PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY
УЧЕНЫЕ ЗАПИСКИ ЕРЕВАНСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА
Geology and Geography **59**(1), 2025 *Геология и география*

Geography

УДК 631.43

ASSESSMENT OF ECOSYSTEM SERVICES IN THE ARDVI VILLAGE

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The importance of assessing ecosystem services (ES) via case study of Ardvi settlement stems from an unprecedented increase in global, regional, and local interest towards the evaluation and valuation of various ecosystem services.

A comprehensive assessment and valuation of the diverse and numerous ES (provisioning, regulating, cultural, and supporting) in Armenia's ecosystems is essential for sustainable resource management, the latter's multifunctional use, and effective conservation. The assessment of ecosystem services is a crucial step in developing the ES concept for decision-making and management.

The need for this assessment of ES by the example of the Ardvi Village is also driven by targeted actions initiated since 2011 by the government and various organizations in Armenia. These actions aim to demonstrate the value of ES for a small village and illustrate how this value can be integrated into spatial and community development planning.

https://doi.org/10.46991/PYSUC.2025.59.1.019

***Keywords*:** ecosystem services, comprehensive geographic assessment, carbon dioxide.

Introduction. According to the research conducted by R. Costanza and others still in 1997, the annual global value of ecosystem services (ES) provided by forests was conservatively estimated at approximately USD 4.7 trillion [1]. Fifteen years later, subsequent reputable studies revised this estimate to nearly threefold higher, valuing it at approximately USD 16.6 trillion [2]. "Following the publication of the report "Ecosystem Approach at the Dawn of the Millennium", the number of studies on ecosystem service assessment has increased worldwide" [3]. The economic assessment of ES has become increasingly significant in environmental planning, ecosystem-based management, and the transition toward a sustainable green economy [3–5]. ES take on new relevance in spatial and community development planning: for instance, in how to enhance ES within urban environments through nature-based solutions [1]. Alternatively, the lack of ES assessments can lead to the underestimation and inefficient use of resources, which in turn may reduc the flow of ES [6].

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Considering the geographical characteristics of ES and assessing them are crucial steps in developing the ES concept, supporting science-based decision-making, and enhancing management practices.

Development programs and policies are often implemented at the cost of natural ecosystems. Improved capacities for assessing and valuing ES can help development program planners better understand the extent to which their actions depend on the ecosystems of an area and how these actions affect the services provided by those ecosystems [7].

The first attempt to assess and include ES value in a community development plan in Armenia was implemented based on the example of the village of Ardvi (as a result of community consolidation, the Ardvi Village was incorporated in the structure of Alaverdi consolidated community) within the "Youth for the Involvement of Ecosystem Services Assessment into Decision-Making" project implemented by "Public Awareness and Monitoring Centre" non-governmental organization granted by the Bureau of Public Affairs of the United States Department of State U.S. Embassy, in 2018 [8].

Research Methods. ES assessment requires an interdisciplinary approach, incorporating perspectives from nature-related sciences such as economics, geography, law, biology, geology, and other scientific fields [9]. Therefore, our studies have been based on both physico-geographical and socio-economic comprehensive geographic research methods and toolkits. Geographic Information Systems (GIS) and spatial analysis methods have been applied for spatial mapping and modeling of ES, integrating ecological data with socio-economic ones. Economic and mathematical methods have been also applied to assess the capacity of ecosystems to provide services and their actual utilization by the population. The carbon sequestration capacity of ecosystems has also been calculated, which holds both local and global significance, particularly in the context of climate change.

The methodology of the study is based on the globally recognized classification of ES. It is worth noting that the first attempt for global assessment of ES was made by R. Costanza in the seminal work "The Value of the World's Ecosystem Services and Natural Capital" [1]. This study is considered the first classical geographic research related to defining and economically evaluating ES.

Different authors hold varying opinions regarding the classification of ES [10]. Currently, the most widely accepted approach to identifying and classifying ES is proposed within the framework of "The Economics of Ecosystems and Biodiversity" [11]. This approach categorizes ES into four main groups: provisioning, regulating, cultural, and supporting services.

1. *Provisioning services* describe the tangible and energy-based outputs (products) obtained from ecosystems such as food, water, and other resources.

2. *Regulating services* describe the regulatory functions of ecosystems. These include regulating microclimates and air quality, absorbing carbon dioxide and carbon storage, mitigating the impacts of natural disasters, maintaining soil fertility, and controlling the spread of pests and diseases.

3. *Cultural services* encompass the intangible benefits people derive from ecosystems such as aesthetic, spiritual, and recreational values.

4. *Supporting services* of natural ecosystems refer to the underlying processes and functions essential for the provision of all other ES. These include photosynthesis, soil formation, nutrient cycling, and more. Ecosystems also provide habitats for plants and animals, fostering species diversity.

Methodology for Assessing Provisioning Ecosystem Services. Valuation of such type of ES was conducted using the market price method in line with widely recognized approaches in benefit transfer for ecosystem valuation [12], while the crop yield was estimated based on field studies. During the field studies, the distribution of forest fruit and berry species was mapped, and the yield was calculated in accordance with the guidelines for assessing the yield of fruit and berry species in the forests of the Caucasus [13] (Fig. 1).

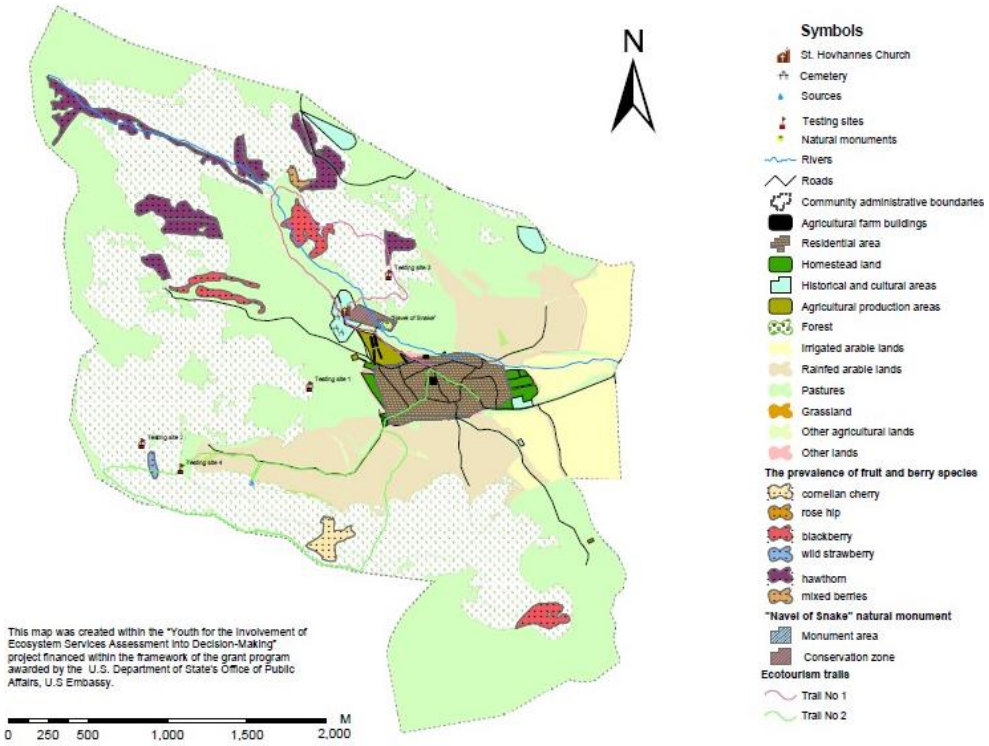

Fig. 1. Map-scheme of ecosystem servicies in the Ardvi Village.

To determine the productivity (yield capacity) of pastures and hayfields, experimental plots with an area of 1 m^2 were established. The yield per hectare of pasture or hayfield was calculated using the following formula [13]:

$$Y = B_w \cdot C_d \cdot 10\,000,$$

where Y is the yield, expressed in *kg*; B_w is the wet biomass measured in the experimental plot, *kg*; C_d is the conversion factor for wet to dry biomass, 0.35.

The permissible grazing load/rate of the pastures was also calculated, indicating the maximum number of livestock that can be sustainably grazed per unit area (1 *ha*) throughout the grazing season without causing pasture degradation.

The permissible grazing load/rate of the pastures was determined using the following formula:

$$PGL = Y / F \cdot D,$$

where PGL is the permissible grazing load of the pasture; *Y* is the yield per hectare of pasture, *kg*/*ha*; *F* is the daily forage requirement of a standard/conventional livestock unit, *kg*; *D* is the duration of the grazing season, expressed in days [13].

Methodology for Assessing Regulating Ecosystem Services. Carbon accumulation is driven by the growth of living biomass. To calculate carbon dioxide sequestration, it is necessary to determine the average annual growth (m^3) of the primary forest-forming and accompanying tree species. Subsequently, the average growth (m^3) per hectare for all tree species is derived using the average weight method. Then, based on the conducted arboricultural studies the basic wood density factors for the specified tree species are identified in order to convert the wet mass (living biomass) into dry matter. The coefficients obtained for different tree species (basic wood density) are converted into an average coefficient using the average weight method. The amount of carbon in dry matter is then determined per different tree species, after which the average is derived using the previously mentioned method (average weight method):

$$A = G\,P,\ C = A\,k,\ CO_2 = C \cdot 44/12,$$

where *A* is the biomass, *t*; *G* is the annual current growth, m^3; *P* is the basic density, t/m^3; *K* is the biomass-to-carbon conversion factor (0.48) as defined by the IPCC (Intergovernmental Panel on Climate Change); *C* is the amount of accumulated carbon, *t*; CO_2 is the amount of carbon dioxide sequestered, *t*.

Results and Discussion.

Provisioning Services. The mountainous and forest ecosystems of the Ardvi settlement in the consolidated Alaverdi community, serve as a source of provisioning services for the local population, including food, fresh water, fuel, fodder, etc. Meadows and pastures are used by the local population as grazing lands and natural hayfields, as well as for beekeeping, whereas forested areas are utilized for collecting wild fruits, berries, and mushrooms.

Among the various forms of forest utilization, the by-products of the forest hold particular importance for the local population. The population primarily collects black thorn, cornelian cherries, pears, blackberries, and rose hips, mainly for personal and household needs. The area of Ardvi is also rich in various useful plant species, including edible herbs, medicinal, and honey-producing plants. Surveys have disclosed the annual quantity of fruits and berries collected by the population and their average selling price as of 2018, as field study was conducted in the autumn of 2018. Thus, the value of the ecosystem service for food provision amounts to 780 000 AMD annually. The results are brought in Tabs. 1 and 2.

The population of the Ardvi Village has historically obtained firewood from the nearby forests. According to our surveys, the local population uses approximately 350 m^3 of firewood annually. The price of 1 m^3 of firewood, as set by the "Hayantar" SNCO, is 10 800 AMD. This means that the annual value of the firewood service provided by the forests amounts to 4,32 million AMD, or 12 340 AMD per hectare.

Table 1

The value of fruits and berries annually collected from the forest areas of the Ardvi settlement

Name	Area, *ha*	Quantity, *kg*	Average market price per 1 *kg*, in the collection area, AMD	Total market value, AMD
Pear	–	500	150	75 000
Blackberry	12	450	420	189 000
Wild strawberry	4	80	1000	80 000
Rose hip	10	200	200	40 000
Total		1 230		384 000

Table 2

The value of edible plant species and mushrooms annually collected from the forest areas of the Ardvi settlement

Name	Quantity, *kg*	Average market price per 1 *kg*, in the collection area, AMD	Total market value, AMD
Thyme (dry)	80	1200	96 000
Mint (dry)	40	800	32 000
Solomon's seal	70	1300	91 000
Sorrels	50	1500	75 000
Hornbeam	40	1300	52 000
Mushroom	50	1000	50 000
Total	330		396 000

In the experimental plots established in the pasture and hayfield areas of the Ardvi Village, the wet biomass was measured. Using the aforementioned formula, the yield per hectare of the grazing lands and hayfields/grasslands was calculated:

$$Y = 450 \cdot 0.35 \cdot 10\,000 = 1600\ kg.$$

Permissible grazing load of the pasture is equal to 0.26:

$$\mathrm{PGL} = 1600/40 \cdot 150.$$

That is, 0.26 head of cattle per hectare throughout the pasture area. For the village's 566.7 *ha* pastureland, under the permissible grazing load, the number of large cattle is 147. The price of 1 *kg* of hay is 50 AMD (as of 2018). The economic value of 1 *ha* is 80 000 AMD for pastures and 122 500 AMD for hayfields.

To achieve a comprehensive assessment of the village's ES, it was necessary to gather information on the benefits derived by the local population from ecosystem use, as well as the extent to which their well-being and livelihoods depend on these benefits. Therefore, in collaboration with the research team of the "Public Awareness and Monitoring Center" NGO, we conducted surveys in all households in the village that had residents as of October 12–18, 2018 (40 out of 50 households).

The majority of them do not have stable employment; 20% are self-employed in agriculture, 20% are employed in the public or private sectors, and 9% are engaged in other fields or are expatriates of seasonal jobs/seasonal labor migrants. According

to the survey results, the following forms of non-timber forest use have declined over the past two decades: haymaking, fruit and berry harvesting, mushroom collection, and beekeeping. Respondents attributed this decline to the lack of consumer markets, high costs in the case of haymaking, and lack of necessary skills for beekeeping. The most common forms of non-timber forest use currently are recreation and grazing.

Out of the 40 surveyed households, 13 utilize nearly all the resources provided by the surrounding environment, either for personal consumption or for market sale.

The share of income from non-timber forest use in a household budget does not exceed 50%. For approximately one-third of the surveyed households, this share is up to 10%, for 7% it is between 10–30%, and for only 2% it ranges from 30–50%. Additionally, 3% of respondents reported that they derive no income from non-timber forest use (Fig. 2).

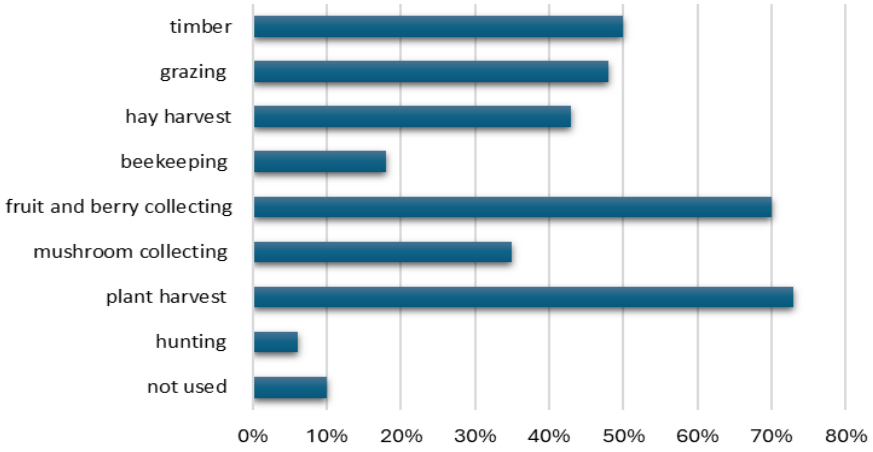

Fig. 2. The extent of utilization of environmental resources in the Ardvi Village.

The respondents emphasized the importance of job creation for the development of the community, particularly through the establishment of agricultural product marketing centers, fruit and berry processing facilities, greenhouse farming enterprises, and the promotion of tourism and guest house services.

Regulating Services. Carbon dioxide sequestration (climate change mitigation) is one of the most crucial regulating ecosystem services provided by forests [5]. Forest ecosystems sequester carbon dioxide from the atmosphere during their biological activities and effectively store carbon in their biomass. The biomass stock and carbon accumulation were assessed according to the methodological guidelines proposed in the manual developed by the intergovernmental panel engaged in climate change issues [14, 15].

In the framework of this study, an assessment of the ES for carbon dioxide sequestration (climate change mitigation) was conducted. In the Ardvi Village, forest ecosystems cover an area of 350 *ha*, with the dominant tree species being oak (240 *ha*), hornbeam (78 *ha*), beech (18 *ha*), and pine (14 *ha*). Using the presented methodology, the carbon dioxide sequestration/absorption in the forests of the Ardvi Village was calculated.

There are several methods for determining the economic value of carbon sequestration. Depending on the chosen method, the economic value of sequestering 1 *t* of carbon varies (ranging from USD 5 to USD 65) [14]. In our study, we have used the market price method based on European Union (EU) Emissions Trading System (ETS) data, consistent with benefit transfer practices outlined by Plummer (2009) [12], which emphasize contextual adjustments for local applications. According to the 2023–2024 data from the EU ETS, the cost of emitting 1 *t* of carbon dioxide has increased and currently exceeds USD 80.

As it is seen from Tab. 3, as a result, the annual carbon dioxide sequestration amounts to 473 *t*. In economic terms, this equates to an ecosystem service value of USD 37 840 per year (equivalent to AMD 15.136 million, with an exchange rate of USD 1 = AMD 400), or AMD 43 246 per hectare of forest area per year.

Table 3

The amount of carbon dioxide sequestered by the forested areas in the community lands of the Ardvi settlement

Dominant tree species	Annual current growth, m^3	Basic density, t/m^3	Biomass, *t*	IPCC factor	Carbon (C) uptake/ sequestration, *t*	CO_2, *t*
Oak	283.2	0.57	161.424	0.48	–	C × 44/12
Hornbeam	123.2	0.64	78.848			
Beech	31.7	0.538	17.0546			
Pine	27.6	0.415	11.454			
Total	465.7	–	268.8	–	129.0	473.0

Cultural Ecosystem Servicies (Recreation and Ecotourism). Ecotourism contributes to the recognition of natural and cultural heritage and generates sufficient profit for the local population, encouraging them to value and preserve the environment as a source of income.

The territory of the Ardvi Village is distinguished by its picturesque nature. The rich natural environment, clean air and water, the presence of numerous historical and cultural structures, and organic food provide excellent preconditions for the tourism development.

In the Ardvi, there are six monuments and four monument complexes of national and local significance, including an early medieval church, the St. Hovhannes Monastery Complex (8^{th}–19^{th} centuries, reconstructed in the 17^{th} century, 1902), cemeteries (7^{th}–13^{th} centuries), khachkars/cross-stones, stelae, and the "Okhty Monti" sanctuary [16]. Here is located the "Navel of Snake" monument, which is included in the list of natural monuments of Lori Region, approved by the Government of the Republic of Armenia [17].

These monuments have merged with nature over time and, therefore, are considered an integral part of the environment. The development of tourism services (tours, horseback riding, hiking, sightseeing, guest house services, etc.) could make a significant additional contribution to the development of the area.

The value of cultural services has not been expressed in monetary terms within the framework of this study, as it could be subjective.

Conclusion and Suggestion. For the 566.7 *ha* of pasture in the village, in case of permissible pasture/grazing load, the population of large cattle livestock makes 147 (as of October 2018, 150 heads). The economic value of ES per hectare of hayfields/grassland is 122 500 AMD, while the cost of haymaking and hay storage per hectare amounts to 45 000 AMD. Considering all other expenses, livestock farming can be considered a moderately profitable sector. Nevertheless, livestock farming is the main source of income for 50% of households, and furthermore, 80% of the respondents consider it a key direction for the village development.

There are numerous prerequisites for the combined development of three branches of tourism: rural, cultural-historical, and ecotourism. Additionally, 78% of the respondents consider tourism to be a priority sector.

Upon our assessment, the potential of natural ecosystems is much higher than the estimated value of the food provision ecosystem service derived from our research and surveys (Fig. 2). Besides, through conversations with residents, we found out that they are willing to engage more actively in foraging, if consumption can be organized locally. However, this would need to be regulated to prevent undesirable pressure on ecosystems.

The forests of the Ardvi Village sequester approximately 473 *t* of carbon dioxide annually. The forest area is generally well-preserved, the impacts of widespread logging during the 1990s are still evident. Since then, the forest has largely regenerated naturally without human intervention.

To enhance the flow of ecosystem services in the Ardvi settlement, a series of actions are recommended:

- Livestock farming can be expanded by utilizing remote pastures. To ensure the development or sustainability of this sector, the minimum local sale price for 1 *L* of milk should be at least 190 AMD. According to livestock farmers, the introduction (or acquisition) of automated milking systems is necessary to reduce costs and increase milk production.
- It is necessary to develop tourism infrastructure such as establishing an information center in the village center, creating pavilions, installing route and informational signage/board, benches, and eco-toilets. Additionally, B&B (bed and breakfast) services and other hospitality offerings should be expanded enhancing the capacity of local entrepreneurs to provide market-oriented services.
- A small processing facility/production site for fruits, berries, medicinal herbs, and edible plants can be established, as the potential for providing these ecosystem services is significantly higher than what is currently utilized.
- There is a need to develop guidelines for the collection, use, and marketing of non-timber forest products, as well as to enhance related capacities.
- It is necessary to implement coppice shoot regeneration measures in the forest to establish a foundation for increasing the flow of ecosystem services it provides.

Received 05.12.2024
Reviewed 03.03.2025
Accepted 30.04.2025

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ԷԿՈՀԱՄԱԿԱՐԳԱՅԻՆ ԾԱՌԱՅՈՒԹՅՈՒՆՆԵՐԻ ԳՆԱՀԱՏՈՒՄՆ ԱՐԴՎԻ ԳՅՈՒՂՈՒՄ

Ամփոփում

Արդվի բնակավայրի օրինակով Էկոհամակարգային ծառայությունների (ԷԾ) գնահատման արդիականությունը պայմանավորված է տարաբնույթ

էկոհամակարգերի ԷԾ-ի գնահատման և արժևորման նկատմամբ համամոլորակային, տարածաշրջանային և տեղական մակարդակով հետաքրքրությունների աննախադեպ աճով:

Հայաստանի էկոհամակարգերի բազմաթիվ և բազմազան ԷԾ-ի (ապահովող, կարգավորող, մշակութային և օժանդակ՝ նպաստող-աջակցող) համալիր գնահատումը և արժևորումը շատ կարևոր է նաև պաշարների կայուն կառավարման, բազմակողմանի օգտագործման և արդյունավետ պահպանության առումներով: Գնահատման աշխատանքները կարևոր քայլ են ԷԾ հայեցակարգի ձևավորման, որոշումների ընդունման և կառավարման համար:

ԷԾ-ի այս գնահատման անհրաժեշտությունը Արդվի գյուղի օրինակով պայմանավորված է նաև 2011 թվականից ՀՀ-ում Կառավարության և տարբեր կազմակերպությունների կողմից մեկնարկած նպատակային գործողություններով ցույց տալու, թե որքան արժե ԷԾ-ն մի փոքր գյուղի համար և ինչպես կարելի է այդ արժեքը հաշվի առնել տարածական և համայնքի զարգացման պլանավորման գործում:

М. В. ЧАКРЯН, Г. Д. АВЕТИСЯН, А. Т. ГРИГОРЯН, А. С. ПИЛОЯН

ОЦЕНКА ЭКОСИСТЕМНЫХ УСЛУГ В ДЕРЕВНЕ АРДВИ

Резюме

Важность оценки экосистемных услуг на примере населенного пункта Ардви обусловлена растущим интересом к данной теме на глобальном, региональном и местном уровнях.

Всесторонняя оценка различных экосистемных услуг (обеспечивающих, регулирующих, культурных и поддерживающих), характерных для экосистем Армении, необходима для устойчивого управления природными ресурсами, их многофункционального использования и эффективного сохранения. Эта оценка является важнейшим этапом в разработке концепции экосистемных услуг, которая будет служить основой для принятия решений и управления ресурсами.

Проведение такой оценки на примере села Ардви также оправдано в контексте целенаправленных мероприятий, инициированных с 2011 г. правительством и различными организациями Армении. Эти мероприятия направлены на демонстрацию ценности экосистемных услуг для небольшой деревни и на иллюстрацию того, как эта ценность может быть интегрирована в процессы пространственного и общинного планирования.