2. Ecosystem Extent

2.1. Testing available land cover datasets and dataset selection for PV1

The data for Armenia from the following five publicly available global land cover datasets were tested (Fig. 2.1-1): 1) Dynamic World; 2) ESRI Land Cover; 3) ESA WorldCover; 4) GLC_FCS30D; 5) GLAD Global Land Cover and Land Use Change. The following datasets were excluded from analysis: MODIS MCD12Q1; Copernicus Global Land Cover; ESA CCI/C3S Global Land Cover product; Globeland30; GlobCover; World Terrestrial Ecosystems; The Global Land Cover by National Mapping Organizations (GLCNMO). See short dataset description in the Appendix 1.

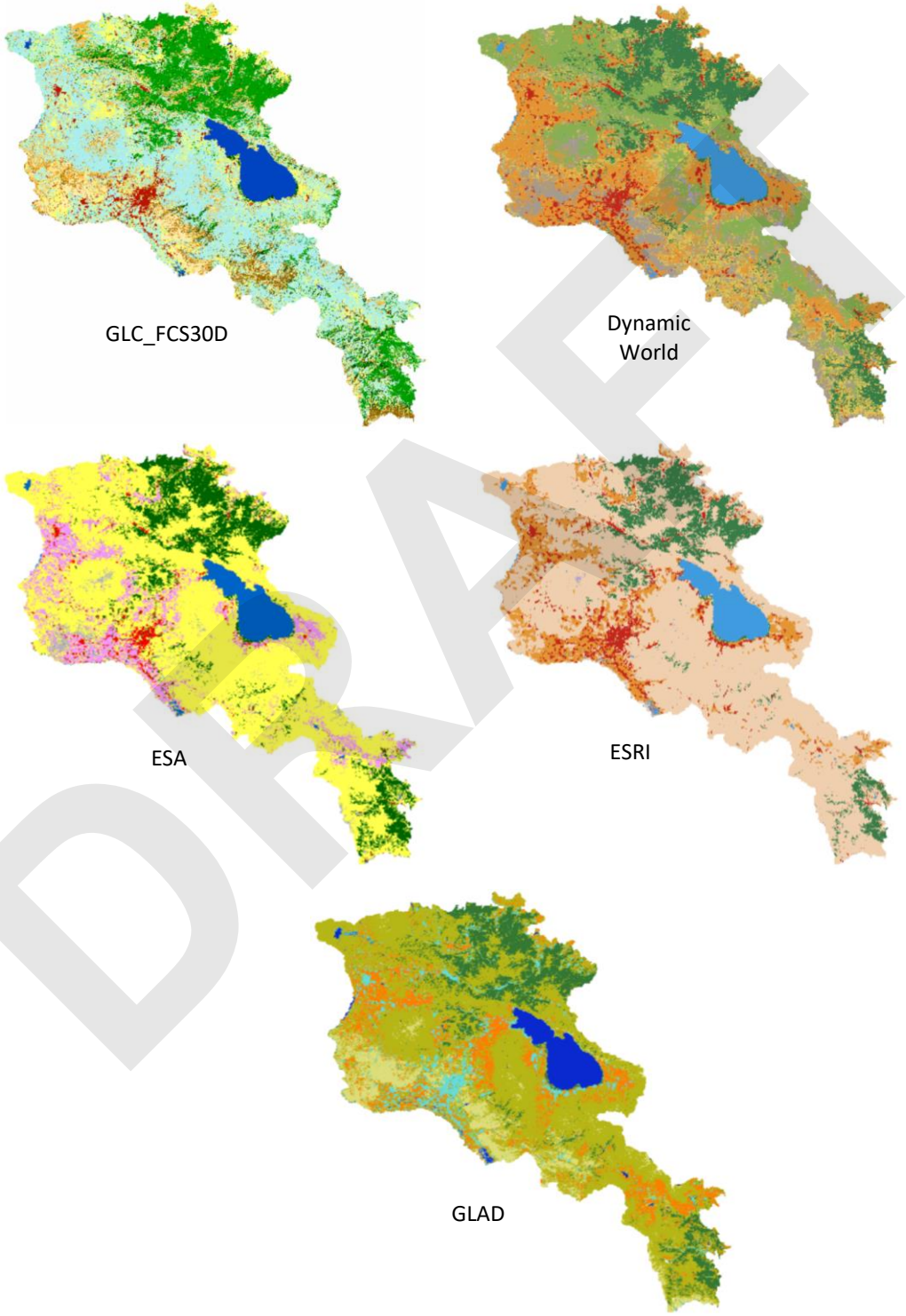


Figure 2.1-1. Tested land cover datasets. For detailed maps see Project web-GIS, section maps in the project web GIS Section Land cover datasets examination (https://bccarmenia.nextgis.com/resource/69/display?panel=none)

2.1.A. Area of land cover classes in the tested datasets

To ensure dataset comparability, all tested land cover datasets and Governmental data on land cover area were generalized into five land cover classes: 1) trees; 2) non-woody natural areas; 3) water, wetlands, flooded vegetation; 4) crops; 5) built-up areas.

The Decision of the Government of the Republic of Armenia in April 11, 2019 defined the following land cover classes for national accounting: Cultivated lands; Grasslands; Tree-covered areas; Shrub-covered areas; Water covered areas; Vegetation-free areas. The more detailed disaggregation of land cover classes by land fund categories provided in the Government-reported data, enables the separation of vegetation-free anthropogenic areas, i.e., built-up areas from natural ones and makes it possible to compare Governmental data and land cover datasets. How to classify grasslands and cultivated lands located within settlement boundaries is a question that needs to be addressed in order to harmonize satellite-based land cover classifications with official land cover statistics. At this stage of the analysis, we kept these lands within grasslands and cultivated lands, respectively.

Further, to ensure comparability of tested datasets and Government-reported data three land cover classes - Grasslands, Shrub-covered areas, and Vegetation-free natural areas - were combined into one class Non-woody natural areas. The data for 2022 were used for comparison, as it represents the midpoint between the dates of the tested land cover datasets.

Share of land cover classes in Armenia

GLC_FCS30D landcover data shows very strong excess of cropland area and excess of forest area. The results of the three land cover datasets — ESRI, ESA, and GLAD — are similar and show a smaller cropland area nd larger grassland area than the Government-reported data. In contrast, the DW dataset shows a larger cropland area and smaller grassland area than the Government data (Fig. 2.1.A-1, 2.1.A-2). Dataset GLC_FCS30D 2022 was excluded from the further analysis, as it differed most significantly from all the other datasets and from Government-reported data.

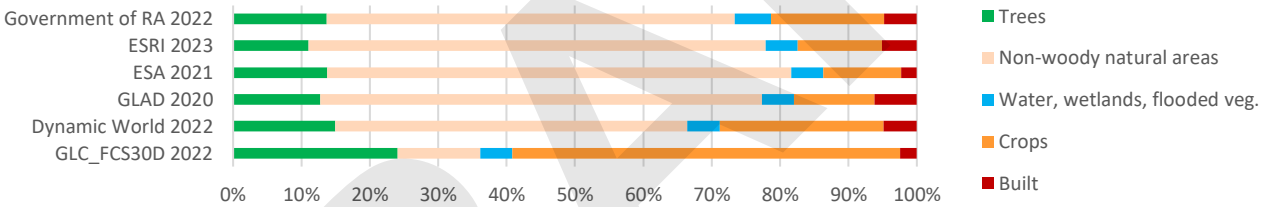


Figure 2.1.A-1. Share of land cover classes in Armenia according the five tested datasets

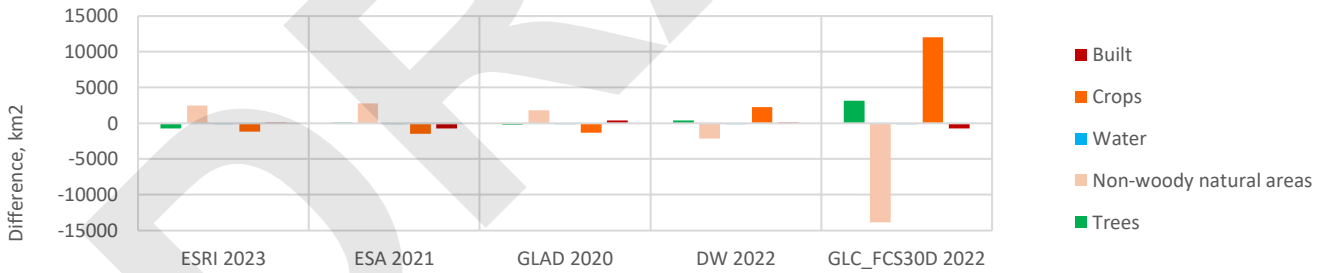


Figure 2.1.A-2. Difference between Government-reported area of land cover classes (2022) and tested datasets

Share of land cover classes across marzes

All four remaining datasets differ significantly from the Government-reported data (Fig. 2.1.A-3). The discrepancies identified at the national level are largely maintained across marzes: ESRI, ESA, and GLAD show larger areas of non-woody natural lands and smaller cropland areas compared to the Government data. In contrast, DW shows smaller non-woody areas and larger cropland areas than the Government data (Fig. 2.1.A-4). This shift persists across the majority of marzes (Fig. 2.1.A-4), suggesting that it is systemic and driven by the differences in the methodology used for satellite image classification. Discrepancies between tested datasets and Government data for forest cover and built-up areas are smaller in magnitude and do not follow the pattern observed in the relationship between cropland and non-woody natural areas. The most prominent shifts include for forest area a reduction in the ESRI data, and increase in the DW data, as well as for built-up area a reduction in the ESA data and increase in the GLAD data. Differences between the land cover datasets and the Government data in terms of water area are minor and fairly consistent across all datasets — each identifies a slightly smaller water area. Figure 2.1.A-5 provides a more detailed view of the area differences across the marzes.

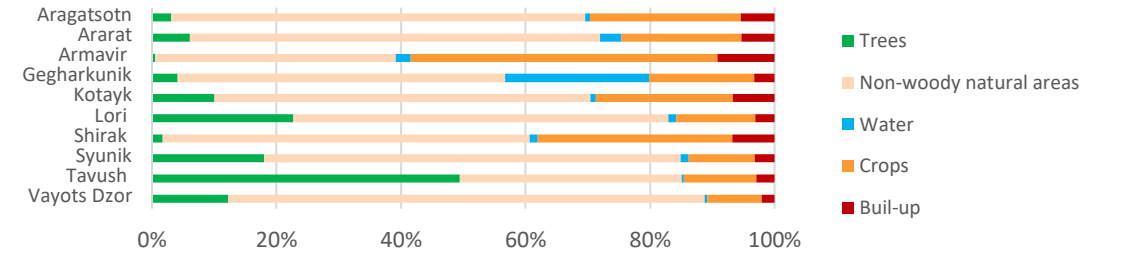
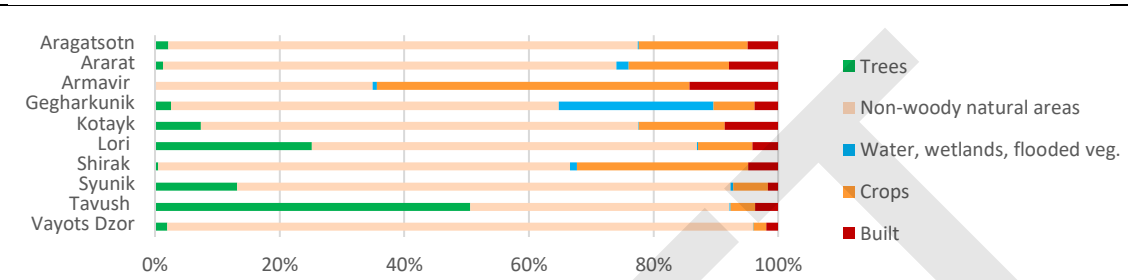
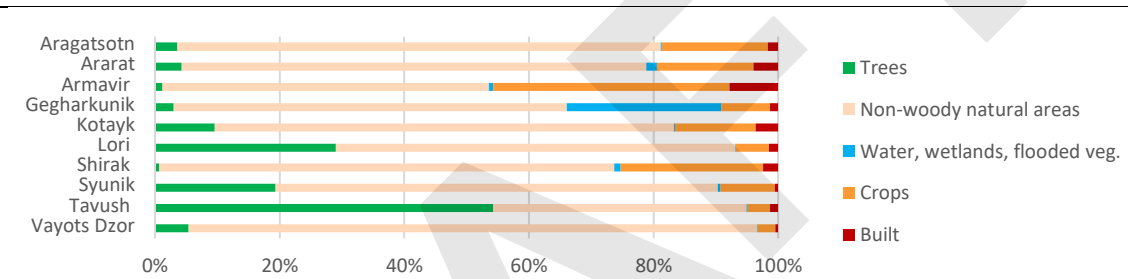
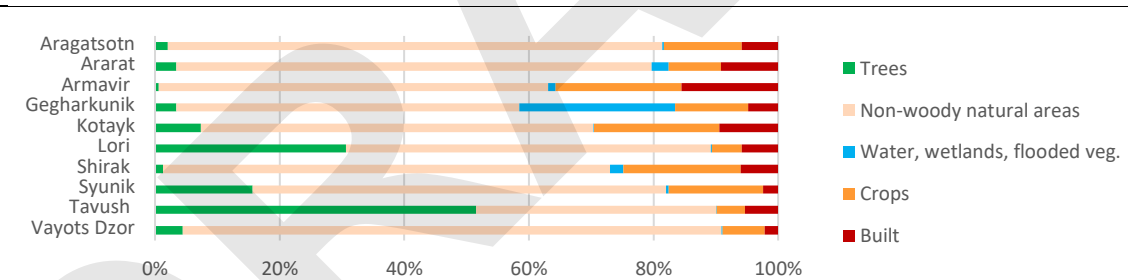
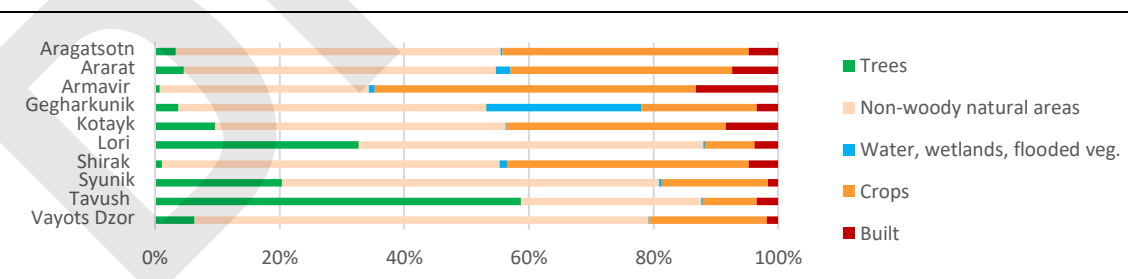
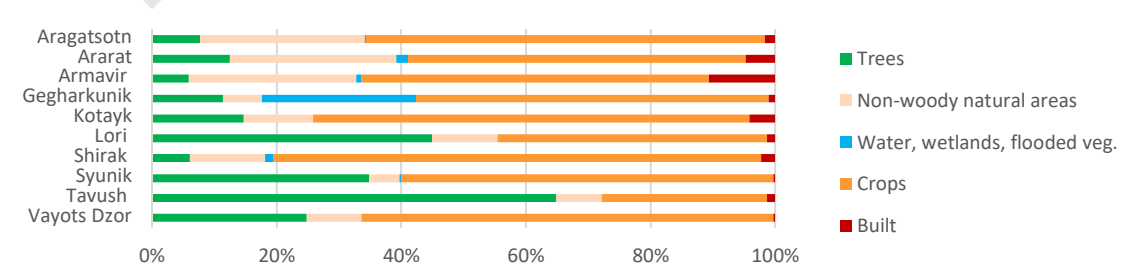
Dataset	*The share of land cover classes area in marzes*
Government-reported data 2022	
ESRI 2023	
ESA 2021	
GLAD 2020	
Dynamic World 2022	
GLC_ FCS30D 2022	

Figure 2.1.A-3. Land cover class shares across marzes according Government-reported data and tested datasets

Figure 2.1.A-4. Land cover area difference: Government-reported areas minus areas from tested datasets. Differences between tested datasets and Government-reported data in marzes are shown in different colors. Provincial differences for each land cover class are combined into a single bar to show the total deviation from the Government-reported data.

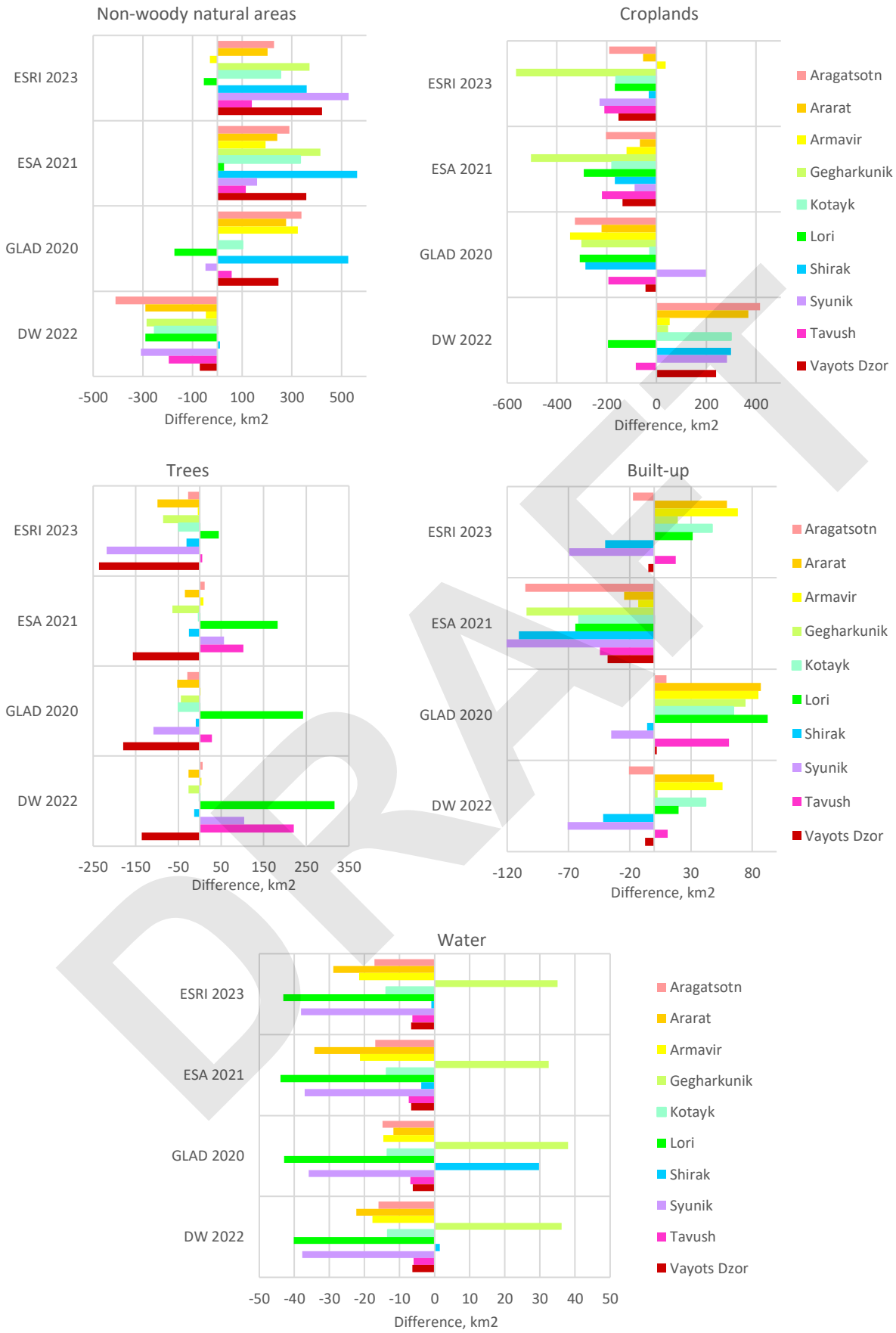


 Figure 2.1.A-5. Land cover area difference across marzes: Government-reported areas minus areas from tested datasets

The absolute discrepancy (km^2) is largest for croplands and grasslands, while in relative terms (percentage relative to Government-reported data), it is greatest for croplands and built-up areas (Figure 2.1.A-6).

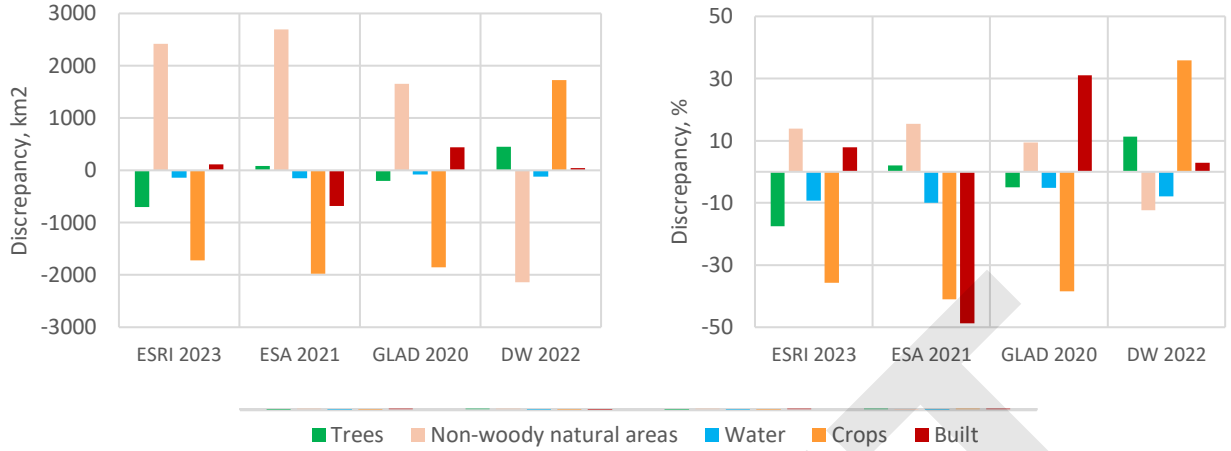


Figure 2.1.A-6. Absolute (km^2) and relative discrepancy (% relative to Government-reported data) in area of land cover classes

The smaller area of built-up area in ESA data can be explained by the fact that ESA identifies trees, grasslands, and crops within settlements. The ESA data generally feature smaller patches across all land cover classes (Fig. 2.1.A-7).

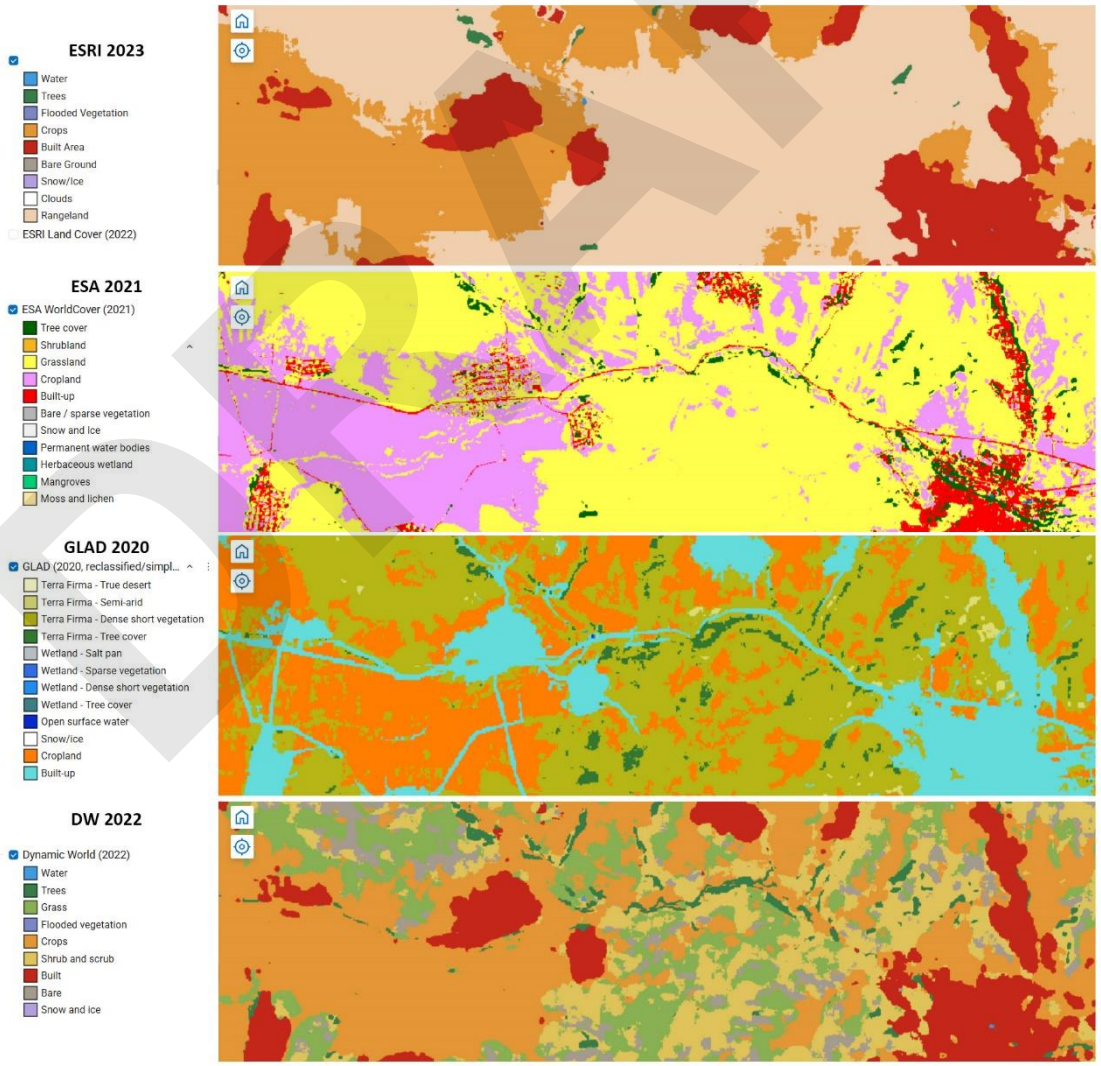


Figure 2.1.A-7. The same area as represented in different land cover datasets

The Government classification of land cover types includes, among others, shrub-covered areas. Of the four land cover datasets retained for analysis, two — ESA and DW — also include this class. However, the shrub areas identified in these datasets differ greatly from the Government-reported areas. According to ESA, shrub area is very small and consistently lower than the Government figures across all marzes. DW, on the contrary, identifies a very large shrub area — several times greater than the Government data (Table 2.1.A-1, Fig. 2.1.A-8). Thus, the presence of a "shrubs" class in these two datasets does not make them more consistent with the Government data.

Table 2.1.A-1. Area of shrub-covered areas in Government-reported data and in two land cover datasets

Marzes	*GOV 2022*	*ESA 2021*	*DW 2022*
Aragatsotn	3.925	0.000	361.594
Ararat	24.962	0.001	387.490
Armavir	6.341	0.001	58.548
Gegharkunik	36.351	0.000	611.396
Kotayk	23.135	0.000	372.450
Lori	48.307	0.057	345.520
Shirak	0.000	0.000	246.146
Syunik	157.423	1.042	1147.185
Tavush	29.433	8.913	310.120
Vayots Dzor	11.479	0.000	843.881

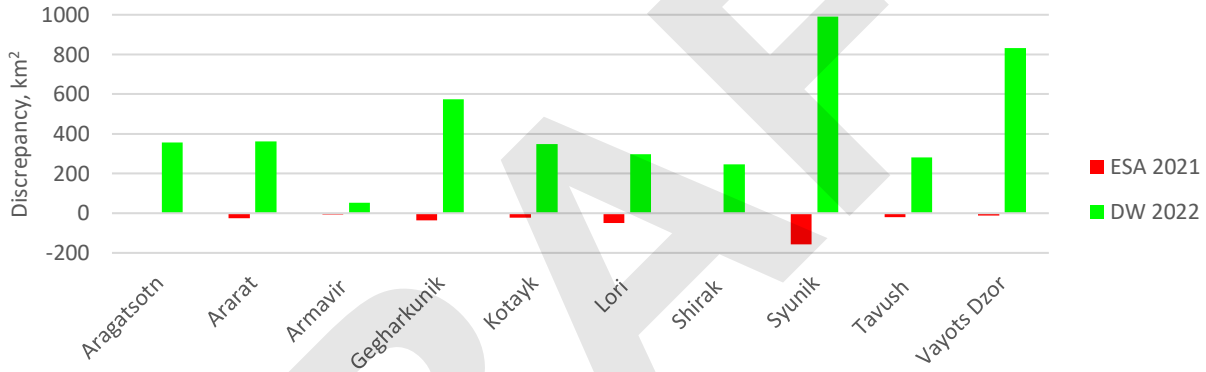


Figure 2.1.A-8. Discrepancy with Government-reported data in shrubland area.

A preliminary overall indicator for assessing land cover data accuracy can be the total discrepancy between land cover class areas in datasets and Government data. The reliability of this indicator increases when absolute errors are summed across the smallest spatial units. In this case, however, data are available only at the marz level, so the indicator we used represents the sum of absolute area discrepancies (by modulus, regardless of sign) across marzes. Overall, all four datasets show a similar total discrepancy from the Government data, ranging from 19.4% to 20.9% of Armenia's total area. The smallest discrepancy is observed in the ESRI dataset, and the largest in ESA (Fig. 2.1.A-9).

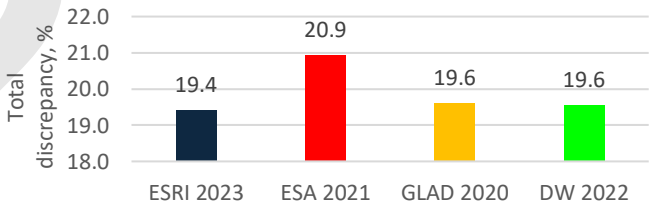


Figure 2.1.A-9. Total relative discrepancy (% relative to total area of Armenia) between tested datasets and Government-reported data

Share of land cover classes across landscape zones

Comparison of land cover class areas across landscape zones according different datasets shows that ESRI, ESA, and GLAD are generally similar to each other (Fig. 2.1.A-10). Dynamic World (DW 2022) data show a significantly larger cropland area compared to the other datasets. This is especially noticeable in mountainous landscapes. Croplands were identified on nearly 10% of the area of the high-altitude and alpine zones. In some mountain ranges (Gegham Range and

southwestern slope of the Karabakh plateau) croplands occupy about 20% (Fig. 2.1.A-11), which is inconsistent with reality. In the subalpine zone, croplands occupy more than 10% in total.

Comparison of ESRI, ESA, and GLAD datasets shows that in ESRI, the cropland area is significantly larger in mountain-valley semi-desert and dry steppe zones, whereas in GLAD, the cropland area in mountain-valley semi-desert zone is smaller than in the other two datasets (Fig. 2.1.A-10). The ESA dataset is characterized by larger area of tree cover and smaller built-up area, which is particularly noticeable in the semi-deserts, dry steppe, and forest shelter belt. One of the reasons for this is that, as mentioned above, ESA identifies trees within settlements. The presence of trees in submountain semidesert zone in the ESA data is entirely due to this factor – all trees there are located inside settlements. ESRI and GLAD datasets do not show any tree cover in this zone.

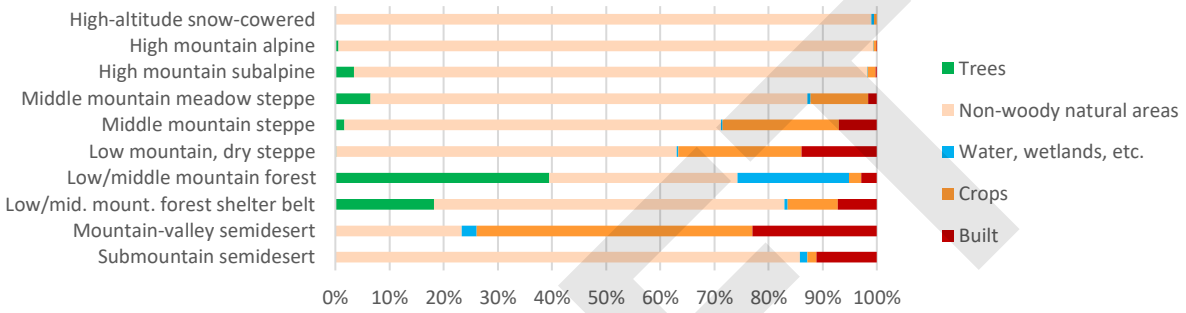
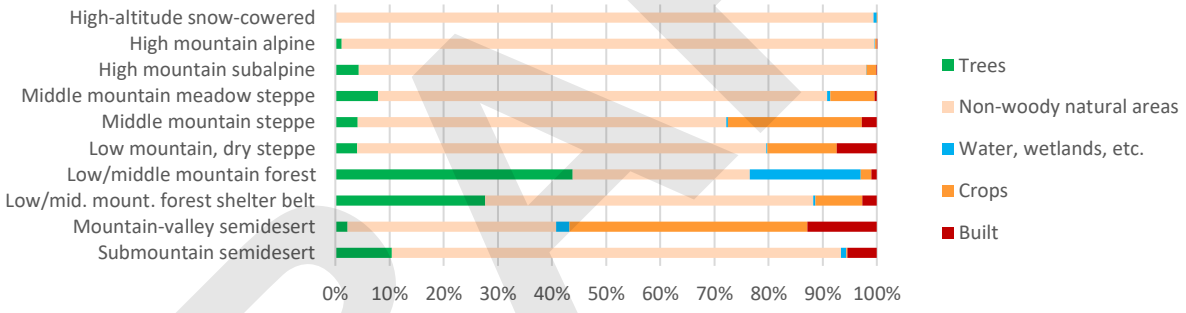
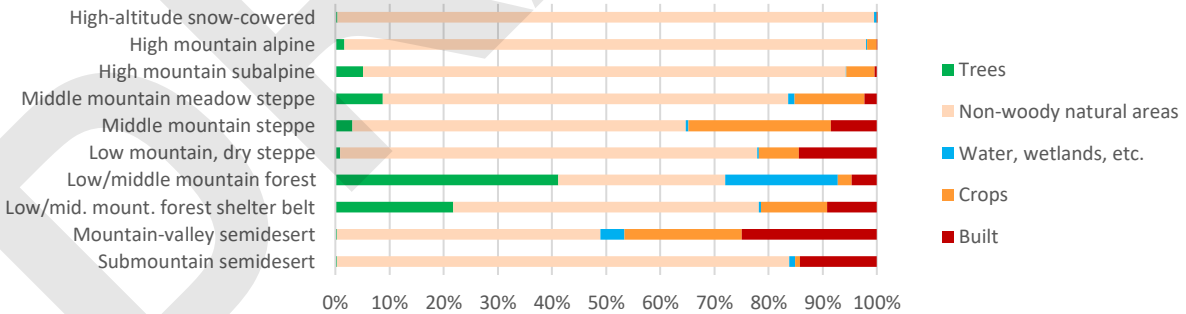
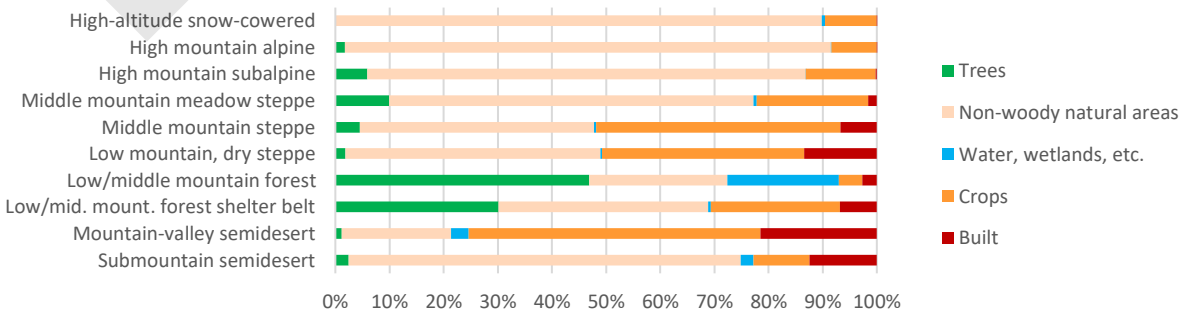
Dataset	*The share of land cover classes area in landscape zones*
ESRI 2023	
ESA 2021	
GLAD 2020	
Dyna-mic World 2022	

Figure 21A-10. Land cover class shares across landscape zones according tested datasets

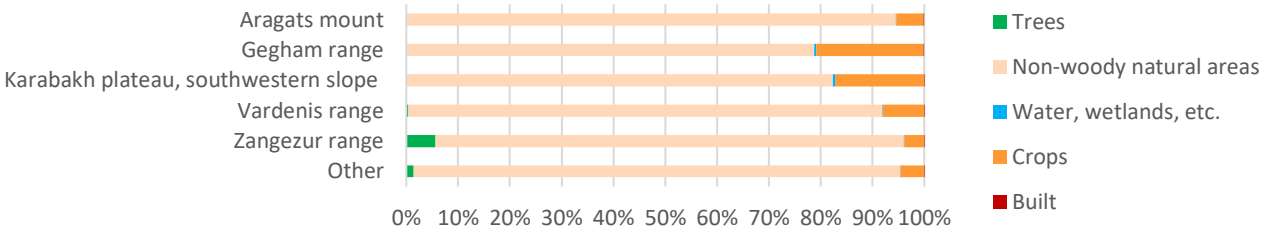


Figure 2.1.A-11. Land cover class shares in high-altitude snow-cowered and high mountain alpine zones across highland systems of Armenia according DW 2022 data

2.1.B. Comparison of cropland area according to land cover datasets and ARMSTAT data

A comparison with ARMSTAT data on cultivated areas was conducted for four land cover datasets – ESRI, ESA, GLAD, and Dynamic World (GLC_FCS30D was excluded from the analysis, see Section 2.1.A). For comparison, we also used 2022 Government-reported data on the area of cultivated land in Armenia.

Cropland area according to landcover data was compared with three ARMSTAT indicators for the same year as the landcover data:

1) Arable land, that is, an area intended for cultivation, but not necessarily used every year;

2) Annually cultivated area, that is the sum of annually plowed area, the area of fruit and berry plantations (including greenhouses, hothouses and inter-row fruit-bearing plantations), and vineyards;

3) Annually plowed area that is plantations of grains and leguminous crops, potatoes, vegetables and melons.

According to ESRI, ESA, and GLAD datasets, the cropland area in most marzes is smaller than the area of arable land but larger than annually cultivated area reported by ARMSTAT. The cropland area identified by DW exceeds the arable land reported by ARMSTAT in almost all marzes, except for marzes Lori and Tavush (Figure 21B-1). The cultivated area reported in the 2022 Government data exceeds the arable land area in all marzes (GOV (A) in Fig.21B-1). If the cultivated area within settlements is excluded, the difference with the ARMSTAT data becomes smaller (GOV (B) in Fig.21B-1). The cropland areas identified by all datasets exceed the annually cultivated area reported by ARMSTAT, except for the GLAD data in marzes Ararat and Armavir.

Figure 21B-2 provides a more detailed breakdown by marz.

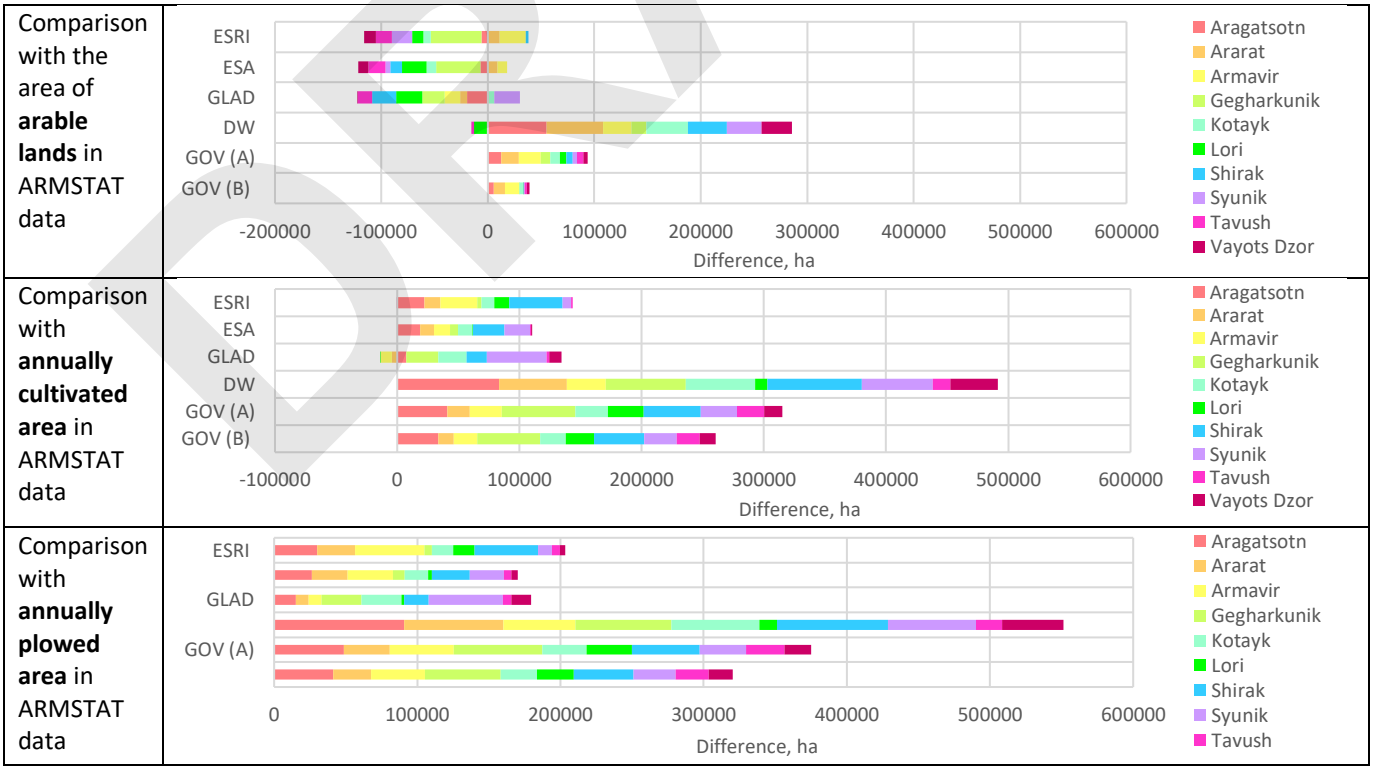


Figure 21B-1. Difference between areas of croplands in tested datasets and ARMSTAT data on arable lands, annually cultivated, and annually plowed areas (dataset data minus ARMSTAT data)

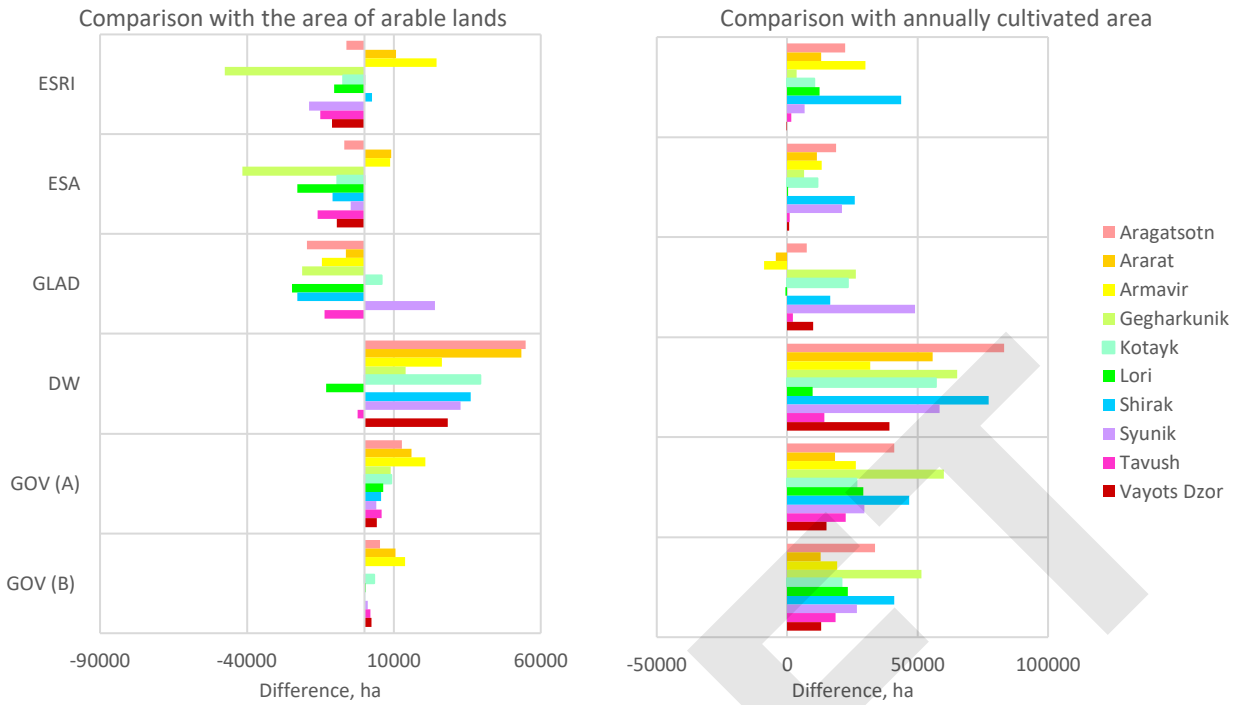


Figure 21B-2. Difference between areas of croplands in tested datasets and ARMSTAT data on arable lands, annually cultivated, and annually plowed areas (dataset data minus ARMSTAT data) across marzes

The fact that in ESRI, ESA, and GLAD datasets the cropland area is smaller than arable area but larger than annually cultivated area indicates that these datasets classify a part of arable lands which are not cultivated during the reference year as croplands. The area of land designated for cultivation that was left uncultivated in the given year is equal to Astat-Cstat, where Cstat is cultivated area in ARMSTAT data; Astat is arable area in ARMSTAT data. Thus, the share of uncultivated fields that are identified in ESRI, ESA, and GLAD datasets as croplands can be defined as U=(C-Cstat)/(Astat-Cstat), where C is cropland area in a dataset. Across the marzes, this figure varies between 0% and 100% (Fig. 21B-3). In cases where the cropland area from land cover datasets exceeds arable land area reported by ARMSTAT, this indicator exceeds 100%. This is most evident in the ESA and ESRI data for the Ararat and Armavir marzes, where these datasets estimate the cropland area to be 20–40% larger than the arable land area reported by ARMSTAT, while approximately 90% of the arable land in these marzes is annually cultivated. The cropland area in all datasets exceeds the annually plowed area. The Government data exceed both annually cultivated and annually plowed area reported by ARMSTAT.

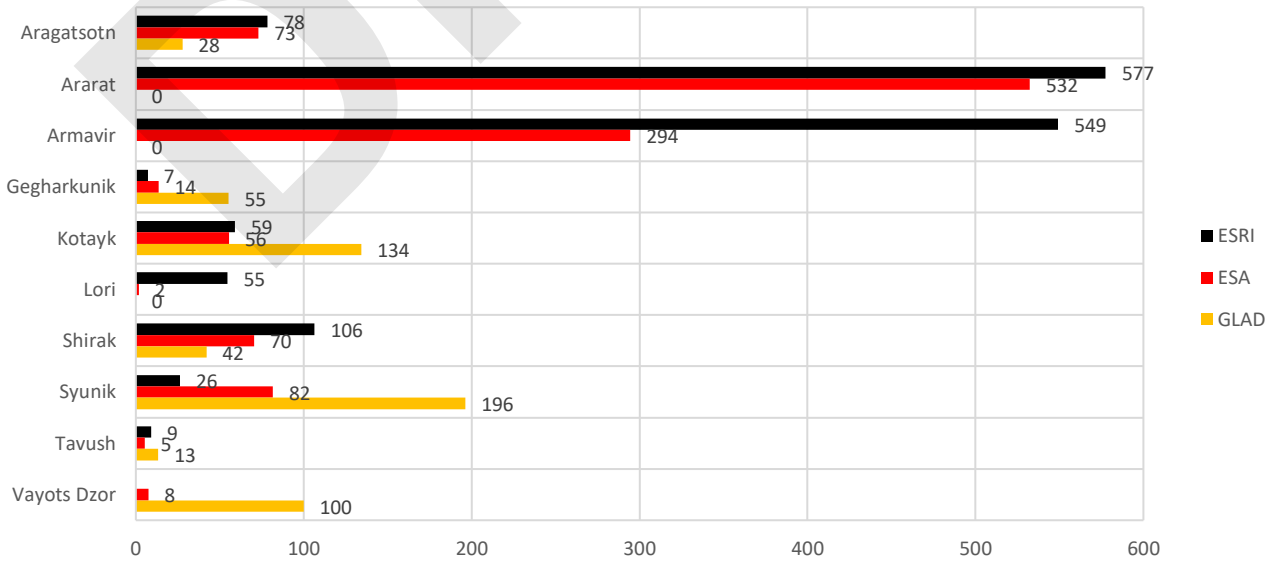


Figure 21B-3. The share (%) of uncultivated arable land that is classified as cropland by the land cover datasets

Similar to the comparisons with Government-reported data (Section 2.1.A), a preliminary overall indicator for assessing land cover data accuracy can be the total discrepancy between cropland areas in datasets and ARMSTAT data which is the sum of absolute area discrepancies (by modulus, regardless of sign) across marzes (Figure 21B-4). Overall, ESRI, ESA, and GLAD datasets show a similar total discrepancy from the ARMSTAT data, DW shows a substantial overestimation of cropland area.

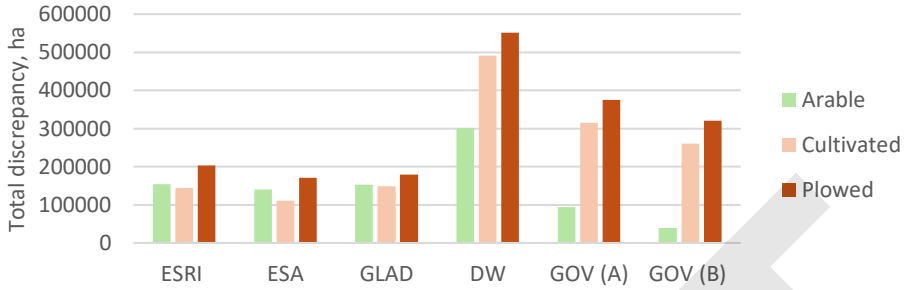


Figure 21B-4. Total discrepancy between cropland areas in datasets and ARMSTAT

2.1.C. Selection of land cover dataset for use in the project

The ESRI land cover dataset was selected as the basis for the project implementation. The ESA and GLAD datasets can be additionally used for specific methodological tasks. The choice was made based on the following reasons:

- GLC_FCS30D land cover data shows very strong excess of cropland area and excess of forest area and was therefore excluded.
- Dynamic World dataset shows good agreement with the Government-reported data in indicator of total area discrepancy. However, it significantly overestimates cropland area compared to ARMSTAT data and shows strong excess of cropland area in the mountains. Therefore, it was excluded.
- ESA, ESRI and GLAD are similar in identified areas of of the generalized land cover classes and are most consistent with ARMSTAT data on cropland area.
- ESRI data provide the best opportunity for demonstrating the accounting of ecosystem indicator dynamics from 2017 and 2023.

2.2. Extent of land cover classes in Armenia

2.2.A. Extent of land cover classes reported by Government of Armenia

The Decision of the Government of the Republic of Armenia in April 11, 2019 n 431-n "On approval of the procedure for classification of the land cover of the Republic of Armenia" defined the following land cover classes for national accounting: Cultivated lands; Grasslands; Tree-covered areas; Shrub-covered areas; Water covered areas; Vegetation-free areas. Open-access annual data on the area of land-cover classes nationl and marz levels are available for 2020–2024[9]. The data for Armenia are presented in Table 2.2.A-1 and Figure 2.2.A-1.

Table 2.2.A-1. Land cover of the Republic of Armenia (2974258.8 ha area) by classes, 2020-2024

Land cover classes	*As of July 1, 2020*	*As of July 1, 2021*	*As of July 1, 2022*	*As of July 1, 2023*	*As of July 1, 2024*
Cultivated lands	538361.22	538580.09	538930.12	538919.19	539620.52
Grasslands	1366386.896	1371066.28	1370749.11	1370618.62	1363686.44
Tree-covered areas	400522.06	400375.84	400279.49	382109.06	382361.15
Shrub-covered areas	34200.612	34193.77	34135.56	34124.48	34374.33
Water covered areas	151491.8	153889.698	153890.39	172088.29	172117.81
Vegetation-free areas	483295.83	476152.342	476274.17	476398.959	482098.73

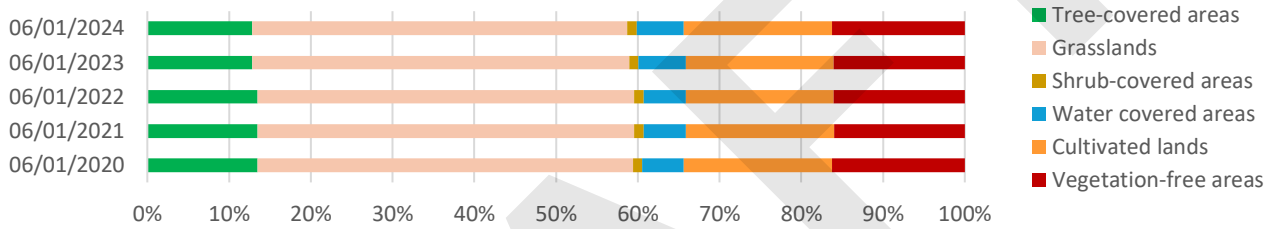


Figure 22A-1. The share of land cover classes in Armenia by Government-reported data

These data are sufficient to fill in the accounting table in the SEEA EA-recommended format only partially (Table 2.2.A-2) since only data on the opening and closing extent are availabla (rows 1 and 9). From these data, the net change in areas is calculated (row 8). Data on gross expansion and reduction in the areas of land cover classes, which may offset each other (rows 2 and 5), as well as a breakdown of change drivers into managed and unmanaged (rows 3,4 and 6,7), are not available.

Table 2.2.A-2. Accounting table of land-cover class extent for 2020 and 2024, based on government-reported data

	Cultivated lands	*Grasslands*	*Tree-covered areas*	*Shrub-covered areas*	*Water covered areas*	*Vegetation-free areas*
1. Opening extent in 2020	**538361.22**	**1366386.9**	**400522.06**	**34200.612**	**151491.8**	**483295.83**
2. Additions to extent	NA					
3. Managed expansion	NA					
4. Unmanaged expansion	NA					
5. Reductions in extent	NA					
6. Managed reductions	NA					
7. Unmanaged reductions	NA					
8. Net change in extent	1259.3	-2700.46	-18160.9	173.718	20626.01	-1197.1
9. Closing extent in 2024	**539620.52**	**1363686.44**	**382361.15**	**34374.33**	**172117.81**	**482098.73**

The more detailed disaggregation of land cover classes by land fund categories provided in the Government-reported data, enables the separation of vegetation-free anthropogenic areas, i.e., built-up areas from natural ones and makes it possible to compare Governmental data and land cover datasets (see here). The result with reclassified vegetation-free areas for Armenia and across marzes is shown in Table 22A-3 and Fig.22A-2.

[9] Sources:
(2021) http://www.irtek.am/DOCUMENTS/PDF/148034_havelvac.pdf; https://faolex.fao.org/docs/pdf/arm209550.pdf
(2022) http://www.irtek.am/views/act.aspx?aid=156501; https://www.arlis.am/DocumentView.aspx?DocID=171671
(2023) https://www.e-draft.am/projects/6427/about
(2024) https://www.e-draft.am/projects/7902/about

How to classify grasslands and cultivated lands located within settlement boundaries is a question that needs to be addressed in order to harmonize satellite-based land cover classifications with official land cover statistics. At this stage of the analysis, we kept these lands within grasslands and cultivated lands, respectively.

Table 2.2.A-3. Land cover class extent by marzes in 2022 by Government-reported data, ha

	Tree-covered areas	*Grasslands*	*Shrub-covered areas*	*Vegetation-free areas*	*Water covered areas*	*Cultivated*	*Buil-up*
Aragatsotn	8571.9	163313.3	392.5	20565.3	2189.9	67143.7	15095.6
Ararat	12724.74	99272.39	2496.22	35572.84	7090.2	40224.09	11061.98
Armavir	582.41	29283.57	634.13	17666.4	3010.438	60572.6	11345.59
Gegharkunik	21889.88	238054.4	3635.07	39933.93	124010.7	90318.54	17289.28
Kotayk	20810.43	102757.6	2313.48	20405.93	1661.12	45813.84	13820.73
Lori	86365.8	200387.6	4830.7	23510.69	4751.58	48300.81	11717.3
Shirak	4598.8	144403.9	0	13622.23	3427.13	83846.24	18128.89
Syunik	80905.01	194761.5	15742.25	91253.96	5576.07	47958	14345
Tavush	133659.9	82690.46	2943.31	10681.01	1094.24	31359.26	7970.77
Vayots Dzor	28325.5	114823.3	1147.9	60825.9	923.4	20109.42	4857.7
Yerevan	1845.1	1001.2	0	1133.29	155.61	3283.62	14909.08
Armenia	400279.5	1370749	34135.56	335171.5	153890.4	538930.1	140541.9

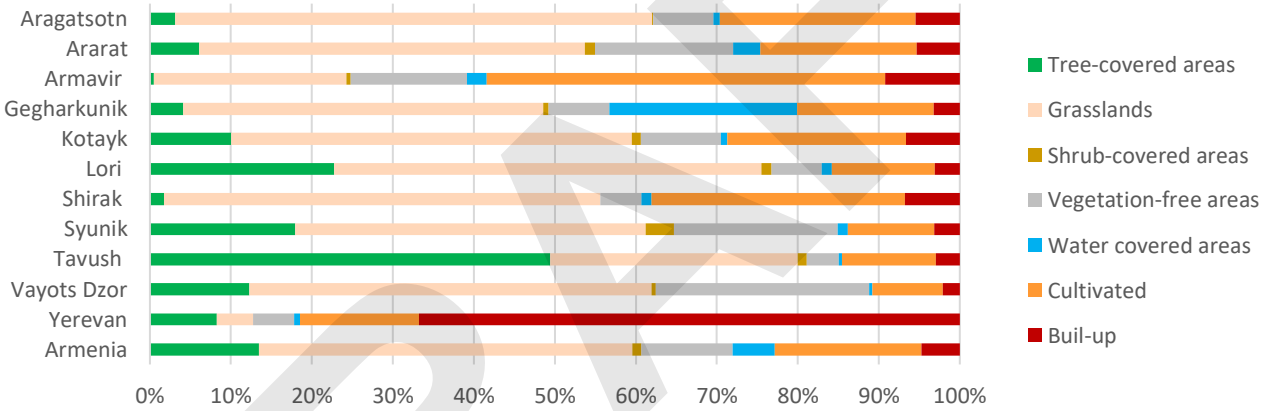


Figure 22A-2. The share of land cover classes in Armenia and across marzes by Government-reported data

2.2.B. Extent of land cover classes by ESRI data

Since the ESRI land cover dataset was selected for use in the project (Section 2.1.A), the subsequent extent assessment was conducted by ESRI data based on the area of 1 pixel equal to 100 m^2. The extent of different land cover classes according to the other datasets can be found in the Section 2.1.A. The area of Lake Sevan and the administrative area of Yerevan were excluded from the extent assessment.

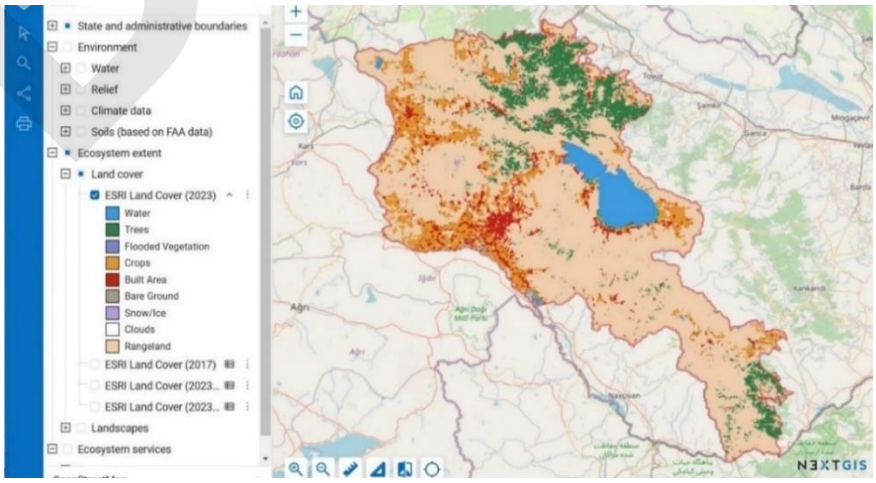


Figure 22B-1. ESRI dataset for Armenia. For detailed maps see project Web-GIS, section "Ecosystem extent - Landcover"

2.2.B1. Extent of land cover classes at the national, marz, and watershed levels

The majority of Armenia's territory is covered by grasslands (68% according to ESRI data), forests occupy 11% (13% according to Government data), croplands and built-up areas account for 12% and 5%, respectively. The most human-transformed marz is Armavir, where croplands and built-up areas together make up over 60% of the territory. The least transformed marzes are Vayots Dzor, Tavush, and Syunik. Forests cover the largest area in Tavush (around 50%), and are also widespread in Lori, where they exceed 20% of the territory (Tables 22B-1 and 22B-2; Figures 22B-2 and 22B-3).

Table 22B-1. Extent of land cover classes in 2017, km²

	Rangeland	Trees	Bare ground	Snow/Ice	Flooded veget.	Water	Crops	Built Area	Total
Aragatsotn	2,161.08	52.54	12.60	0.02	0.00	3.43	380.13	126.33	2,736.12
Ararat	1,522.66	30.47	16.35	0.01	11.71	29.16	359.92	144.64	2,114.91
Armavir	455.53	2.84	5.45	0.00	1.81	6.67	645.14	146.25	1,263.70
Gegharkunik	3,320.37	134.93	19.08	0.04	1.40	1,274.09	315.10	182.98	5,248.00
Kotayk	1,506.57	171.74	7.47	0.74	0.01	2.49	270.63	155.14	2,114.80
Lori	2,558.39	869.51	4.55	0.02	0.44	2.64	189.21	138.24	3,763.00
Shirak	1,998.79	13.08	4.31	0.00	0.07	27.21	537.55	137.61	2,718.63
Syunik	3,571.06	634.26	33.14	0.13	0.04	17.98	170.64	66.09	4,493.35
Tavush	1,234.28	1,304.10	1.34	0.00	0.00	4.00	91.52	91.00	2,726.24
Vayots Dzor	2,157.65	47.10	14.01	0.02	0.01	2.76	35.26	39.74	2,296.54
Armenia	20,549.27	3,261.03	119.68	0.97	15.47	1,371.25	3,018.23	1,372.59	29,708.49

Table 22B-2. Extent of land cover classes in 2023, km²

	Rangeland	Trees	Bare ground	Snow/Ice	Flooded veget.	Water	Crops	Built Area	Total
Aragatsotn	2,096.86	48.25	3.48	6.38	0.00	3.50	438.49	139.17	2,736.12
Ararat	1,560.01	26.20	6.94	0.04	6.74	32.42	305.46	177.10	2,114.91
Armavir	461.83	0.55	2.05	0.00	0.15	7.10	609.26	182.76	1,263.70
Gegharkunik	3,239.85	129.56	4.28	0.94	0.65	1,274.08	404.99	193.66	5,248.00
Kotayk	1,508.64	153.10	1.08	1.60	0.00	2.57	265.38	182.43	2,114.80
Lori	2,424.92	883.74	2.83	0.31	0.79	3.81	298.87	147.73	3,763.00
Shirak	1,784.67	13.43	0.91	2.47	0.00	31.48	742.89	142.79	2,718.63
Syunik	3,650.25	507.74	12.65	0.09	0.02	15.86	233.22	73.53	4,493.35
Tavush	1,227.75	1,316.33	0.05	0.04	0.02	4.35	82.03	95.67	2,726.24
Vayots Dzor	2,174.55	38.13	2.51	0.35	0.00	2.35	33.28	45.37	2,296.54
Armenia	20,185.02	3,117.51	37.33	12.21	8.39	1,378.29	3,422.08	1,547.66	29,708.49

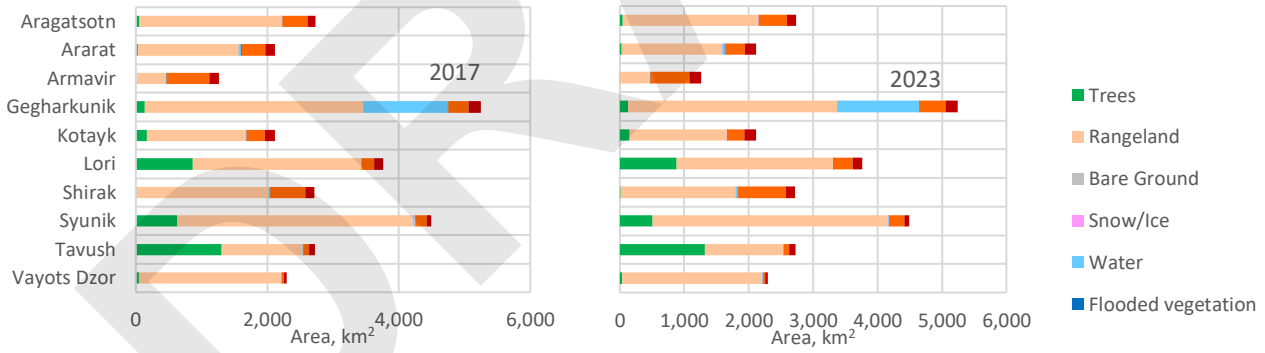


Figure 22B-2. Area of land cover classes in 2017 and 2023, km²

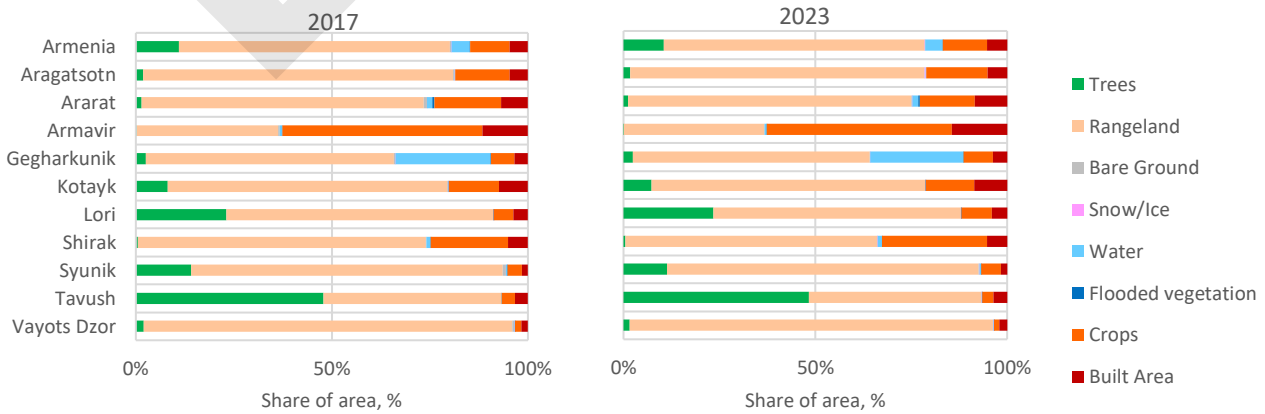


Figure 22B-3. The share of land cover classes in 2017 and 2023, %

Land cover class extent accounting was also carried out for the large watersheds, since one of the key purposes of ecosystem accounting is to assess water-regulating ecosystem services, which are modeled at the watershed level. Since in Armenia watershed boundaries largely coincide with marz boundaries (the Hrazdan, Metsamor, and Arpa watersheds each include two marzes), the pattern of land cover class area distribution and its changes from 2017 to 2023 mirrors the pattern identified at the marz level.

The most human-transformed watersheds are Metsamor (marzes Aragatsotn and Armavir) and Akhuryan (marz Shirak), where croplands and built-up areas together make up around 30% of the territory. The least transformed watersheds are Aghstev (marz Tavush) and Vorotan (marz Syunik). Forests cover large areas in Aghstev watershed (marz Tavush) and Debed watershed (marz Lori) (Tables 22B-6 and 22B-7; Figures 22B-5 nd 22B-6).

Table 22B-6. Area of land cover classes in watersheds in 2017, km²

	Trees	Rangeland	Bare Ground	Snow/Ice	Flooded vegetation	Water	Crops	Built Area
Aghstev	1401.27	1600.07	1.99	0.01	0.00	3.70	69.63	98.72
Akhuryan	9.30	1999.78	4.42	0.00	0.07	27.25	599.85	144.59
Arpa	79.92	3839.27	30.63	0.15	10.84	26.36	288.32	134.83
Debed	843.51	2719.90	4.83	0.02	0.44	3.11	212.89	141.05
Hrazdan	243.39	4384.18	27.42	0.65	1.68	1281.05	765.19	545.57
Metsamor	49.32	2420.53	17.31	0.02	2.41	11.80	911.62	241.75
Vorotan	634.26	3573.45	32.93	0.13	0.04	17.98	170.65	66.09

Table 22B-7. Area of land cover classes in watersheds in 2023, km²

	Trees	Rangeland	Bare Ground	Snow/Ice	Flooded vegetation	Water	Crops	Built Area
Aghstev	1397.07	1590.30	0.09	0.08	0.02	4.04	80.02	103.76
Akhuryan	9.54	1801.94	0.90	2.36	0.00	31.54	789.01	149.95
Arpa	66.30	3890.99	9.26	0.73	6.22	29.55	249.59	157.67
Debed	865.33	2575.47	2.84	0.27	0.79	4.29	325.58	151.17
Hrazdan	228.70	4305.51	6.24	2.17	0.67	1280.73	794.73	630.37
Metsamor	42.74	2356.44	5.25	6.48	0.66	12.27	949.72	281.20
Vorotan	507.74	3652.35	12.65	0.11	0.02	15.86	233.26	73.54

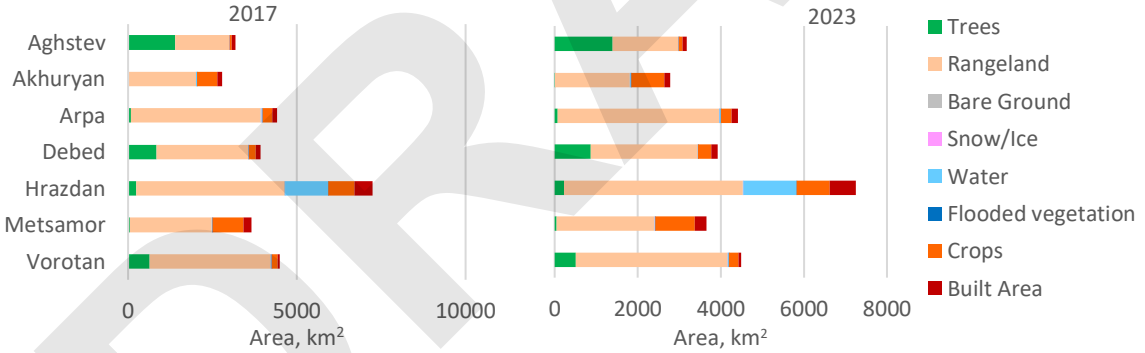


Figure 22B-5. Area of land cover classes across watersheds in 2017 and 2023, km²

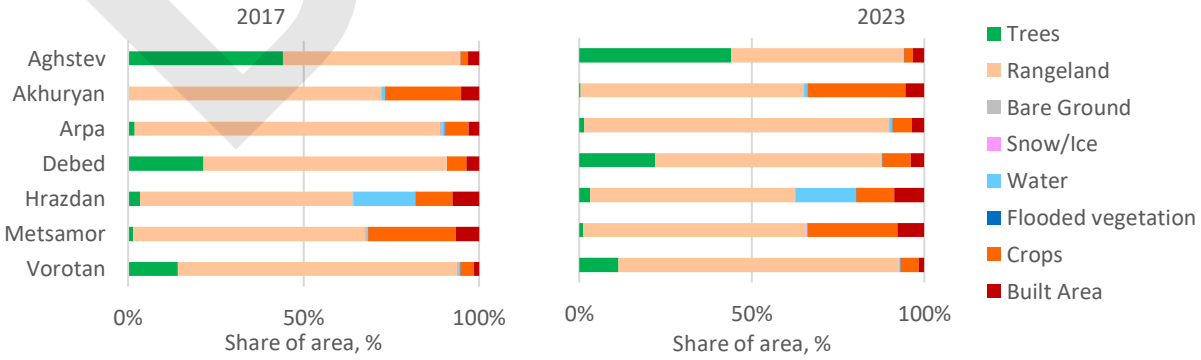


Figure 22B-6. The share of land cover classes across watersheds in 2017 and 2023, %

2.2.B2. Changes in land cover class extent

Between 2017 and 2023, according to ESRI data, the area of croplands and built-up areas in Armenia increased by 417 km² and 175 km², respectively, while the area of forests and grasslands decreased by 139 km² and 383 km².(Figure 22B-4; Table 22B-3). The total area of natural land-cover types decreased by 578.9 km² (1.95% of the country's total area) over these years, transitioning to croplands and built-up areas.

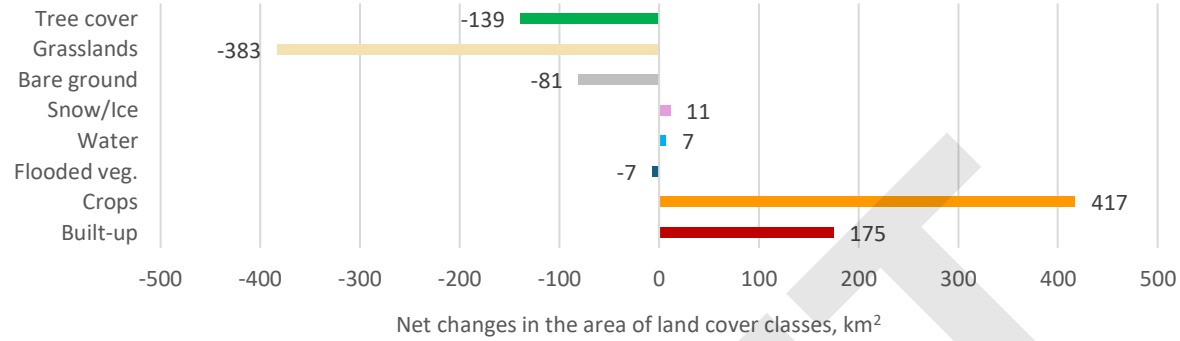


Figure 22B-4. Changes in the area of land cover classes from 2017 to 2023

The map of changes in land cover (Figure 22B-XX) shows that built-up areas expanded primarily in the Ararat Valley and around Yerevan (maroon color), while croplands expanded most intensively in the north-western part of the country (orange color in Fig 22B-XX). Local forest expansion occurred in several locations within Armenia's forest zone in the north-east; however, overall forest extent decreased, mainly due to transitions to grasslands in Syunik. Grasslands expanded in the southern part of Syunik marz, but their total extent across Armenia also decreased due to transitions to croplands.

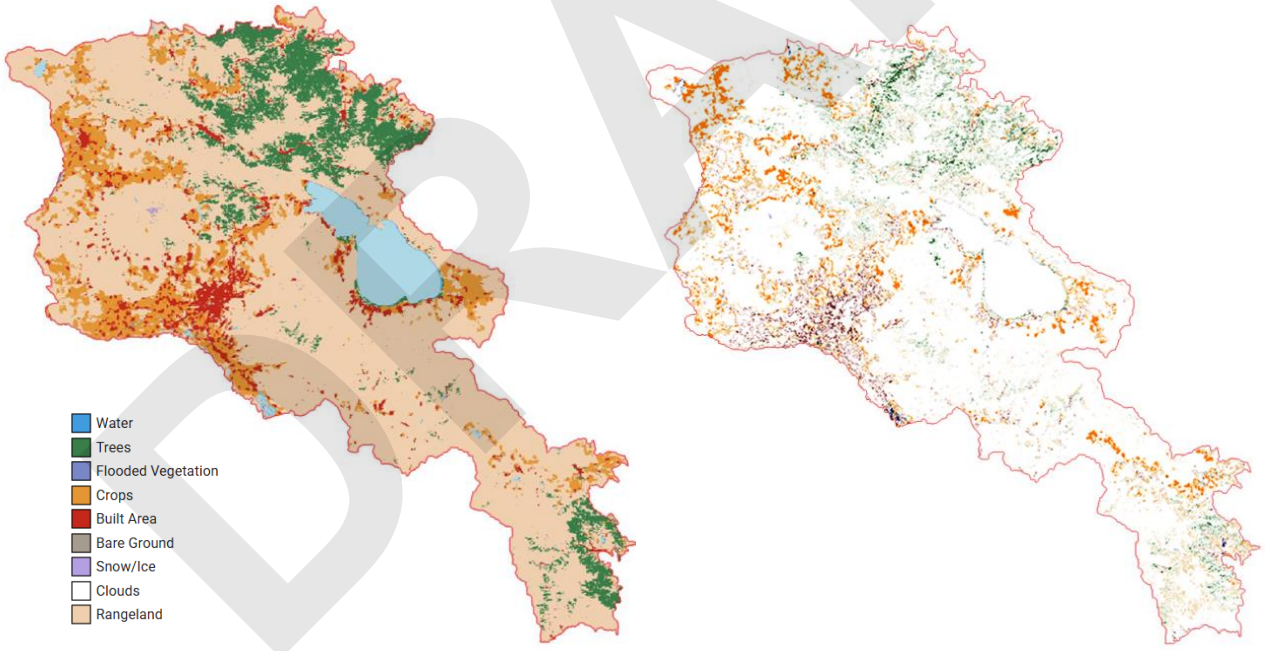


Figure 22B-XX. The land cover and its chnges: a) ESRI land cover data for 2023; b) The land-cover changes that occurred since 2017, specifically the new land-cover classes that emerged in place of previous ones, are shown.

The land-cover class transition matrix shows how much area of each class transitioned to another class (22B-3). In this matrix, the classes listed in the first column transform into the classes shown across each row. Example: In the *tree cover* row, the area that remained tree cover is 2909.87 km² (tree cover transitioned to tree cover), tree cover transitioned to grasslands over an area of 362.79 km², to bare ground - 0.02 km², and so on. The most intensive transition was from grasslands to croplands (941 km^2), while the reverse transition is less than half of that value (444 km^2). A shift from tree cover to grasslands is also noticeable (362 km^2). Other transitions are negligible (Fig. 22B-5).

The sum of transitions to other classes corresponds to the loss of tree cover due to these conversions (last column, 369.92 km²). At the same time, other classes transitioned into tree cover, producing its gain of 230.88 km² (bottom row).

Thus, the net change in tree cover is a decrease of 139.04 km². These data make it possible to populate rows "Additions to extent" and "Reductions in extent" in the accounting table of land cover class extent (Table 22B-4), which are unknown if we know only the opening and closing extent. As noted in Section 1.4.A, we do not have data to distinguish between managed and unmanaged land cover changes.

Table 22B-3. Land cover class transition matrix from 2017 to 2023, km²

	Tree cover	Grasslands	Bare ground	Snow/ Ice	Water	Flooded veg.	Crops	Built-up	Total area in 2017	Reduc-tion
Tree cover →	2909.87	362.79	0.02	0.05	0.58	0.02	3.74	2.72	3279.79	369.92
Grasslands →	224.03	19221.76	2.12	7.56	13.46	1.74	940.92	114.62	20526.21	1304.45
Bare ground →	0.05	75.63	29.67	3.70	1.97	0.24	2.10	2.59	115.94	86.27
Snow/Ice →	0.01	0.49	0.04	0.33	0.01	0.00	0.02	0.06	0.96	0.63
Water →	0.44	8.74	2.29	0.04	101.20	0.47	7.41	1.53	122.12	20.92
Flooded veg. →	0.05	3.34	0.05	0.00	4.48	4.78	1.81	0.87	15.37	10.59
Crops →	3.04	444.42	0.42	0.29	6.62	1.18	2478.53	97.21	3031.70	553.17
Built-up→	3.27	25.79	0.76	0.03	0.50	0.02	14.40	1335.95	1380.72	44.77
Total area in 2023	3140.75	20142.95	35.35	12.00	128.82	8.46	3448.92	1555.56	28472.82	
Expansion	230.88	921.19	5.69	11.67	27.62	3.68	970.39	219.61		2390.73

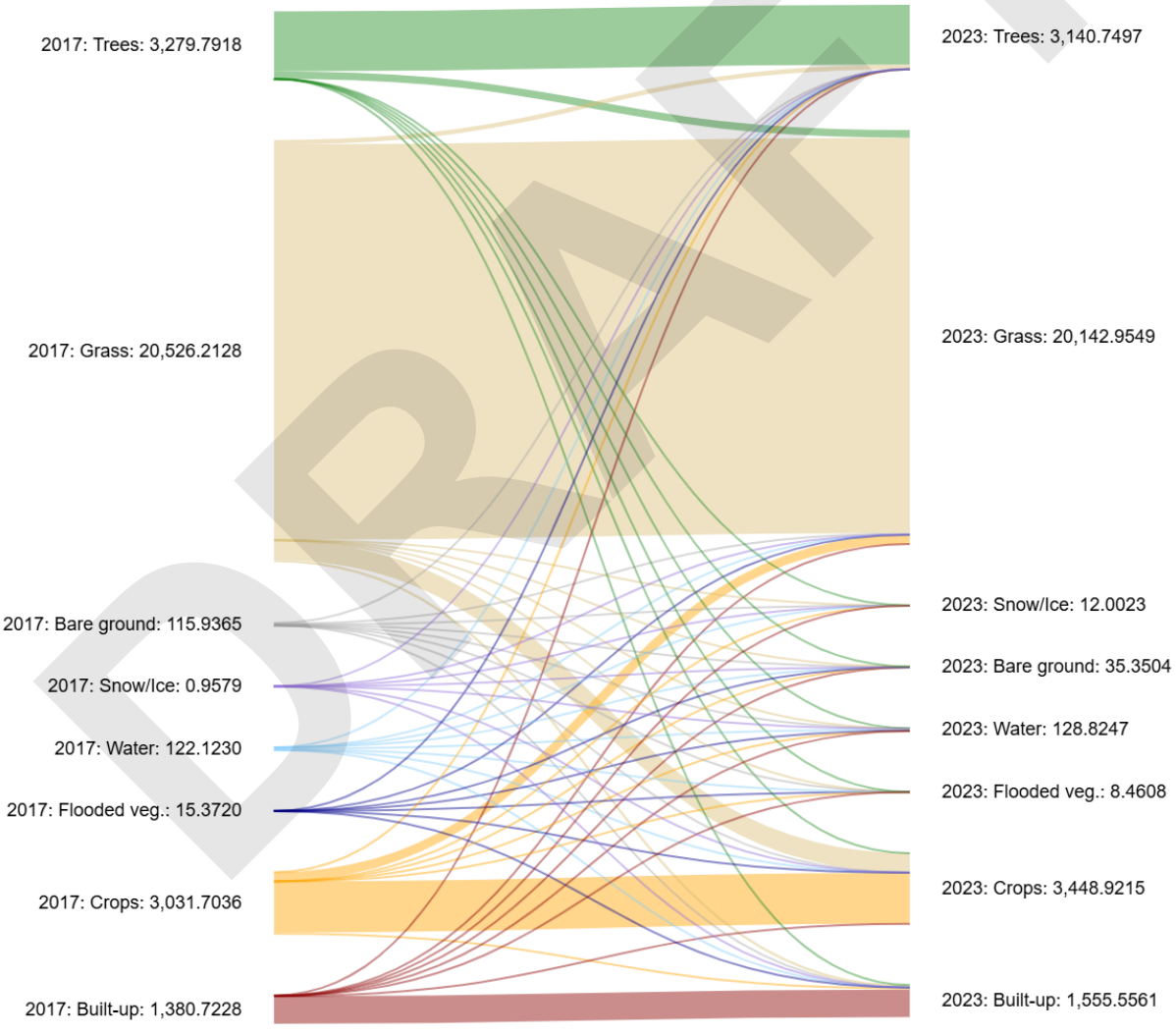


Figure 22B-5. Transiions between land cover classes from 2017 to 2023

Table 2.2.B-4. Accounting table of land-cover class extent for 2017 and 2023, based on ESRI land cover dataset

	Trees	Grass	Bare ground	Snow/Ice	Water	Flooded veg.	Crops	Built-up
1. Opening extent in 2020	**3279.79**	**20526.21**	**115.94**	**0.96**	**122.12**	**15.37**	**3031.70**	**1380.72**
2. Additions to extent	230.88	921.19	5.69	11.67	27.62	3.68	970.39	219.61
3. Managed expansion	NA							
4. Unmanaged expansion	NA							
5. Reductions in extent	369.92	1304.45	86.27	0.63	20.92	10.59	553.17	44.77
6. Managed reductions	NA							
7. Unmanaged reductions	NA							
8. Net change in extent	-139.04	-383.26	-80.59	11.04	6.70	-6.91	417.22	174.83
9. Closing extent in 2024	**3140.75**	**20142.95**	**35.35**	**12.00**	**128.82**	**8.46**	**3448.92**	**1555.56**

The most significant changes occurred in Shirak marz, where cropland area increased by 200 km² at the expense of grasslands . Similar but less extensive cropland expansion at the expense of grasslands took place in Lori, Gegharkunik, and Aragatsotn. In contrast, in Armavir and Ararat, cropland area decreased. In Armavir, this was due to an increase in built-up areas, while in Ararat, it resulted from both an expansion of built-up areas and grasslands. In Syunik marz, forest area noticeably declined due to an increase in grasslands and croplands (Table 22B-5; Figure 22B-4 a). Relative changes in land cover areas present a somewhat different picture. In 2023, the ESRI land cover dataset shows an 80% loss of tree cover in Armavir marz compared to 2017, although this loss is barely noticeable in absolute terms due to the initially small woody area in that marz. The largest relative increase in cropland area was identified in Lori marz — nearly 60% (Figure 22B-4 b).

Table 22B-5. Changes in area of land cover classes from 2017 to 2023, km²

	Rangeland	Trees	Bare Ground	Snow/Ice	Flooded vegetation	Water	Crops	Built Area
Aragatsotn	-64.22	-4.29	-9.12	6.36	0.00	0.06	58.36	12.84
Ararat	37.35	-4.28	-9.42	0.04	-4.96	3.27	-54.46	32.46
Armavir	6.30	-2.29	-3.41	0.00	-1.65	0.43	-35.88	36.50
Gegharkunik	-80.52	-5.37	-14.81	0.90	-0.75	-0.02	89.89	10.68
Kotayk	2.07	-18.64	-6.39	0.86	-0.01	0.08	-5.26	27.28
Lori	-133.47	14.22	-1.72	0.28	0.35	1.17	109.66	9.50
Shirak	-214.12	0.34	-3.40	2.47	-0.06	4.26	205.33	5.18
Syunik	79.18	-126.52	-20.49	-0.04	-0.02	-2.12	62.58	7.44
Tavush	-6.54	12.23	-1.28	0.04	0.02	0.35	-9.49	4.68
Vayots Dzor	16.90	-8.97	-11.50	0.33	-0.01	-0.41	-1.98	5.63
Armenia	-364.25	-143.52	-82.35	11.23	-7.08	7.04	403.85	175.08

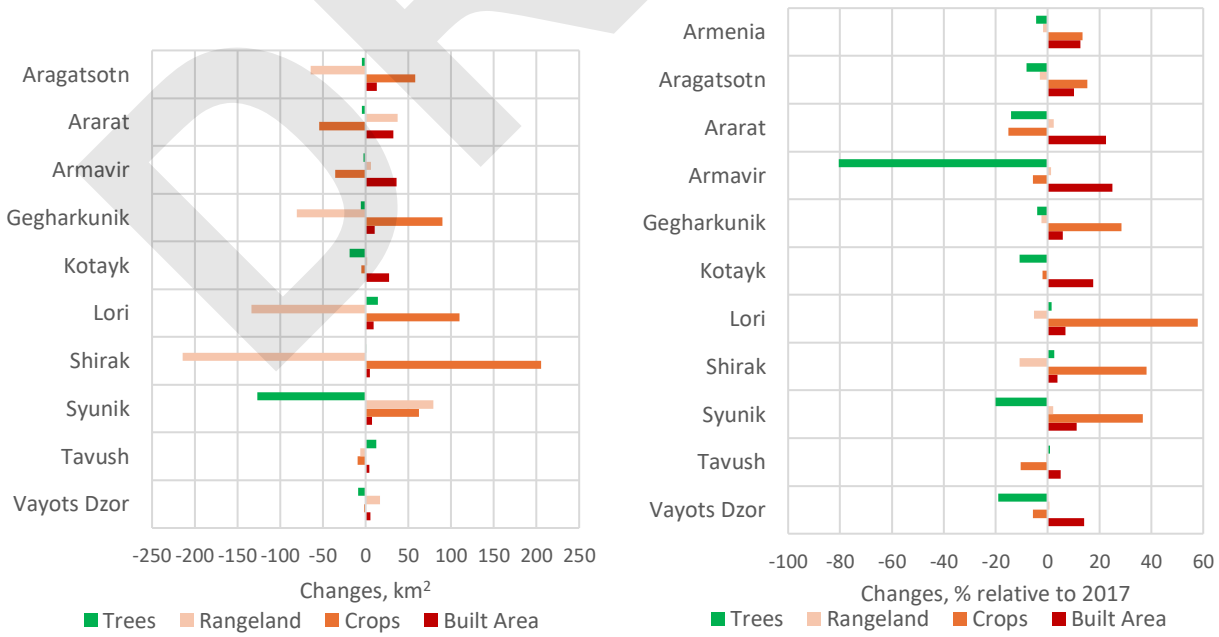


Figure 22B-4. Absolute (km²) and relative (% of 2017 area) changes in area of the main land cover classes in Armenia and across marzes from 2017 to 2023

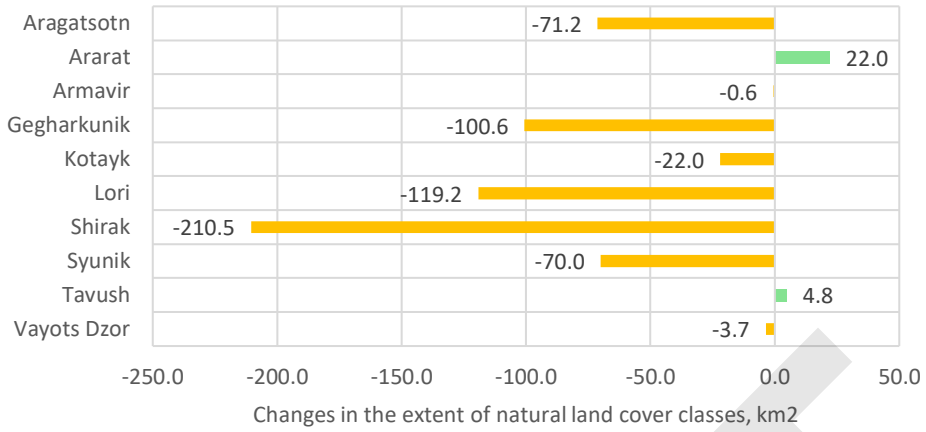


Figure 22B-XX. Total changes in the extent of natural land cover classes across marzes from 2017 to 2023

Across watersheds, the most significant changes in land cover area occurred in Akhurian watershed (Shirak marz), where cropland area increased by 200 km² at the expense of grasslands. Similar but less extensive cropland expansion at the expense of grasslands took place in Debed watershed (Lori marz). In the Razdan and Metsamor watersheds, grassland areas decreased due to the expansion of croplands and built-up areas. Changes in the Arpa watershed are driven by changes in Ararat marz, where cropland area decreased due to the expansion of built-up areas and grasslands. In Vorotan watershed (Syunik marz), forest area noticeably declined due to an increase in grasslands and croplands (Table 22B-8; Figure 22B-7 a).

Relative changes show the largest relative increase in cropland area in Debed watershed (Lori marz) and significant increase in cropland area in Vorotan watershed (Syunik marz) and Akhuryan watershed (Shirak marz). In the Vorotan, Arpa, and Metsamor watersheds, forest area decreased by 10–20% (Figure 22B-7 b).

Table 22B-8.Changes in area of land cover classes from 2017 to 2023, km2

	Trees	Rangeland	Bare Ground	Snow/Ice	Flooded vegetation	Water	Crops	Built Area
Aghstev	-4.20	-9.77	-1.90	0.08	0.02	0.34	10.39	5.04
Akhuryan	0.25	-197.84	-3.52	2.36	-0.06	4.29	189.17	5.35
Arpa	-13.62	51.72	-21.36	0.58	-4.62	3.19	-38.73	22.85
Debed	21.82	-144.43	-1.99	0.25	0.35	1.18	112.69	10.12
Hrazdan	-14.69	-78.67	-21.18	1.52	-1.01	-0.32	29.54	84.81
Metsamor	-6.59	-64.09	-12.06	6.46	-1.75	0.47	38.10	39.46
Vorotan	-126.52	78.89	-20.28	-0.02	-0.02	-2.12	62.62	7.45

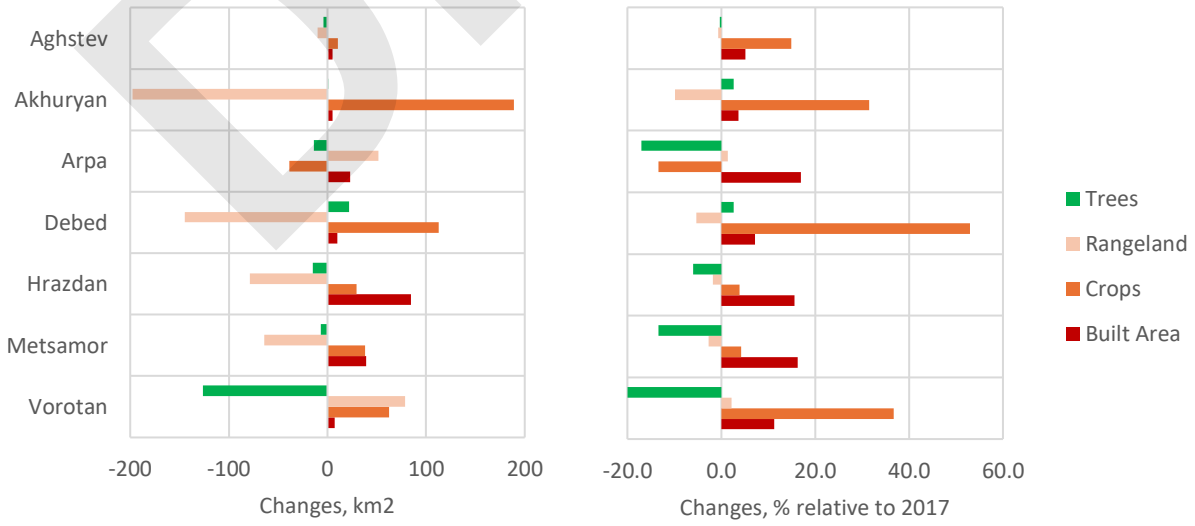


Figure 22B-7. Absolute (km²) and relative (% of 2017 area) changes in area of the main land cover classes across watersheds from 2017 to 2023

2.3. Extent of ecosystems (vegetation types)

2.3.A. Ecosystem extent at national and marz levels

Vegetation types most accurately reflect the characteristics of terrestrial ecosystems, because vegetation reflects all the main habitat conditions (climate, soil, topography) and forms the trophic basis of ecosystems and largely determines both their functioning and their species diversity. The assessment of the extent of ecosystem types was made based on a vegetation map created by the project experts Alla Aleksanyan and Vardan Asatryan (Fig. 23A-1a). The map was created based on Barseghyan (2007) and other materials.

The current natural area of vegetation zones is defined as the potential area of a given vegetation type minus cropland and built-up areas based on ESRI land cover data 2023 (Fig. 23A-1b). The current distribution of forests is also derived from ESRI land-cover data (Fig. 23A-1c). At this scoping stage, all forests are treated as a single type, regardless of the vegetation zone in which they occur. In the future, when producing a detailed terrestrial ecosystem map, forests should also be classified by type.

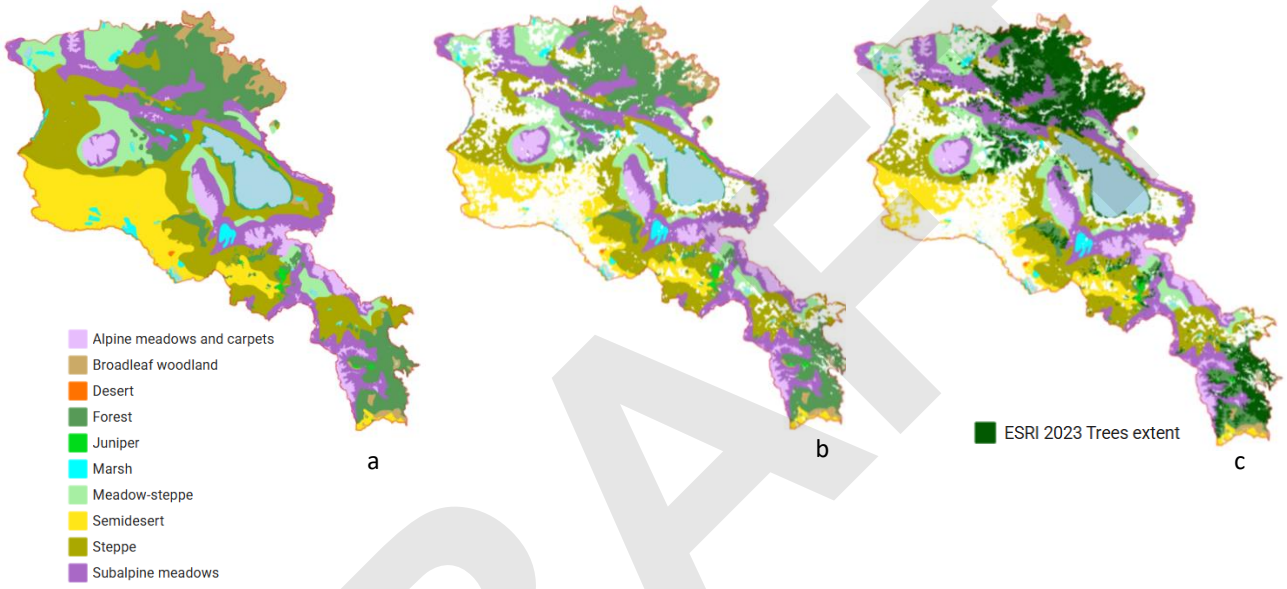


Figure 23A-1. Maps of vegetation: a) potential distribution of vegetation types; b) current natural area of vegetation zones; c) ecosystem types, including current tree cover [For detailed map see project Web-GIS, sections Ecosystem Extent/Vegetation/Vegetation map 2025]

According to ESRI data, the most human-transformed vegetation zone is semi-desert, where 56% of natural areas remain. It is followed by marshes and steppe with 70% and 76% of natural areas remaining, respectively.Tree cover occupies more than 40% of the forest zone and more than 20% of the broadleaf woodland zone. Significant forest patches are also present in subalpine meadows, meadow-steppe, and steppe zones. In the remaining zones, the tree cover identified by ESRI occupies a very small area — from 0 to 4 km². In the marsh zone, water bodies occupy a substantial area (Lake Sevan is excluded from the analysis) (Table 23A-1; Figure 23A-2).

Table 23A-1. Current area of land cover classes across vegetation zones, km²

	Grass-lands	*Tree cover*	*Bare gr-d*	*Snow/ Ice*	*Flood. veg.*	*Water*	*Crops*	*Built-up*	*Total*	*Share of natural classes, %*
Alpine	1625.72	0.63	10.21	11.70	0.03	1.93	3.32	0.80	1654.34	99.75
Subalpine	4287.98	256.92	5.28	0.26	0.09	2.85	85.56	25.20	4664.14	97.63
Meadow-steppe	2587.14	77.83	0.22	0.04	0.76	6.66	460.94	93.06	3226.64	82.83
Steppe	5229.35	95.86	3.24	0.00	0.03	4.89	1317.52	403.45	7054.33	75.60
Forest zone	2892.93	2431.91	3.91	0.00	0.60	30.37	155.70	199.61	5715.04	93.78
Broadleaf woodl.	695.02	269.12	2.64	0.00	0.01	7.29	125.86	83.92	1183.86	82.28
Juniper	129.59	4.20	0.00	0.00	0.16	0.08	0.87	0.12	135.02	99.27
Semidesert	2459.00	3.44	8.62	0.00	2.90	29.21	1212.83	716.50	4432.49	56.47
Desert	6.64	0.00	0.21	0.00	0.00	0.00	0.52	0.28	7.65	89.58
Marsh	229.59	0.84	1.00	0.00	3.89	45.54	85.81	32.63	399.30	70.34
Total in Armenia	20142.95	3140.75	35.35	12.00	8.46	128.82	3448.92	1555.56	28472.82	82.42

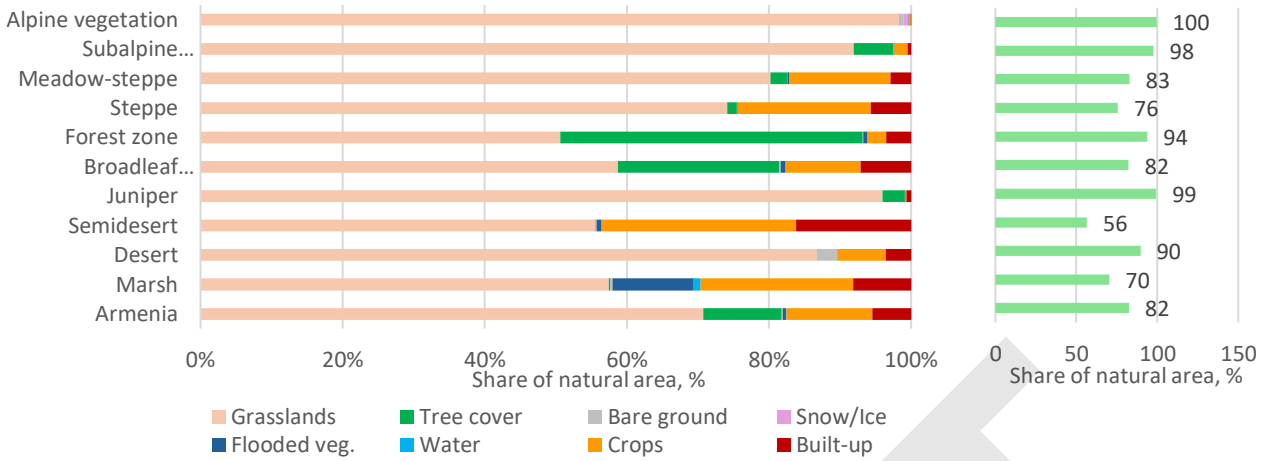


Figure 23A-2. Share of land cover classes across vegetation zones, %

Considering all tree-covered areas as forest, the most widespread natural areas are in steppe and subalpine zones (exceeding 5,000 km² and 4,000 km² respectively), followed by forests and grasslands in forest zone each covering approximately 3,000 km². The smallest zones are marshes and juniper woodlands (270 and 130 km², respectively), as well as the extreme small desert zone, which consists of a single patch covering only 7 km² (Figure 23A-3).

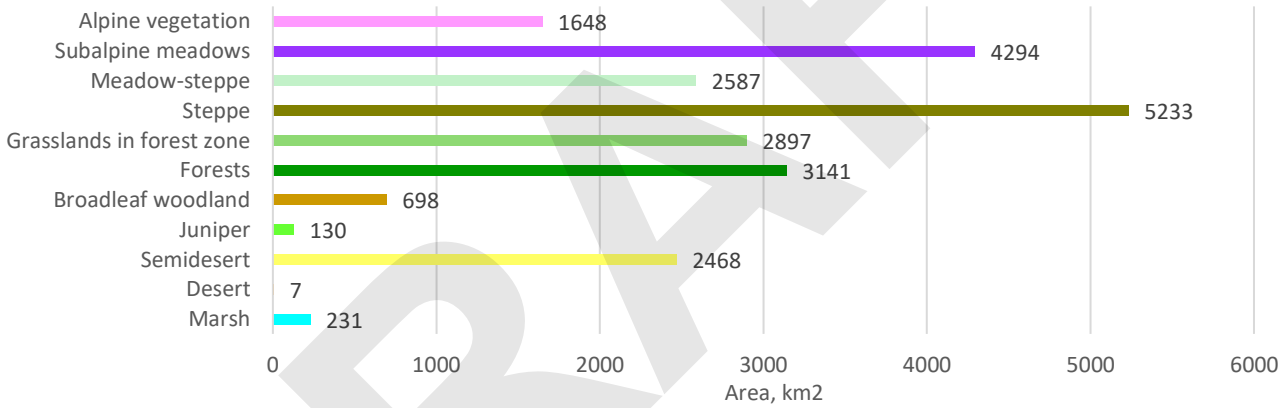


Figure 23A-3. Area of natural ecosystem types, km²

The ecosystem extent (i.e., the area not occupied by croplands or built-up areas) is greatest in Syunik marz and smallest in Armavir marz (Table 23A-2; Figure 23A-4). Forests and grasslands in forest zone occupy the largest areas in the marzes of Lori, Syunik, and Tavush. Alpine and subalpine ecosystems are most extensive in Syunik and Gegharkunik marzes. Steppe and meadow-steppe occupy substantial areas across all marzes except Armavir and Tavush, with the greatest extents in Gegharkunik and Shirak. The largest areas of natural semidesert have been preserved in the marzes of Aragatsotn, Armavir, and Ararat.

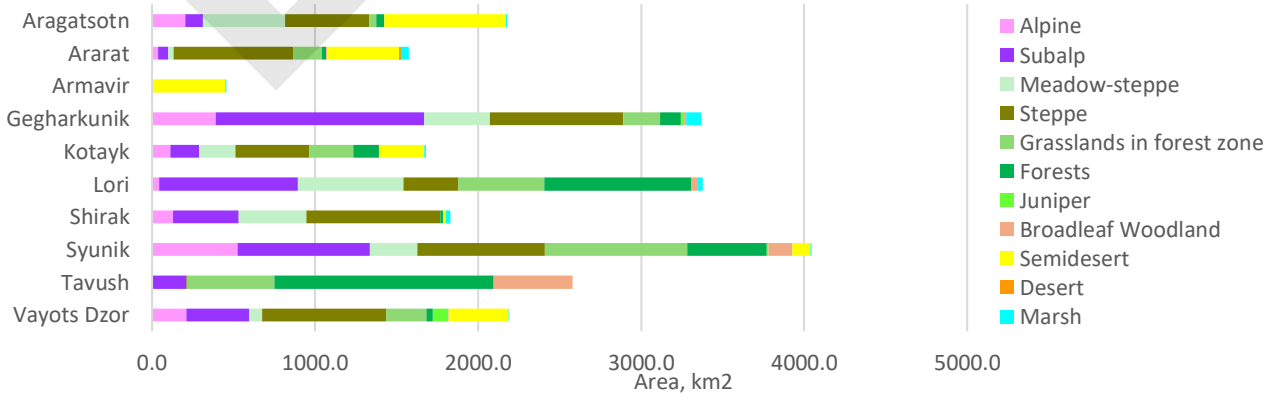


Figure 23A-4. Extent of natural vegetation types across marzesin 2023

Table 23A-2. Extent of natural ecosystems, antropogenic land cover classes, and water (excuding Sevan Lake) by marzes in 2023

		Water	*Crops*	*Built-up*	*Alpine*	*Subalp*	*Meadow-steppe*	*Steppe*	*Grasslands in forest zone*	*Forests*	*Juniper*	*Broadleaf woodland*	*Semidesert*	*Desert*	*Marsh*	Total
Extent in 2023, km2	Aragatsotn	3.4	443.4	140.3	204.5	107.1	502.7	517.5	42.9	48.9	0	0	746.6	0	5.3	2762.6
	Ararat	37.9	303.4	176.6	37.2	62.9	30.8	733.2	176.2	26.1	0	9.5	444.1	6.9	49.8	2094.6
	Armavir	6.7	609.6	183.2	0	0	0	0	0	0.4	0	0	448.8	0	6.9	1255.6
	Gegharkunik	28.2	407.2	192.9	389.9	1280.8	400.3	817.8	227	127.9	20.8	10.6	0	0	92.8	3996.2
	Kotayk	2.6	267.5	183.8	113.9	175.9	221.7	451.6	272.6	155.1	0	1.7	278.8	0	8.2	2133.4
	Lori	4.7	307.2	151.5	45	847.9	649.5	337.3	526.4	899.2	0	41.8	0	0	31.3	3841.8
	Shirak	30.9	758	145.5	128.3	403.9	413.5	823.9	0	13.7	0	0	17.3	0	29	2764
	Syunik	15	228.7	72	524.3	813.1	291.1	781.4	871.8	487.4	12.6	145.7	110.2	0	6.5	4359.8
	Tavush	4.4	82.1	97.7	0.3	210.9	0	6.5	534	1343.7	0	483.5	0	0	0	2763.1
	Vayots Dzor	2.3	32.9	44.9	210.7	385.1	77.7	763.3	246	37.9	96.3	4.6	364.7	0	0.8	2267.2
	Total	136.1	3440	1388.4	1654.1	4287.6	2587.3	5232.5	2896.9	3140.3	129.7	697.4	2410.5	6.9	230.6	28238.3

2.3.B. Ecosystem rarity in Armenia

Currently, desert, juniper, and marsh zones have the smallest natural areas (less than 1% of Armenia's area). Broadleaf woodlands also are rare (2%) The most widespread are steppe and subalpine meadows (18% and 14%) following by forests (11%). Other types of grasslands account from 6% to 10% of Armenia's area and can be considered common (Fig. 23B-1, 23B-2).

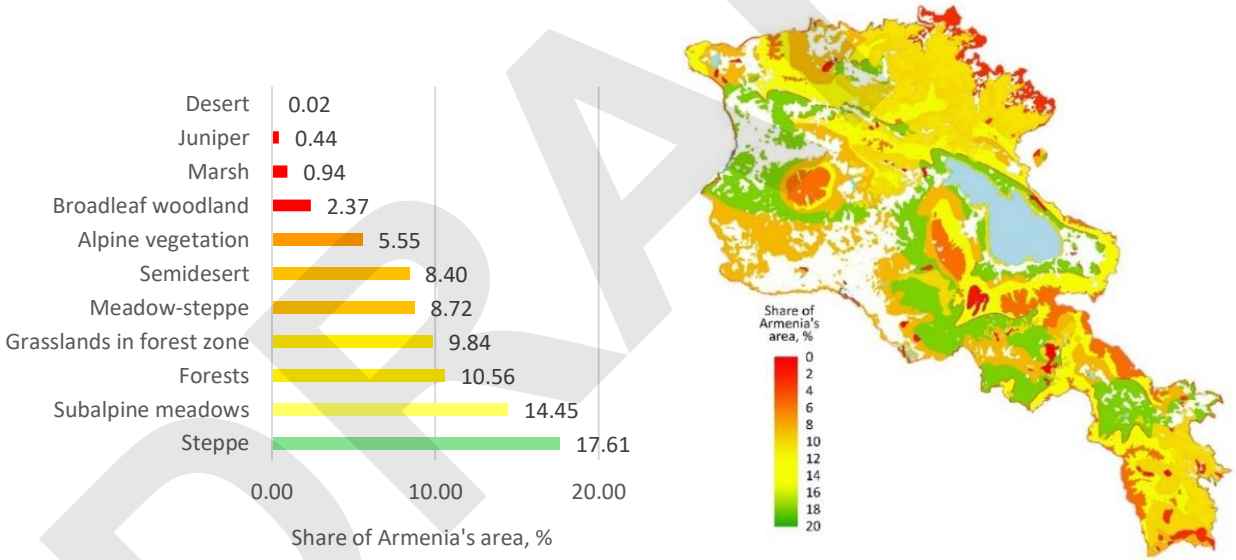


Figure 23B-1. Ranking of ecosystem types by rarity (a) and the map of ecosystem rarity (b)

To assess the importance of marzes for conserving ecosystem diversity in Armenia, we used the indicator of the share of the national area of ecosystem types that is conserved within the marzes and the sum ov these values in marzes (Table 23B-1). This approach was applied to ensure that the value of rare ecosystems is not diminished. According to this criterion, the marz of Ararat is the most important for conserving Armenia's ecosystem diversity, as it contains the country's only desert area (100%). The high value of Syunik marz is determined by the fact that it encompasses the full range of ecosystem types. The contribution of Gegharkunik is largely determined by the high proportion of marshes located within it, and the contribution of Vayots Dzor by the high proportion of juniper woodlands (Figure 23B-2).

Table 23B-1. Share of the national area of ecosystem types that is conserved within the marzes, %.

	Alpine vegetation	Subalpine meadows	Meadow-steppe	Steppe	Grasslands in forest zone	Forests	Juniper	Broadleaf woodland	Semidesert	Desert	Marsh	Total
Aragatsotn	12.36	2.50	19.43	9.89	1.48	1.56	0.00	0.00	30.97	0.00	2.30	80.49
Ararat	2.25	1.47	1.19	14.01	6.08	0.83	0.00	1.36	18.42	100.00	21.60	167.21
Armavir	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	18.62	0.00	2.99	21.62
Gegharkunik	23.57	29.87	15.47	15.63	7.84	4.07	16.04	1.52	0.00	0.00	40.24	154.25
Kotayk	6.89	4.10	8.57	8.63	9.41	4.94	0.00	0.24	11.57	0.00	3.56	57.90
Lori	2.72	19.78	25.10	6.45	18.17	28.63	0.00	5.99	0.00	0.00	13.57	120.42
Shirak	7.76	9.42	15.98	15.75	0.00	0.44	0.00	0.00	0.72	0.00	12.58	62.63
Syunik	31.70	18.96	11.25	14.93	30.09	15.52	9.71	20.89	4.57	0.00	2.82	160.46
Tavush	0.02	4.92	0.00	0.12	18.43	42.79	0.00	69.33	0.00	0.00	0.00	135.61
Vayots Dzor	12.74	8.98	3.00	14.59	8.49	1.21	74.25	0.66	15.13	0.00	0.35	139.39
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

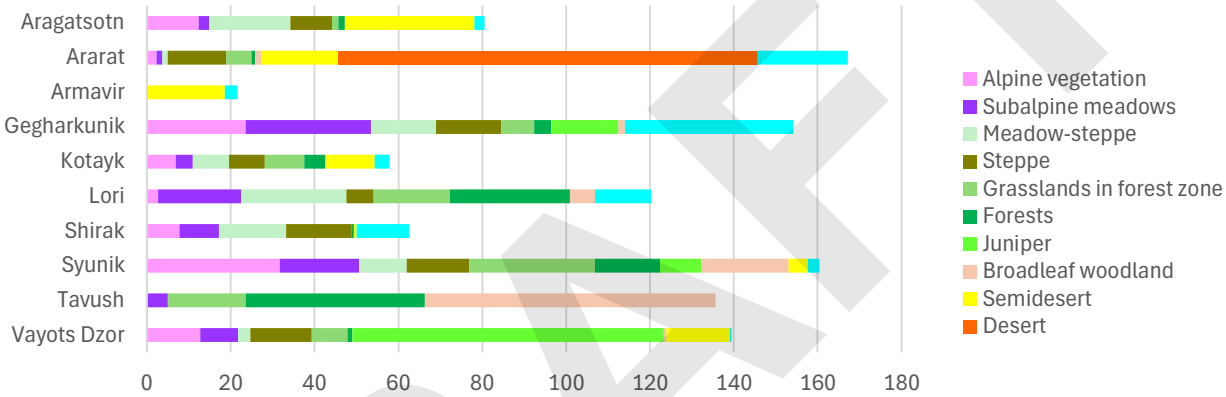


Figure 23B-2. The sum of the shares (%%) of the national area of ecosystem types that are conserved within the marzes.

2.3.C. Changes in ecosystem extent from 2017 to 2023

The vegetation-type transition matrix shows how areas of vegetation zones transited into land-cover classes (e.g., steppe vegetation converting to croplands, built-up, bare ground, or tree cover, and vice versa). Zone-to-zone vegetation transitions are not recorded in PV1, because the zone boundaries did not change. Table 23C-1 presents aggregated data: bare ground and snow/ice are added to the natural area of the corresponding vegetation zone, and the areas of water and flooded vegetation are combined (for full matrix see Appendix 3). Data on transitions from the natural areas of vegetation zones to anthropogenic territories and to tree cover—and back—allow us to populate rows “Additions to extent” and “Reductions in extent” in the accounting table (Table 23C-2).

Table 23C-1. Aggregated vegetation type transition matrix from 2017 to 2023, km²

	Alpine vege-tation	Subalpine meadows	Meadow-steppe	Steppe	Grassl. in forest zone	Juniper	Broadleaf woodland	Semi-desert	Desert	Marsh	Forests	Water and flood. veg.	Crops	Built-up	Total area in 2017	Reduc-tion
Alpine veg.	1642.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	2.3	0.1	1645.9	3.0
Subalpine meadows	0.0	4216.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.6	0.5	60.9	2.9	4300.5	83.8
Meadow-steppe	0.0	0.0	2552.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	2.3	270.0	6.2	2841.5	289.4
Steppe	0.0	0.0	0.0	5039.5	0.0	0.0	0.0	0.0	0.0	0.0	11.3	1.0	370.2	21.3	5443.2	403.8
Grassl. in forest zone	0.0	0.0	0.0	0.0	2628.1	0.0	0.0	0.0	0.0	0.0	143.6	1.4	54.9	22.2	2850.2	222.1
Juniper	0.0	0.0	0.0	0.0	0.0	127.5	0.0	0.0	0.0	0.0	0.9	0.0	0.2	0.2	128.8	1.2
Broadleaf woodland	0.0	0.0	0.0	0.0	0.0	0.0	640.4	0.0	0.0	0.0	36.2	2.5	24.9	6.6	710.6	70.2
Semi-desert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2274.9	0.0	0.0	1.1	4.4	142.5	55.8	2478.5	203.6
Desert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0	0.3	7.1	0.3
Marsh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	212.5	0.2	5.1	17.1	1.9	236.8	24.3
Forests	3.2	62.5	11.4	22.7	238.5	2.0	18.8	3.3	0.0	0.4	2909.9	0.6	3.7	2.7	3279.8	369.9
Water/floode d veg.	0.2	0.4	1.2	0.8	1.8	0.0	0.6	4.2	0.0	5.3	0.5	110.9	9.2	2.4	137.5	26.6
Crops	1.3	12.6	20.3	162.8	21.8	0.0	35.5	179.1	0.1	11.5	3.0	7.8	2478.5	97.2	3031.7	553.2
Built-up	0.1	1.4	2.4	6.8	6.6	0.2	2.3	6.0	0.0	0.8	3.3	0.5	13.7	1336.6	1380.7	44.1
Total area in 2023	1647.6	4293.5	2587.4	5232.6	2896.8	129.7	697.7	2467.6	6.9	230.6	3140.7	137.1	3448.2	1556.3	28472.8	2295.46
Expansion	4.8	76.9	35.3	193.1	268.8	2.2	57.2	192.7	0.1	18.0	230.9	26.2	969.7	219.7	2295.5	

Table 2.3.C-2. Accounting table of vegetation type extent for 2017 and 2023, km2

	Alpine vege-tation	Sub-alpine mea-dows	Mea-dow-step-pe	Step-pe	Grassl. in forest zone	Juni-per	Broad-leaf wood-land	Semi-desert	Desert	Marsh	Fo-rests
Opening extent in 2017	**1645.93**	**4300.46**	**2841.47**	**5443.24**	**2850.19**	**128.78**	**710.63**	**2478.53**	**7.06**	**236.81**	**3279.79**
Additions to extent	4.76	76.90	35.29	193.11	268.77	2.17	57.23	192.71	0.06	18.04	230.88
Managed expansion	NA										
Unmanaged expansion	NA										
Reductions in extent	3.05	83.84	289.36	403.76	222.11	1.24	70.20	203.62	0.27	24.26	369.92
Managed reductions	NA										
Unmanaged reductions	NA										
Net change in extent	1.71	-6.94	-254.06	-210.66	46.66	0.93	-12.97	-10.92	-0.21	-6.22	-139.04
Closing extent in 2024	**1647.64**	**4293.52**	**2587.41**	**5232.59**	**2896.85**	**129.71**	**697.67**	**2467.61**	**6.85**	**230.59**	**3140.75**
Additional row – see dicussion below											
Closing extent in 2024 of ecosystems unconverted since 2017	**1642.88**	**4216.62**	**2552.11**	**5039.48**	**2628.08**	**127.54**	**640.43**	**2274.91**	**6.79**	**212.55**	**2909.87**

The largest transformation areas are represented by transitions of various grassland types into croplands: 370 km² of steppes, 270 km² of meadow-steppes, 144 km² of semideserts, and 61 km² of subalpine meadows were converted into croplands. The total increase in cropland area amounted to 970 km² (Table 23C-1; Figure 23C-1). The reverse process—conversion of croplands back into grasslands—was weaker and could not compensate for their loss. The exceptions are semideserts and woodlands, where the reverse transition from croplands exceeded new agricultural expansion. Based on the formal ratio of areas over the six-year period, the intensity of agricultural development in these zones has decreased. The opposite trend is observed in meadow-steppes and alpine meadows, where reverse transitions are extremely small, indicating an increase in agricultural expansion intensity (Figure 23C-2).

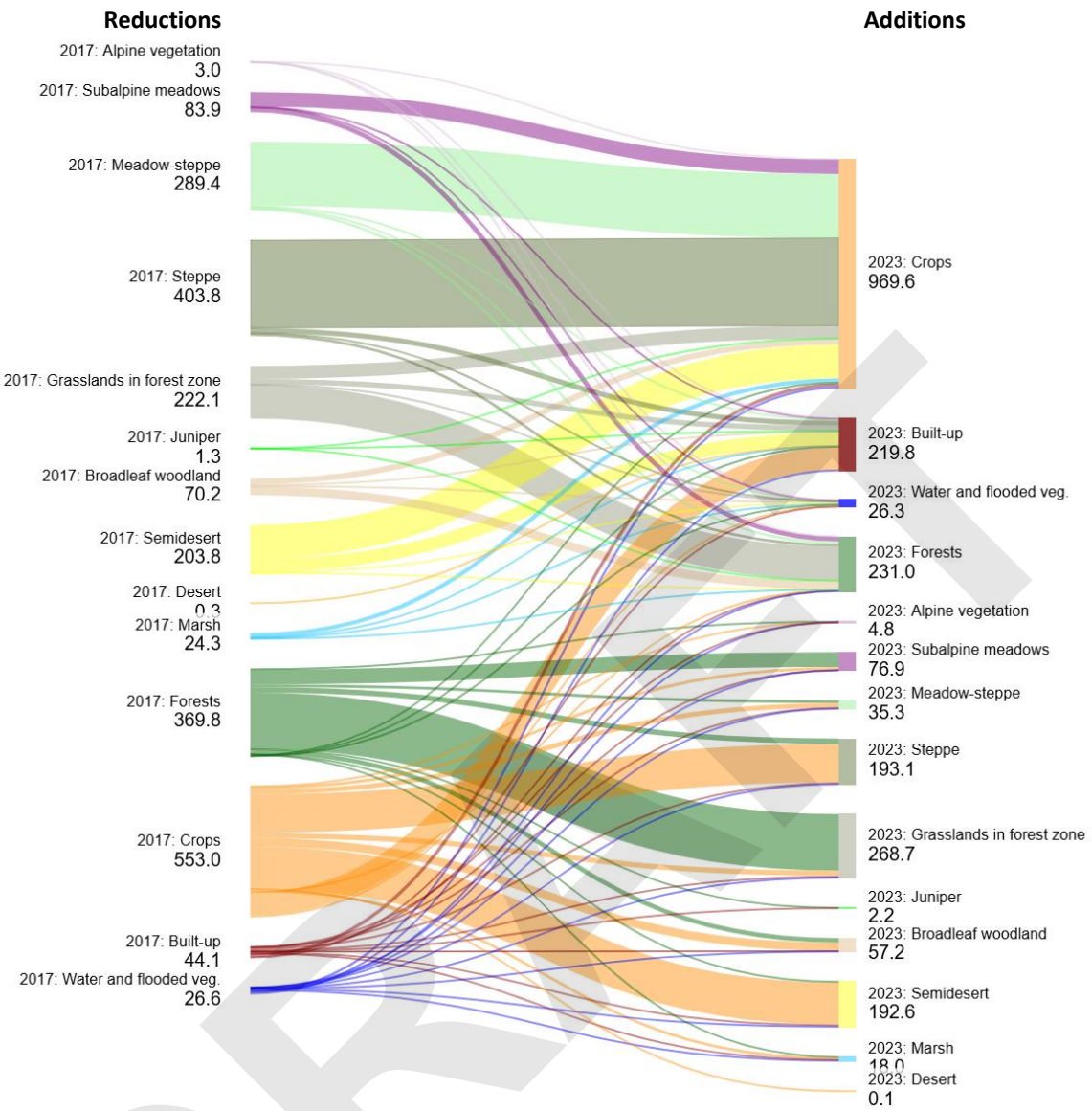


Figure 23C-1. Transitions between vegetation zones and land cover classes. Self-transitions (categories remaining the same) are not shown. The total losses and gains in the diagram differ slightly from Table 23C-1 because they were computed by SankeyMATIC using a different rounding approach for totals.

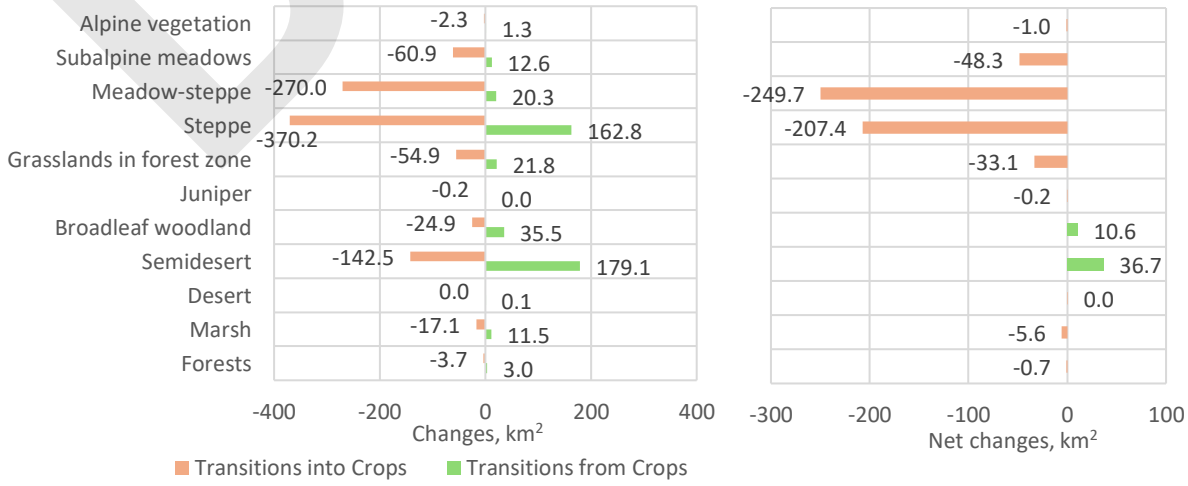


Figure 23C-2. Transitions between vegetation zones and croplands

Considering not only the net extent changes but also the transitions between natural ecosystems and anthropogenic areas and vice versa is crucial for conserving biodiversity and maintaining ecosystems' full capacity to provide ES. It is evident that any new additions to ecosystem area resulting from transitions out of croplands or built-up areas are merely nominal increases in area. In our case study, over six years the areas freed from cultivation and development did not recover into functioning ecosystems. In reality, these are abandoned fields or wastelands that, in terms of biodiversity and ecosystem functioning, are far from natural ecosystems. Thus, the closing extent for ecosystems that were not transformed during the reporting period equals the opening extent minus the reductions during the reporting period (Table 23C-2). To set up accounting of unchanged natural ecosystems, it is advisable to designate areas converted from croplands and built-up areas as "abandoned fields and sites" within each vegetation zone. Under such accounting, their re-use will not reduce the reported extent of unchanged ecosystems.

Totally, from 2017 to 2023, the area of the most vegetation types not occupied by croplands and built-up areas decreased. The exceptions are grasslands in forest zone, juniper woodlands and alpine vegetation (Figure 23C-3). The most significant reductions, both in absolute and relative terms, occurred in the meadow-steppe (254 km2, 8.9% relative to area in 2017). Steppes and forests declined by roughly 4% (211 km² and 139 km², respectively). Reductions in other vegetation types are small in absolute terms—only a few square kilometres, and for desert just 0.2 km².

However, for conserving ecosystem diversity, not only absolute but also relative changes in area matter, especially for ecosystem types with a small total extent. Thus, the very small absolute changes in the area of marshes and desert correspond to relative declines of 2.6% and 3%, respectively—comparable to the reductions in steppe and forest. In other words, for the purpose of conserving ecosystem diversity, they are no less important than the 100–200 km² losses observed for steppe and forest.

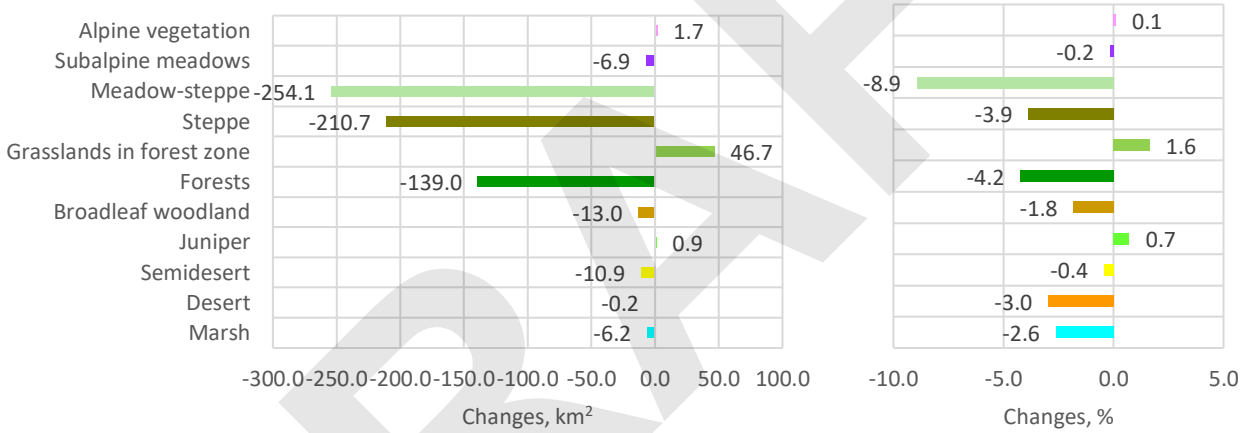


Figure 23C-3. Net changes in area of vegetation types from 2017 to 2023

Changes in the natural vegetation types from 2017 to 2023 are small in absolute terms—on the order of tens of square kilometers or less. The most noticeable absolute losses of natural vegetation occurred in the steppe and meadow-steppe zones, especially in the provinces of Shirak, Gegharkunik, and Lori, as well in forests in the mars Syunik (Fig. 23C-4a; Table 23C-3). However, in relative terms (the share of area lost or gained relative to 2017, %), the largest loss of tree cover is in Armavir marz with very small total tree cover area. Changes in the area of marshes and broadleaf woodlands also become noticeable, whereas they are almost imperceptible in absolute terms (Fig. 23C-4b; Table 23C-3).

[The transformation matrices for the marzes will be included in the final version of the report].

Table 23C-3. Extent of natural vegetation types, antropogenic land cover classes, and water (excuding Sevan Lake) by marzes in 2017 and in 2023 and changes in it

		Water	*Crops*	*Built-up*	*Alpine*	*Subalp*	*Meadow-steppe*	*Steppe*	*Grasslands in forest zone*	*Forests*	*Juniper*	*Broadleaf woodland*	*Semidesert*	*Desert*	*Marsh*	Total
Extent in 2017, km2	Aragatsotn	3.5	384	127.3	204.3	108.2	564.4	510.5	42.4	53.2	0	0	759.2	0	5.8	2762.8
	Ararat	39.8	356.1	144.3	37.2	62.6	30.8	730.7	174.7	30.4	0	9.5	425.1	7.1	46.2	2094.5
	Armavir	7.9	645.2	146.5	0	0	0	0	0	2.5	0	0	448	0	5.6	1255.7
	Gegharkunik	28.9	316.6	182.4	389.3	1292.6	420.5	878	230.9	133.6	20.7	8.8	0	0	93.9	3996.2
	Kotayk	2.5	272.6	156.2	113.3	168.8	219.2	456.8	271.1	174	0	1.7	288.6	0	8.6	2133.4
	Lori	3.2	194.2	141.7	43.9	851.1	701.1	385.1	554.3	885.4	0	50.2	0	0	31.7	3841.9
	Shirak	27.2	547.7	140.2	127.9	427.1	512	910.9	0	13.4	0	0	17.4	0	40.2	2764
	Syunik	19.4	165.8	64.7	518.9	793.8	315.7	801.9	799.9	608.7	11.9	140.6	110.6	0	7.9	4359.8
	Tavush	4	91.6	93.1	0.3	205.2	0	5.9	536.6	1331.5	0	494.9	0	0	0	2763.1

	Vayots Dzor	2.8	34.9	39.3	210.7	385.2	77.7	763.4	240.2	46.8	96.2	4.7	364.6	0	0.7	2267.2
	Total	139.2	3008.7	1235.7	1645.8	4294.6	2841.4	5443.2	2850.1	3279.5	128.8	710.4	2413.5	7.1	240.6	28238.6
Extent in 2023, km2	Aragatsotn	3.4	443.4	140.3	204.5	107.1	502.7	517.5	42.9	48.9	0	0	746.6	0	5.3	2762.6
	Ararat	37.9	303.4	176.6	37.2	62.9	30.8	733.2	176.2	26.1	0	9.5	444.1	6.9	49.8	2094.6
	Armavir	6.7	609.6	183.2	0	0	0	0	0	0.4	0	0	448.8	0	6.9	1255.6
	Gegharkunik	28.2	407.2	192.9	389.9	1280.8	400.3	817.8	227	127.9	20.8	10.6	0	0	92.8	3996.2
	Kotayk	2.6	267.5	183.8	113.9	175.9	221.7	451.6	272.6	155.1	0	1.7	278.8	0	8.2	2133.4
	Lori	4.7	307.2	151.5	45	847.9	649.5	337.3	526.4	899.2	0	41.8	0	0	31.3	3841.8
	Shirak	30.9	758	145.5	128.3	403.9	413.5	823.9	0	13.7	0	0	17.3	0	29	2764
	Syunik	15	228.7	72	524.3	813.1	291.1	781.4	871.8	487.4	12.6	145.7	110.2	0	6.5	4359.8
	Tavush	4.4	82.1	97.7	0.3	210.9	0	6.5	534	1343.7	0	483.5	0	0	0	2763.1
	Vayots Dzor	2.3	32.9	44.9	210.7	385.1	77.7	763.3	246	37.9	96.3	4.6	364.7	0	0.8	2267.2
	Total	136.1	3440	1388.4	1654.1	4287.6	2587.3	5232.5	2896.9	3140.3	129.7	697.4	2410.5	6.9	230.6	28238.3
Change, km2	Aragatsotn	0	59.4	13	0.1	-1.1	-61.7	7.1	0.4	-4.2	0	0	-12.6	0	-0.5	
	Ararat	-1.9	-52.8	32.4	-0.1	0.3	0	2.5	1.4	-4.3	0	0	19	-0.2	3.7	
	Armavir	-1.2	-35.6	36.7	0	0	0	0	0	-2.1	0	0	0.9	0	1.3	
	Gegharkunik	-0.7	90.6	10.5	0.6	-11.8	-20.2	-60.2	-3.9	-5.7	0	1.8	0	0	-1.1	
	Kotayk	0.1	-5.1	27.6	0.6	7.1	2.5	-5.3	1.5	-18.9	0	0	-9.7	0	-0.4	
	Lori	1.5	113	9.8	1.1	-3.1	-51.6	-47.8	-27.9	13.8	0	-8.4	0	0	-0.4	
	Shirak	3.7	210.3	5.2	0.4	-23.2	-98.5	-86.9	0	0.3	0	0	-0.1	0	-11.2	
	Syunik	-4.4	62.8	7.3	5.4	19.3	-24.6	-20.5	71.9	-121.3	0.7	5.1	-0.4	0	-1.4	
	Tavush	0.4	-9.4	4.6	0	5.6	0	0.6	-2.6	12.2	0	-11.4	0	0	0	
	Vayots Dzor	-0.4	-1.9	5.6	0	-0.1	0	-0.1	5.7	-8.9	0.2	-0.1	0	0	0	
	Total	-2.9	431.3	152.7	8.1	-7	-254.1	-210.6	46.5	-139.1	0.9	-13	-2.9	-0.2	-10	
Change, relative to 2017, %	Aragatsotn	-0.2	15.5	10.2	0.1	-1	-10.9	1.4	1	-8	0	0	-1.7	0	-8.7	
	Ararat	-4.9	-14.8	22.4	-0.2	0.5	0.1	0.3	0.8	-14.1	0	0	4.5	-3	7.9	
	Armavir	-14.9	-5.5	25	0	0	0	0	0	-83.5	0	0	0.2	0	23.1	
	Gegharkunik	-2.3	28.6	5.7	0.2	-0.9	-4.8	-6.9	-1.7	-4.2	0.1	20.5	0	0	-1.2	
	Kotayk	3.2	-1.9	17.7	0.6	4.2	1.2	-1.2	0.6	-10.9	0	0.1	-3.4	0	-4.6	
	Lori	48.3	58.2	6.9	2.5	-0.4	-7.4	-12.4	-5	1.6	0	-16.7	0	0	-1.1	
	Shirak	13.7	38.4	3.7	0.3	-5.4	-19.2	-9.5	0	2.3	0	0	-0.5	0	-27.9	
	Syunik	-22.8	37.9	11.2	1	2.4	-7.8	-2.6	9	-19.9	6.2	3.7	-0.4	0	-17.3	
	Tavush	9.3	-10.3	5	0	2.7	0	10.3	-0.5	0.9	0	-2.3	0	0	0	
	Vayots Dzor	-14.9	-5.5	14.2	0	0	0	0	2.4	-19	0.2	-2.1	0	0	0.6	

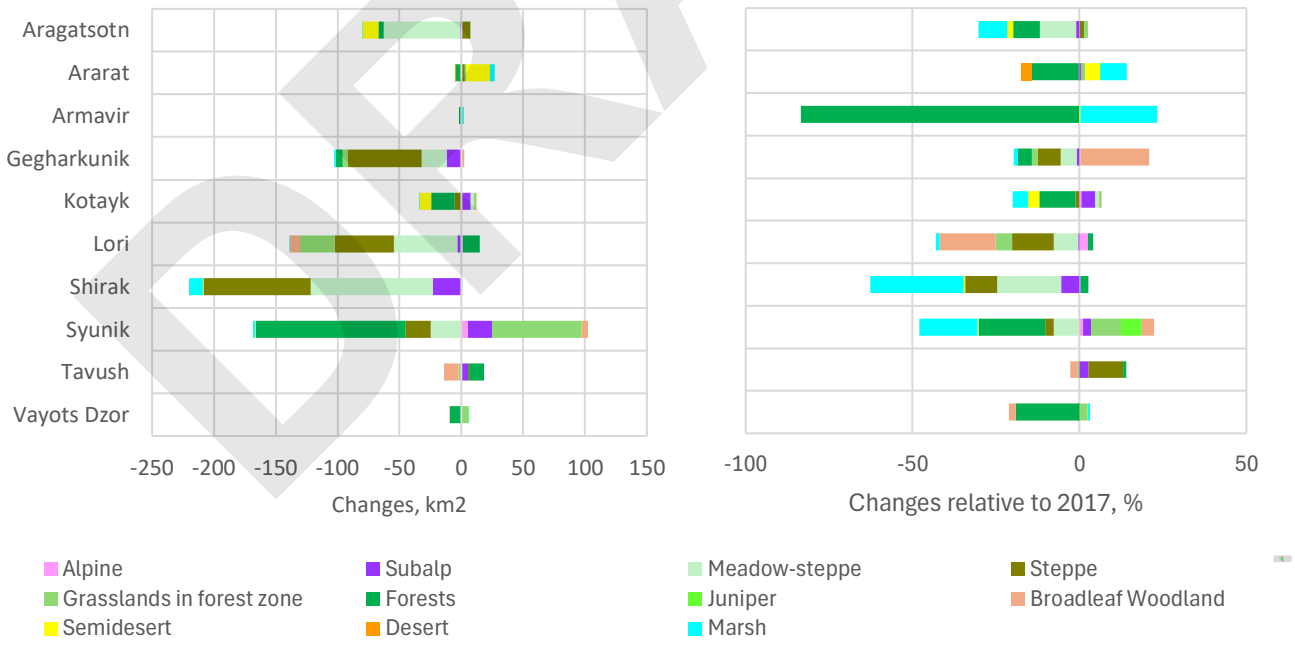


Figure 23C-4. Changes in natural area of vegetation types by provinces from 2017 to 2023: a) absolute changes, km2; b) chare of lost/gained area, % relative to 2017.

2.3.D. Reduction of the potential area of vegetation types identified on the 1961 vegetation map

For this analysis, the vegetation map from the 1961 Atlas of the Armenian SSR (1961), digitized by Vardan Asatryan, and the ESRI land cover data for 2023 were used. The current distribution of vegetation types was considered as potential vegetation zones (Figure 23D-1a), excluding croplands and built-up areas based on ESRI data for 2023 (Figure 23D-1b).

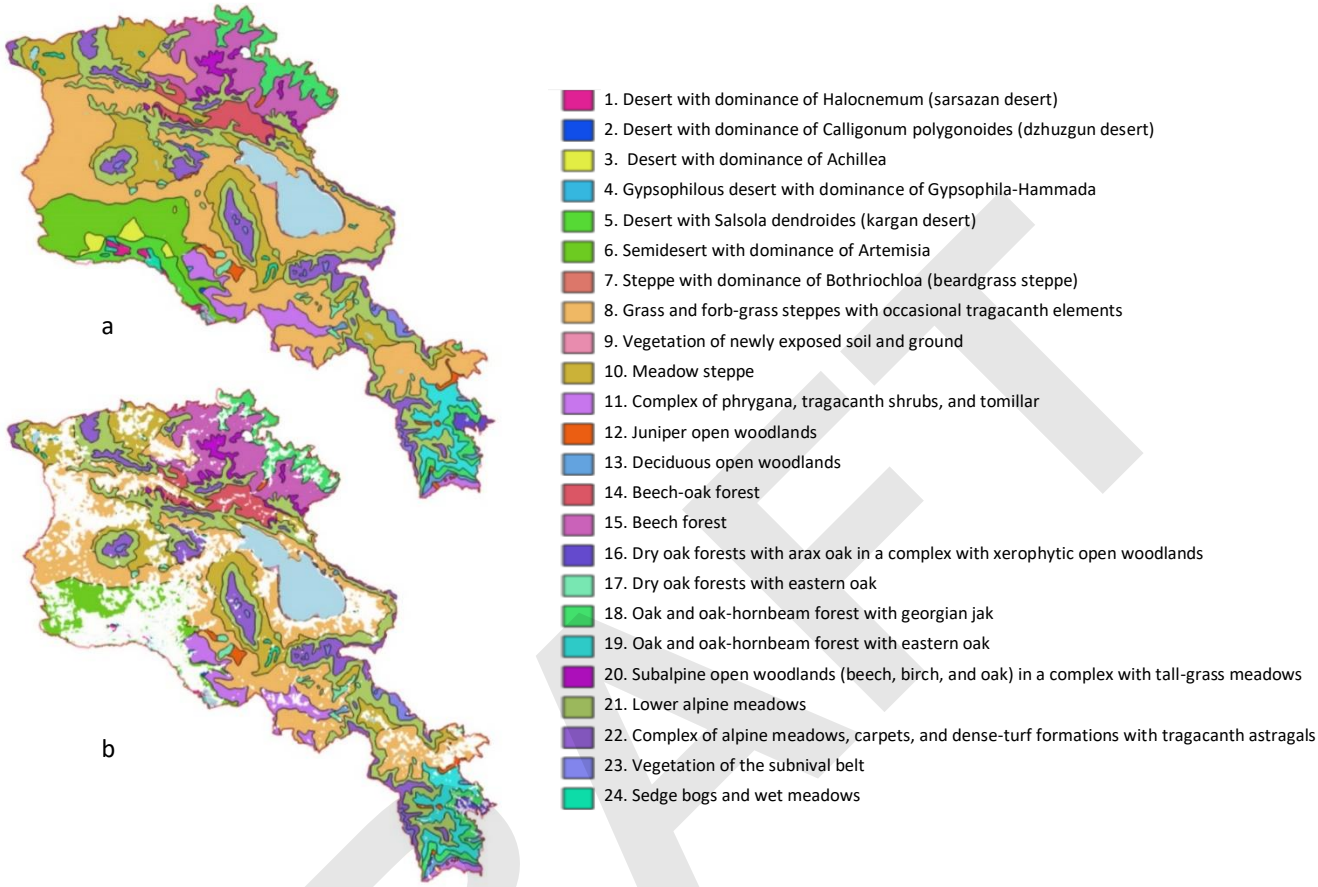


Figure 23D-1. Vegetation map of 1961: a) potential vegetation; b) vegetation excluding croplands and built-up areas in 2023. For detailed maps see in the Section Ecosystem Extent/Vegetation

Ranking of vegetation types by their current rarity (Figure 23D-2) shows that, at present, all desert types (1–5) as well as steppe with dominance of Bothriochloa (type 7) are the rarest. Each of them occupies less than 100 km². The potential distribution areas of the two rarest desert types (2 and 4), each occupying less than 10 km², have largely preserved and mostly not covered by croplands or built-up areas according to ESRI data. The distribution area of steppe with dominance of Bothriochloa (7) also appears to be relatively well preserved.

The most severely affected was the distribution area of desert with dominance of Achillea (3), of which only 7% remains, as well as desert with Salsola dendroides (5), with only 16% remaining. The distribution area of desert with dominance of Halocnemum (1) has also been significantly reduced, with 43% remaining. These three vegetation types have experienced the greatest decline among all types shown on the map.

Relatively rare vegetation types occupying between 100 and 200 km² — deciduous and juniper open woodland (12, 13) and variants of oak forests (16, 17) — have relatively well-preserved distribution areas, with 85–99% remaining.

Among the more widespread vegetation types, occupying between 200 and 1,000 km², a significant reduction was observed only for sedge bogs and wet meadows (type 24), which declined to 63%. The distribution areas of other types — subnival vegetation, subalpine open woodlands, variants of oak and birch-oak forests, as well as shrublands — have been largely unaffected by human activity, with 94–100% of their area remaining intact.

Among the common and widespread vegetation types occupying more than 1,000 km², significant reductions have occurred in semi-desert with dominance of Artemisia (type 6) with 57% remaining and the most widespread vegetation zone - grass and forb-grass steppes (type 8) with 75% remaining, both of which are located in areas of arable agriculture.

714 *Table 23D-1. Potential and current areas of vegetation types and the degree of their preservation*

Vegetation zones	*Total potential distribution area, km2*	*Area not occupied by croplands and built-up areas in 2023, km2*	*Area share not occupied by croplands and built-up areas relative to the total potential distribution area, %*
1. Desert with dominance of Halocnemum (sarsazan desert)	135.1	57.5	42.5
2. Desert with dominance of Calligonum polygonoides (dzhuzgun desert)	7.4	6.6	89.6
3. Desert with dominance of Achillea	256.0	17.6	6.9
4. Gypsophilous desert with dominance of Gypsophila-Hammada	9.8	8.1	82.6
5. Desert with Salsola dendroides (kargan desert)	582.7	95.3	16.4
6. Semidesert with dominance of Artemisia	2107.2	1201.5	57.0
7. Steppe with dominance of Bothriochloa (beardgrass steppe)	39.1	31.3	80.0
8. Grass and forb-grass steppes with occasional tragacanth elements	8614.1	6464.9	75.1
9. Vegetation of newly exposed soil and ground	124.5	107.8	86.6
10. Meadow steppe	3347.4	2781.2	83.1
11. Complex of phrygana, tragacanth shrubs, and tomillar	944.1	886.5	93.9
12. Juniper open woodlands	209.5	198.9	94.9
13. Deciduous open woodlands	153.5	151.6	98.8
14. Beech-oak forest	650.5	625.7	96.2
15. Beech forest	1934.6	1884.0	97.4
16. Dry oak forests with arax oak in a complex with xerophytic open woodlands	143.1	121.1	84.6
17. Dry oak forests with eastern oak	200.9	199.1	99.1
18. Oak and oak-hornbeam forest with georgian jak	1252.1	1088.1	86.9
19. Oak and oak-hornbeam forest with eastern oak	737.8	728.2	98.7
20. Subalpine open woodlands (beech, birch, and oak) in a complex with tall-grass meadows	360.6	360.5	100.0
21. Lower alpine meadows	4398.9	4370.6	99.4
22. Complex of alpine meadows, carpets, and dense-turf formations with tragacanth astragals	1932.9	1919.6	99.3
23. Vegetation of the subnival belt	246.7	245.7	99.6
24. Sedge bogs and wet meadows	327.8	207.2	63.2

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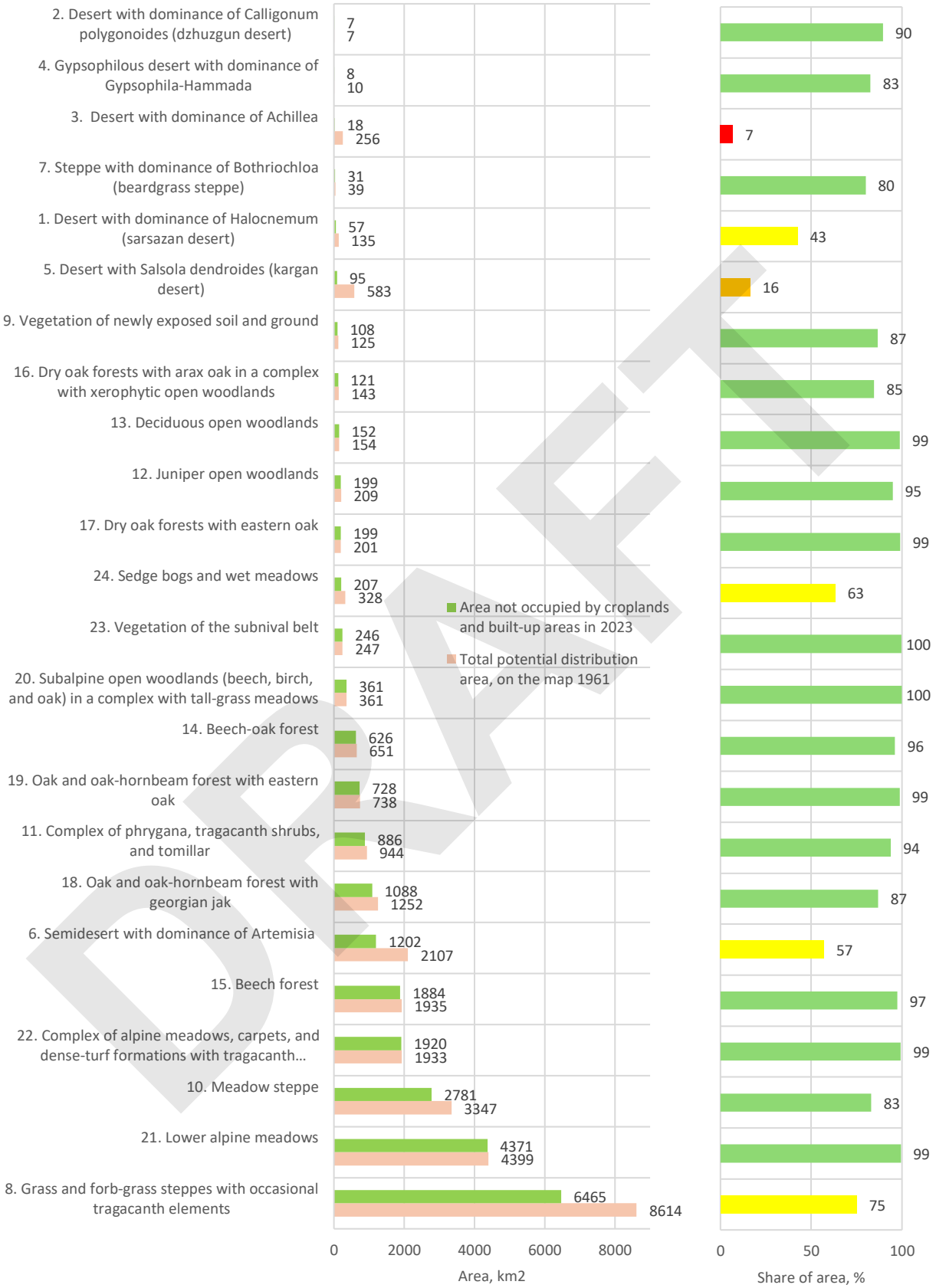


Figure 23D-2. Potential area of vegetation types and their current state: a) potential area of each vegetation type and the area remaining as of 2023; vegetation types are ranked by their rarity in 2023; b) share of the area not occupied by croplands and built-up areas relative to the total potential distribution area, %.

2.4. Extent of natural landscapes

2.4.A. Extent of natural landscapes in Armenia

To estimate extent of natural landscapes, the map of landscape zones published in the Fifth National Report of Armenia to the CBD (2014) was used (available in digital form in Forest Atlas of Armenia FAA), along with ESRI land cover data for 2017 and 2023 as well as ESA 2021 data for comparison (Fig. 24A-1).

The area of natural landscapes was calculated as the area of a given landscape zone minus waterbodies and anthropogenically transformed territories, that is, built-up areas and croplands.

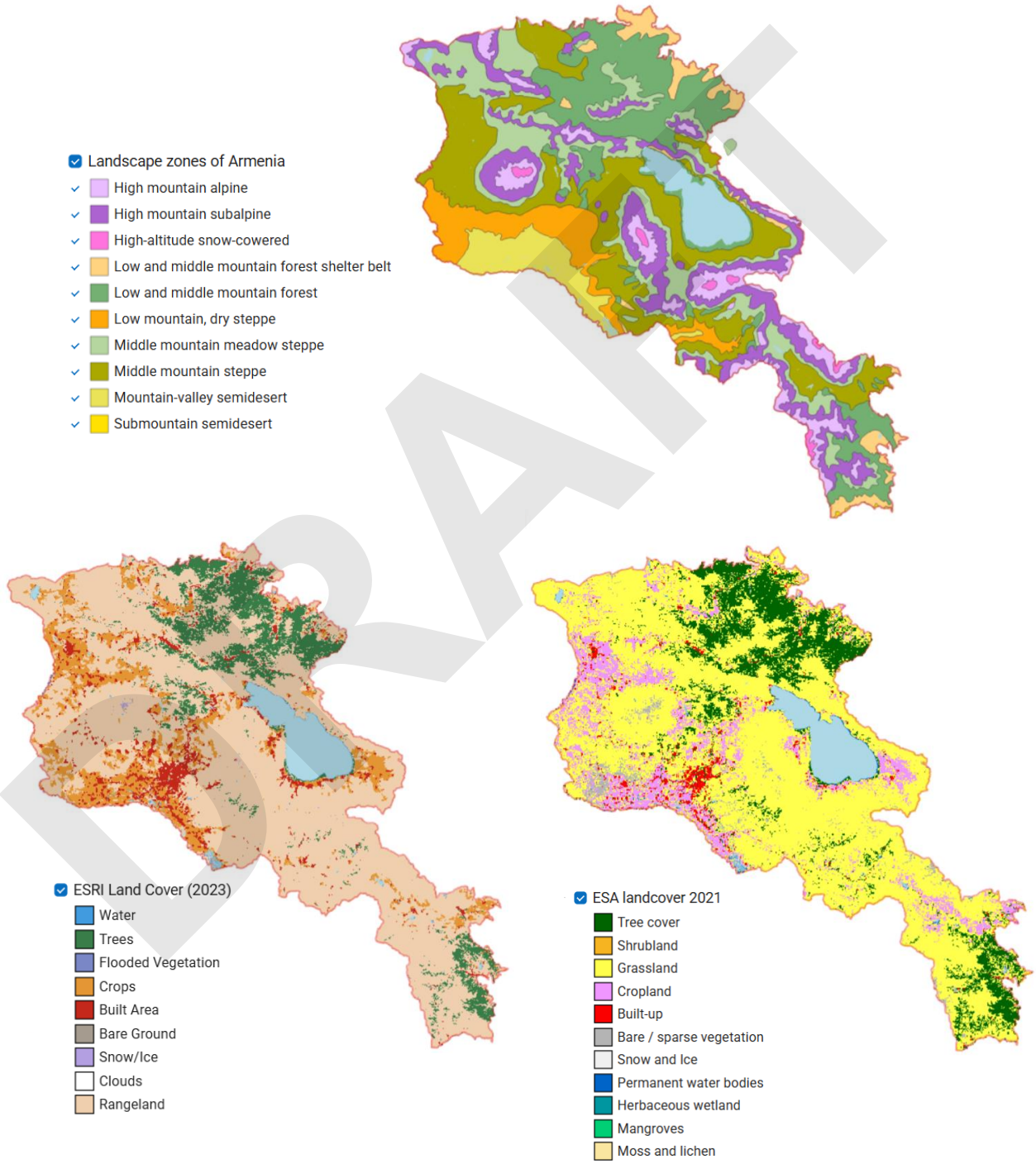


Figure 24A-1. The maps used for estimation of the extent of natural landscapes. For detailed maps see project Web-GIS, section "Ecosystem extent"

According to ESRI data, the most human-transformed zone is mountain-valley semi-desert, where only 27% of natural landscapes remain. It is followed by low mountain dry steppe and the middle mountain steppe zones, with 65% and 71% of natural landscapes remaining, respectively. High-mountain snow-covered, alpine, and subalpine zones have been almost unaffected by human activity. Forests are most widespread in zones of low-middle mountain forest (38%) and low-middle mountain forest shelter belt (17%). There is almost no forests in the half of landscape zones - high-altitude snow-cowered, alpine, dry steppe, and semi-deserts (Figures 24A-2 and 24A-3; Table 24A-1).

ESA data show a generally similar picture, but with smaller built-up area and larger area of tree cover and bare ground, which is particularly noticeable in the semi-deserts, dry steppe, and forest shelter belt (Figure 24A-2 and 24A-3; Table 24A-2). One of the reasons for this is that, as mentioned above, ESA identifies trees within settlements. The presence of trees in submountain semidesert zone in the ESA data is entirely due to this factor – all trees there are located inside settlements (see Section 2.1.A). In the semi-desert zone, some areas classified by ESRI as croplands were identified by ESA as bare ground and grasslands. As a result, the degree of transformation of this zone is considerably lower in ESA data than in ESRI data.

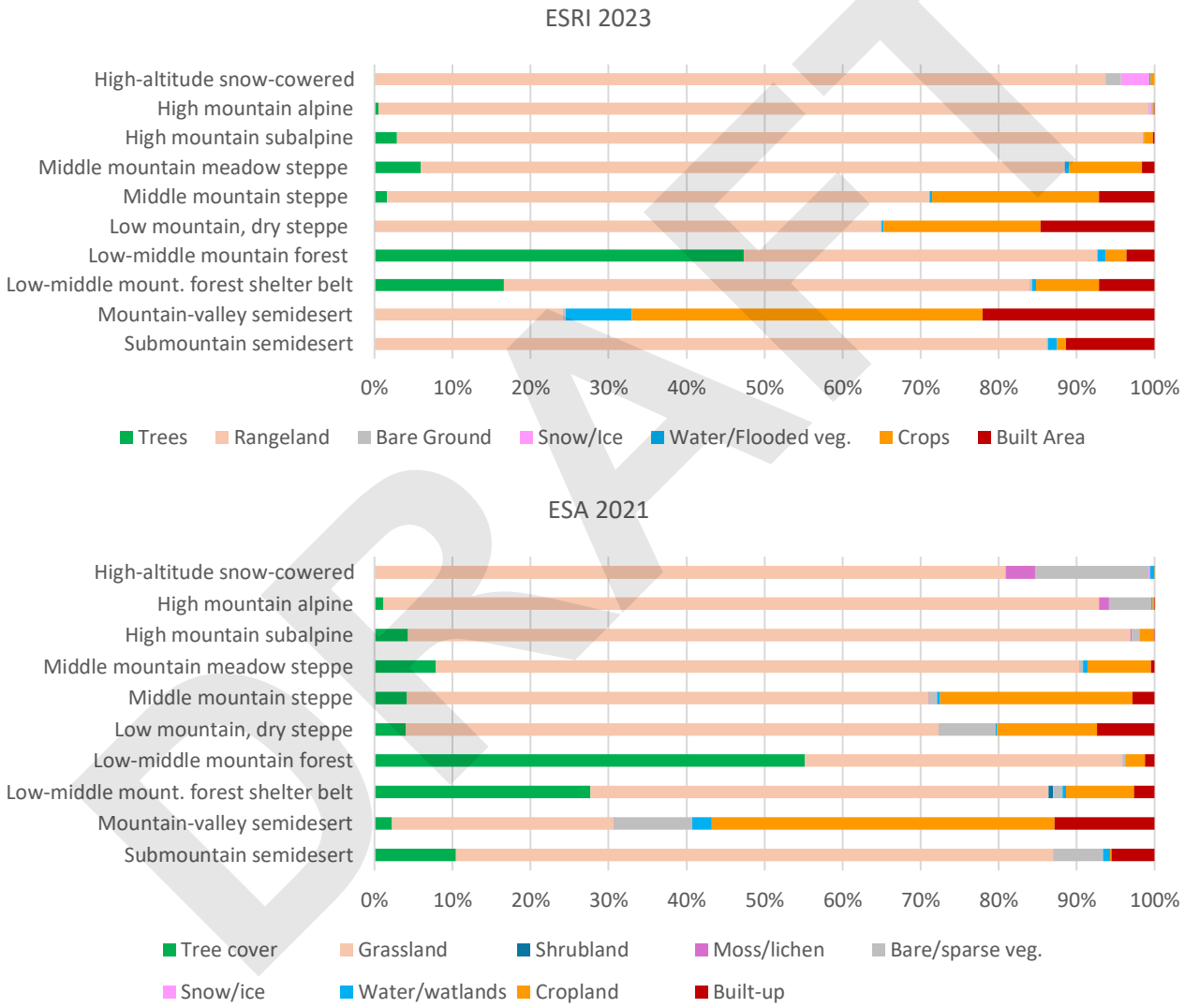


Figure 24A-2. Share of land cover classes within landscape zones according ESRI 2023 and ESA 2021 data

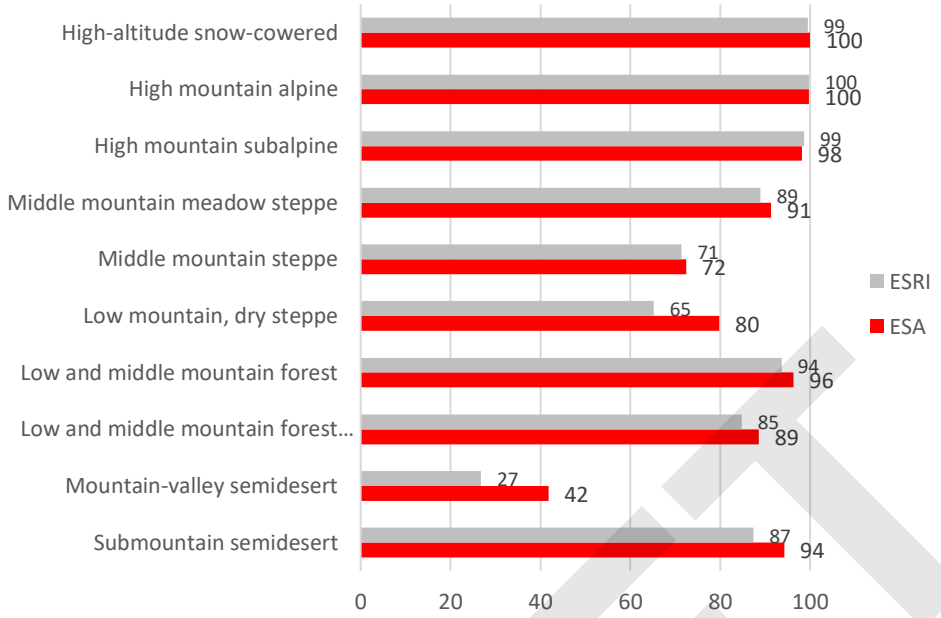


Figure 24A-3. Share of area of natural land cover classes within landscape zones (%) according ESRI and ESA data

Table 24A-1. Area of land cover classes within landscape zones according to ESRI 2023 data, km²

	Trees	Rangeland	Bare Ground	Snow/ Ice	Water/ Flooded veg.	Crops	Built Area	Total
High-altitude snow-cowered	0.06	183.27	3.83	7.09	0.32	1.01	0.00	195.58
High mountain alpine	9.90	1948.68	5.67	4.45	1.83	3.72	1.38	1975.62
High mountain subalpine	125.93	4222.75	3.73	0.00	2.73	49.13	10.25	4414.52
Middle mountain meadow steppe	294.31	4057.45	4.27	0.00	27.14	460.92	78.35	4922.44
Middle mountain steppe	108.88	4723.60	2.97	0.00	20.69	1454.46	484.65	6795.24
Low mountain, dry steppe	3.21	1461.86	3.35	0.00	5.61	454.76	329.90	2258.69
Low-middle mountain forest	2361.03	2261.51	2.81	0.00	50.26	133.77	180.49	4989.87
Low-middle mount. forest sh. belt	195.79	796.09	3.87	0.00	6.34	95.20	84.08	1181.37
Mountain-valley semidesert	0.52	411.32	5.75	0.00	144.50	766.06	376.07	1704.21
Submountain semidesert	0.00	14.93	0.03	0.00	0.20	0.19	1.97	17.33
Sevan	0	0	0	0	1227	0	0	1227.00

Table 24A-2. Area of land cover classes within landscape zones according to ESA 2021 data, km²

	Tree cover	Grass-land	Shrub-land	Moss/ lichen	Bare/ sparse veg.	Snow/ ice	Water/ Wet-lands	Crop-land	Built-up	Total
High-altitude snow-cowered	0.01	189.85	0.00	8.91	34.14	0.44	1.37	0.00	0.00	234.72
High mountain alpine	22.95	1814.63	0.00	25.59	106.82	0.11	2.24	5.78	0.11	1978.24
High mountain subalpine	189.42	4066.87	0.00	6.11	45.19	0.01	1.87	78.13	3.13	4390.74
Middle mountain meadow steppe	391.79	4088.71	0.00	0.92	21.20	0.00	28.58	404.81	22.02	4958.03
Middle mountain steppe	283.17	4578.27	0.18	0.00	69.91	0.00	23.36	1688.78	191.46	6835.12
Low mountain, dry steppe	90.96	1549.08	0.00	0.00	165.79	0.00	5.12	289.93	167.83	2268.72
Low-middle mountain forest	2751.63	2034.38	2.97	0.00	10.54	0.00	3.74	122.38	62.19	4987.84
Low-middle mount. forest sh. belt	327.59	695.87	6.82	0.00	14.03	0.00	5.26	103.17	31.54	1184.29
Mountain-valley semidesert	36.26	458.47	0.00	0.00	160.83	0.00	39.78	706.90	206.75	1608.98
Submountain semidesert	1.78	13.08	0.00	0.00	1.09	0.00	0.16	0.03	0.94	17.08
Sevan	0.00	0.00	0.00	0.00	0.00	0.00	1279.24	0.00	0.00	1279.24

The extent of natural areas within landscape zones differs significantly from the total extent of those zones (Figure 24A-4). When comparing the total area of the landscape zones, middle mountain steppes far exceed all other landscape zones. However, if anthropogenic areas are excluded, four types of natural landscapes have similar extents, each covering 15–16% of Armenia's territory – middle mountain steppe and meadow steppe, subalpine and forest zones. Mountain-valley semi-desert zone is shrinking the most – from 5.4% to 1.4-2.3% – as it has been transformed by human activity to the greatest extent. Differences in the estimated extent of natural landscapes between ESRI and ESA are greatest for the zones most heavily transformed by human activity, as ESA identifies smaller areas of croplands and built-up land (see above).

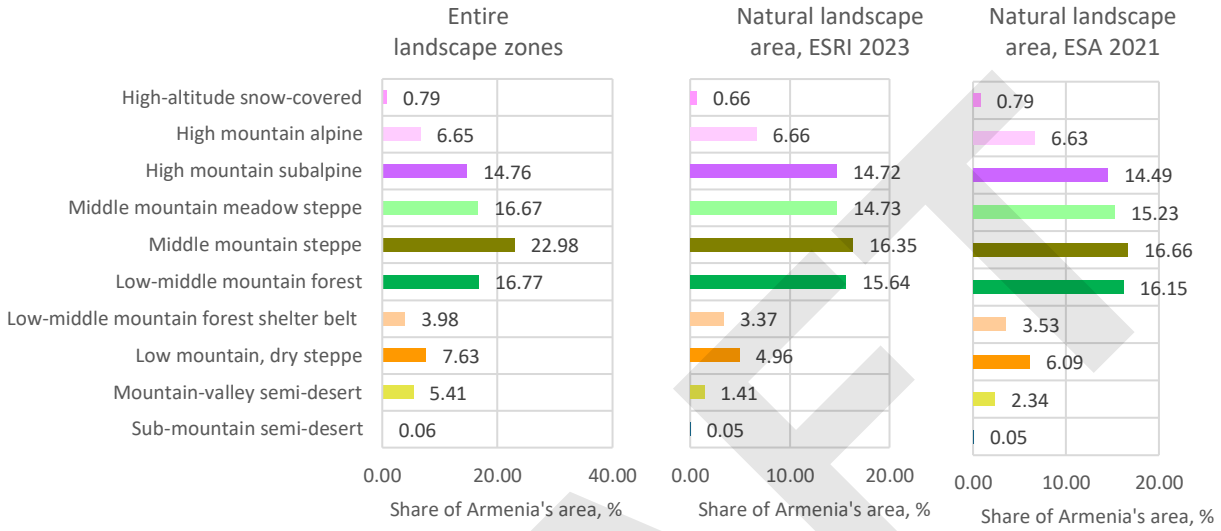


Figure 24A-4. The share of landscape zones and natural landscapes in Armenia's total area, %

2.4.B. Changes in extent of natural landscapes from 2017 to 2023 based on ESRI data

The extent of most natural landscapes decreased from 2017 to 2023 due to the expansion of human-occupied areas (croplands and built-up zones), as described in the Section 2.2.B. A noticeable increase in natural area was observed only in mountain-valley semi-desert in marzes Armavir and Ararat (see Section 2.4.C below)

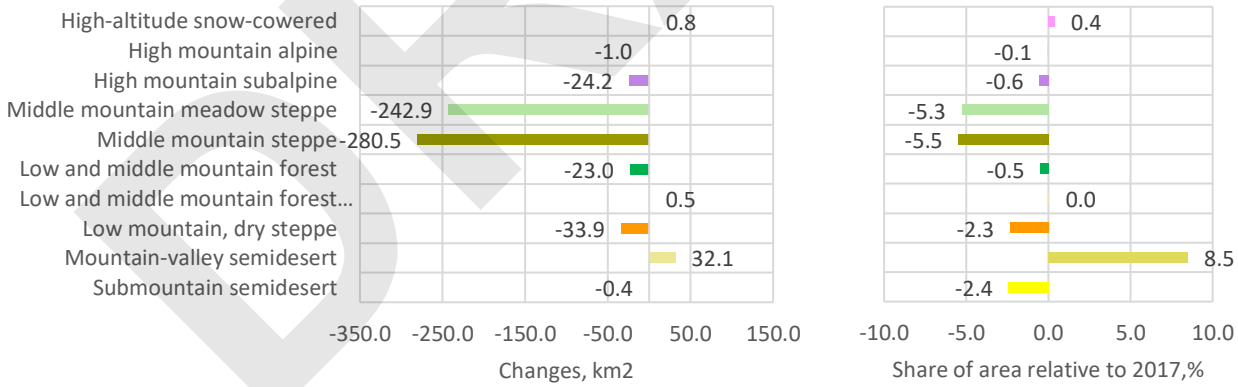


Figure 24B-1. Absolute and relative changes in natural landscape extent

2.4.C. Natural landscape extent at marz level

In terms of the extent of natural landscapes in marzes, ESRI and ESA provide a very similar picture. The main part of the forest landscape zone is located in three marzes — Lori, Tavush, and Syunik. The largest areas of alpine and subalpine landscapes are found in Syunik and Gegharkunik, although these landscapes are also notably present in all other marzes except Armavir and Tavush. Steppe landscapes are present in all marzes, but in Tavush and Armavir marzes, their area is small. The remaining natural areas of mountain-valley semi-desert are mainly located in the marzes of Ararat and Armavir. Submountain semi-desert is represented by small patches only in the south of Syunik marz (Figure 24C-1; Tables 24C-1, 24C-2).

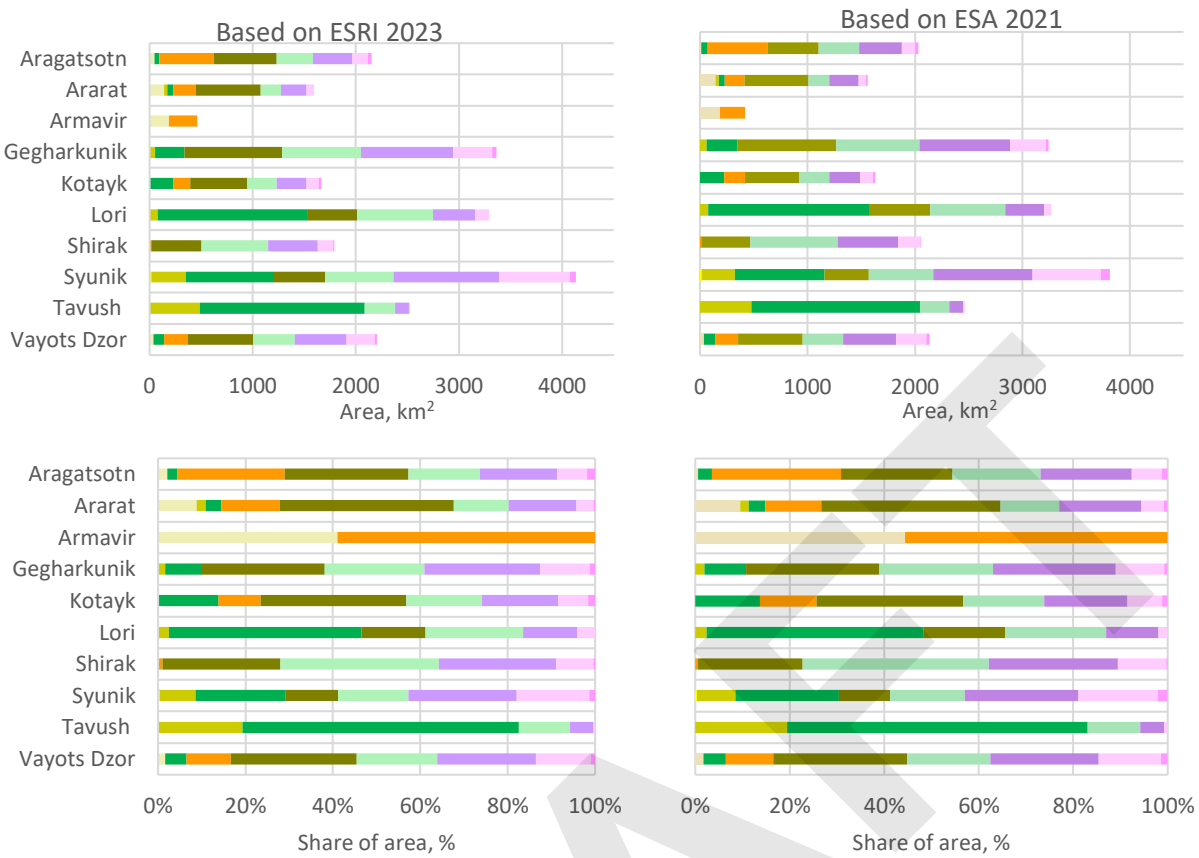


Figure 24C-1. Area and share of natural landscapes in marzes

Table 24C-1. Area of natural landscapes, based on ESRI 2023 land cover data, km²

Landscape zone	Aragat sotn	Ararat	Arma-vir	Geghar kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayots Dzor
High-altitude snow-cowered	39.1	5.9	0.0	40.2	26.2	0.0	7.5	54.5	0.0	20.9
High mountain alpine	146.4	62.6	0.0	380.5	114.8	134.5	152.9	688.8	10.2	278.0
High mountain subalpine	383.5	245.1	0.0	892.1	290.0	407.7	479.4	1021.6	134.1	499.5
Middle mount. meadow steppe	351.3	199.8	0.0	768.9	288.0	735.7	648.7	664.7	294.6	404.3
Middle mountain steppe	611.2	631.7	0.0	943.5	553.7	481.4	482.9	494.4	0.0	636.7
Low mountain, dry steppe	527.8	214.3	272.5	0.0	160.4	0.0	19.0	0.0	0.0	224.1
Low-middle mountain forest	50.1	55.7	0.0	284.5	231.3	1448.1	0.0	854.0	1595.4	106.3
Low-mid. mount. forest shelter belt	0.0	33.7	0.0	53.3	0.0	81.3	0.0	338.2	489.3	0.0
Mountain-valley semidesert	45.1	139.6	189.3	0.0	0.0	0.0	0.0	0.0	0.0	37.0
Submountain semidesert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0

Table 24C-2. Area of natural landscapes, based on ESA 2021 land cover data, km²

Landscape zone	Aragats otn	Ararat	Arma-vir	Geghar kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayots Dzor
High-altitude snow-cowered	25.6	13.7	0.0	24.8	19.2	0.0	5.1	81.2	0.0	29.6
High mountain alpine	128.2	72.6	0.0	331.2	119.1	63.1	212.4	639.3	16.7	282.8
High mountain subalpine	393.5	271.4	0.0	842.9	287.5	361.7	561.3	919.2	127.2	489.4
Middle mount. meadow steppe	378.0	195.1	0.0	778.4	279.1	699.1	811.6	601.3	274.1	376.5
Middle mountain steppe	478.6	591.4	0.0	915.3	506.6	562.9	457.4	411.9	0.2	604.4
Low mountain, dry steppe	555.8	184.8	232.9	0.0	195.7	0.0	11.2	0.0	0.0	213.2
Low-middle mountain forest	59.0	54.8	0.0	286.9	222.7	1502.0	0.0	836.1	1567.9	102.7

Low-mid. mount. forest sh. belt	0.0	28.6	0.0	63.3	0.0	77.6	0.0	309.6	479.1	0.0
Mountain-valley semidesert	11.6	147.5	186.3	0.0	0.0	0.0	0.0	0.0	0.0	36.1
Sub-mountain semidesert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4	0.0	0.0

According to the ESRI land-cover data, the natural area of steppe and meadow-steppe landscapes decreased in all marzes except Vayots Dzor, Tavush, and Ararat (these landscape zones are absent in Armavir); subalpine landscape decreased in Shirak mars; low-mountain dry steppe – in Aragatsotn and Armavir marzes (Figure 24C-2; Table 24C-3). The only noticeable increases in the natural (non-cropland, non-built-up) area of landscape zones are the increase in mountain-valley semidesert area in the Ararat and Armavir marzes and in area of low mountain, dry steppe in Ararat, driven by a reduction in cropland in these marzes (see Section 2.2.B).

Table 24C-3. Changes in the area of natural landscapes from 2017 to 2023, % relative to 2017

	Aragats-otn	Ararat	Arma-vir	Geghar-kunik	Kotayk	Lori	Shirak	Syunik	Ta-vush	Vayots Dzor	Total
	Changes, km2										
High-altitude snow-cowered	0.01	0.02	0.00	0.00	0.73	0.00	0.00	-0.02	0.00	0.00	0.75
High mountain alpine	-1.34	-0.06	0.00	0.12	-0.03	0.00	-0.01	0.39	0.00	-0.10	-1.03
High mountain subalpine	-1.25	-0.27	0.00	4.27	-0.88	-0.61	-20.75	-4.58	-0.01	-0.13	-24.20
Middle mountain meadow steppe	-50.33	0.25	0.00	-14.64	0.38	-21.47	-131.42	-25.29	-0.10	-0.24	-242.86
Middle mountain steppe	3.15	0.60	0.00	-79.17	-24.57	-85.90	-61.12	-33.06	0.00	-0.45	-280.52
Low and middle mountain forest	-2.17	0.01	0.00	-7.23	5.60	-10.54	0.00	-7.54	-0.74	-0.41	-23.03
Low-mid. mount. forest shelter belt	0.00	-0.09	0.00	-3.13	0.00	-2.25	0.00	1.33	4.63	0.00	0.48
Low mountain, dry steppe	-18.98	9.98	-19.59	0.00	-3.44	0.00	-0.66	0.00	0.00	-1.19	-33.88
Mountain-valley semidesert	-0.36	13.03	20.23	0.00	0.00	0.00	0.00	0.00	0.00	-0.76	32.14
Submountain semidesert	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.37	0.00	0.00	-0.37
	Share of changed area, relative to 2017, %										
High-altitude snow-cowered	0.03	0.39	0.00	0.00	2.88	0.00	0.00	-0.03	0.00	0.00	
High mountain alpine	-0.91	-0.09	0.00	0.03	-0.02	0.00	0.00	0.06	0.00	-0.04	
High mountain subalpine	-0.32	-0.11	0.00	0.48	-0.30	-0.15	-4.15	-0.45	-0.01	-0.03	
Middle mountain meadow steppe	-12.53	0.12	0.00	-1.87	0.13	-2.84	-16.85	-3.67	-0.04	-0.06	
Middle mountain steppe	0.52	0.10	0.00	-7.74	-4.25	-15.14	-11.24	-6.27	0.00	-0.07	
Low and middle mountain forest	-4.16	0.01	0.00	-2.48	2.48	-0.72	0.00	-0.88	-0.05	-0.38	
Low-mid. mount. forest shelter belt	0.00	-0.28	0.00	-5.55	0.00	-2.70	0.00	0.39	0.95	0.00	
Low mountain, dry steppe	-3.47	4.89	-6.71	0.00	-2.10	0.00	-3.36	0.00	0.00	-0.53	
Mountain-valley semidesert	-0.80	10.29	11.97	0.00	0.00	0.00	0.00	0.00	0.00	-2.01	
Submountain semidesert	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.43	0.00	0.00	

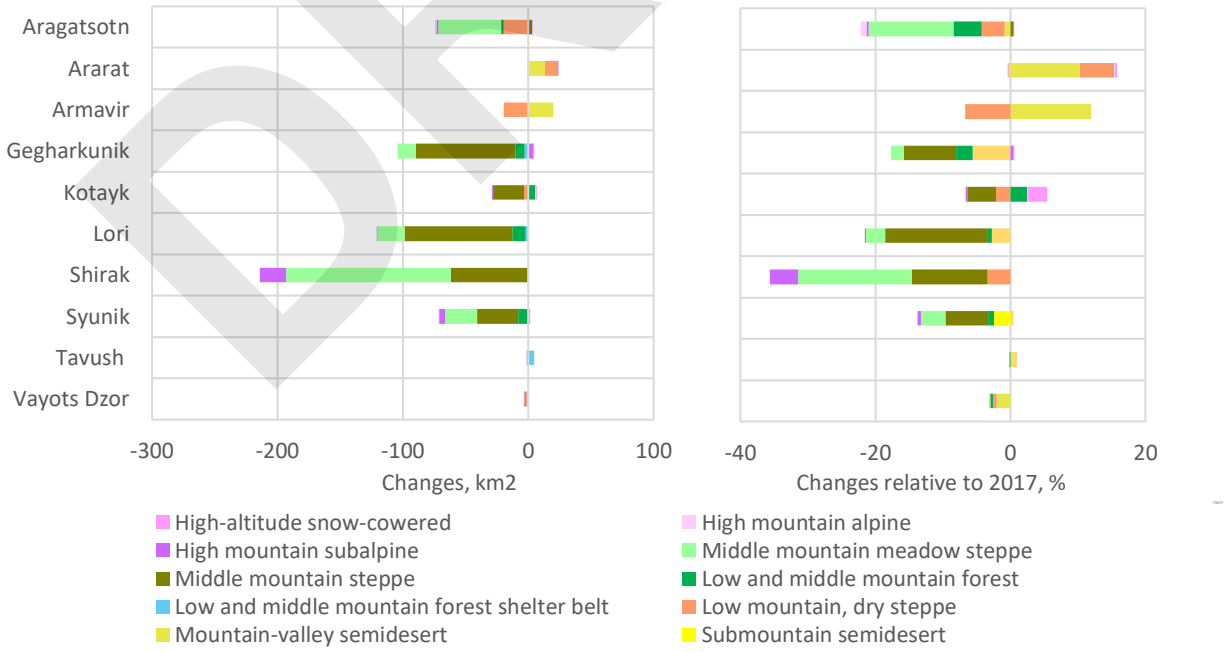


Figure 24C-2. Changes in natural landscape extent from 2017 to 2023, based on ESRI data: a) absolute changes, km2; b) share of changed area relative to 2017, %

2.4.D. Assessment of marz importance for conservation of natural landscape diversity in Armenia

To assess the importance of provinces for conserving natural landscapes in Armenia, we used the indicator of the total share of landscape areas located within each province relative to the total area of that landscape in Armenia. This approach was applied to ensure that the value of rare landscapes is not diminished.

The rankings based on ESRI and ESA data are very similar, differing only in the positions of some provinces with similar indicators in the middle of the list. According to the criterion we used, Syunik marz has the greatest value for conserving Armenia's landscape diversity, because it contains the highest cumulative share of the national extent of all landscape zones. The high summed Syunik value is largely due to the fact that 100% of submountain semidesert zone occurs in Syunik. However, even without it, Syunik still ranks above the other marzes. The least valuable are Shirak, Kotayk, and Armavir marzes (Fig. 24D-1; Tables 24D-1 and 24D-2).

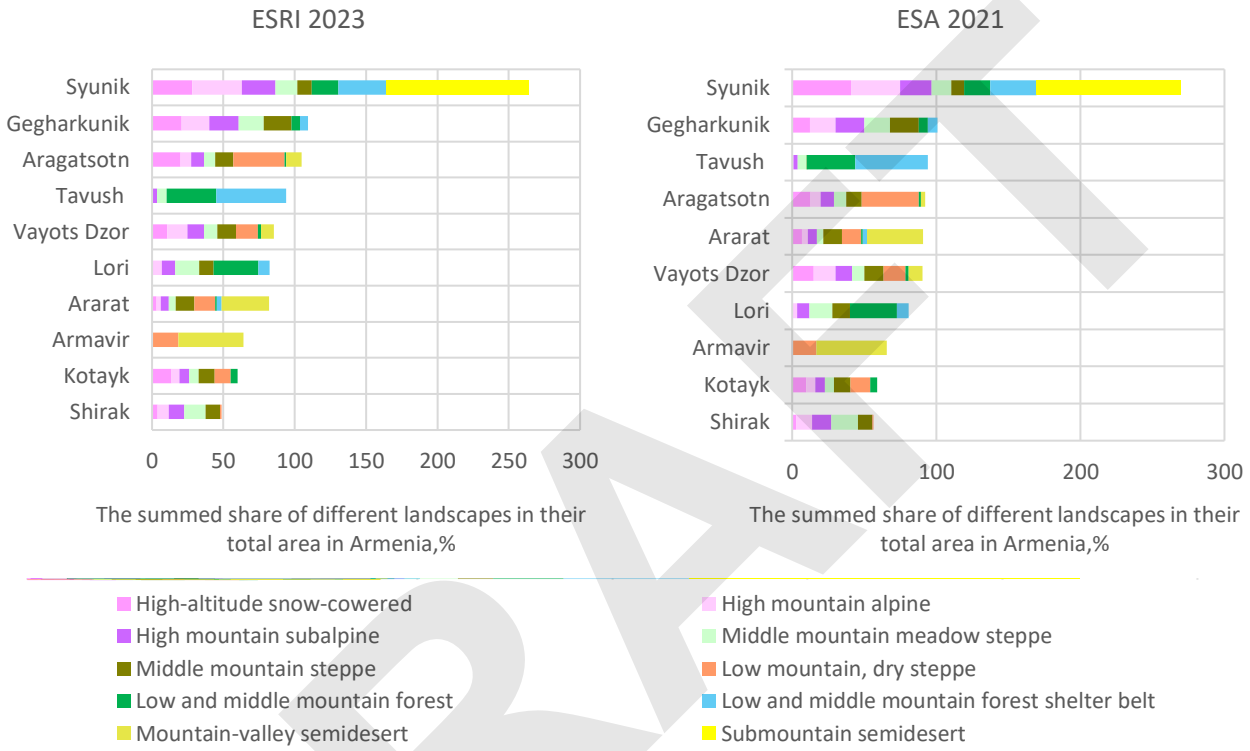


Figure 24D-1. The rankings of marz importance for conservation of natural landscape diversity in Armenia. The total percentage for provinces can exceed 100%.

Table 24D-1. The share of different landscapes in their total area in Armenia according to ESRI data, %. The total percentage for provinces can exceed 100%.

	Syunik	Geghar-kunik	Aragats-otn	Tavush	Vayots Dzor	Lori	Ararat	Arma-vir	Kotayk	Shirak
	2023									
High-altitude snow-cowered	28.05	20.71	20.11	0	10.74	0	3.03	0	13.5	3.85
High mountain alpine	34.99	19.33	7.44	0.52	14.12	6.83	3.18	0	5.83	7.77
High mountain subalpine	23.47	20.49	8.81	3.08	11.47	9.37	5.63	0	6.66	11.01
Middle mountain meadow steppe	15.26	17.65	8.07	6.76	9.28	16.89	4.59	0	6.61	14.89
Middle mountain steppe	10.22	19.51	12.64	0	13.17	9.96	13.06	0	11.45	9.99
Low mountain, dry steppe	0	0	35.94	0	15.26	0	14.59	18.56	10.93	1.3
Low and middle mountain forest	18.46	6.15	1.08	34.49	2.3	31.31	1.2	0	5	0
Low-mid. mountain forest shelter belt	33.97	5.35	0	49.13	0	8.16	3.39	0	0	0
Mountain-valley semidesert	0	0	10.81	0	8.87	0	33.44	45.33	0	0
Sub-mountain semidesert	100	0	0	0	0	0	0	0	0	0
Total share	264.42	109.2	104.9	93.99	85.21	82.51	82.11	63.89	59.98	48.8
	2017									
High-altitude snow-cowered	28.2	20.8	20.2	0.0	10.8	0.0	3.0	0.0	13.2	3.9
High mountain alpine	35.0	19.3	7.5	0.5	14.1	6.8	3.2	0.0	5.8	7.8
High mountain subalpine	23.4	20.3	8.8	3.1	11.4	9.3	5.6	0.0	6.6	11.4
Middle mountain meadow steppe	15.0	17.0	8.7	6.4	8.8	16.5	4.3	0.0	6.3	17.0
Middle mountain steppe	10.3	20.0	11.9	0.0	12.5	11.1	12.3	0.0	11.3	10.6

Low mountain, dry steppe	0.0	0.0	36.2	0.0	14.9	0.0	13.5	19.4	10.9	1.3
Low and middle mountain forest	18.5	6.3	1.1	34.3	2.3	31.4	1.2	0.0	4.9	0.0
Low-mid. mountain forest shelter belt	33.8	5.7	0.0	48.7	0.0	8.4	3.4	0.0	0.0	0.0
Mountain-valley semidesert	0.0	0.0	11.7	0.0	9.8	0.0	32.7	43.6	0.0	0.0
Sub-mountain semidesert	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total share	264.3	109.4	106.2	93.0	84.6	83.5	79.3	63.0	58.9	52.0

Table 24D-2. The share of different landscapes in their total area in Armenia according to ESA 2021 data, %. The total percentage for provinces can exceed 100%.

%	Syunik	Geghar-kunik	Tavush	Aragats-otn	Ararat	Vayots Dzor	Lori	Armavir	Kotayk	Shirak
High-altitude snow-cowered	40.78	12.45	0	12.85	6.88	14.86	0	0	9.63	2.57
High mountain alpine	34.27	17.76	0.9	6.87	3.89	15.16	3.38	0	6.38	11.39
High mountain subalpine	21.61	19.81	2.99	9.25	6.38	11.5	8.5	0	6.76	13.19
Middle mountain meadow steppe	13.69	17.72	6.24	8.61	4.44	8.57	15.91	0	6.35	18.47
Middle mountain steppe	9.1	20.21	0	10.57	13.06	13.35	12.43	0	11.19	10.1
Low mountain, dry steppe	0	0	0	39.88	13.26	15.3	0	16.71	14.04	0.81
Low and middle mountain forest	18.05	6.19	33.85	1.27	1.18	2.22	32.43	0	4.81	0
Low-middle mountain forest shelter belt	32.32	6.6	50	0	2.99	0	8.1	0	0	0
Mountain-valley semidesert	0	0	0	3.04	38.68	9.45	0	48.84	0	0
Submountain semidesert	100	0	0	0	0	0	0	0	0	0
Total share	269.81	100.74	93.97	92.33	90.76	90.4	80.75	65.55	59.16	56.53

From 2017 to 2023, summed value indicator changed by no more than 3% across marzes (Figure 24D-2). The value for Shirak marz declined from 52.0% to 48.8%, primarily due to a decrease in the share of the national meadow-steppe extent conserved there. For Ararat marz, this indicator rose from 79.3% to 82.1% owing to increases in the shares of the forest, steppe, and semidesert zones. For the other marzes, changes in the aggregate indicator were smaller.

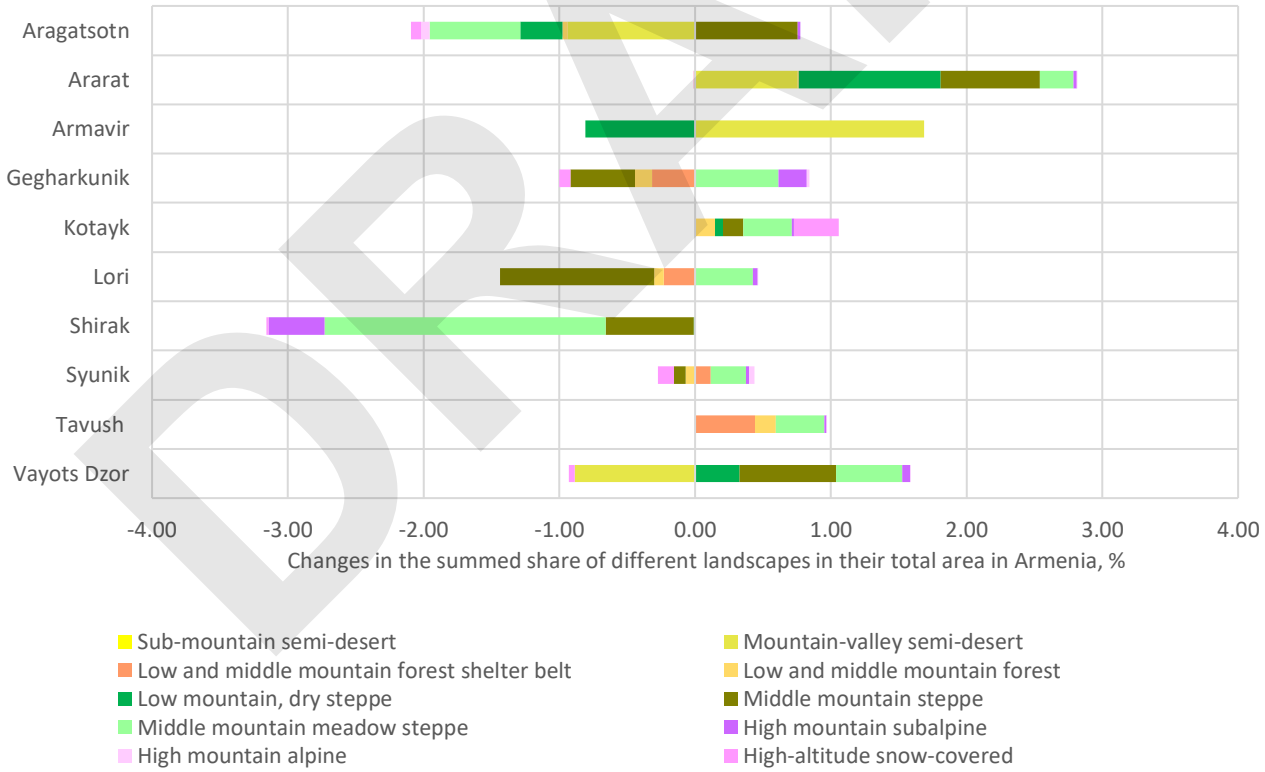


Figure 24D-2. Changes in marz importance for conservation of natural landscape diversity in Armenia from 2017 to 2023.

2.5. Ecosystem extent estimated by landscape-land cover classes (LLCCs)

Publication: Bukvareva E., Grigoryan A., Dubinin M., Kazakov E. Integrating actual land cover data and landscape zone map to assess terrestrial ecosystems in Armenia. Explora: Environment and Resource 4996.
https://doi.org/10.36922/eer.4996

The assessment presented in this section uses the same data sources as Section 2.4: the map of landscape zones of Armenia; ESRI land cover data for 2017 and 2023; and ESA 2021 data.

We intersected ten landscape zones with terrestrial land cover classes. The raster landscape map produced for accounting the extent of natural landscapes (Section 3) was spatially intersected with the land cover raster maps through two steps: (i) the pixel values of the land cover map were multiplied by 100, and (ii) these adjusted values were added to the corresponding pixel values of the landscape map, resulting in a unified raster. For example, a final pixel value of 204 indicates that the pixel has a land cover value of two (e.g., trees) and a landscape value of four (e.g., low and middle mountain forest).

The ESRI land cover dataset includes four terrestrial natural classes (trees, rangelands, bare ground, and snow/ ice), the ESA dataset includes six terrestrial natural classes (tree cover, shrubland, grassland, moss and lichen, bare and sparse vegetation, and snow and ice). The intersection of ten landscape zones with land cover classes resulted in 60 and 40 combinations, respectively. We termed these combinations as LLCCs since they serve as proxies for ecosystems at this stage of analysis without precisely defining the ecosystems they represent. For simplicity of analysis, LLCCs were grouped into 20 combinations, woody (W) and non-woody (N-W) LLCCs in each landscape zone. We found it appropriate to combine all N-W natural classes (shrubland, grassland, moss and lichen, bare and sparse vegetation, and snow and ice) into one category named N-W LLCCs for several reasons: (i) to reduce the number of analyzed LLCCs for a clearer interpretation of the results, (ii) due to relative imprecision in distinguishing between different non-tree land cover classes, (iii) because of the very small area covered by shrubland, moss and lichen, and snow and ice, and (iv) because the IUCN and EUNIS ecosystem and habitat classifications,[20,22,26] including the EUNIS version adapted for Armenia,[34] group shrub vegetation with heathlands and tundra rather than woody vegetation. Thus, the resulting map includes 20 LLCCs obtained by intersecting woody and non-woody areas with 10 landscape zones.

We used LLCCs as a proxy for ecosystems to assess ecosystem rarity and diversity. We estimated the rarity of LLCCs based on their area – LLCCs with the smallest area were considered rare. To assess the importance of provinces for conserving LLCC diversity in Armenia, we calculated the total share of each LLCC area located within each province. Unlike the rarity ranking, which used the share of an LLCC area relative to its total area in Armenia, this method focused on the proportion of an LLCC area within a province compared to its total area in Armenia. This approach was applied to ensure that the value of rare LLCCs is not diminished.

2.5.A. Extent and rarity of LLCC in Armenia

In all landscape zones, non-woody LLCC combinations occupy the predominant area. The only exception is the low and middle mountain forest zone, where woody combinations account for 51% of the natural area (Fig. 25A-1).

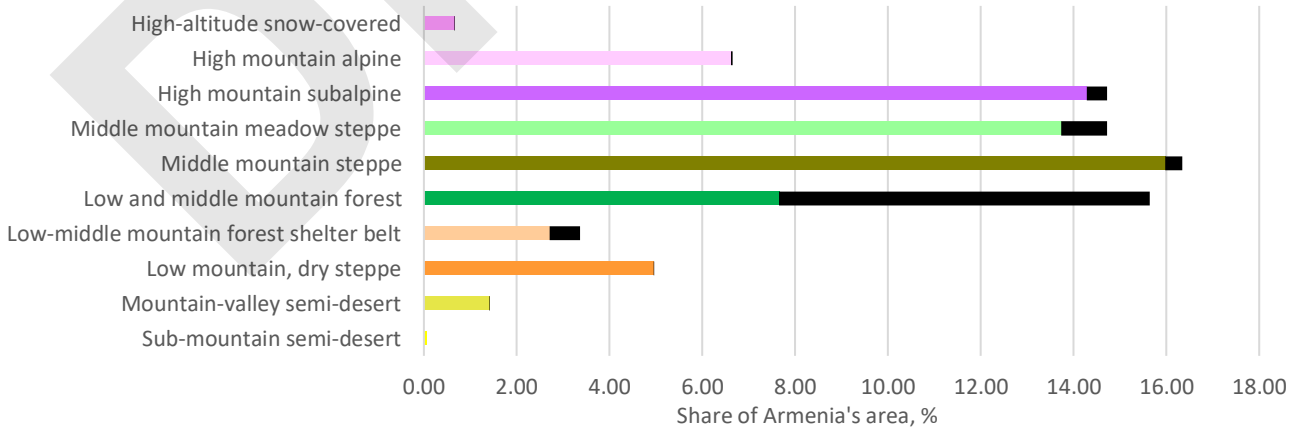
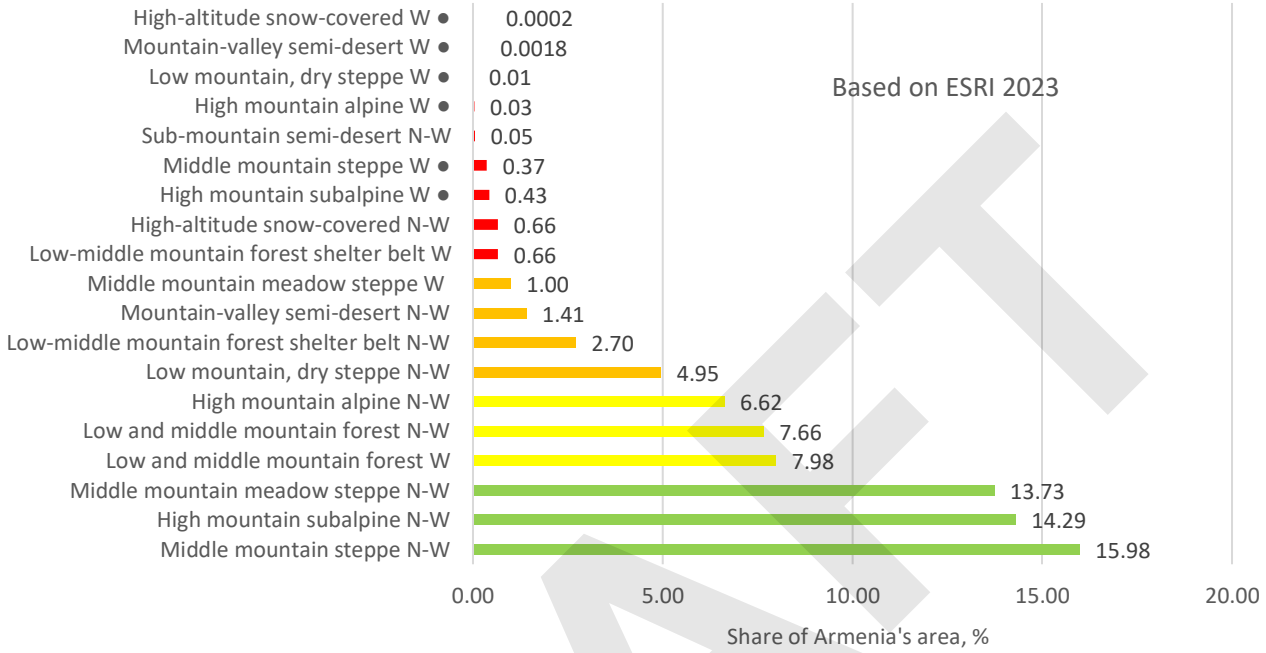


Figure 25A-1. Extent of non-woody LLCC combinations (shown in different colors) and woody combinations (shown in black) across landscape zones in Armenia

The area of the 20 analyzed W LLCCs and N-W LLCCs ranges from 0.005 km2 to 4,700 km2. Half of these LLCCs occupy <1% of the country's area and can thus be formally classified as rare (Figure 25A-2). This group includes nearly all woody LLCCs, except those in the low and middle mountain forest, forest shelter belt, and middle mountain meadow steppe.

Among N-W LLCCs, only two, located in the sub-mountain semi-desert and high-altitude zones, were classified as rare. Three LLCCs, N-W ecosystems in subalpine, middle-mountain, and meadow steppe zones, are widespread, each covering between 14% and 16% of the country's territory. The remaining LLCCs fall between these extremes. Notably, most of the rare LLCCs do not align with the dominant vegetation types of their respective landscape (e.g., trees in high-altitude zones or semi-deserts). These anomalies require careful verification, as they may result from land cover interpretation errors or may belong to anthropogenic areas. Despite the differences in ESA and ESRI land cover data, the rarity rankings of LLCCs derived from both sources are very similar.



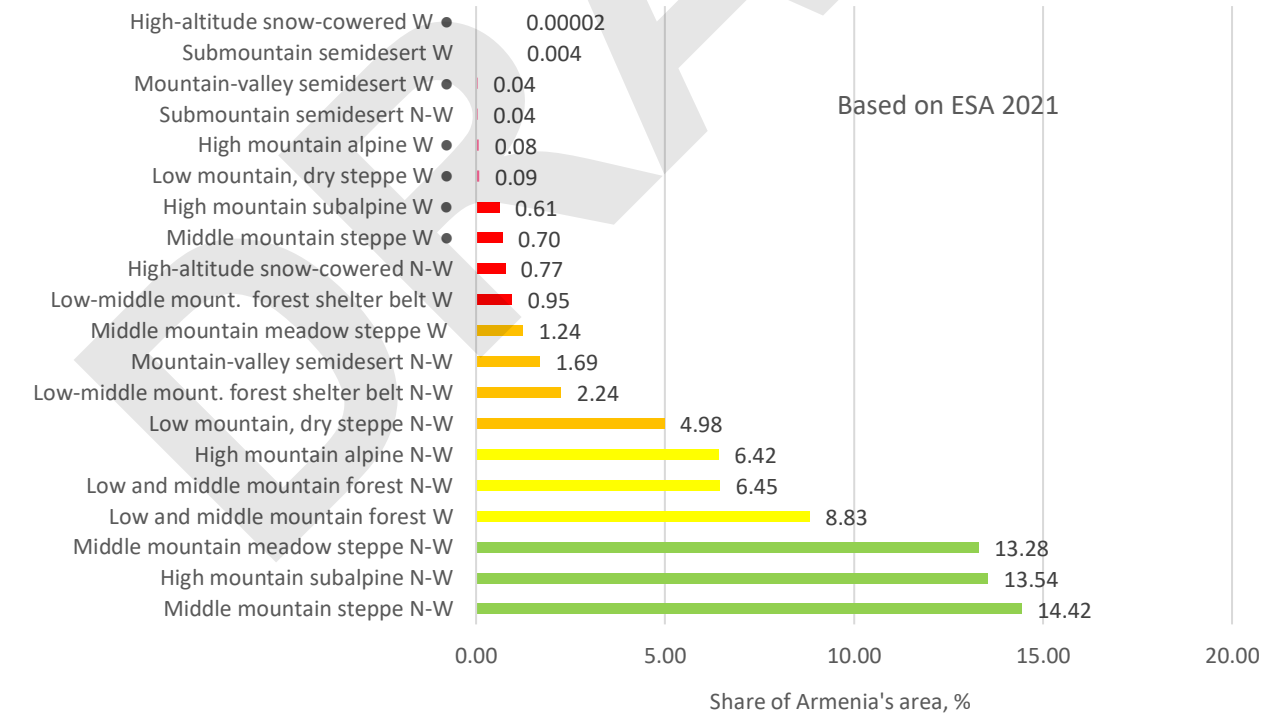


Figure 25A-2. Ranking LLCC types by their area; woody LLCCs are indicated as W, non-woody as N-W; LLCCs occupying no more than 5% of the area of corresponding landscape zone are marked with a '●' symbol

Maps of LLCC rarity, based on these rankings, show a similar distribution pattern (Figure 25A-3). The rarest LLCCs, covering <1% of the country's area, are distributed in small areas throughout the country, especially in the south, notably in the province of Syunik. Relatively rare LLCCs, occupying 1 – 5% of the country's area, are primarily found in the Ararat

Valley and its surroundings. These include mountain-valley semi-desert and low-mountain dry steppe LLCCs. Although these LLCCs formally cover a large area, natural vegetation occupies only a small area due to significant anthropogenic transformation. The most widespread LLCCs are located in the central part of the country.

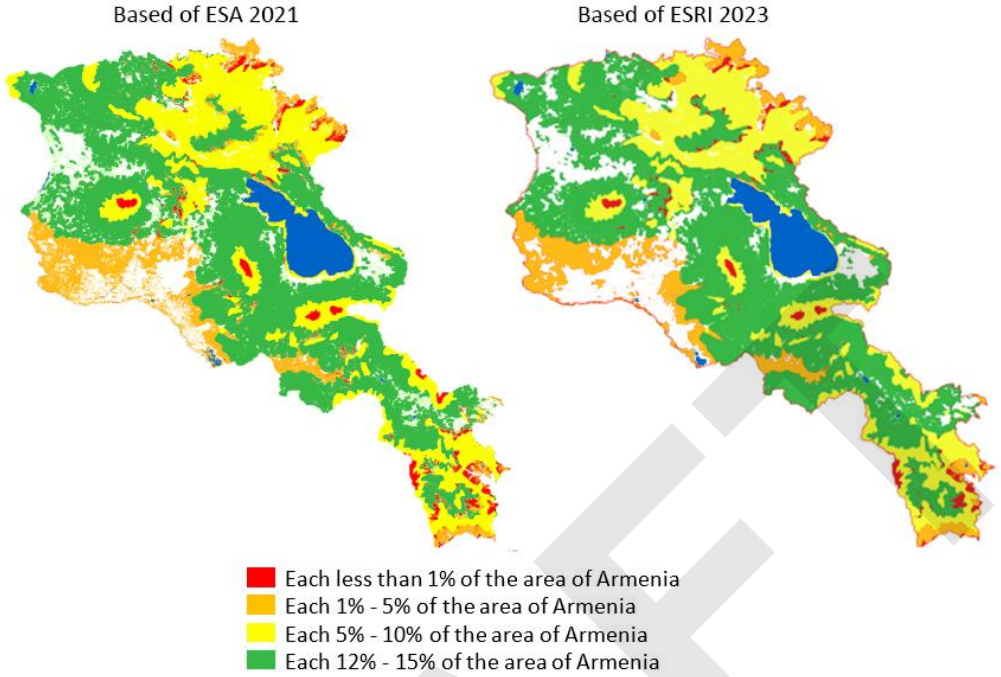


Figure 25A-3. Maps of LLCC rarity based on ESA and ESRI land cover datsets

2.5.B. Marz level: LLCC extent and marz importance for conservation of LLCC diversity in Armenia

This section is primarily aimed at analyzing the role of the marzes in conserving Armenia's ecosystem diversity. Therefore, instead of using absolute extent values in km², we use the indicator of the share of the area of each LLCC that is preserved within the marzes: $S_{im}=LLCC_{im}/LLCC_{ia}$*100%, where $LLCC_{im}$ is the area of *LLCC i*-type in marz *m*, and $LLCC_{ia}$ is the total area of *LLCC i*-type in Armenia. This indicator was applied to ensure that the value of rare LLCCs is not diminished.

The pattern of distribution of non-woody LLCCs across marzes generally mirrors the distribution of landscape zones. Moreover, these patterns are very similar based on ESRI and ESA data. In contrast, the distribution of woody LLCCs differs significantly both from landscapes zones and between ESRI and ESA datasets. According to ESRI, marzes Gegharkunik, Kotayk, Lori, and Tavush account for a larger share of woody LLCCs than of landscape zones overall. In contrast, Aragatsotn, Ararat, Shirak, Syunik, and Vyots Dzor account for a smaller share of woody LLCCs (Figure 25B-1, a-c). According to ESA, marzes Lori, Syunik, and Tavush account for a larger share of woody LLCCs while Aragatsotn, Armavir, Gegharkunik, and Shirak account for a smaller share of woody LLCCs (Figure 25B-1, d-f).

Marked discrepancies appear when rare LLCCs are concentrated entirely within a single marz—for instance, nearly 100% of woody LLCCs in the high-altitude snow covered zone of Gegharkunik according to ESRI (Fig. 25B-1c), versus nearly 100% of the same LLCC type in Syunik according to ESA (Fig. 25B-1f). These patterns are most likely the result of land-cover misclassifications affecting different marzes in the two datasets. A similar inconsistency is observed in the submountain semi-desert zone, where ESA records 100% of woody LLCC in this zone in Syunik (Fig. 25B-1f), while ESRI reports none. Such differences reflect the different methodologies of image interpretation applied in the ESA and ESRI datasets (see Section 2.1.A). Overall, the most significant inconsistencies are associated with the rarest LLCCs—woody LLCCs in general, and especially their rarest variants in high-altitude and semi-desert zones—some of which may represent artifacts of land-cover classification rather than actual distribution patterns.

The cumulative value of index S_{im} indicates the overall contribution of a marz to the conservation of LLCC diversity in Armenia. As shown in Figure 25B-1, the contribution of the marzes to the conservation of non-woody LLCCs is similar to their contribution to the conservation of natural landscapes as a whole, whereas their role in conserving woody LLCCs follows a somewhat different pattern.

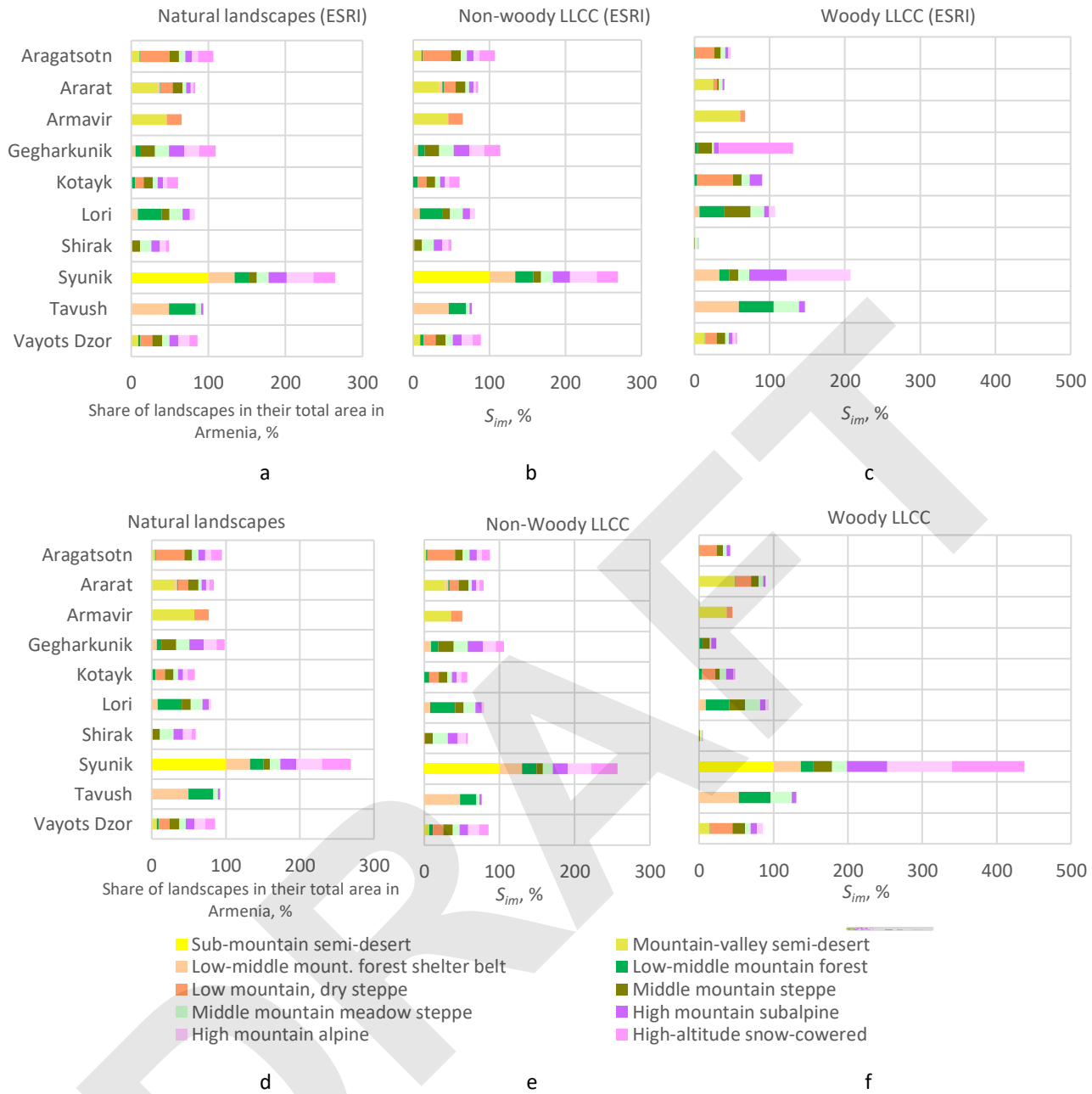


Figure 25B-1. The share of the area of natural landscapes and LLCCs in their total area in Armenia, %: a-c) Based on ESRI data; d-f) Based on ESA data. The scales have been made uniform for easier comparison of the data.

Figure 25B-1. The proportion of natural landscapes in their total area in Armenia, S_{im} %, based on ESRI 2023 data

	Sub-mountain semi-desert	Mountain-valley semi-desert	Low-mid. mountain forest shelter belt	Low and middle mountain forest	Low mountain, dry steppe	Middle mountain steppe	Middle mountain meadow steppe	High mountain subalpine	High mountain alpine	High-altitude snow-cowered
	Natural landscapes as a whole									
Aragatsotn	0.00	10.98	0.00	1.08	37.21	12.64	8.07	8.81	7.44	20.11
Ararat	0.00	33.96	3.39	1.20	15.11	13.06	4.59	5.63	3.18	3.03
Armavir	0.00	46.05	0.00	0.00	19.22	0.00	0.00	0.00	0.00	0.00
Gegharkunik	0.00	0.00	5.35	6.15	0.00	19.51	17.65	20.49	19.33	20.71
Kotayk	0.00	0.00	0.00	5.00	11.31	11.45	6.61	6.66	5.83	13.50
Lori	0.00	0.00	8.16	31.31	0.00	9.96	16.89	9.37	6.83	0.00
Shirak	0.00	0.00	0.00	0.00	1.34	9.99	14.89	11.01	7.77	3.85
Syunik	100.00	0.00	33.97	18.46	0.00	10.22	15.26	23.47	34.99	28.05

Tavush	0.00	0.00	49.13	34.49	0.00	0.00	6.76	3.08	0.52	0.00
Vayots Dzor	0.00	9.01	0.00	2.30	15.80	13.17	9.28	11.47	14.12	10.74
	Non-woody LLCC									
Aragatsotn	0.00	10.99	0.00	1.57	37.24	12.74	8.21	8.93	7.47	20.12
Ararat	0.00	33.98	4.21	2.24	15.13	13.31	4.55	5.72	3.20	3.04
Armavir	0.00	46.03	0.00	0.00	19.24	0.00	0.00	0.00	0.00	0.00
Gegharkunik	0.00	0.00	6.50	8.47	0.00	19.52	18.79	20.90	19.42	20.68
Kotayk	0.00	0.00	0.00	6.34	11.24	11.46	6.33	6.37	5.85	13.51
Lori	0.00	0.00	8.47	30.41	0.00	9.37	16.79	9.44	6.83	0.00
Shirak	0.00	0.00	0.00	0.00	1.35	10.20	15.67	11.33	7.80	3.85
Syunik	100.00	0.00	34.14	24.03	0.00	10.18	15.31	22.69	34.74	28.06
Tavush	0.00	0.00	46.67	22.42	0.00	0.00	4.79	2.95	0.52	0.00
Vayots Dzor	0.00	9.00	0.00	4.54	15.80	13.22	9.57	11.68	14.17	10.75
	Woody LLCC									
Aragatsotn	0.00	0.00	0.00	0.62	25.74	8.31	6.05	4.65	1.99	0.48
Ararat	0.00	25.29	0.00	0.22	4.43	2.34	5.09	2.66	0.00	0.00
Armavir	0.00	60.71	0.00	0.00	6.58	0.00	0.00	0.00	0.00	0.00
Gegharkunik	0.00	0.00	0.66	3.93	0.00	19.10	2.00	6.99	0.55	97.75
Kotayk	0.00	0.00	0.00	3.72	47.68	11.21	10.53	16.47	1.00	0.00
Lori	0.00	0.00	6.88	32.17	0.00	35.36	18.24	6.82	7.70	0.00
Shirak	0.00	0.00	0.00	0.00	0.00	0.66	4.17	0.31	0.00	0.00
Syunik	0.00	0.00	33.26	13.13	0.00	12.10	14.62	49.80	84.48	0.00
Tavush	0.00	0.00	59.20	46.07	0.00	0.00	33.94	7.56	0.00	0.00
Vayots Dzor	0.00	14.01	0.00	0.15	15.57	10.94	5.37	4.74	4.27	1.77

Figure 25B-2. The proportion of natural landscapes in their total area in Armenia, S_{im} %, based on ESRI 2023 data

	Sub-mountain semi-desert	Mountain-valley semi-desert	Low-mid. mount. forest shelter belt	Low-middle mountain forest	Low mountain, dry steppe	Middle mountain steppe	Middle mountain meadow steppe	High mountain subalpine	High mountain alpine	High-altitude snow-cowered
	Natural landscapes as a whole									
Aragatsotn	0.00	4.31	0.00	1.27	38.30	10.55	8.60	9.27	7.83	14.42
Ararat	0.00	31.22	3.19	1.20	13.62	13.50	4.44	6.34	4.07	6.01
Armavir	0.00	57.41	0.00	0.00	19.66	0.00	0.00	0.00	0.00	0.00
Gegharkunik	0.00	0.00	6.58	6.23	0.00	20.01	17.69	19.86	17.35	10.96
Kotayk	0.00	0.00	0.00	4.81	13.15	11.17	6.34	6.76	6.27	9.92
Lori	0.00	0.00	8.06	32.43		12.27	15.85	8.42	3.20	0.00
Shirak	0.00	0.00	0.00	0.00	0.76	10.08	18.41	13.14	11.47	5.66
Syunik	100.00	0.00	32.76	18.03	0.00	9.00	13.77	21.63	34.35	39.49
Tavush	0.00	0.00	49.39	33.78	0.00	0.00	6.21	2.96	0.85	0.00
Vayots Dzor	0.00	7.07	0.00	2.24	14.50	13.43	8.69	11.63	14.61	13.55
	Non-woody LLCC									
Aragatsotn	0.00	2.25	0.00	2.20	36.34	10.49	8.92	9.36	6.58	10.94
Ararat	0.00	27.54	4.19	2.15	11.86	12.98	4.26	6.46	3.73	5.86
Armavir	0.00	35.38	0.00	0.00	15.26	0.00	0.00	0.00	0.00	0.00
Gegharkunik	0.00	0.00	8.94	9.50	0.00	20.40	19.15	20.17	16.99	10.60
Kotayk	0.00	0.00	0.00	6.52	12.62	11.28	6.13	6.55	6.10	8.20
Lori	0.00	0.00	7.54	33.17	0.00	11.83	15.42	8.47	3.19	0.00
Shirak	0.00	0.00	0.00	0.00	0.74	10.39	19.82	13.63	10.89	2.19
Syunik	100.00	0.00	29.84	19.57	0.00	8.18	13.02	19.91	31.77	34.74
Tavush	0.00	0.00	47.61	21.71	0.00	0.00	4.12	2.82	0.86	0.00
Vayots Dzor	0.00	6.67	0.00	4.80	13.56	12.97	8.66	11.52	14.41	12.65
	Woody LLCC									
Aragatsotn	0.00	0.19	0.00	0.60	22.55	8.98	4.79	4.64	0.00	0.00
Ararat	0.00	48.34	0.02	0.47	20.77	10.72	6.10	3.00	0.04	0.00
Armavir	0.00	37.04	0.00	0.00	7.88	0.00	0.00	0.00	0.00	0.00
Gegharkunik	0.00	0.00	0.80	3.76	0.00	10.06	1.44	7.07	0.12	0.00
Kotayk	0.00	0.00	0.00	3.54	18.30	5.86	8.42	9.72	0.27	2.60
Lori	0.00	0.00	9.06	31.79	0.00	21.13	20.29	7.06	4.10	0.00
Shirak	0.00	0.00	0.00	0.00	0.18	1.01	3.03	0.41	0.24	0.00
Syunik	100.00	0.00	36.71	16.89	0.00	25.29	20.15	53.83	86.99	97.40
Tavush	0.00	0.00	53.40	42.62	0.00	0.00	28.66	5.93	0.00	0.00
Vayots Dzor	0.00	14.43	0.00	0.32	30.32	16.96	7.12	8.34	8.24	0.00

Based on the rankings of overall marz contribution to the conservation of all LLCC types (the sum of S_i indices for each marz) derived from the ESRI and ESA datasets, only the top-ranked province (Syunik) and the lowest-ranked province (Shirak) remain consistent (Figure 25B-2 a,b). The positions of other marzes vary within the rankings. When accounting all LLCC types, the rankings are largely influenced by the rarest LLCCs, which may be errors in the land cover datasets. For example, Syunik province ranks exceptionally high based on ESA data because almost all pixels of three rare LLCCs (woody areas in high-altitude snowy and alpine zones and sub-mountain semi-desert) are concentrated there. This pattern is not observed in ESRI data. Conversely, Gegharkunik province ranks second in the ESRI-based ranking because almost all woody pixels in the high-altitude snowy zone are concentrated there. If the rarest LLCCs, occupying no more than 5% of the landscape zone's area (marked with a "●" symbol in Figure 25A-2), are excluded from the calculations, the province rankings based on ESRI and ESA data become more similar (Figure 25B-2 c,d). However, some provinces with similar indicators occupy different positions in the middle of the list.

Figure 25B-2. The rankings of marz cumulative importance for conserving LLCC diversity in Armenia (the sum of Si indices for each marz): a,b) all LLCCs; b,c) excluding LLCCs that occupy no more than 5% of the landscape zone's area. The LLCCs are shown in red, the less rare ones in orange, the relatively common in yellow, and the most common in green, as in the figure 25A-2. The total percentage for provinces can exceed 100%.

Table 25B-3. Mars importance for conserving all LLCC types in Armenia (the sum of Si indices for each marz)

	Aragats-otn	Ararat	Arma-vir	Geghar-kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayots Dzor
	ESRI 2023									
High mountain alpine N-W	7	4	0	17	6	3	11	32	1	14
High mountain alpine W	0	0	0	0	0	4	0	87	0	8
High mountain subalpine N-W	9	6	0	20	7	8	14	20	3	12
High mountain subalpine W	5	3	0	7	10	7	0	54	6	8
High-altitude snow-cowered N-W	11	6	0	11	8	0	2	35	0	13
High-altitude snow-cowered W	0	0	0	0	3	0	0	97	0	0
Low mountain, dry steppe N-W	36	12	15	0	13	0	1	0	0	14

Low mountain, dry steppe W	23	21	8	0	18	0	0	0	0	30
Low-middle mount. forest N-W	2	2	0	10	7	33	0	20	22	5
Low-middle mount. forest shelter belt W	0	0	0	1	0	9	0	37	53	0
Low-middle mount. forest shelter… N-W	0	4	0	9	0	8	0	30	48	0
Low-middle mount. forest W	1	0	0	4	4	32	0	17	43	0
Middle mountain meadow steppe N-W	9	4	0	19	6	15	20	13	4	9
Middle mountain meadow steppe W	5	6	0	1	8	20	3	20	29	7
Middle mountain steppe N-W	10	13	0	20	11	12	10	8	0	13
Middle mountain steppe W	9	11	0	10	6	21	1	25	0	17
Mountain-valley semidesert N-W	2	28	35	0	0	0	0	0	0	7
Mountain-valley semidesert W	0	48	37	0	0	0	0	0	0	14
Submountain semidesert N-W	0	0	0	0	0	0	0	100	0	0
Submountain semidesert W	0	0	0	0	0	0	0	100	0	0
Total share	129	168	96	129	106	173	63	694	208	171
	ESA 2021									
High mountain alpine N-W	7	4	0	17	6	3	11	32	1	14
High mountain alpine W	0	0	0	0	0	4	0	87	0	8
High mountain subalpine N-W	9	6	0	20	7	8	14	20	3	12
High mountain subalpine W	5	3	0	7	10	7	0	54	6	8
High-altitude snow-cowered N-W	11	6	0	11	8	0	2	35	0	13
High-altitude snow-cowered W	0	0	0	0	3	0	0	97	0	0
Low mountain, dry steppe N-W	36	12	15	0	13	0	1	0	0	14
Low mountain, dry steppe W	23	21	8	0	18	0	0	0	0	30
Low-middle mount. forest N-W	2	2	0	10	7	33	0	20	22	5
Low-middle mount. forest shelter belt W	0	0	0	1	0	9	0	37	53	0
Low-middle mount. forest shelter… N-W	0	4	0	9	0	8	0	30	48	0
Low-middle mount. forest W	1	0	0	4	4	32	0	17	43	0
Middle mountain meadow steppe N-W	9	4	0	19	6	15	20	13	4	9
Middle mountain meadow steppe W	5	6	0	1	8	20	3	20	29	7
Middle mountain steppe N-W	10	13	0	20	11	12	10	8	0	13
Middle mountain steppe W	9	11	0	10	6	21	1	25	0	17
Mountain-valley semidesert N-W	2	28	35	0	0	0	0	0	0	7
Mountain-valley semidesert W	0	48	37	0	0	0	0	0	0	14
Submountain semidesert N-W	0	0	0	0	0	0	0	100	0	0
Submountain semidesert W	0	0	0	0	0	0	0	100	0	0
Total share	129	168	96	129	106	173	63	694	208	171

Table 25B-4. Mars importance for conserving LLCC types excluding LLCCs that occupy no more than 5% of the landscape zone's area in Armenia (the sum of Si indices for each marz)

	Aragats-otn	Ararat	Arma-vir	Geghar-kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayots Dzor
	ESRI 2023									
High mountain alpine N-W	7	4	0	17	6	3	11	32	1	14
High mountain alpine N-W	7	3	0	19	6	7	8	35	1	14
High mountain subalpine N-W	9	6	0	21	6	9	11	23	3	12
High-altitude snow-cowered N-W	20	3	0	21	14	0	4	28	0	11
Low and middle mountain forest N-W	2	2	0	8	6	30	0	24	22	5
Low and middle mountain forest W	1	0	0	4	4	32	0	13	46	0
Low mountain, dry steppe N-W	36	15	19	0	11	0	1	0	0	15
Low/mid. mount. forest shelter belt N-W	0	4	0	7	0	8	0	34	47	0
Low/mid. mount. forest shelter belt W	0	0	0	1	0	7	0	33	59	0
Middle mount. meadow steppe W	6	5	0	2	11	18	4	15	34	5
Middle mountain meadow steppe N-W	8	5	0	19	6	17	16	15	5	10
Middle mountain steppe N-W	13	13	0	20	11	9	10	10	0	13
Mountain-valley semidesert N-W	11	33	45	0	0	0	0	0	0	9
Submountain semidesert N-W	0	0	0	0	0	0	0	100	0	0
Total	112	90	64	121	75	139	54	330	217	94
	ESA									
High mountain alpine N-W	7	4	0	17	6	3	11	32	1	14
High mountain subalpine N-W	9	7	0	20	7	9	14	20	3	12
High-altitude snow-cowered N-W	11	6	0	11	8	0	2	35	0	13
Low mountain, dry steppe N-W	36	12	15	0	13	0	1	0	0	14
Low-middle mount. forest N-W	2	2	0	10	7	33	0	20	22	5
Low-middle mount. forest shelter belt W	0	0	0	1	0	9	0	37	53	0
Low-middle mount. forest shelter… N-W	0	4	0	9	0	8	0	30	48	0
Low-middle mount. forest W	1	1	0	4	4	32	0	17	43	0
Middle mountain meadow steppe N-W	9	4	0	19	6	15	20	13	4	9

Middle mountain meadow steppe W	5	6	0	1	8	20	3	20	29	7
Middle mountain steppe N-W	11	13	0	20	11	12	10	8	0	13
Mountain-valley semidesert N-W	2	28	35	0	0	0	0	0	0	7
Submountain semidesert N-W	0	0	0	0	0	0	0	100	0	0
Total share	112	93	61	93	69	141	51	331	202	86

The contribution of marzes Tavush, Syunik, and Lori to the conservation of LLCC diversity differs of their importance for landscape diversity (Section 2.4). Moreover, these differences are revealed in both the ESRI and ESA data, indicating that they are not the result of land-cover misclassifications (Figure 25B-3). These three marzes stand out from the others because they preserve most of the woody LLCCs (Figure 25B-4), which are generally rarer in Armenia than the non-woody ones.

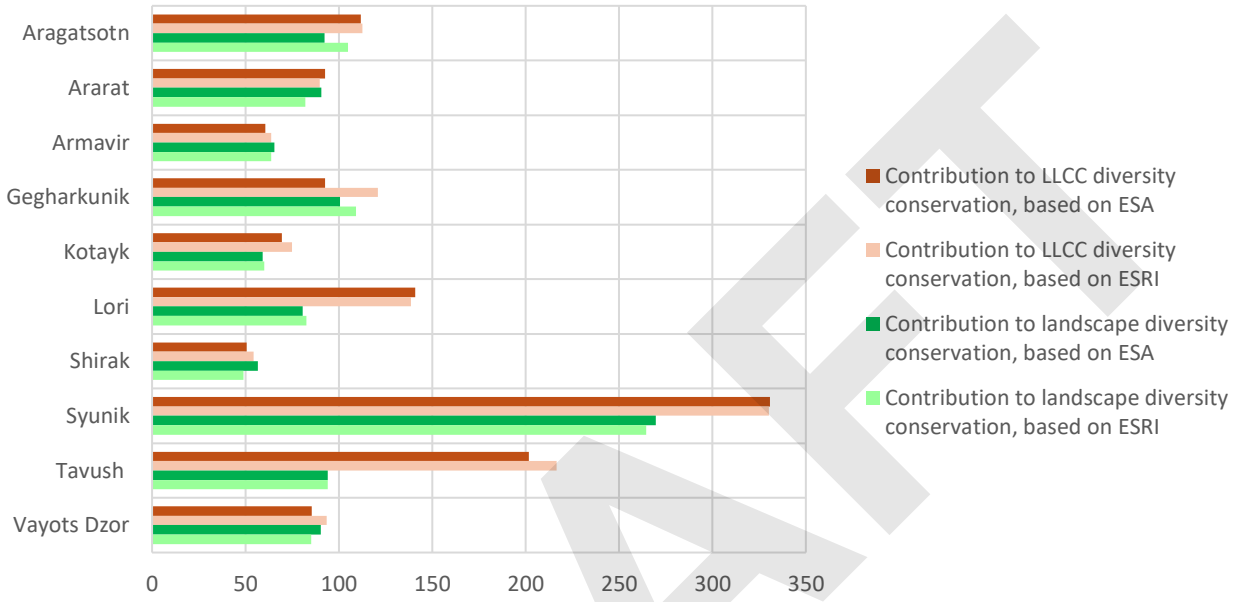


Figure 25B-3. Marz contribution to conservation of LLCC and landscape diversity in Armenia, based on ESRI and ESA data

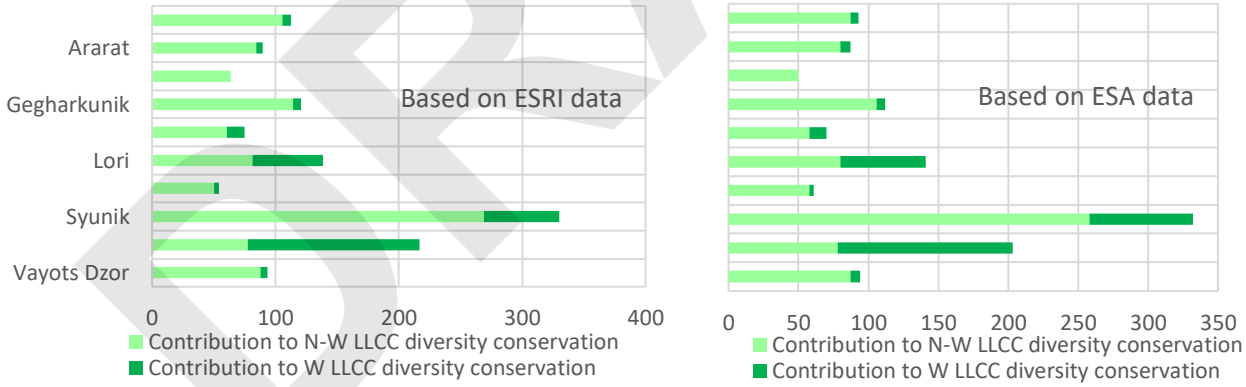
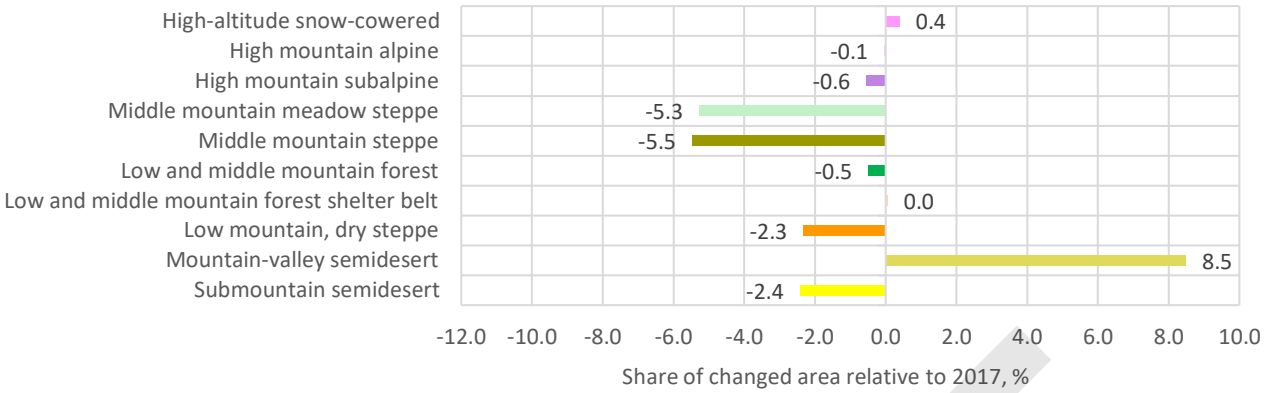


Figure 25B-4. Marz contribution to conservation of non woody and woody LLCC diversity, based on ESRI and ESA data.

2.5.C. Changes in LLCC extent and marz importance for conservation of LLCC diversity in Armenia

Land cover changes recorded by ESRI data from 2017 to 2023 have resulted in changes in the area of natural landscapes and LLCC extent (Figure 25C-1). The data on LLCC changes provides the following additional information compared to the data on landscape changes (Section 2.4.B):

- The area of woody LLCCs has decreased more significantly than that of non woody LLCCs within the middle-mountain meadow steppe;
- The total reduction in the area of mountain forest landscapes is driven by opposing changes in woody and N-W LLCCs, specifically, a decrease in woody LLCCs and an increase in N-W LLCCs;
- The total area of the forest shelter belt has remained unchanged, although the woody LLCCs within it have decreased.



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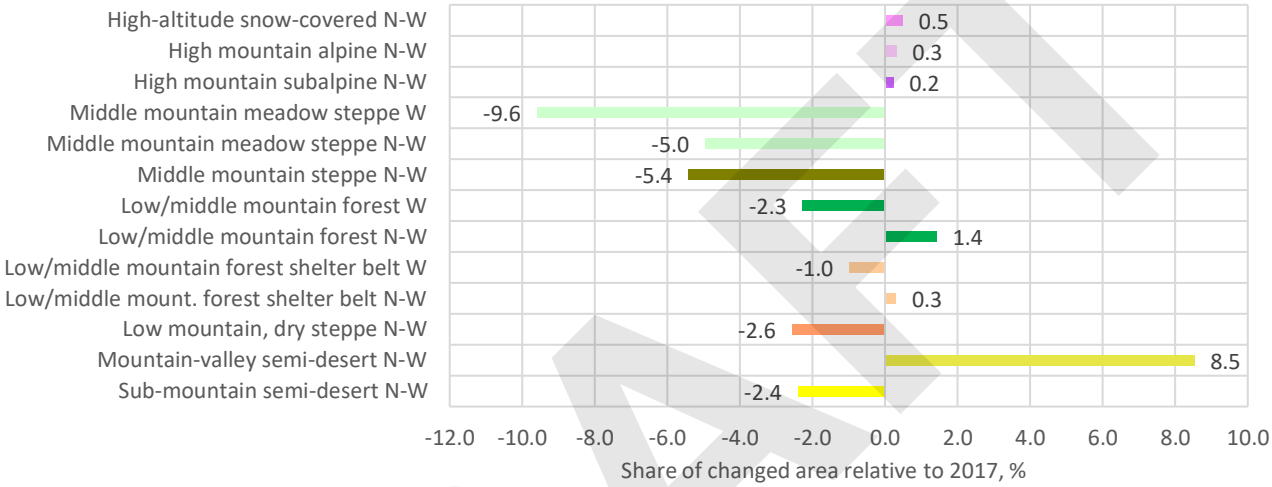


965

966 *Figure 25C-1. Changes in the extent of natural landscapes (a) and LLCC (b) from 2017 to 2023 based on ESRI data*

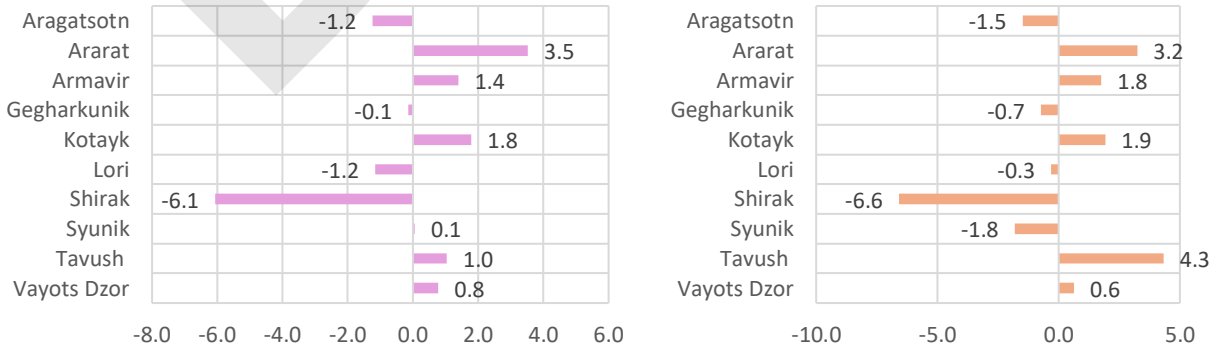
967 For the assessment of changes in provincial importance (Figure 25C-2), the data on LLCCs provides the following
968 additional information: (i) the importance of the Syunik province for conserving LLCCs has decreased, even though it has
969 remained unchanged with respect to landscapes and (ii) the importance of the Tavush province for conserving LLCCs has
970 grown significantly more than it has for landscapes.

971 Preliminary conclusions for organizing ecosystem accounting from the LLCC exercise are as follows:

972 - The LLCC map makes it possible to identify rare LLCCs, however, rare LLCCs with a very small area must be carefully
973 validated to exclude land cover classification errors;

974 - The rarer the LLCCs are, the greater the differences in estimates between the land-cover datasets. The same can be
975 expected when accounting for real rare ecosystems with small areas;

976 - LLCC mapping provides additional information compared to the data on landscape extent.



977

978 *Figure 25C-2. Changes in marz importance for conservation of diversity of natural landscapes (a) and LLCC (b) in*
979 *Armenia from 2017 to 2023 based on ESRI data*

2.6. Ecosystem extent in protected areas

2.6.A. Extent of protected areas in Armenia

In accordance with Decree N 1059-Ա (25.09.2014) of the Government of the Republic of Armenia, the PAs in 2014 were as follows:

- 3 state reserves ("Khosrov Forest", "Shikahogh" and "Erebuni"), which occupy an area of 35,439.6 hectares or 1.19% of the total area of Armenia,
- 4 national parks ("Sevan", "Dilijan", "Lake Arpi" and "Arevik"), which occupy an area of 236,802.1 hectares or 7.96% of the total area of Armenia,
- 232 natural monuments,
- 27 state sanctuaries, which occupy an area of 114,812.7 hectares or 3.95% of the total area of Armenia.

The total area of state reserves, sanctuaries, and national parks was 387,054.4 hectares, which accounted for 13.1% of Armenia's total territory.

Table 1. PAs areas in 2014 according to the Ministry of Environment of Armenia

PA	*Area, ha*
STATE RESERVES	
Khosrov Forest	23 213.5
Shikahogh	12 137.1
Erebuni	89.0
NATIONAL PARKS	
Sevan	147 455.0
Dilijan	33 765.0
Lake Arpi	21 179.3
Arevik	34 401.8
NATURAL SANCTUARIES	
Akhnabad	25.0
Arjatkhlenu	40.0
Juniper sparse forest	3 312.0
Gyulagarak	2 576.0
Herher sparse forest	6 139.0
Jermuk Forest	3 865.0
Sosu Park	64.2
Aragats Alpine	300.0
Banks pine	4.0
Goravan sand dunes	95.99
Caucasian rosehip	1 000.0
Arzakan-Meghradzor	13 532.0
Gandzakar	6 813.0
Getik	5 728.0
Ijevan	5 908.0
Margahovitti	3 368.0
Yeghegnadzor	4 200.0
Goris	1850.0
Red worm	219.85
Boghakar	2 728.0
Black Lake	240.0
Deep wound	50.28
Hanqavan Hydrological	5 169.04
Jermuk Hydrological	17 371.0
Zangezur	25 870.64
Zikatar	150.0
Khustup	6946.74

2.6.B. Ecosystem extent in PAs based on ESRI land cover data

At the present stage, we do not have access to official data covering all Armenian PAs for the period after 2014, official digitized maps of PA boundaries, or land cover data specifically refined for the territory of Armenia. Therefore, the following analyses are based on the available digital PA map referenced below and the global ESRI land cover dataset.

The use of the ESRI land cover dataset for relatively small PA areas leads to significant errors in area estimation. In the examples below, we demonstrate only the type of analysis that can, in principle, be conducted for ecosystem accounting of PAs based on land cover data. **All estimates are of methodological value only and should be refined using official PA boundaries and land cover data provided by the PAs.**

This example of accounting is based on the PA map provided by Acopian Center for the Environment, American University of Armenia (Figure 26B-1), the vegetation map prepared in the framework of our project (Section 2.3), and ESRI land cover data from 2017 and 2023.

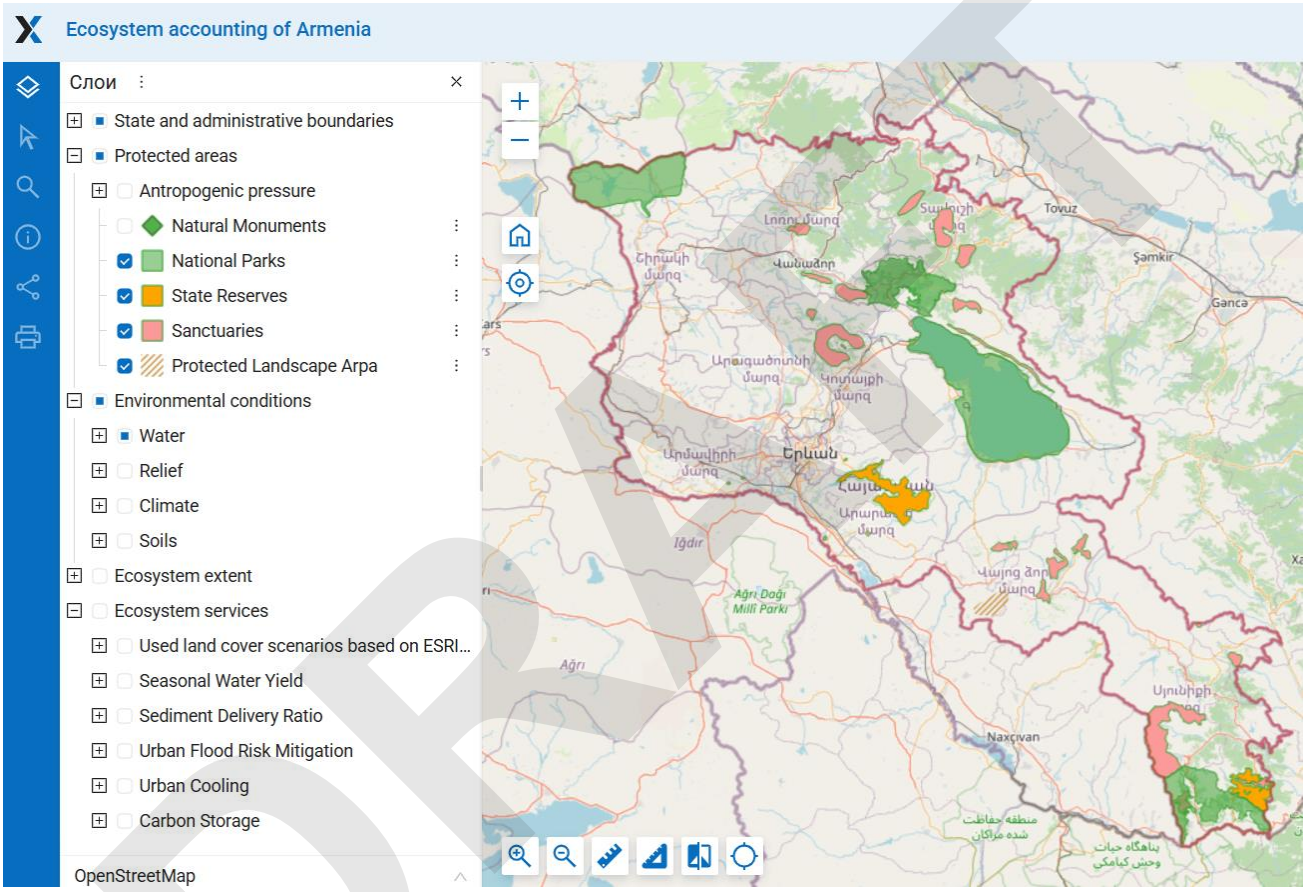


Figure 26B-1. The map of protected areas of Armenia. For details see project WEB GIS, Protected areas here. (The location of the Goravan Sands Sanctuary needs to be clarified)

The extent of land-cover classes in the PAs indicates the area of woody vegetation and the degree of human-induced transformation (Figure 26B-2; Table 26B-1). According to ESRI (2023), the entire area of the Ararat Vordan Karmir Sanctuary is occupied by croplands and built-up areas. Human-modified territories cover about half of the Goravan Sands and Goris Sanctuaries. The areas of Sevan and Arpi Lake National Parks, as well as the Khor Virap Sanctuary, are also significantly transformed. Forest vegetation occupies most of the territory of the Shikahogh Reserve and the Dilijan National Park, as well as the Gandzakar–Upper Aghdan, Ijevan, Pine of Gyulagarak, and Zikatar Sanctuaries. By contrast, forest is almost absent in the Erebuni Reserve, Arpi Lake National Park, and in 11 other sanctuaries.

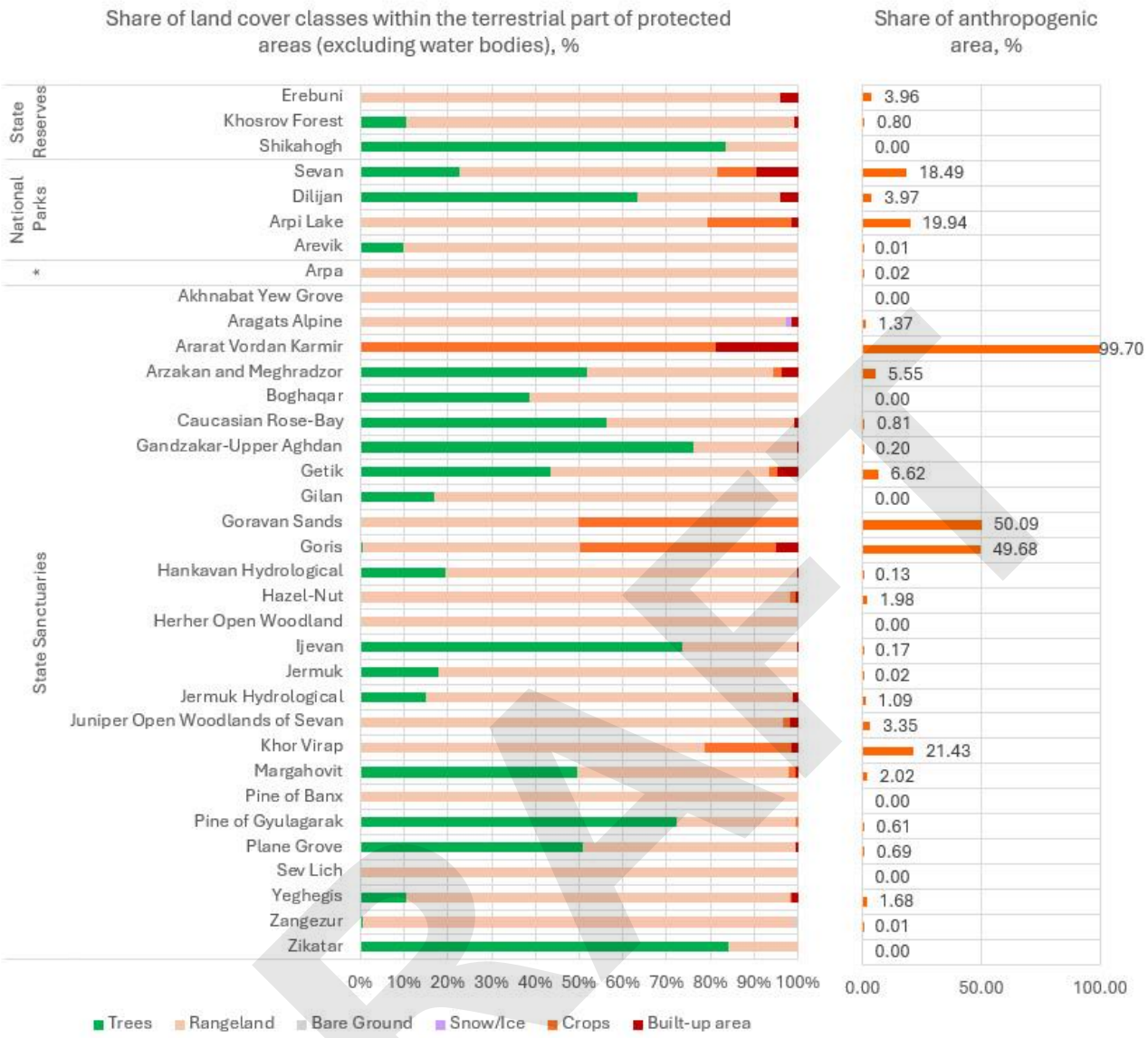


*Figure 26B-2. The share of area of land cover classes and anthropogenic areas, %. *Arpa is protected landscape*

All vegetation zones are represented in the PAs. The area of some PAs is entirely covered by vegetation of a single zone, for example: Goravan Sands – desert; Erebuni, Ararat, and Khor Virap — semi-desert;Hazel Nut – broadleaf woodlands; Gandzakar-Upper Aghdan, Goris, Hankavan Hydrological, Pine of Gyulagarak, Plane Grove – forest zone; Akhnabat Yew Grove, Pine of Banx, Sev Lich — subalpine meadows; Aragats Alpine – alpine meadows (Figure 26B-3).

Overall, vegetation zones are unevenly represented in the PAs. The forest zone occupies the largest area within the PAs—about 1,400 km². Other zones are much smaller, ranging from 500 km² of subalpine zone to 46 km² of marshes (Figure 26B-4 a). The shares of the zones' areas preserved in the PAs are also highly unequal. 26% and 32% of the forest and juniper zones are preserved in the PAs while for the semi-desert, steppe, and open woodland zones this share is less than 10% (Figure 26B-4 b). The desert zone is not indicative in this analysis, as it is represented by only one small unique site).

Between the total area of a vegetation zone and the share of its area preserved in the PAs, a weak, non-significant tendency towards a negative relationship between the total zonearea of a vegetation zone and its representation in the PAs: the larger the total area of a zone, the lower its representation in the PAs (Figure 26B-5). Even from this weak trend it is possible to distinguish zones that are better represented in the PAs, lying above the trend line (juniper, forest), and underrepresented zones, lying below the trend line (semi-desert, broadleaf woodland).

Figure 26B-3. The share of area of vegetation zones in PAs, %

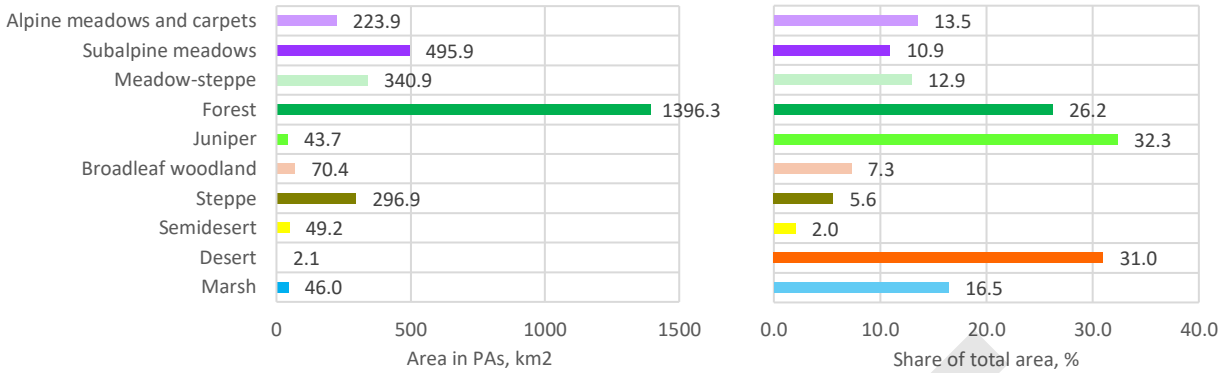


Figure 26B-4. Area and the share of the natural area of a vegetation zone located in the PAs

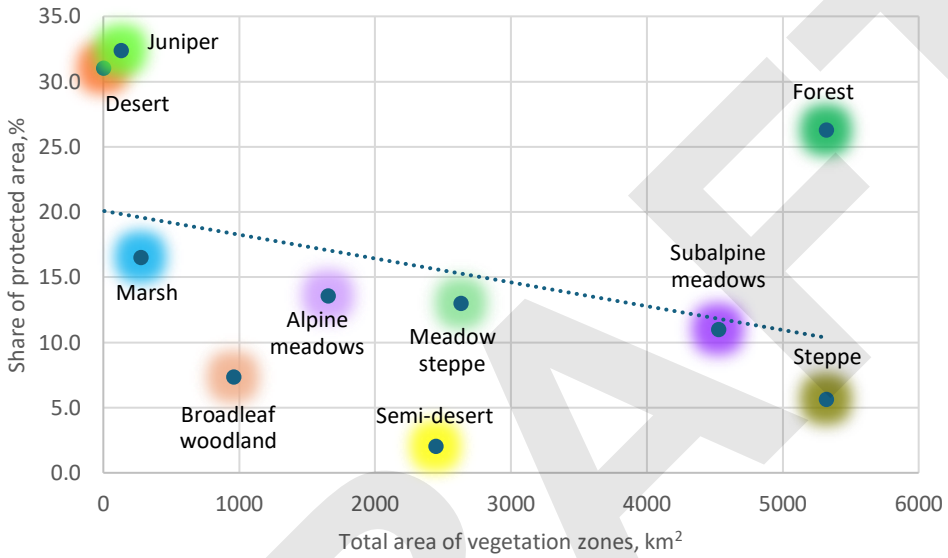


Figure 26B-5. A weak, non-significant tendency towards a negative relationship between the total area of a vegetation zone and its representation in the PAs.

Table 26B-1. Area of land cover classes in PAs, han (the total area of PAs shown on the map used may differ from the official data, as the PA boundaries on the map require further clarification)*

PA type	*PA*	*Trees*	*Rangeland*	*Bare Ground*	*Snow/ Ice*	*Water and flood. veg.*	*Crops*	*Built-up area*	*Total area of PA**
State Reserves	Erebuni	0	84.84	0	0	0	0	3.5	88.30
	Khosrov Forest	2404.91	20231.17	31.76	0	0.51	5.33	176.63	22868.59
	Shikahogh	9854.31	1937.14	0	0	0	0	0	11810.26
National Parks	Sevan	5525.1	14346.23	13.23	0	126863.3	2173.48	2336.68	151374.99
	Dilijan	24757.79	12862.58	0	0	5.21	11.41	1546.26	39214.50
	Arpi Lake	186.33	43922.3	8.64	0	2123.82	10719.45	810.1	57828.90
	Arevik	4158.48	37530.44	36.28	1.25	3.11	0	5.12	41852.62
Protected landscape	Arpa	1.49	8148.12	1.01	0	0	0	1.7	8158.56
State Sanctuaries	Akhnabat Yew Grove	0	24.85	0	0	0	0	0	24.86
	Aragats Alpine	0	276.72	0.17	4.1	15.67	0	4.11	301.07
	Ararat Vordan Karmir	0	0.37	0	0	0	166.63	38.36	205.60
	Arzakan and Meghradzor	7503.25	6181.2	3.39	0	7.27	285.16	521.26	14518.08
	Boghaqar	1112.76	1757.96	0	0	0	0	0	2872.27
	Caucasian Rose-Bay	1037.93	794.25	0	0	0	0	15.02	1848.58
	Gandzakar-Upper Aghdan	2973.96	925.74	0	0	0	0.07	7.73	3910.26
	Getik	1354.88	1559.37	0.03	0	1.65	58.24	148.68	3124.67
	Gilan	48.48	238.6	0.23	0	0	0	0	287.41

	Goravan Sands	0	106.47	0	0	0	106.93	0	213.47
	Goris	11.93	934.73	0	0	0	847.96	96.39	1901.05
	Hankavan Hydrological	191.05	783.42	0	0	0	0	1.3	976.53
	Hazel-Nut	0	40.73	0	0	0	0.58	0.24	41.48
	Herher Open Woodland	7.17	2047.41	6.58	0	35.85	0	0	2098.67
	Ijevan	5725.75	2048.54	0	0	0	5.7	7.29	7793.64
	Jermuk	726.01	3336.61	0	0	0	0.94	0	4066.48
	Jermuk Hydrological	388.69	2163.31	0	0	0.05	0	28.1	2581.86
	Juniper Open Woodlands of Sevan	8.9	3764.79	21.6	0	0.2	60.96	70.75	3930.40
	Khor Virap	0.01	124.8	0	0	0.28	31.71	2.45	159.37
	Margahovit	2285.4	2222.63	0	0.14	0	69.85	23.13	4604.38
	Pine of Banx	0	4.62	0	0	0	0	0	4.61
	Pine of Gyulagarak	1768.24	661.81	0	0	0	14.27	0.61	2446.95
	Plane Grove	1098.25	1049.34	0	0	0	1.43	13.58	2174.57
	Sev Lich	0	150.56	0.47	0	89.14	0	0	240.32
	Yeghegis	230.75	1927.08	0.45	0	0	0.52	36.32	2196.95
	Zangezur	127.06	24156.19	241.24	3.54	33.9	2.03	0	24711.29
	Zikatar	2691.57	504.37	0	0	0	0	0	3198.61

Table 26B-2. Area of vegetation zones in PAs, ha (the total area of PAs shown on the map used may differ from the official data, as the PA boundaries on the map require further clarification)*

PA type	PA	Alpine meadows and carpets	Sub-alpine meadows	Meadow-step-pe	Forest	Juniper	Broad-leaf woodland	Steppe	Semi-desert	Marsh	No data	Total area of PA*
State Reserves	Erebuni	0	0	0	0	0	0	0	88.34	0	0	88.34
	Khosrov Forest	0	268.64	0	8533.69	0	14.72	12399.13	1626.9	3.58	3.65	22850.31
	Shikahogh	0	405.25	0	11224.97	0	0	0	0	0	176.04	11806.26
National Parks	Sevan	0	0	16.03	20957.52	0	0	5204.09	0	0	125080.4	151258.04
	Dilijan	0	6667.11	15.37	30799.09	0	0	1701.68	0	0	0	39183.25
	Arpi Lake	2375.27	17575.65	32567.5	0	0	0	40.31	0	4514.36	726.2	57799.33
	Arevik	4371.3	6231.62	0	23943.92	0	5172.4	0	1651.39	0	461.3	41831.9
Protected landscape	Arpa	0	490.08	0	73.14	17.23	0	6997.61	574.26	0	0	8152.32
State Sanctuaries	Akhnabat Yew Grove	0	24.85	0	0	0	0	0	0	0	0	24.85
	Aragats Alpine	300.77	0	0	0	0	0	0	0	0	0	300.77
	Ararat Vordan Karmir	0	0	0	0	0	0	0	205.36	0	0	205.36
	Arzakan and Meghradzor	1.87	5171.99	699.07	8547.13	0	0	0	0	86.52	0	14506.58
	Boghaqar	0.32	600.73	0	2269.67	0	0	0	0	0	0	2870.72
	Caucasian Rose-Bay	0	235.19	0	1051.5	0	560.51	0	0	0	0	1847.2
	Gandzakar-Upper Aghdan	0	0	0	3907.5	0	0	0	0	0	0	3907.5
	Getik	0	1057.62	491.27	1573.96	0	0	0	0	0	0	3122.85
	Gilan	0	0	0	187.18	0	0	87.72	11.24	0	1.17	287.31
	Goravan Sands	0	0	0	0	0	0	0	213.4 (desert)	0	0	213.4
	Goris	0	0	0	1900.32	0	0	0	0	0	0	1900.32
	Hankavan Hydrological	0	0	0	975.77	0	0	0	0	0	0	975.77
	Hazel-Nut	0	0	0	0	0	41.55	0	0	0	0	41.55
	Herher Open Woodland	0	0	0	177.97	938.57	0	388.05	592.42	0	0	2097.01
	Ijevan	0	0	0	6581.18	0	1206.1	0	0	0	0	7787.28
	Jermuk	0	0	164.7	1896.6	1932.9	0	69.29	0	0	0	4063.56

	Jermuk Hydrological	0	351.27	136.5	2092.38	0	0	0	0	0	0	2580.15
	Juniper Open Woodlands of Sevan	0	0	0	298.17	861.8	0	2767.2	0	0	0	3927.2
	Khor Virap	0	0	0	0	0	0	0	159.25	0	0	159.25
	Margahovit	0	2440.85	0	2160.31	0	0	0	0	0	0	4601.16
	Pine of Banx	0	4.62	0	0	0	0	0	0	0	0	4.62
	Pine of Gyulagarak	0	2.62	0	2442.31	0	0	0	0	0	0	2444.93
	Plane Grove	0	0	0	2160.46	0	0	0	0	0	12.97	2173.43
	Sev Lich	0.07	240.1	0	0	0	0	0	0	0	0	240.17
	Yeghegis	0	0	0	1527.23	619.0	0	37.75	11.1	0	0	2195.12
	Zangezur	15340.9	7825.73	0	1148.02	0	45.62	0	0	0	336.6	24696.79
	Zikatar	0	0	0	3195.94	0	0	0	0	0	0	3195.94

2.6.C. Changes in the area of land cover classes in state reserves and national parks

According to ESRI, between 2017 and 2023 the most notable changes occurred in Arpi Lake National Park, where the area of croplands increased by more than half, and in the Erebuni Reserve, where it decreased by one third. In the Arevik Reserve, the forest area decreased by 18% (Figure 26C-1).

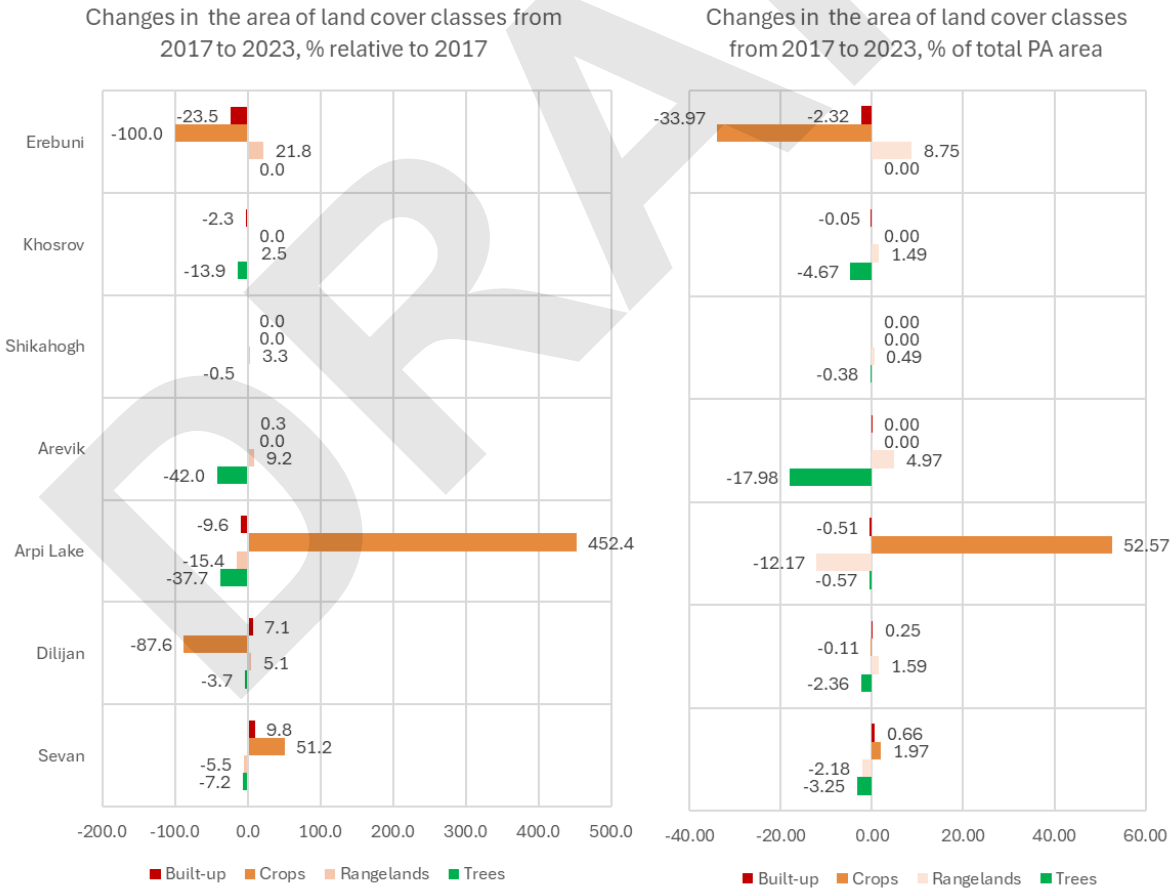


Figure 26C-1. Changes in the area of land cover classes within PAs

2.6.D. Distance from natural monuments to anthropogenic areas and roads

As an example of assessing anthropogenic threats to 'point' ecosystems and natural objects of very small area, distances were measured between the natural monuments shown on the PA map provided by Acopian Center for the Environment, American University of Armenia (Figure 26D-1), and anthropogenic areas (built-up areas and croplands according to the ESRI 2023 land cover data), roads including main roads and all other roads including trails from the dataset of Forest Atlas of Armenia, and population polygons with more than 100 residents based on the Kontur Population Dataset (Figure 26D-2).

This example shows, that even minor errors in land cover classification—amounting to just a few pixels—can significantly distort the calculated distances to natural monuments. Therefore, to obtain reliable results, it is essential to use land cover data specifically refined for Armenia.

Unfortunately, at this stage the lack of an officially approved digital map of PA boundaries, combined with errors in the ESRI land-cover data, prevents accurate accounting of ecosystem extent within PAs. For PAs with small areas, even minor land-cover errors can significantly distort the actual proportions of different ecosystem types. Moreover, the misclassification of anthropogenic areas where none exist leads to inaccurate assessments of threats to natural ecosystems and natural monuments. For instance, the misclassification of cropland and built-up areas in the high-mountain zone of the Gegham Ridge in the land-cover data artificially reduced the estimated distance between natural monuments and anthropogenic territories (26D-4).

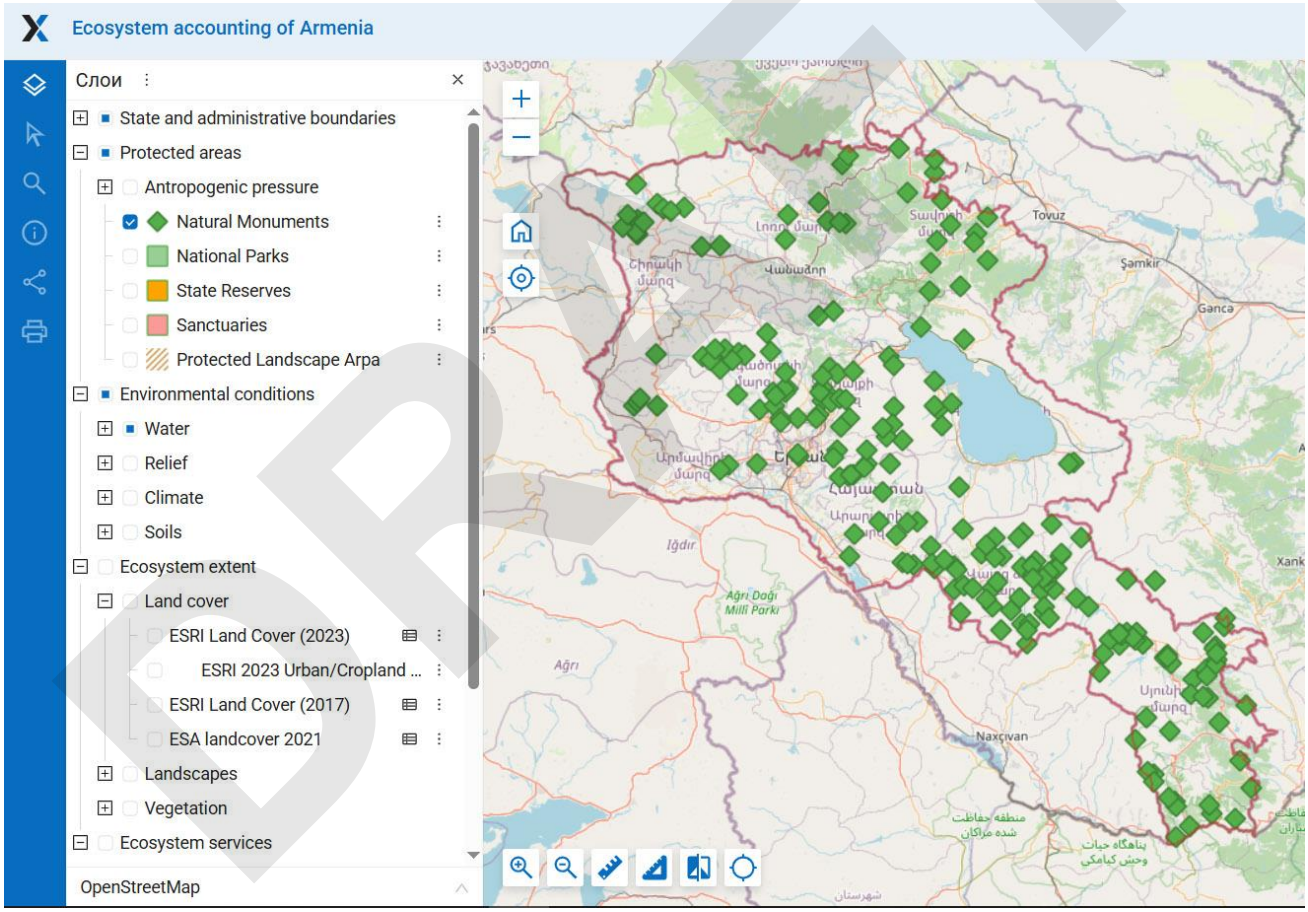


*Figure 26D-1. The map of natural monuments used (in details see project WEB GIS **Section Protected Areas**)*

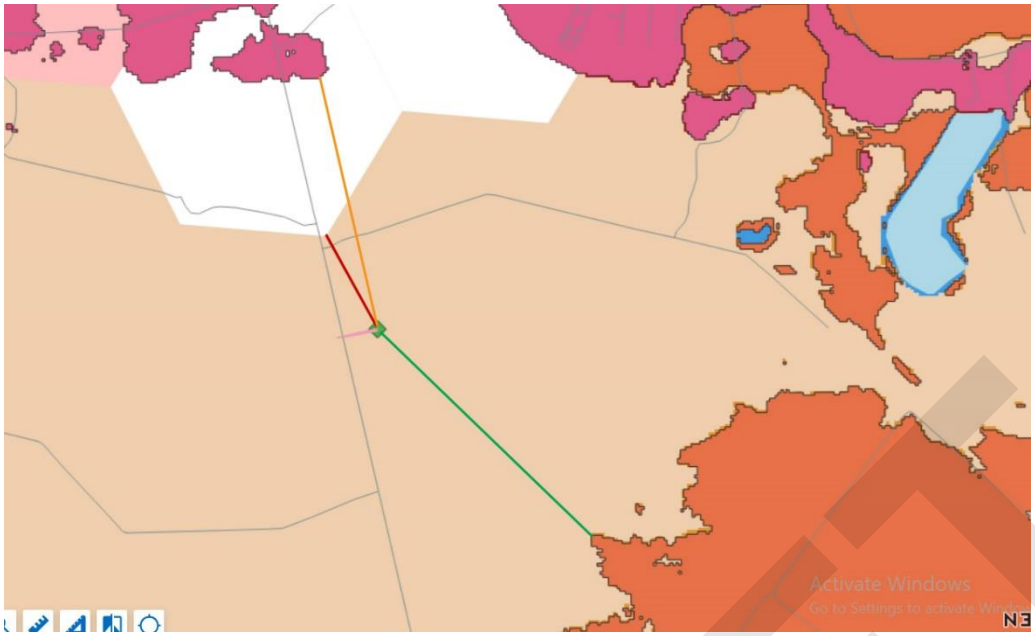


Figure 26D-2. An Example of distances for Dasak Biological Monument in Armavir marz

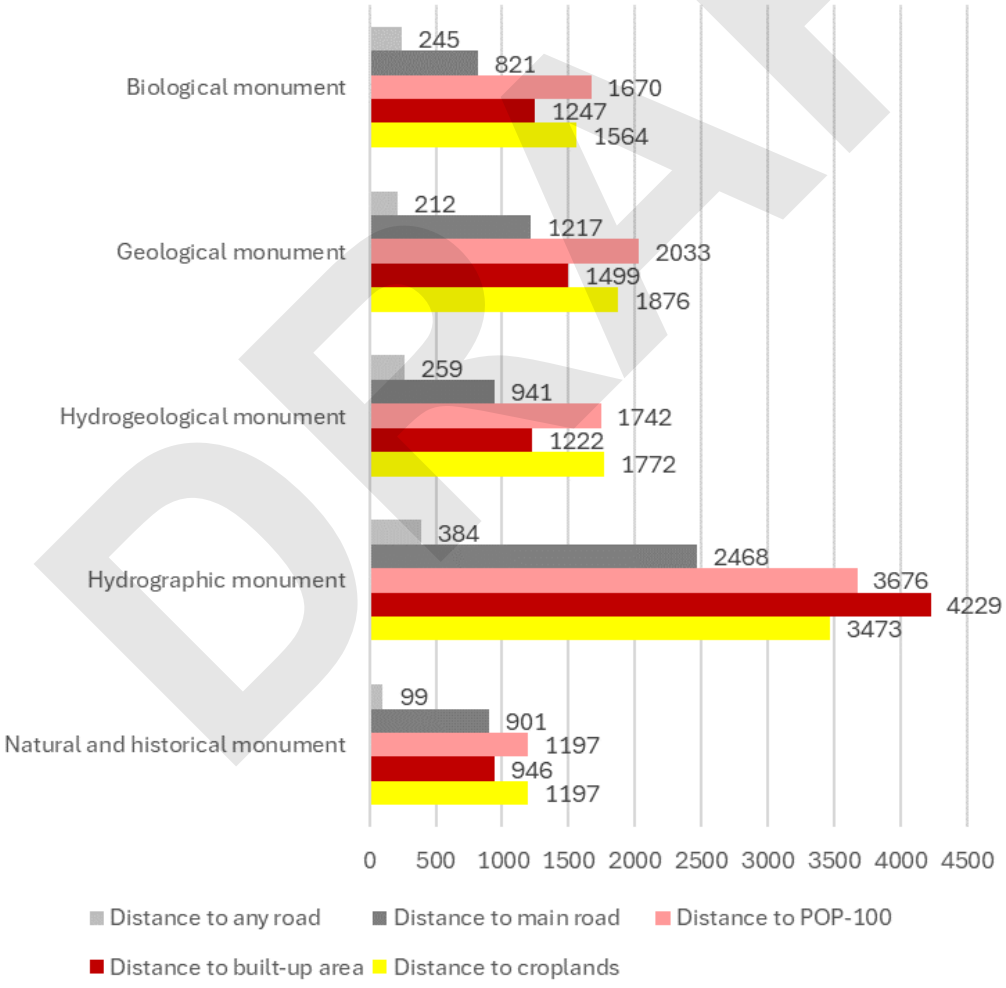


Figure 26D-3. Distance from different categories of natural monuments to various types of anthropogenic areas and roads, in meters (Pop-100 - hexagons with a population of more than 100 people).

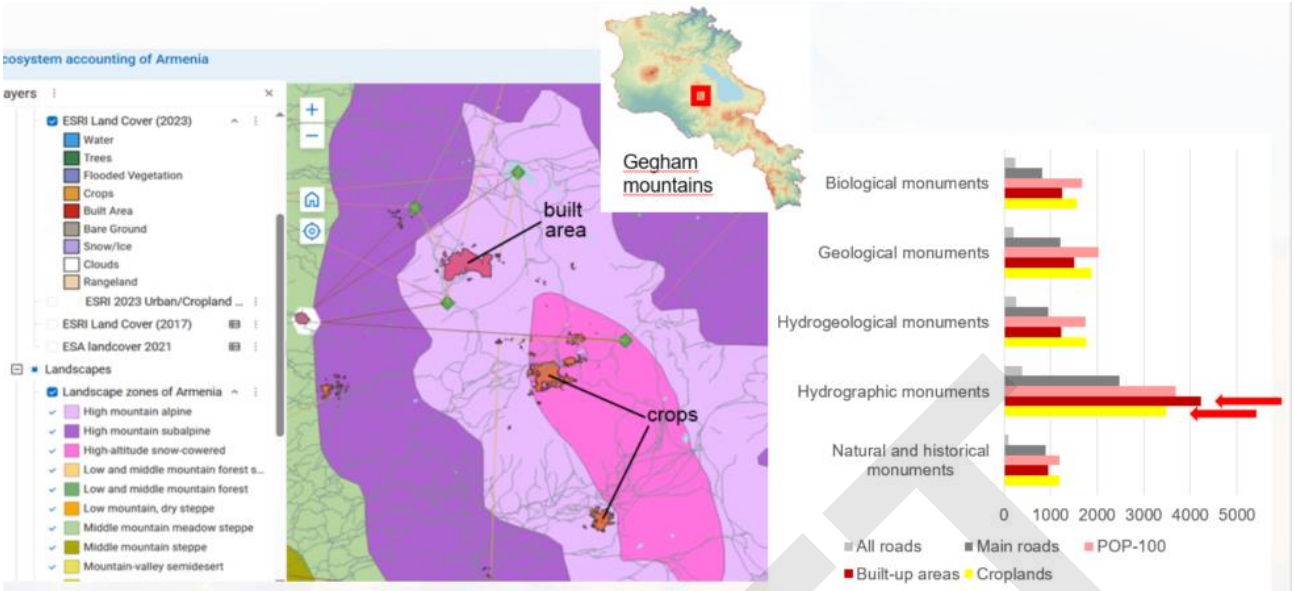


Figure 26D-4. Erroneous underestimation of the distance between anthropogenic areas and hydrographic monuments due to ESRI land cover mistakenly detecting croplands and built-up areas on the Gegham Ridge.

2.7. Approaches for the inclusion of Armenia in the Global Ecosystem Atlas

The Global Ecosystems Atlas (GEA) will be the first comprehensive harmonized open resource on the extent, change, condition and risk of all the world's ecosystems. The inclusion of Armenia in the GEA is seen by us as an important step to demonstrate the international significance of national ecosystem accounting.

Our approach consists in the integration of a scientific vegetation map with regularly updated land cover data. Scientific map takes into account the ecological and biodiversity features of terrestrial ecosystems that are difficult or impossible to detect from space. Regularly updated land cover data allows for timely monitoring of changes in the extent of natural ecosystems. This approach was tested for extent accounting of natural vegetation types (TR Section 2.3) and natural landscapes (TRSection 2.4).

2.7.A. Initial data to start

Data from two required sources were available to us: scientific vegetation maps and global land cover datasets (Figure 2.7A-1).

Armenia has an world-class scientific tradition in botany and geobotany. Over many decades, Armenian scientists have developed a wide range of vegetation maps with varying levels of detail. Based on this long-term academic foundation, the updated vegetation map was developed and recoded to IUCN GET within the framework of the BCC-Armenia project on the Prototype Ecosystem Accounting of Armenia (https://biodiversity-armenia.am/en/; TR Section 2.3) by Alla Aleksanyan and George Fayvush (Institute of Botany after A. Takhtajyan of the National Academy of Sciences of the Republic of Armenia) and digitized by Vardan Asatryan (Scientific center of zoology and hydroecology of NAS RA).

Since Armenia currently lacks a national regularly updated land cover dataset, we tested five land cover datasets available in open access (TR Section 2.1). Three of them — ESRI, ESA, and GLAD datasets — most accurately reflect the current land cover of Armenia and can be used for the zero version of the Armenia ecosystem map for the GEA.

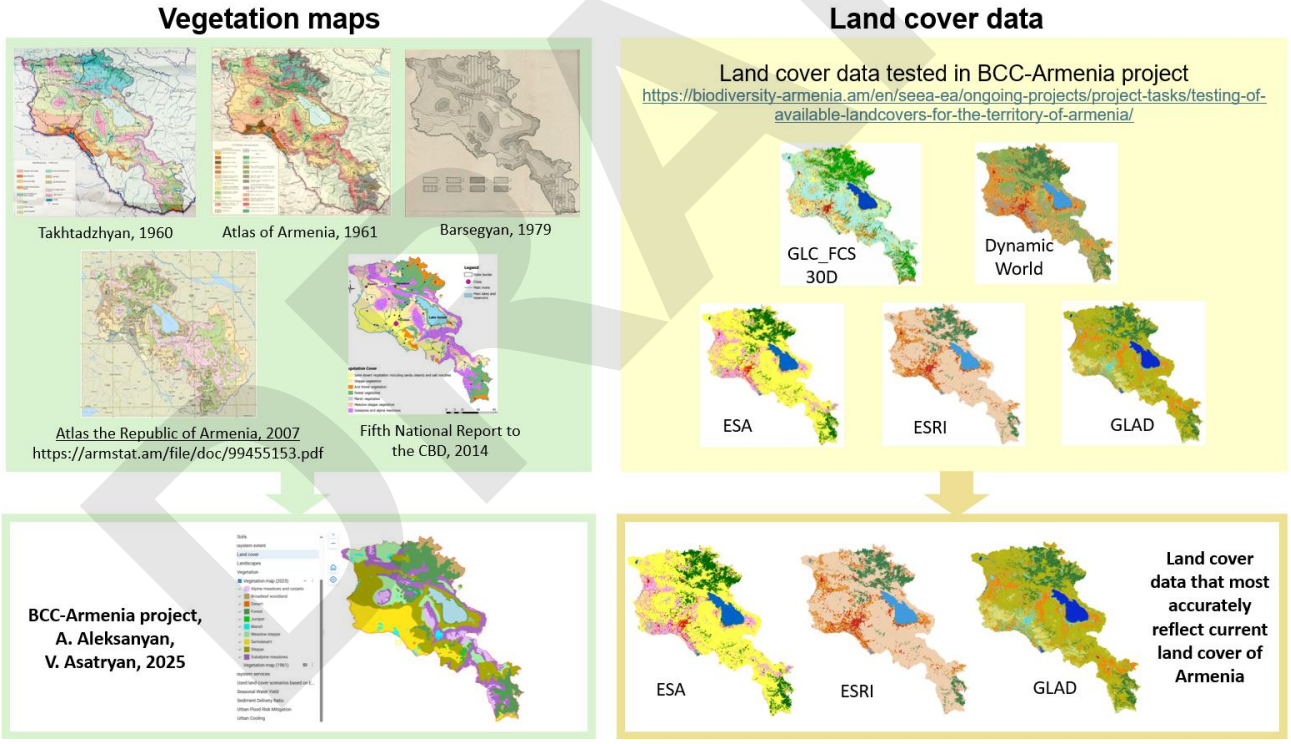


Figure 2.7A-1. Source data for representing Armenia in the GEA

2.7.B. Zero version of Armenian ecosystem map for the GEA

The current area of natural terrestrial ecosystems, is defined as the potential area of a given vegetation type minus cropland and built-up areas based on land cover data. The current distribution of forests is also derived from land-cover data (Fig. 2.7B-1).

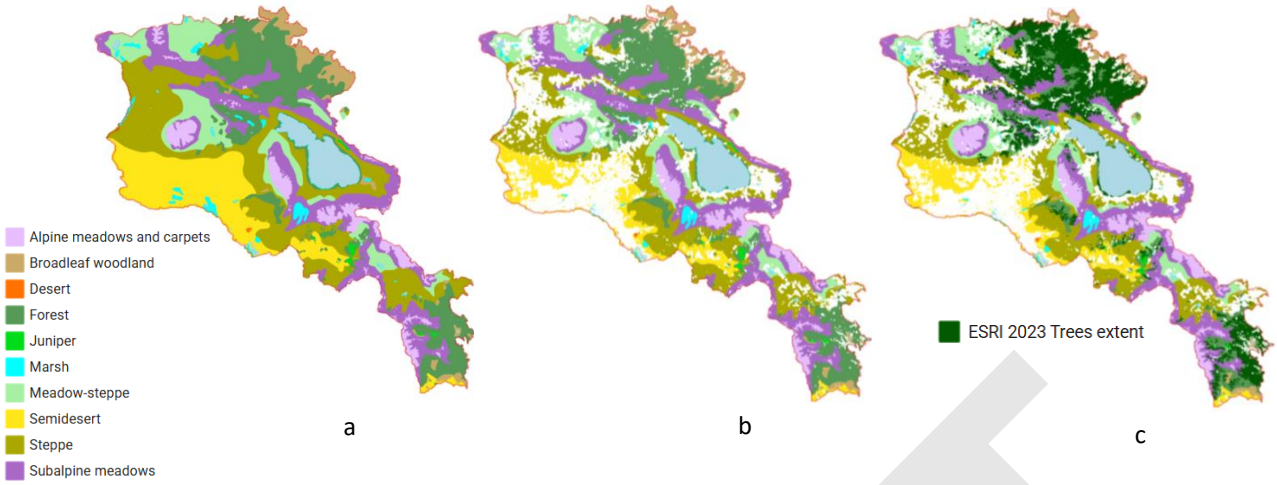


Figure 2.7B-1. Main steps to produce a map of current terrestrial ecosystems using ESRI data as an example: a) potential distribution of vegetation types; b) current natural area of vegetation zones excluding croplands and built-up areas; c) ecosystem types, including current tree cover [For detailed map see project Web-GIS, sections Ecosystem Extent/Vegetation/Vegetation map 2025]

The vegetation map, originally created as a vector dataset, was rasterized to a spatial resolution of 10 m and was subsequently reclassified into ecosystem types according to the IUCN Global Ecosystem Typology (GET).

Vegetation map of Armenia	*IUCN GET*
Alpine vegetation	T6.4 Temperate alpine grasslands and shrublands
Subalpine meadows	T4.5 Temperate subhumid grasslands
Meadow-steppe	T4.5 Temperate subhumid grasslands
Steppe	T5.1 Semi-desert steppes
Grasslands within forest vegetation zone	T4.5 Temperate subhumid grasslands
Juniper woodlands	T4.4 Temperate woodlands
Broadleaf woodlands	T4.4 Temperate woodlands
Semidesert	T5.1 Semi-desert steppes
Desert	T5.1 Semi-desert steppes

Next, we used data from two land cover datasets – ESRI 2023 and ESA 2021 - to produce different versions of the zero version map. Four land cover classes were used from the land cover data and reclassified into the IUCN GET. Since the Prototype Ecosystem Accounting for Armenia focuses exclusively on terrestrial ecosystems, aquatic ecosystems were not classified and were defined generally as Water.

Land cover data	*IUCN GET*
Trees; Tree cover	T2.2 Deciduous temperate forests
Built-up areas	T7.4 Urban and industrial ecosystems
Crops; Croplands	T7.1 Annual croplands
Water; Permanent water bodies	Water

As our analysis comparing cropland areas from land cover datasets and ARMSTAT data has shown (Section 2.1.B), tested land cover datasets include the following categories of agricultural land in the 'cropland' class:

– annually plowed areas (T7.1 Annual croplands);

– perennial agricultural plantations, i.e., vineyards and orchards (T7.3 Plantations);

– some of the fields that have not been plowed this year (T7.5 Derived semi-natural pastures and oldfields).

At this stage, we do not have the data necessary to separate these three categories within cropland land cover class, therefore, we reclassified it as T7.1 Annual croplands. Land categories such as "T7.2 Sown pastures and fields" and forest plantations aimed at timber production are not typical for Armenia; therefore, we did not consider them. Category "T7.5 Derived semi-natural pastures and oldfields" can be found in three vegetation zones: meadow-steppe, steppe, and semidesert. However, at this stage, we do not have the data necessary to identify T7.5 within these zones.

Four classes (trees, crops, built areas, water) from the ESRI 2023 and ESA 2021 land-cover datasets (10 m resolution) were overlaid onto the vegetation raster using a priority-based approach; that is, these classes replaced the underlying

vegetation class, while all other pixels retained their original vegetation classification. Thus, two versions of the map with a 10 m resolution were produced based on ESRI and ESA data.

Next, ESA- and ESRI-based 10 m categorical rasters were aggregated to a 100 m resolution using a majority (modal) resampling approach. For each 100 m cell, the corresponding block of 10 × 10 underlying 10 m pixels (100 pixels in total) was identified, and the ecosystem class occurring most frequently within that block was assigned to the output cell. NoData values were excluded from the calculation. This approach preserves categorical integrity and avoids artificial class mixing that would result from averaging or interpolative resampling methods. Resulting rasters are ESA_based_100m.tif and ESRI_based_100m.tif (Figure 2.7B-2).

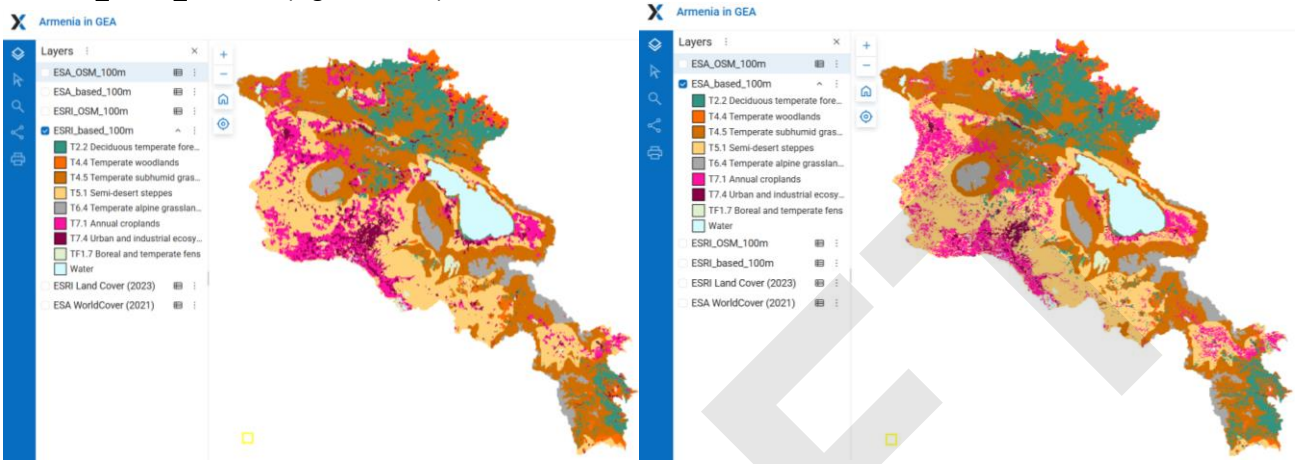
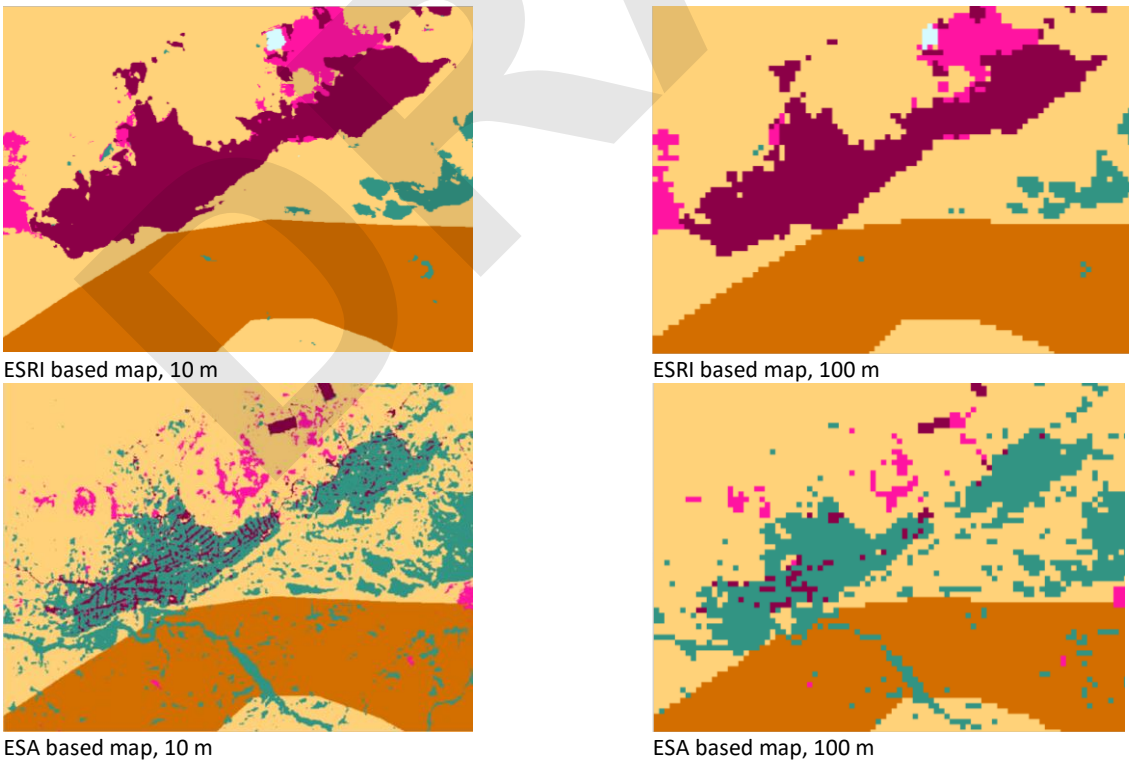


Figure 2.7B-2. Maps of current terrestrial ecosystems of Armenia based on ESRI 2023 and ESA 2021 land cover data. See in details here [Armenia in GEA]

Due to differences in the methodologies used by ESRI and ESA to identify built-up areas, croplands, and tree cover, the resulting maps show noticeable differences in the areas of these classes. The more detailed ESA land-cover dataset identifies grasslands, croplands, and tree cover within settlement areas; therefore, in the raster based on ESA data, built-up area is smaller than in the raster based on ESRI data and some settlements with a high density of trees (small private gardens, street trees, and parks) are identified in the ESA data predominantly as tree cover (Fig. 2.7B-3).



ESRI based map, 10 m

ESRI based map, 100 m

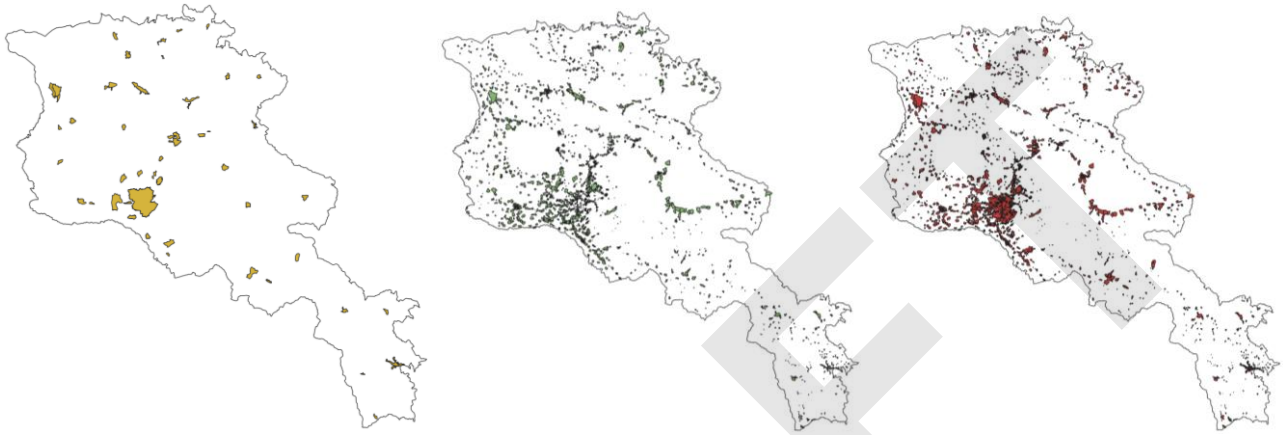
ESA based map, 10 m

ESA based map, 100 m

Figure 2.7B-3. The settlement of Garni in the map versions based on ESRI and ESA data.

However, according to the understanding of urban ecosystem types in the IUCN GET, all tree-covered, herbaceous, and vacant land areas located within urban boundaries are considered part of urban ecosystems. Therefore, we considered it appropriate to provide the GEA team with two additional versions of the map, in which all areas within settlement boundaries are assigned to class T7.4 Urban and industrial ecosystems.

Settlement areas were delineated using OpenStreetMap data by combining administrative boundaries of towns and the city of Yerevan (Fig. 2.7B-4 a) with built-up area polygons which represent the actually built-up areas of settlements at a lower hierarchical level than towns and city Yerevan ((Fig. 2.7B-4 b). These features were merged into a single settlement layer (Fig. 2.7B-4 c), which was overlaid onto the ESA- and ESRI-based rasters and classified as T7.4 Urban and industrial ecosystems. Resulting rasters are ESA_OSM_100m.tif and ESRI_OSM_100m.tif (Figure 2.7B-5; see in details here Armenia in GEA).



a b c

Figure 2.7B-4. Used OSM layers: (a) administrative boundaries of towns and the city of Yerevan; (b) built-up area polygons; (c) combined layer.

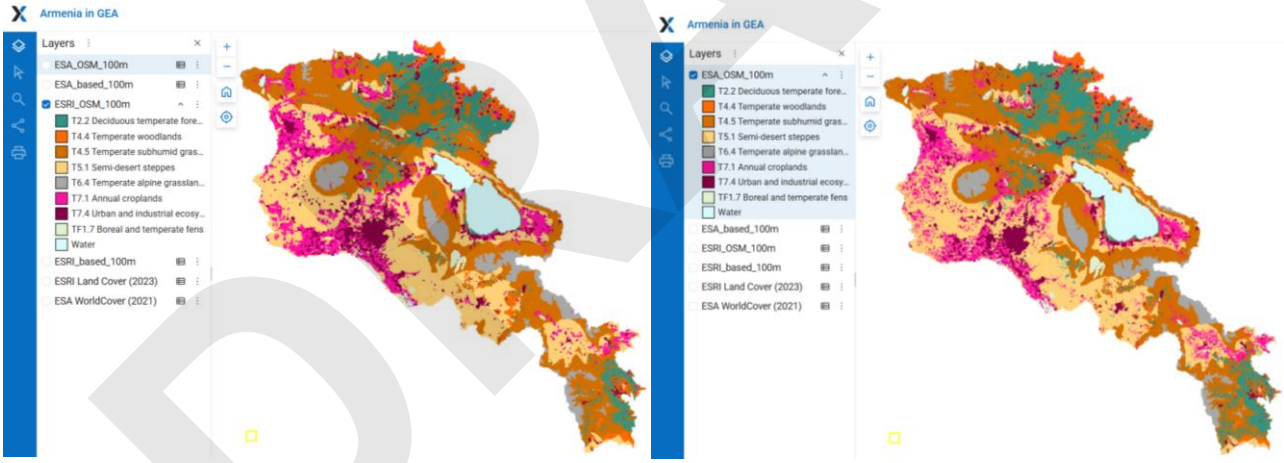


Figure 2.7B-5. Maps of current terrestrial ecosystems of Armenia based on ESRI 2023 and ESA 2021 land cover data and built-up areas from OSM. See in details here Armenia in GEA

2.7C. Comparison of Zero version maps for the GEA with Government-reported data

To compare the created ecosystem maps with land-cover class area data provided by the Government of Armenia (TR Section 2.2A), all non-forest ecosystem classes in our maps were aggregated into a single class. We used government-reported data for 2022 (https://www.arlis.am/hy/acts/171671). All versions of created maps show cropland areas that are smaller than those reported in the official government statistics, while the area of non-forest ecosystems is larger. This indicates that part of croplands included in government statistics is identified as grassland by the land-cover datasets. Built-up area in maps created for the GEA exceeds the values reported in government statistics, except for the map version based on ESA data, where the built-up area is substantially smaller. With respect to forest area, the map versions based on ESA data show better agreement with the government statistics (Figure 2.7C-1).

The sum of the absolute differences between class areas in the cerated maps and the government statistics is smallest for the map based on ESA and OSM data - ESA_OSM_100m.tif (Figure 2.7C-2).

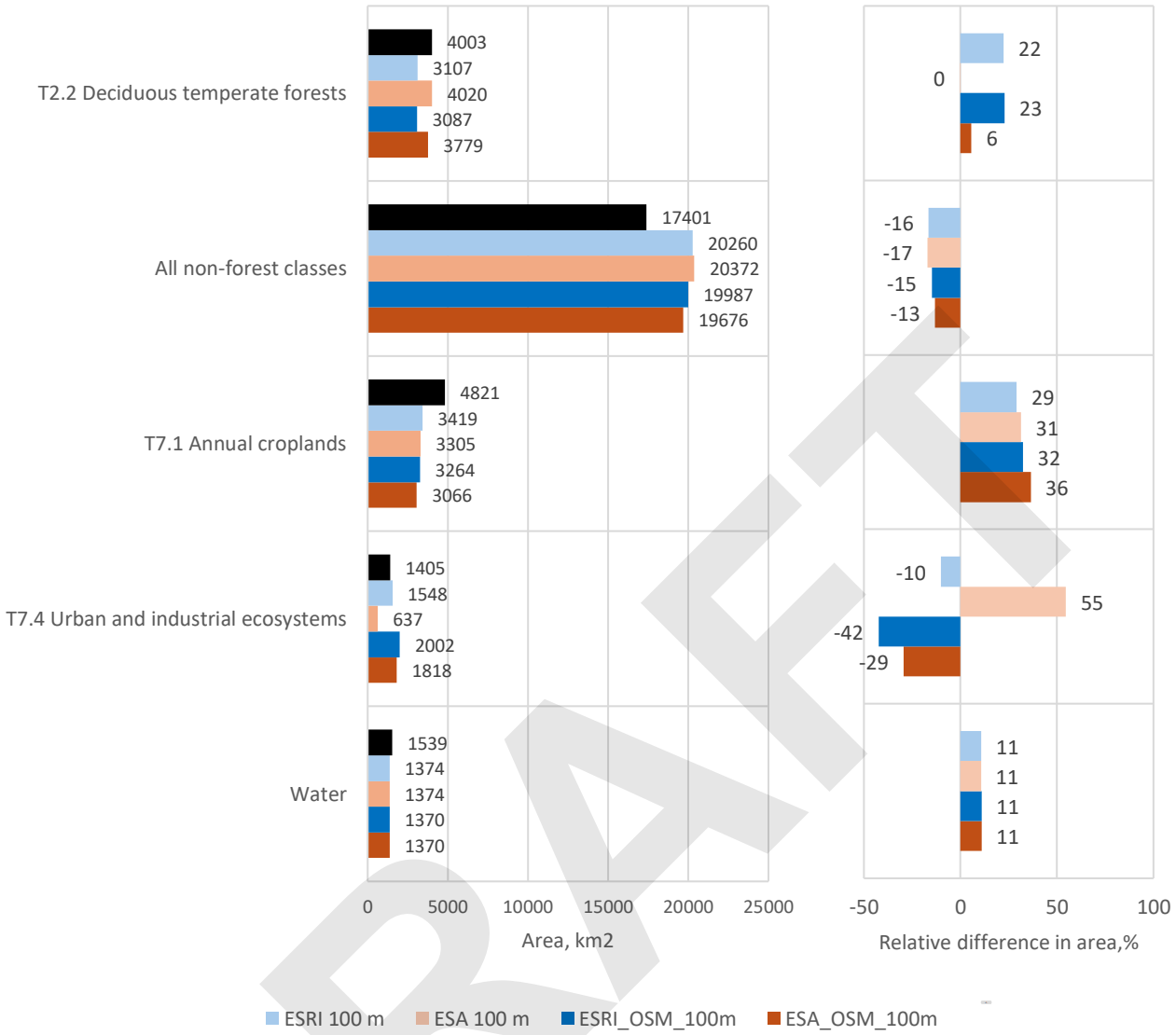


Figure 2.7C-1. Area of main land cover classes in ecosystem maps created for GEA and in government-reported data (a) and relative differences in area between GEA maps and government statistics, % of government-reported area (b)

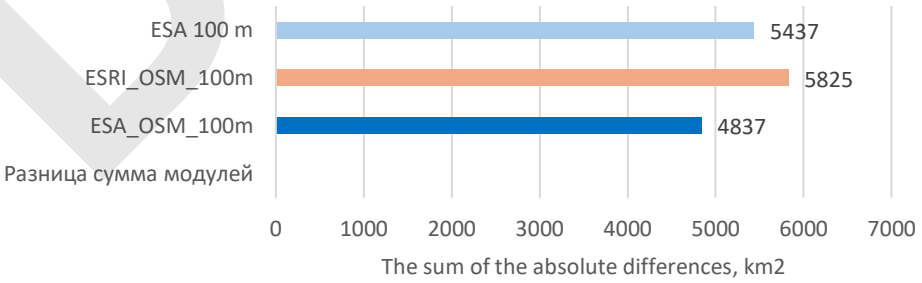


Figure 2.7C-2. The sum of the absolute differences between maps for GEA and government statistics

2.7D. Subsequent versions of the map

As shown by our analysis (TR Section 2.1), all global land cover datasets contain significant errors, and therefore, the ecosystem map of Armenia and the ecosystem accounting should eventually be based on a corrected national land cover dataset.

Currently, we are at the stage of the **Zero version** of the map, which can be created based on the Prototype ecosystem accounting V1 and available global land cover datasets. Moving forward, two main stages of improvement for this map can be foreseen. Along this path, improvements are needed both in the vegetation map and in the land cover data.

Version 1 may be based on a detailed map of Armenian ecosystems developed using the ELU approach (TR Section 4.2C) as well as sertain refinments of land cover data:

– Corrections of obvious errors in land cover data (e.g., built-up areas and croplands in high mountain zones);

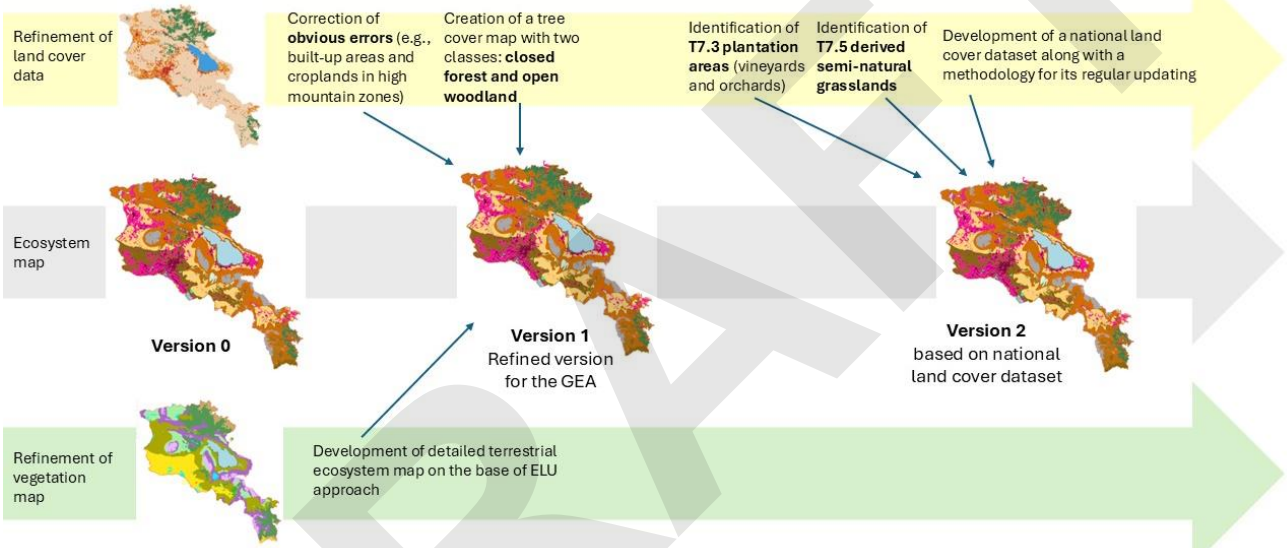
– Creation of tree cover map with two classes – closed forest and open woodlands

Version 2 shold be based on an accurate national land cover dataset including

– Refinement of T7.1 Annual cropland areas;

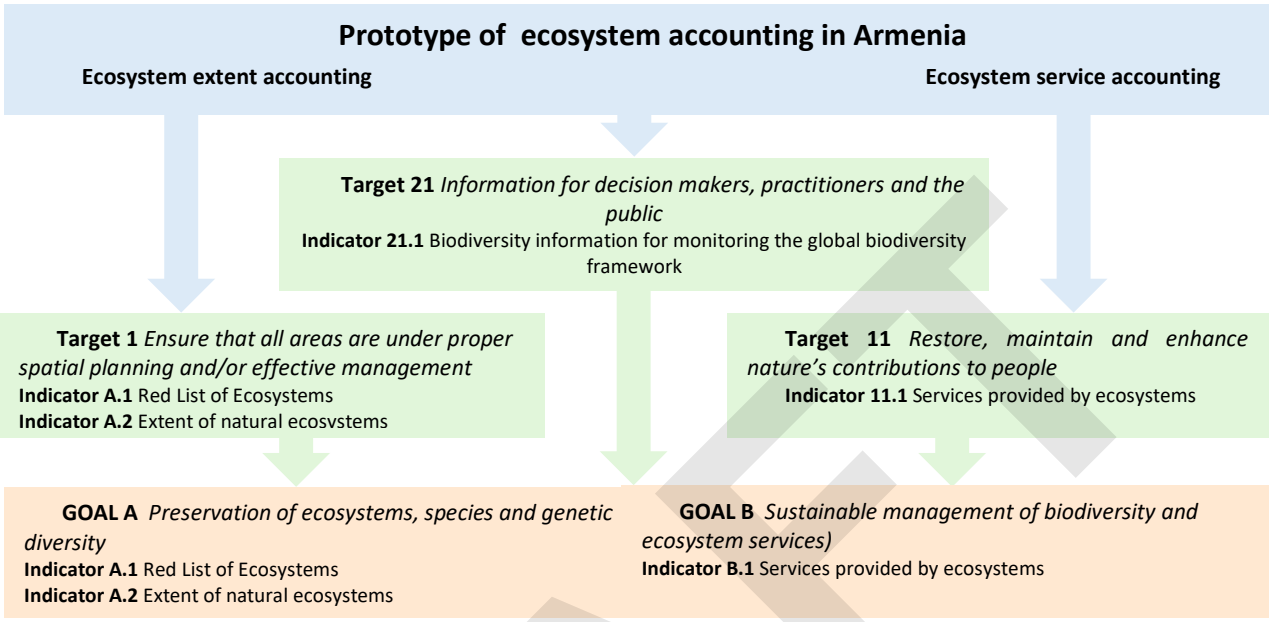
– Identification of T7.3 Plantation areas (vineyards and orchards)

– Identification of T7.5 Derived semi-natural grasslands, which requires analysis of satellite imagery and agricultural statistics not only for the current period but also for previous years.



2.8. Contribution to Global Biodiversity Framework

EA Prototype V1 makes a direct contribution to Targets 1, 11, 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.



Target		Indicator		EA Prototype V1 contribution
21	Ensure that the best available data, information and knowledge are accessible to decision makers, practitioners and the public to guide effective and equitable governance, integrated and participatory management of biodiversity, and to strengthen communication, awareness-raising, education, monitoring, research and knowledge management and, also in this context, traditional knowledge, innovations, practices and technologies of indigenous peoples and local communities should only be accessed with their free, prior and informed consent, in accordance with national legislation	21.1	Indicator on biodiversity information for monitoring the global biodiversity framework	Data on Ecosystem Extent and Ecosystem Services (maps, national and marz indicators, changes from 2017 to 2023)
1	Ensure that all areas are under participatory, integrated and biodiversity inclusive spatial planning and/or effective management processes addressing land- and sea-use change, to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030, while respecting the rights of indigenous peoples and local communities	A.1	Red List of Ecosystems	Assessed criteria of ecosystems for RLE (Section 2.3): - Rarity ranking and rarity maps of ecosystems - Trends in ecosystem extent
		A.2	Extent of natural ecosystems	Extent accounting for the following natural ecosystem types (Section 2.3): - Alpine ecosystems - Subalpine ecosystems - Meadow-steppe - Steppe - Grasslands in forest zone - Forests - Juniper woodlands - Broadleaf woodlands - Semidesert - Desert - Marches
11	Restore, maintain and enhance nature's contributions to people, including ecosystem functions and services, such as the regulation of air, water and climate, soil health, pollination and reduction of disease risk, as well as protection from natural hazards and disasters, through nature-based solutions and/or ecosystem-based	11.1	Services provided by ecosystems	Accounting for the ES provided by ecosystems (Section 3): - Production of forage and fodder by natural grasslands - Wild plants biomass provisioning: edible, culinary and medicinal plants

	approaches for the benefit of all people and nature			- Nectar production by wild plants for honey bees to produce honey - Global climate regulation: Storage of carbon in ecosystems in soil and tree biomass - Local climate regulation: Effect of natural ecosystems on surface temperature (cooling effect) - Prevention of soil erosion; - Prevention of ediment export to streams - Water flow regulation: Baseflow provisioning - Flood risk mitigation - Crop pollination by wild insects - Natural conditions for recreation: hiking in Pas - Importanse of biodiversity for Armenian culture

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2.9. Examples of EE accounting tables

Explanations are provided in the corresponding sections

Extent of land cover classes by Government-reported data (Section 2.2.A)

EE accounting table: *Table 2.2.A-2. Land cover classes in 2020 and 2024, by Government-reported data, ha*

	Cultivated lands	*Grasslands*	*Tree-covered areas*	*Shrub-covered areas*	*Water covered areas*	*Vegetation-free areas*
Opening extent in 2020	**538361.22**	**1366386.9**	**400522.06**	**34200.612**	**151491.8**	**483295.83**
Additions to extent	NA					
Managed expansion	NA					
Unmanaged expansion	NA					
Reductions in extent	NA					
Managed reductions	NA					
Unmanaged reductions	NA					
Net change in extent	1259.3	-2700.46	-18160.9	173.718	20626.01	-1197.1
Closing extent in 2024	**539620.52**	**1363686.44**	**382361.15**	**34374.33**	**172117.81**	**482098.73**

EE by economic units: *Table 2.2.A-3. Land cover class extent by marzes in 2022 by Government-reported data, ha*

	Tree-covered areas	Grasslands	Shrub-covered areas	Vegetation-free areas	Water covered areas	Cultivated	Buil-up
Aragatsotn	8571.9	163313.3	392.5	20565.3	2189.9	67143.7	15095.6
Ararat	12724.74	99272.39	2496.22	35572.84	7090.2	40224.09	11061.98
Armavir	582.41	29283.57	634.13	17666.4	3010.438	60572.6	11345.59
Gegharkunik	21889.88	238054.4	3635.07	39933.93	124010.7	90318.54	17289.28
Kotayk	20810.43	102757.6	2313.48	20405.93	1661.12	45813.84	13820.73
Lori	86365.8	200387.6	4830.7	23510.69	4751.58	48300.81	11717.3
Shirak	4598.8	144403.9	0	13622.23	3427.13	83846.24	18128.89
Syunik	80905.01	194761.5	15742.25	91253.96	5576.07	47958	14345
Tavush	133659.9	82690.46	2943.31	10681.01	1094.24	31359.26	7970.77
Vayots Dzor	28325.5	114823.3	1147.9	60825.9	923.4	20109.42	4857.7
Yerevan	1845.1	1001.2	0	1133.29	155.61	3283.62	14909.08
Armenia	400279.5	1370749	34135.56	335171.5	153890.4	538930.1	140541.9

Extent of land cover classes by ESRI land cover data (Section 2.2.B)

Transition matrix: *Table 22B-3. Land cover class transition matrix from 2017 to 2023, km^2*

	Tree cover	Grasslands	Bare ground	Snow/ Ice	Water	Flooded veg.	Crops	Built-up	Total area in 2017	Reduc-tion
Tree cover →	2909.87	362.79	0.02	0.05	0.58	0.02	3.74	2.72	3279.79	369.92
Grasslands →	224.03	19221.76	2.12	7.56	13.46	1.74	940.92	114.62	20526.21	1304.45
Bare ground →	0.05	75.63	29.67	3.70	1.97	0.24	2.10	2.59	115.94	86.27
Snow/Ice →	0.01	0.49	0.04	0.33	0.01	0.00	0.02	0.06	0.96	0.63
Water →	0.44	8.74	2.29	0.04	101.20	0.47	7.41	1.53	122.12	20.92
Flooded veg. →	0.05	3.34	0.05	0.00	4.48	4.78	1.81	0.87	15.37	10.59
Crops →	3.04	444.42	0.42	0.29	6.62	1.18	2478.53	97.21	3031.70	553.17
Built-up→	3.27	25.79	0.76	0.03	0.50	0.02	14.40	1335.95	1380.72	44.77
Total area in 2023	3140.75	20142.95	35.35	12.00	128.82	8.46	3448.92	1555.56	28472.82	
Expansion	230.88	921.19	5.69	11.67	27.62	3.68	970.39	219.61		2390.73

EE accounting table: *Table 2.2.B-4. Land-cover class extent for 2017 and 2023, based on ESRI land cover dataset, km2*

	Trees	Grass	Bare ground	Snow/Ice	Water	Flooded veg.	Crops	Built-up
1. Opening extent in 2020	**3279.79**	**20526.21**	**115.94**	**0.96**	**122.12**	**15.37**	**3031.70**	**1380.72**
2. Additions to extent	230.88	921.19	5.69	11.67	27.62	3.68	970.39	219.61
3. Managed expansion	NA							
4. Unmanaged expansion	NA							
5. Reductions in extent	369.92	1304.45	86.27	0.63	20.92	10.59	553.17	44.77
6. Managed reductions	NA							
7. Unmanaged reductions	NA							
8. Net change in extent	-139.04	-383.26	-80.59	11.04	6.70	-6.91	417.22	174.83
9. Closing extent in 2024	**3140.75**	**20142.95**	**35.35**	**12.00**	**128.82**	**8.46**	**3448.92**	**1555.56**

EE by economic units: *Table 22B-2. Extent of land cover classes in 2023 by marses based on ESRI land cover data, km²*

	Grasslands	Trees	Bare ground	Snow/Ice	Flooded veget.	Water	Crops	Built Area	Total
Aragatsotn	2,096.86	48.25	3.48	6.38	0.00	3.50	438.49	139.17	2,736.12
Ararat	1,560.01	26.20	6.94	0.04	6.74	32.42	305.46	177.10	2,114.91
Armavir	461.83	0.55	2.05	0.00	0.15	7.10	609.26	182.76	1,263.70
Gegharkunik	3,239.85	129.56	4.28	0.94	0.65	1,274.08	404.99	193.66	5,248.00
Kotayk	1,508.64	153.10	1.08	1.60	0.00	2.57	265.38	182.43	2,114.80
Lori	2,424.92	883.74	2.83	0.31	0.79	3.81	298.87	147.73	3,763.00
Shirak	1,784.67	13.43	0.91	2.47	0.00	31.48	742.89	142.79	2,718.63
Syunik	3,650.25	507.74	12.65	0.09	0.02	15.86	233.22	73.53	4,493.35
Tavush	1,227.75	1,316.33	0.05	0.04	0.02	4.35	82.03	95.67	2,726.24
Vayots Dzor	2,174.55	38.13	2.51	0.35	0.00	2.35	33.28	45.37	2,296.54
Armenia	20,185.02	3,117.51	37.33	12.21	8.39	1,378.29	3,422.08	1,547.66	29,708.49

Extent of natural vegetation types (Section 2.3)

Transition matrix*: Table 23C-1. Aggregated vegetation type transition matrix from 2017 to 2023, km²*

	Alpine vege-tation	Sub-alpine mea-dows	Mea-dow-step-pe	Step-pe	Grassl. in forest zone	Juni-per	Broad-leaf wood-land	Semi-desert	De-sert	Marsh	Fo-rests	Water and flood. veg.	Crops	Built-up	Total area in 2017	Reduc-tion
Alpine veg.	1642.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	2.3	0.1	1645.9	3.0
Subalpine meadows	0.0	4216.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.6	0.5	60.9	2.9	4300.5	83.8
Meadow-steppe	0.0	0.0	2552.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.9	2.3	270.0	6.2	2841.5	289.4
Steppe	0.0	0.0	0.0	5039.5	0.0	0.0	0.0	0.0	0.0	0.0	11.3	1.0	370.2	21.3	5443.2	403.8
Grassl. in forest zone	0.0	0.0	0.0	0.0	2628.1	0.0	0.0	0.0	0.0	0.0	143.6	1.4	54.9	22.2	2850.2	222.1
Juniper	0.0	0.0	0.0	0.0	0.0	127.5	0.0	0.0	0.0	0.0	0.9	0.0	0.2	0.2	128.8	1.2
Broadleaf woodland	0.0	0.0	0.0	0.0	0.0	0.0	640.4	0.0	0.0	0.0	36.2	2.5	24.9	6.6	710.6	70.2
Semi-desert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2274.9	0.0	0.0	1.1	4.4	142.5	55.8	2478.5	203.6
Desert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0	0.3	7.1	0.3
Marsh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	212.5	0.2	5.1	17.1	1.9	236.8	24.3
Forests	3.2	62.5	11.4	22.7	238.5	2.0	18.8	3.3	0.0	0.4	2909.9	0.6	3.7	2.7	3279.8	369.9
Water and flooded veg.	0.2	0.4	1.2	0.8	1.8	0.0	0.6	4.2	0.0	5.3	0.5	110.9	9.2	2.4	137.5	26.6
Crops	1.3	12.6	20.3	162.8	21.8	0.0	35.5	179.1	0.1	11.5	3.0	7.8	2478.5	97.2	3031.7	553.2
Built-up	0.1	1.4	2.4	6.8	6.6	0.2	2.3	6.0	0.0	0.8	3.3	0.5	13.7	1336.6	1380.7	44.1

Total area in 2023	1647.6	4293.5	2587.4	5232.6	2896.8	129.7	697.7	2467.6	6.9	230.6	3140.7	137.1	3448.2	1556.3	28472.8	2295.46
Expansion	4.8	76.9	35.3	193.1	268.8	2.2	57.2	192.7	0.1	18.0	230.9	26.2	969.7	219.7	2295.5	

EE accounting table: *Table 2.3.C-2. Accounting table of vegetation type extent for 2017 and 2023*

	Alpine vege-tation	Sub-alpine mea-dows	Mea-dow-step-pe	Steppe	Grassl. in forest zone	Juni-per	Broad-leaf wood-land	Semi-desert	Desert	Marsh	Forests
Opening extent in 2017	**1645.93**	**4300.46**	**2841.47**	**5443.24**	**2850.19**	**128.78**	**710.63**	**2478.53**	**7.06**	**236.81**	**3279.79**
Additions to extent	4.76	76.90	35.29	193.11	268.77	2.17	57.23	192.71	0.06	18.04	230.88
Managed expansion	NA										
Unmanaged expansion	NA										
Reductions in extent	3.05	83.84	289.36	403.76	222.11	1.24	70.20	203.62	0.27	24.26	369.92
Managed reductions	NA										
Unmanaged reductions	NA										
Net change in extent	1.71	-6.94	-254.06	-210.66	46.66	0.93	-12.97	-10.92	-0.21	-6.22	-139.04
Closing extent in 2024	**1647.64**	**4293.52**	**2587.41**	**5232.59**	**2896.85**	**129.71**	**697.67**	**2467.61**	**6.85**	**230.59**	**3140.75**
Additional row – see Section 4											
Closing extent in 2024 of ecosystems unconverted since 2017	**1642.88**	**4216.62**	**2552.11**	**5039.48**	**2628.08**	**127.54**	**640.43**	**2274.91**	**6.79**	**212.55**	**2909.87**

EE by economic units: *Table 23D-1. Extent of natural vegetation types by marzes in 2023*

		Alpine vegetation	*Subalpine meadows*	*Meadow-steppe*	*Steppe*	*Forest*	*Juniper*	*Broadleaf woodland*	*Semi-desert*	*Desert*	*Marsh*
Area in 2023, km2	Aragatsotn	202.59	106.04	524.94	525.73	48.88	0	0	743.31	0	7.05
	Ararat	37.16	64.63	30.77	751.66	187.13	0	9.46	470.97	6.89	64.27
	Armavir	0	0	0	0	0	0	0	456.02	0	7.73
	Gegharkunik	391.05	1307.91	405.23	824.14	334.03	20.62	10.63	0	0	92.94
	Kotayk	113.68	208.24	234.95	451.72	370.1	0	1.68	279.08	0	8.18
	Lori	44.06	904.53	656.93	362.86	1224.23	0	73.41	0	0	31.88
	Shirak	126.14	397.7	408.82	819.41	0	0	0	17.15	0	53.23
	Syunik	530.55	878.07	295.18	803.66	1337.58	13.74	164.17	115.78	0	12.95
	Tavush	0.31	275.54	0	11.81	1541.85	0	701.92	0	0	0
	Vayotz Dzor	212.47	390.5	78.74	773.48	280.41	100.79	4.65	369.73	0	1.47

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