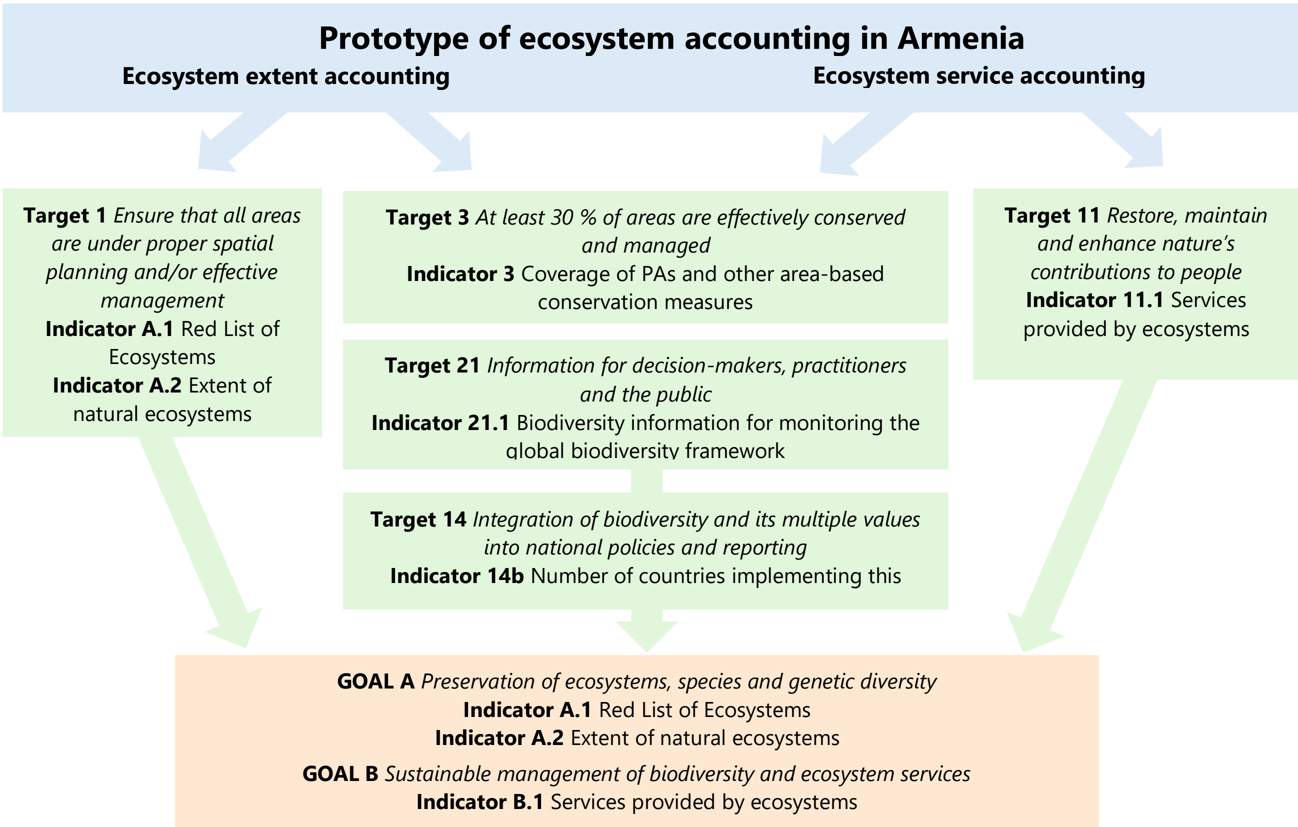
The launch of the first phase of ecosystem accounting requires only standard, commonly available hardware and software. The first data-related steps for accounting for terrestrial natural ecosystems are as follows:

- Develop the national land cover dataset, verified using Armenian data and harmonized with the official land-cover area statistics.
- Develop a detailed national ecosystem map using GIS-based methods and Ecological Land Units (ELU).
- Develop a framework for integrating scoping-stage ES models (InVEST and others) with advanced hydrological and meteorological models to account for the high diversity of natural conditions in Armenia.
- Use nationally verified data for ES modelling based on *in situ* measurements in Armenia. Develop national and regional databases/monitorings of ES modelling coefficients.

In addition, the next step should be to improve the structural conditions at national level and institutionalize ecosystem accounting, ideally through the national statistics organisation ArmStat, in order to ensure continuity. Interdisciplinary, transdisciplinary and cross-sectoral dialogue formats as well as alliances should be encouraged so that Armenia's natural capital is recognized as an economic factor, integrated into reporting systems and can support biodiversity-friendly decisions.

Project contribution to biodiversity conservation in Armenia

The project "Ecosystem Accounting in Armenia: Setting the Scene" (biodiversity-armenia.am) aims to develop a prototype of ecosystem accounting in Armenia for terrestrial ecosystems using physical indicators. It makes a direct informational contribution to Targets 1, 3, 11, 14 and 21, as well as Goals A and B of the Global Biodiversity Framework (https://www.gbf-indicators.org/) and indirectly contributes to other GBF targets by providing an informational basis for management and educational efforts.



Central motto: 'Nature is our capital'

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