PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY
УЧЕНЫЕ ЗАПИСКИ ЕРЕВАНСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА
Geology and Geography **59**(2), 2025 *Геология и география*

Geography

УДК 551.5

ESTABLISHING AGROFORESTRY FOR THE ADAPTATION TO CLIMATE CHANGE IN THE LAKE SEVAN BASIN

H. Ya. SAYADYAN [1*], A. H. GHULIJANYAN [2**], V. P. SARGSYAN [1***]

[1] *German International Development Company (GIZ), Armenia*
[2] *Young Foresters Union (YFU) NGO, Armenia*

The agroforestry system combines the best features of agricultural practices and forest ecosystems. This approach provides diverse environmental and socio-economic benefits, such as preventing soil erosion and degradation, increasing soil moisture and water retention, and yielding harvests from planted fruit trees, bushes, edible plants, and various agricultural crops. Additionally, agroforestry offers several added benefits, including enhanced biodiversity, beekeeping and improved pollination, carbon sequestration, and climate change mitigation and adaptation. With these advantages in mind, a 3.5 *ha* model agroforest was established in 2022 on the Southern bank of lake Sevan, near the village of Tsovinar in the Martuni consolidated community. Over two years of project implementation, all major activities and system-forming elements were put in place, including fencing, an irrigation system, and the planting of approximately 10 000 tree and bush species, along with edible plants.

This model, through further monitoring and evaluation, could provide strong justification for the Government of Armenia to expand its forest cover in alignment with its international commitments under the 2015 Paris Climate Agreement.

https://doi.org/10.46991/PYSUC.2025.59.2.522

***Keywords*:** agroforest, soil degradation, tree-bush species, irrigation, fencing, environmental and social-economic benefits.

Introduction. Large-scale uncoordinated deforestation in the Republic of Armenia (RA) over previous decades has severely impacted the anti-erosion, water-regulating, climate-regulating, and self-regenerating functions of mountain forests. This has led to undesirable changes in species composition and significant damage to the gene pool of the dendroflora [1–3].

These processes have not spared the Gegharkunik Region, one of the least forested areas in the country, with only 3% forest cover – compared to the neighboring Tavush Region, where forests cover approximately 56%. Historically, the Sevan Basin was heavily forested, as evidenced by archaeological and paleontological

* E-mail: hovik.sayadyan@giz.de
** E-mail: zikatar_center@yahoo.com
*** E-mail: varazdat.sargsyan@giz.de

studies indicating that the lake's coastal areas were once densely populated. However, deforestation in the region has primarily resulted from human activity. The forest ecosystem here is an essential component of lake Sevan's overall ecosystem, making its protection and restoration a national environmental priority [2, 4–8].

Recently, efforts to raise lake Sevan's water level to restore its natural balance have created serious challenges, particularly the flooding of coastal forests.

A study conducted as part of the "Planting of New Forests around Lake Sevan" project – developed by the Ministry of Nature Protection in 2011 and approved by Government Decision No. 1441-N on November 15, 2012 – assessed potential areas for afforestation within Sevan National Park and nearby communities. The study identified a total of 446.9 *ha* above 1 950 *m* sea level as suitable for fores*t establishment.*

Materials and Methods.

Objective of the Pilot and Applied Methodological Approaches.

Objective. Improve degraded mountain ecosystems and its adaptation potential to climate change impact through the establishment of agroforest system and support of environmental situation and community socio-economic development. The agroforest will improve the environmental situation from different perspectives: decreasing land degradation, improving soil conditions and water accumulation capacity, mitigating the climate change impact, improving water balance of area, practicing the case of natural agriculture, and developing source of social-economic benefit [9–12].

Applied Methodological Approaches:

a) measurement and GIS mapping of 3.5 *ha* of non-forested area envisaged for planting in the administrative territory of Tsovinar settlement of Martuni enlarged community of Gegharkunik Marz of RA.

b) Preparation of technical design of agroforest project for 2022–2024 period and over: including technological card of silviculture establishment, planting scheme, planting material type and quantity, the most cost-effective irrigation options, labor needs assessment, planting summary, work schedule and financial summary, and its implementation.

c) Discuss and agree on the technical design of agroforest project with the EU4Sevan project team and ensure that appropriate changes are made according to comments/suggestions.

d) Set up proper monitoring actions to ensure the project compliance with relevant provisions of national legislation (e.g., Environmental Impact Assessment, etc.).

Natural-Climatic Conditions of the Pilot Project Area. The enlarged community of Martuni is in the South-Eastern part of the Lake Sevan basin, between the Northern slopes of Vardenis mountain range and in the Southern range of Geghama mountains. The area is mountainous, mainly dissected by small river valleys. Relatively flat areas are located at 7–10 *km* from the shore of Lake Sevan. Volcanic cones, gorges and river valleys are typical. The prevailing landscapes are mountain-steppe and mountain-meadows. The major rivers in the area are Argitchi, Tsakkar, Martuni, and Vardenis.

In winter, the minimum temperature reaches -30–-35°C in the highlands, the number of days above 0°C reaches about 200, and in the lowlands – 260 days. The maximum temperature is recorded in July–August, and the minimum in

January–February. The average annual temperature varies between 5–6°C. The annual precipitation is from 400 *mm* (on the lake shore) to 900 *mm* (near the mountains), with an average of 500–600 *mm*. The brown mountain soils are found above the liberated ground of the lake, while the dry mountain-steppe soils are found in the juniper-oak hilly and mountainous parts. At altitudes of 2400 *m* and above, mountain-meadow soils are common. According to the 2005 Sevan National Park Management Plan (the preparation of new management plan for the Sevan National Park is envisaged within EU4Sevan on-going project (2021–2024)), as well as the literary and herbal data, the flora of Sevan National Park and its conservation zone includes 1619 species of vascular plants. There are about 60 plants in the national park and its conservation zone that can be used as herbs. About 100 plant species are considered edible.

Description of Pilot Agro-Forest Area. The agroforestry occupies an area of 3.5 *ha* and located 1 *km* South to Tsovinar village, 2 *km* from the center of the village (Fig. 1). The area has gentle sloping with the North-East aspect. The altitude of area varies from 2050 *m* to 2070 *m* a.s.l. The form has a quadrangular shape with the following coordinates of corners:

1. 40°08'36" North latitude, 45°27'44" East longitude;
2. 40°08'38" North latitude, 45°27'49" East longitude;
3. 40°08'47" North latitude, 45°27'43" East longitude;
4. 40°08'45" North latitude, 45°27'39" East longitude.

Fig. 1. Geographic location of pilot agroforest area next to Tsovinar settlement.

The Technological Card for the Establishing of Agroforest. The following main indicators are indicated in the technologic card (Tab. 1): the position of the planting area and the slope degree, soil type, erosion degree, rockiness and sedimentation, suitability of cultivation, name of the soil type, methods of soil

preparation and establishment of agroforest, tree planting and required care for 2022–2024.

Table 1

Estimation technological card of 3.5 ha area under the management of Tsovinar settlement

N	Characteristics	Value
1	Above see leve, *m*	2050
2	Exposition and slope	North-East 5°
3	Soils	Mountain black soil
4	Degree of erosion	Weak
5	Degree of rockiness	Weak
6	Rock outcrops, suitable for forest growth	till 20%
7	Forest growing conditions	1st
8	Turfness degree	Weak
9	Name of the soil type	Non-vegetated, unused agricultural area
10	Soil preparation method	With holes
11	The number of planting holes	8200
12	Tree-bush species	Caucasian pear, Greek walnut, tart cherry, wild cherry, cherry plum, blackthorn, necklace poplar, dog rose, blackberry.
13	Current state of land use	Not used
14	Supplementation works	20%
15	Possibility of irrigation	From the water pipe

Planned and Implemented Field Activities.

- Spring 2022 – cleaning of the area, fencing. Marking of planting sites, preparation of holes, preparation of seedlings, planting, compaction of soil around the seedlings and removal of weeds 4 times, grass harvesting and harvesting 1 time in the inter-row areas of forest crops, irrigation – 5 times.
- 2023 – preparation of holes for supplementation, preparation of seedlings, planting (spring), compaction of soil around the seedlings and removal of weeds 3 times, grass harvesting and gathering in the inter-row areas of silvicultures – 1 time, irrigation – 4 times.
- 1st half of 2024 – soil compaction and removal of weeds around the seedlings once, grass harvesting and gathering in the inter-row areas of silvicultures – 1, irrigation –1.
- 2nd half of 2024 – soil loosening and weeding once, irrigation – twice.
- 2025 – plowing the soil around the seedlings and removing weeds twice, harvesting and harvesting grass once in the inter-row areas of silvicultures, irrigation – thrice.
- 2026 – plowing the soil around the seedlings and removing weeds once, mowing and harvesting once in the inter-row areas of silvicultures – once, irrigation – twice.

The selection of planting material for afforestation was made based on local natural-climatic conditions, local planting practices and previous similar activities. For the 3.5 *ha* area under the management of Tsovinar settlement, a wide variety is offered: *Populus deltoides* Marsh., *Fraxinus caucasica* Fed., *Juglans regia* L.,

Pyrus caucasica Fed., *Malus orientalis* Uglitzk., *Prunus divaricata, Prunus spinosa, Cerasus vulgaris* Mill. *Cerasus avium* Moench., *Rubus caesius* L., *Rosa canina* L., *Caragana arborescens* Lam. The mentioned tree-bush species can be obtained from state and private nurseries of the Lake Sevan basin and highland areas of Northeastern Armenia that are more adaptive and acceptable for the Lake Sevan basin.

Planting Schema. During the preparation of planting schemes, the peculiarrities of creating a field-protection forest layer and growing individual tree species were taken into account (Fig. 2).

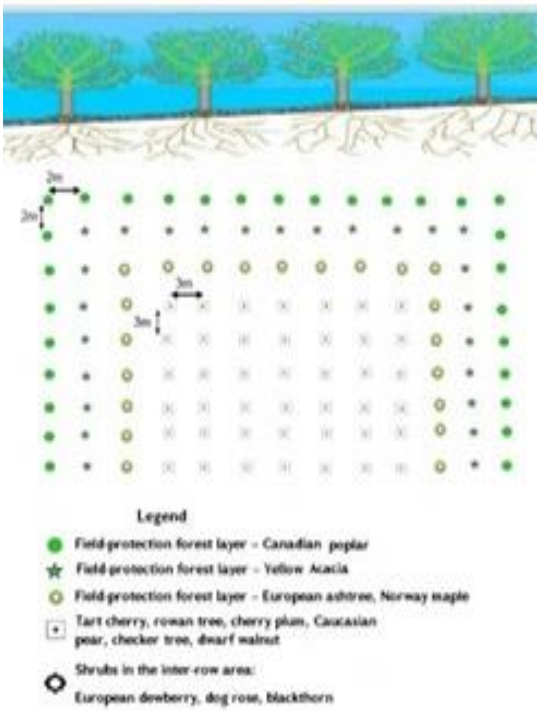

Fig. 2. The pilot agroforest area technical design.

1. Field protection and wind protection forest layers are envisaged by 2×2 *m* Scheme along the established area. It is planned to plant the first row of Canadian poplar, the second row of yellow acacia, and the third row of European ash. The created forest layer will also contribute to the growth and yield of crops grown by the residents of the area.

2. Fruit-bearing species are planned to be planted at 3×3 *m* of inter-plant and inter-row a distance, which will allow the area to be used for planting edible shrubs before the foliage expands.

Results of Pilot Agroforest in Tsovinar Settlement of Gegharkunik Regons. In total calc. 10 000 trees and bushes initially were planted in April 2022 in the agroforest area (Tab. 2) including 8000 edible trees and bushes. The major planted species are wild pear, apple, plum, cherry, blackberry, etc. The agroforest is managed via a locally hired field coordinator and local supporting staff. The major activities

now are linked to organization of proper irrigation and regular treatment of trees and bushes. It is planned to replace dyed-out trees and bushes during Spring 2024.

Table 2

The number of planted tree-bush-herb species of agroforest

Tree-bush-herb species	Initially planted	Replacement of dried-out plantings	Total
Blackberry	2000	–	2000
Blackthorn	1100	–	1100
Pear	740	150	890
Ash	750	–	750
Plum	1000	200	1200
Cherry	400	300	700
Poplar	650	150	800
Yellow acacia	650	20	670
Apple	300	–	300
Mahaleb cherry	300	–	300
Asparagus	60	–	60
Seabackthorn	–	500	500
Raspberry	–	700	700
Total	7 950	2 030	9 980

The harvest from the fruit trees would be available in 2026–2027 years. The expected harvest from 1 *ha* intensively cultivated (with drip irrigation and all treatment measures) apple and cherry orchard is estimated to be 8–10 mln AMD (expert assessment for Gegharkunik Marz conditions). The agroforest is surrounded by a fencing with total 540 *m* length. Fences covering the agroforestry from all sides, beside one short distance in Northern part, where deep ravine exist. Fencing for agroforest: net metallic – 540 *m*; poles for net –180; metallic wire –200 *kg*.

The agroforest is equipped with ***own waterline*** with 200 *m* total length (plastic and iron pipes) (Tab. 3), instead of initially planned 170 *m*. The installed waterline is completely satisfactory for the agroforest and provides extra opportunity for the new potential orchards or agroforest extension, just next to the existing agroforest. This means that existing agroforest with a very little input could be essentially increased its initial area. Beside the waterline pipes, that is connected to Arpa–Sevan system and is functioning starting in June every year. There were prepared calc. 2 *km* soil ditch that collects snow-melt waters from mountain foothills and bring to agroforest area. This self-flow (without any energy consumption) water uses to irrigate the agroforest for April–May period.

Table 3

Agroforest irrigation system

Waterline, initially planned	Length, *m*	Waterline factual	Length, *m*
Pipe plastic	150	Pipe plastic	180
Pipe iron	20	Pipe iron	20

Of course, the agroforest provides many otherservices as well, such as: carbon sequestration, soil and microclimate improvement and biodiversity, that are not tangible now and couldn't be measured (Figs. 3 and 4).

Fig. 3. Agroforest fencing and irrigation arrows.

Fig. 4. Agroforest status in the 2nd year.

Conclusion. In 3 years (2022–2024) Tsovinar agroforest area turned into a nice demo sustainable ecosystem that combines and integrates forest ecosystem elements and agricultural systems, in favor for degraded soil restoration, water retention, biodiversity and potential source of social economic benefits.

- Agroforestry is a challenging concept for Armenia and requires info- and awareness raising campaigns to enhance large audience within society.
- The former experience of Armenian forests-orchards could be a valuable input for the further development of this concept (Armenian forests by 30% are covered by fruit trees and bushes, forest-orchards that are very degraded).
- Harsh climatic conditions: increasing number of heatwaves, decreasing precipitation, droughts, etc. are challenge to further develop agroforestry systems in Armenia.
- Land tenure and consolidation issues are also important challenge for the further development of agroforestry in Armenia.
- Agroforestry could help Government of Armenia to increase forest cover and meet commitments under Paris agreement.

Received 04.04.2025
Reviewed 16.06.2025
Accepted 15.08.2025

REFERENCES

1. Sayadyan H. *The Spatial-Temporal Changes in the forest Geo-systems of Republic of Armenia and Their Management Issues. Manuscript*. Yerevan, YSU Publ. House (2010), 261 (in Armenian).
2. Moreno-Sanchez R., Sayadyan H. Evaluation of the Forest Cover in Armenia. *International Forestry Review* **7** (2005), 113–127.

3. Sayadyan H., Moreno-Sanchez R. Forest Policies, Management and Conservation in Soviet (1920–1991) and post-Soviet (1991–2005) Armenia. *Environ. Conservation* **33** (2006), 1–13. https://doi.org/10.1017/S0376892906002852
4. Kazaryan V.O., Arutyunyan L.V., et al. Scientific Bases of Afforestation and Greening of the Armenian SSR. Yerevan, Publishing house of the NAS of the Arm. SSR (1974), 334 (in Russian).
5. Kara-Murza E.N. Report on Geobotanical Works of the Sevan Expedition of 1927–1928. Lake Sevan Basin. *Hydrometeoizdat* **2** (1931), 113–188 (in Russian).
6. Khurshudyan P.A., Ter-Ghazaryan K.A., Gabrielyan V.G. Forests and Forestry of the Armenian SSR. Forests and Afforestation in the Armenian SSR. *Proceedings of the Institute of Botany* **XII**, Yerevan, Publ. House of the NAS of the Arm. SSR (1987b), 5–41 (in Russian).
7. Abramyan A.G. *Upper Forest Limit of Northern Regions of Armenia and Reasons Determining it*. Col. Works Youth Scientific. Yerevan, Ministry of Agriculture of the Arm. SSR (1957), 212–217 (in Russian).
8. Grigoryan R.A. Natural Forests and Natural Dendroflora of the Lake Sevan Basin. *Proceedings of the BIN AN ArmSSR* **19** (1974), 5–37 (in Russian).
9. Urushadze S., Sayadyan H.Ya. *Agroforestry*. Study Textbook. Yerevan, Meknark (2017), 144 (in Armenian).
10. Armenia Tree Project. Facts and Figures about Armenia's Environment (2005). http://www.armeniatree.org/thethreat/facts_figures.pdf
11. Mitchell A. *Illegal Logging – Survey and Analysis.* Draft Final Report, March 2004. Ministry of Nature Protection. Swedish International Development Agency. Preprint (2004), 47.
12. Sayadyan, H.Ya. Valuation of Mountain Forests: Case Study Armenia. *Annals of Agrarian Science*. *Republic of Georgia* **9** (2011), 144–148.

Հ. Յա. ՍԱՅԱԴՅԱՆ, Ա. Հ. ՂՈՒԼԻՋԱՆՅԱՆ, Վ. Պ. ՍԱՐԳՍՅԱՆ

ԱԳՐՈԱՆՏԱՌԱՅՆՏԵՍՈՒԹՅՈՒՆԸ ՈՐՊԵՍ ԿԼԻՄԱՅԻ ՓՈՓՈԽՈՒԹՅԱՆԸ ՀԱՐՄԱՐՎՈՂՈՒԹՅԱՆ ԱՐԴՅՈՒՆԱՎԵՏ ՄԻՋՈՑ ՍԵՎԱՆԱ ԼՃԻ ԱՎԱԶԱՆՈՒՄ

Ամփոփում

Ագրանտառային համակարգը համատեղում է գյուղատնտեսական գործելակերպի և անտառային էկոհամակարգերի լավագույն առանձնահատկությունները: Այս մոտեցումը ապահովում է մի շարք էկոլոգիական և սոցիալ-տնտեսական օգուտներ, ինչպիսիք են հողի էրոզիայի և քայքայման կանխարգելումը, հողի խոնավության և ջրի պահպանման բարձրացումը, ինչպես նաև տնկված պտղատու ծառերից, թփերից, ուտելի բույսերից և տարբեր գյուղատնտեսական մշակաբույսերից բերք ստանալը: Բացի այդ, ագրանտառային տնտեսությունն առաջարկում է մի շարք լրացուցիչ օգուտներ, այդ թվում՝ կենսաբազմազանության բարելավում, մեղվաբուծություն և փոշոտում, ածխածնի կլանում, կլիմայի փոփոխության մեղմացում և հարմարվողականություն: Հաշվի առնելով այս օգուտները, 2022 թվականին Սևանա լճի հարավային ափին՝ Մարտունի համայնքի Ծովինար գյուղի մոտ, հիմնադրվել է 3,5 *հա* մակերեսով մոդելային ագրանտառ: Ծրագրի իրականացման երկու տարիների ընթացքում իրականացվել են բոլոր հիմնական գործողությունները և հիմնական տարրերը, այդ թվում՝ ցանկապատում, ոռոգման համակարգ և մոտ 10 000 տեսակի ծառերի և թփերի, ինչպես նաև ուտելի բույսերի տնկում: Այս մոդելը,

հետագա մոնիթորինգի և գնահատման միջոցով, կարող է Հայաստանի կառավարությանը տրամադրել ամուր հիմք անտառային ծածկույթը ընդլայնելու համար՝ համաձայն 2015 թվականի Փարիզի կլիմայական համաձայնագրի շրջանակներում ստանձնած միջազգային պարտավորությունների:

О. Я. САЯДЯН, А. А. ГУЛИДЖАНЯН, В. П. САРГСЯН

АГРОЛЕСНОЕ ХОЗЯЙСТВО КАК ЭФФЕКТИВНОЕ СРЕДСТВО АДАПТАЦИИ К ИЗМЕНЕНИЮ КЛИМАТА В БАССЕЙНЕ ОЗЕРА СЕВАН

Резюме

Система агролесоводства сочетает в себе лучшие черты сельскохозяйственных методов и лесных экосистем. Этот подход обеспечивает разнообразные экологические и социально-экономические преимущества, такие как предотвращение эрозии и деградации почвы, повышение влажности почвы и удержание воды, а также получение урожая с посаженных фруктовых деревьев, кустарников, съедобных растений и различных сельскохозяйственных культур. Кроме того, агролесоводство предлагает несколько дополнительных преимуществ, в том числе улучшение биоразнообразия, пчеловодство и улучшение опыления, связывание углерода, а также смягчение последствий изменения климата и адаптацию к ним. Учитывая эти преимущества, в 2022 г. на южном берегу оз. Севан, недалеко от с. Цовинар в объединенной общине Мартуни был создан модельный агролес площадью 3,5 *га*. За два года осуществления проекта были реализованы все основные мероприятия и системообразующие элементы, включая ограждение, систему орошения и посадку около 10 000 видов деревьев и кустарников, а также съедобных растений.

Эта модель посредством дальнейшего мониторинга и оценки может предоставить правительству Армении весомое обоснование для расширения лесного покрова в соответствии с его международными обязательствами по Парижскому климатическому соглашению 2015 г.