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SPECIFIC REHABILITATION WORKS OF DEGRADED AGROSILVOPASTORAL SYSTEMS, IN NONCOLLECTIVIZED AREAS

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Abstract

Agrosilvopastoral systems represented alternative and differentiated systems of exploitation of lands with reduced fertility, especially in the non-collectivized areas of medium and high hills. As a result, in these land exploitation systems, the productive potential of the land is exploited through agricultural, horticultural, forestry and zootechnical production. The objectives of the work are represented by the study and analysis of the works necessary for the rehabilitation of the exploitation process of agrosilvopastoral systems in the area of medium and high hills, abandoned after 1989, in the locality of Vîrfurile, Arad county, an area that was not collectivized. Consequently, field observations, inventories, analyses of information from the agricultural register and from the plot plan of the buildings in the study area were carried out. Also, a series of works necessary for the rehabilitation of the exploitation of agro-forestry and pastoral systems were experimented on experimental areas, making a series of comparisons with their situation prior to 1989. In conclusion, the rehabilitation of these land exploitation systems can be efficiently achieved by establishing owners' associations and respectively by accessing financing projects.

Key words*: agricultural production, agrosilvopastoral systems, forestry production, horticultural production, land exploitation systems, livestock production, non-collectivized area.*

INTRODUCTION

Optimizing the exploitation of arable land has an important influence in ensuring the production of quality, healthy food in optimal quantities, the adequate and secure provision of ecosystem services (e.g. biodiversity, clean air and water) as well as in effectively mitigating and removing the negative effects of climate change (Smith et al., 2022).

The worrying evolution of climate change and the modest standard of living in rural areas, especially in developing countries, require a change towards new, high-performance strategies, relating to agricultural practices and collaboration between farmers and, respectively, to the relationships between them and nature (Cialdella et al., 2023).

Adaptive management of agricultural activities related to arable land needs to be achieved without expanding existing cultivated land areas, in parallel with the protection and conservation of natural resources, but by promoting efficient, systemically integrated production technologies. Consequently, paradoxically, these multiple problems are very clear and relatively easy to solve, at least at the algorithmic level, they represent one of the greatest obstacles facing humanity today (Smith et al., 2022).

Agrosilvopastoral systems are cropping systems that integrate agricultural crops, fodder, woody perennials with livestock, on the same plot of land, promoting a more efficient and sustainable use of resources, compared to monocultures, as a consequence of the structural and functional diversification of the components (Fahad et al., 2022; Chappa et al. 2024).

Integration of forest trees and, respectively, fruit trees in the arable land exploitation system, optimizes soil fertility and its physical, biological and chemical properties, and ensures

the production of fruits, seeds, wood, fodder and animal protection (Fahad et al., 2022).

Relatively recent research shows that agroforestry systems have the capacity to store 3-4 times more carbon in the soil than in biomass, and agro-silvopastoral systems achieve a more efficient, respectively higher, storage of carbon in both soil and biomass, compared to the former. These results show that climatic zones and soil type directly influence carbon stocks and sequestration rates within agro-silvopastoral systems (Ribeiro et al., 2023; Mazumder et al., 2025).

By creating a specific habitat, characterized mainly by the particularities of each type of activity (crop), the microclimate associated with these complex land use systems can optimize biodiversity more than monocultures. Consequently, the internal restoration potential of activities in agro-silvopastoral systems is high, being able to offer effective solutions for inefficiently exploited lands (Fahad et al., 2022). Also, agrosilvopastoral and agrosilvopastoral systems substantially increase functional diversity and overall biodiversity within agricultural landscapes, consequently being necessary and appropriate priority programs and strategies in European agri-environmental financing schemes (Santos et al., 2022).

From the analysis of the component elements of agrosilvopastoral systems, they can be integrated into all agricultural systems, from various areas of Europe. Currently, the way to obtain them can be achieved relatively simply and efficiently, by planting trees, shrubs and fruit trees on agricultural land, by introducing agriculture (agricultural systems) in existing forests, wooded pastures (e.g. silvopastures) and in existing orchards (https://euraf.isa.utl.pt/about/ agroforestry-europe).

On the European continent there is currently a unique heritage of traditional agroforestry and agrosilvopastoral systems, which are characterized by a high ecological and cultural value. Similarly, in Europe, in the last two decades, the activities of research centers related to agroforestry activities have facilitated the promotion of modern and innovative agroforestry systems, capable of optimally exploiting the productive potential of agricultural and forestry land (https://euraf.isa.utl.pt/about/agroforestry-europe).

Agrosilvopastoral systems can be classified according to several criteria, established according to their location, structural and functional characteristics. As a result, depending on their age and tradition, they can be classified into traditional and innovative (Smith et al., 2022).

Traditional exploitations are made up of agricultural, horticultural and forestry crops as well as animal husbandry activities, long-term production activities, which are ultimately managed for the production of quality, diversified food, generally of an ecological nature.

The most representative agrosilvopastoral system known on the world map is the Spanish dehesa (Figure 1) (or montado in Portuguese) existing since the Neolithic period, first mentioned in 924 AD.



Figure 1. Dehesa agrosilvopastoral system (https://www.madr.ro/attachments/article/495/ADER-1521-FAZA-I.pdf).

Although traditional, it is constantly updated, and is perceived as one of the most efficient systems, because it harmoniously combines biodiversity conservation and sustainable rural development. The area related to this type of exploitation is approximately 3.5-5.5 million ha in Spain and Portugal and 1-1.5 million ha in Italy, Greece, western North America, and the specific habitat is characterized by the Mediterranean climate and low soil fertility (https://www.madr.ro/attachments/article/495/ADER-1521-FAZA-I.pdf).

The type of dehesa system in Spain and montado in Portugal, used for the extensive raising of animals, especially cattle, on meadows with rare trees, can also be called a pastoral-silvo-agricultural system, and is carried out on very poorly productive (with very low fertility) or non-agricultural lands. Also, in these farms, firewood, branches, acorns, cork can be

obtained, and various cereals such as oats, barley, rye, wheat are often cultivated, to supplement animal feed and to combat a series of shrubs that invade permanent pastures (https://www.madr.ro/attachments/article/495/ADER-1521-FAZA-I.pdf).

Innovative agrosilvopastoralism refers to multifunctional systems, designed to obtain biomass, ecosystem services and integrated wood (Smith et al., 2022). Some current representative variants of farms are represented by alley groves, alley crops and raising forest hens (Budău et al., 2023).

Although agroforestry and agrosilvopastoral exploitations have been known and have been operating for thousands of years, the agroforestry research field is relatively young and presents a number of opportunities, due to the importance of the context in which agroforestry practices develop, and their future trend (Cialdella et al., 2023).

In Romania, with the exception of forest curtains protecting arable land with various crops, which expanded considerably in the mid-20th century, some authors consider that agroforestry and agrosilvopastoral systems represent a new concept, which is not perceived, for example, as an independent science (Popovici et al., 2018; Budău et al., 2023), although the activities related to agroforestry and agrosilvopastoral exploitations in many historical provinces of our country are known at least two centuries ago (Crainic et al., 2023a).

On hilly lands with relatively low fertility, the promotion of agrosilvopastoral systems can mitigate huge soil losses, and can promote carbon sequestration with high efficiency, ultimately contributing decisively to increasing farmers' income (Sirimalle et al., 2025).

In western Romania, especially in hilly and mountainous areas that were not collectivized, a number of lands were efficiently exploited within agrosilvopastoral systems until 1989, after which the management method gradually changed. As a result, a number of lands were exploited inappropriately, and others were abandoned, for various reasons. The reasons are represented by the depopulation of the areas, economic instability, the drastic reduction of the number of animals, the lack of subsidies, the lack of adequate facilities, the high degree of fragmentation of the plots that prevented the creation of associations, the low fertility of the soils, the trend of climatic conditions in the last three decades, and last but not least the socio-political context.

The paper aims to analyze the climatic conditions, the works and measures necessary for the rehabilitation and reintroduction into the productive circuit of degraded agro-silvopastoral systems and respectively ensuring the premises for their sustainable exploitation.

MATERIALS AND METHODS

Vârfurile village is located in the east of Arad County, in the commune of the same name. The commune also includes the villages of Avram Iancu, Vidra, Măgulicea, Lazuri, Groși, Mermești and Poiana. Geographically, Vârfurile village is located in the northwest of the Hălmagiu Depression in the Apuseni Mountains, being situated at the foot of the Zarandului, Codru-Moma and Bihor Mountains, in the valley of the Crișul Alb River. Vârfurile Commune has an area of 136 km^2 and a population of over 2,200 inhabitants (https://primariavirfurile.ro/despre-noi/prezentare/; https://ro.wikipedia.org/wiki/Comuna_Vârfurile_Arad).

The Hălmagiu Depression is connected to the northwest with the Zarandului Depression. The latter, having a wide opening to the west, towards the Western Plain, favors the easy penetration of humid, oceanic air masses coming from western Europe, but also of Mediterranean air masses, which cause abundant precipitation. As a result, Vârfurile Commune has a temperate-continental, moderate climate, with slight Mediterranean influences, the winters being milder, and the summers being cooler. The commune's location in the shelter of the mountains, in the depression sector, means that it is protected from storms, but during the winter this causes frequent thermal inversions, associated with dense fogs. During the hot summer months, when continental-tropical air masses penetrate southwestern Romania, droughts can also occur in this territory. Overall, the thermally moderate climate with abundant rainfall makes the region well forested (Pop, 2005; https://primariahalmagiu.ro/download/urvqbaO3Rf0Eh7w9f690f8ugJ6lAzB8W4JBO4a7g.pdf).

In the present paper, meteorological data on the monthly and annual average air temperature and the monthly and annual amount of precipitation were used, from the closest weather station to Vârfurile village, respectively Gurahonț. The station has the geographical coordinates 46°27' N latitude, 22°33' E longitude, the code 15182 and the altitude 177 m (www.meteomanz.com). The analyzed period was 1990-2025 (36 years). The deviations of the annual average values of air temperature and precipitation from the multiannual average of the period 1966-2025 (60 years) were calculated (expressed in °C and in mm, respectively). Reporting to the multiannual average of a longer period than the one analyzed better highlights the climatic fluctuations of recent years. The temporal variability of the positive and negative annual deviations of temperature and precipitation, the linear trend of the annual deviations of air temperature and the polynomial trend of the annual deviations of precipitation were analyzed. Subsequently, the maximum and minimum values of monthly average temperatures and monthly precipitation amount from the period 1990-2025 were analyzed.

All meteorological data used in the paper came from the database of the National Meteorological Administration (N.M.A.) of Romania and from the rp5.ru (https://rp5.ru/) and Meteomanz.com (www.meteomanz.com) websites.

The observations were made on the route and respectively at the representative points of the agrosilvopastoral systems studied and analyzed in the Vârfurile commune, using cartographic materials and cadastral records in analog and digital format.

For a complex analysis of the agrosilvopastoral systems, their components were analyzed separately, and in order to establish and propose the necessary rehabilitation works, a similarity was made with the related activities in the agricultural, forestry and zootechnical sectors.

To simulate the spatial structure related to the tree biogroups within the agrosilvopastoral systems, inventories were carried out in experimental areas, and the data recorded in the field were processed with the PROARB 2.0 program (Popa, 1999), obtaining the related spatial profiles.

The recording on digital support of edifying images for the objectives of the case study was used for an objective presentation of the reality in the field.

Finally, the comparative analysis of the current components of the abandoned agrosilvopastoral systems with the functional ones was used to rigorously justify and substantiate the works necessary for their efficient rehabilitation.

The logistical base used is represented by treaties, publications and specialized papers, statistical data from the agricultural register, data from cadastral records, time and production norms for activities in the agroforestry sector, the EXCEL program, the PROARB 2.0 program for generating the structure of forest stands, digital cameras.

RESULTS AND DISCUSSIONS

The multiannual average air temperature for the period 1990-2025 (10.9°C) was higher than the multiannual average temperature of the period 1966-2025 (10.5°C), at the Gurahonț weather station.

Figure 2 shows the positive and negative deviations of the annual average air temperature from the multiannual average of the period 1966-2025 (10.5°C), considered "normal". Warm years (with positive deviations > 0.5°C), cold years (with negative deviations < -0.5°C) and normal years (with deviations between -0.5 and 0.5°C) are highlighted. It is observed that most years of the period 1990-2025 have positive deviations from normal (23 years out of 36). In the 1990-2006 interval, negative deviations prevailed. But only 5 years are cool, 3 years are warm (1994, 2000 and 2002), and 9 are normal.

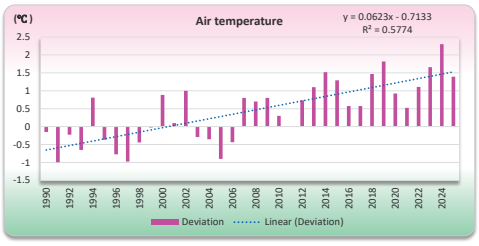


Figure 2. Deviations of the annual average air temperature (1990-2025) from the multiannual average (1966-2025), at the Gurahonț weather station; the linear trend of deviations

Starting with 2007, only positive annual deviations are present. Only 2 years are normal (2010 and 2011), the others being warm or hot. There are 9 hot years, with a deviation of more than 1°C. Of these, 4 years have a deviation of more than 1.5°C: 2024 (+2.3°C), 2019 (+1.8°C), 2023 (+1.7°C) and 2014 (+1.5°C). These are the hottest years of the period 1990-2025.

The linear trend of annual deviations of air temperature is strongly upward (Figure 2). The period 1990-2025 was a very warm one, the 2007-2025 interval being the warmest.

The multiannual average amount of precipitation for the period 1990-2025 (747.5 mm) was slightly lower than the multiannual average amount of the period 1966-2025 (752.0 mm), at the Gurahonț weather station.

Figure 3 shows the positive and negative deviations of the annual precipitation amounts from the multiannual average of the period 1966-2025 (752.0 mm), considered "normal". There are 17 years with positive deviations of precipitation and 19 years with negative deviations. The highest positive deviations exceed 100 mm. There are 9 years with a rainfall surplus of over 100 mm, of which 3 years with over 200 mm: 2005 (+244.2 mm), 2001 (+224.4 mm) and 2004 (+215.5 mm). These are the rainiest years of the period 1990-2025. The highest negative deviations exceed 100 mm, also. There are 8 years with a rainfall deficit of over 100 mm, of which 3 years with over 200 mm and 1 year with over 300 mm: 2025 (-313.6 mm), 2024 (-268.7 mm), 2000 (-257.4 mm) and 2011 (-218.4 mm). They are the driest years of the period 1990-2025.

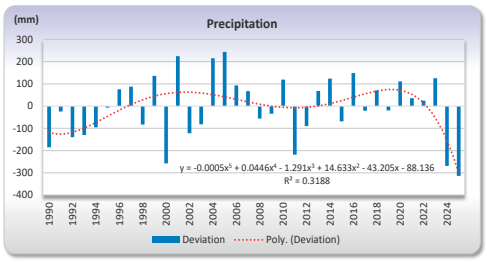


Figure 3. Deviations of the annual precipitation amounts (1990-2025) from the multiannual average (1966-2025), at the Gurahonț weather station; the polynomial trend of deviations

It is noted that the negative deviations are greater than the positive ones – as is usually recorded at the weather stations in Romania. The polynomial trend, represented using the 5th order polynomial, highlights the existence of two long rainy periods (1995-2007 and 2013-2023), interspersed with short dry periods (1990-1994, 2008-2012 and 2024-2025) (Figure 3).

Figure 4 shows the multiannual monthly average air temperature, as well as the highest and lowest monthly average temperatures recorded at the Gurahonț station, during the period 1990-2025. The highest monthly average temperatures were recorded in summer, in July 2024 (24.0°C), July 2012, July 2021, August 1992, August 2024 (all with 23.8°C). They especially occurred towards the end of the analyzed period, in hot weather conditions generated by the advection of the very hot and dry continental-tropical air masses, coming from northern Africa. The lowest monthly average temperatures were reported in winter, in Feb. 2012 (-5.3°C), Jan. 2017 (-5.0°C), Jan. 2000 (-4.0°C), Feb. 2003 (-3.9°C), Dec.1991 (-3.4°C). They occurred due to the advections of continental-arctic or polar air masses, which generate cold waves.

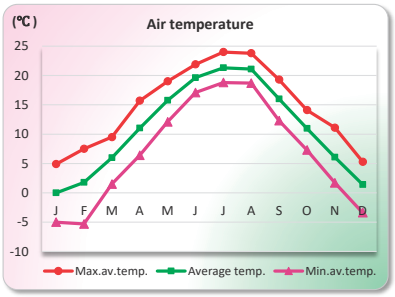


Figure 4. Multiannual monthly average air temperature and the highest/lowest monthly average temperatures, at the Gurahonț weather station (1990-2025)

The highest monthly precipitation amounts exceeded 100 mm, even 200 mm (218.2 mm in June 2020 - the month of the rainfall maximum) (Figure 5). The highest values were reported in the June-September interval (over 150 mm): July 2001 (184.6 mm), July 2011 (181.0 mm), July 2014 (180.4 mm), etc. Such large amounts are linked to the presence of very active cold fronts, which occur after a very hot period. The lowest monthly precipitation amounts ranged between 0 and 26.4 mm. Such small amounts occur when the anticyclonic baric formations persist, generating droughts.

During the period covered by the study, the components of agrosilvopastoral systems were affected by a series of disturbances, which were caused by abiotic and biotic factors, as well as by significant changes in the political and social context.

Consequently, their exploitation changed considerably, with implications for the efficient and sustainable use of the land.

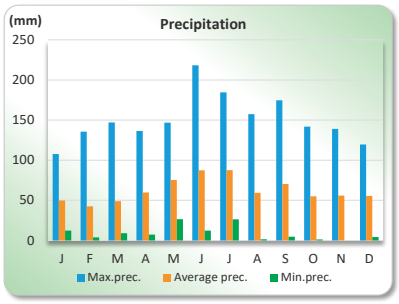


Figure 5. Average, maximum and minimum multiannual monthly amounts of precipitation, at the Gurahonț weather station (1990-2025)

Thus, a series of areas, which were used for grazing animals, in the period after 1989, were partially abandoned, with shrubs and trees of pioneer and invasive species settling on them (Crainic, 2017), which affected the production capacity of the respective lands (Figure 6).



Figure 6. Species of trees and shrubs that have settled on pasture areas within agrosilvopastoral systems

Replacing degraded pastures with agrosilvopastoral systems, especially on lands with clay soils, contributes to increasing soil organic carbon stocks and optimizing microelement circuits, ensuring the premises for sustainable management of these complex systems, against the backdrop of climate change, which is becoming increasingly evident (Ribeiro et al., 2023).

The specific work of rehabilitating agrosilvopastoral systems and reintroducing them into the productive circuit presents a particular specificity, since it is necessary to know the dynamics of how the different components interact during their complex production cycles (Lehmann et al., 2020).

As a result, the works related to the agricultural component, the forestry component, the livestock breeding component (zootechnics) will be analyzed, and last but not least, the aspects related to the sustainable use of the products obtained.

The works necessary for the rehabilitation of the agricultural component of the respective areas are represented by: cutting bushes, shrubs and thin trees, removing stumps by uprooting, works to fill holes and level the land following the uprooting of stumps, plowing the land, cultivating crops for green rotation and for animal feed, respectively. These will be carried out on those areas intended for agricultural crops, meadows and pastures for animal feed (Maruşca, 2018), and classic fruit tree orchards.

Cutting of bushes, shrubs and thin trees, can currently be done mechanized (Table 1), with high efficiency, and the resulting material will be transported and stored at a maximum distance of 20 m from the harvesting site, for recovery, depending on the owner's options.

To remove the stumps, by manual uprooting, excavations will be carried out with hand tools around them, the lateral roots and the central pivot will be cut, the stump will be dislocated and raised on the edge of the pit, later being transported and stored on a specially arranged surface (Table 2), for recovery. Finally, works will be carried out to plug the pits and level the land following the uprooting of the stumps (Table 3).

Table 1. Elements related to the work of cutting bushes, shrubs and thin trees with a Stihl chainsaw, on areas being afforested (processing after Unified time and production standards for forestry work (1997))

Norm symbol	Operation name	Coverage level	Unit of measurement	Framing grid	T.O.[1] (lei/hour)/(€/hour)	N.P.[2] (ari/8hours)	N.T.[3] (hours-man/ar)	T.U.[4] (lei/ar)/(€/ar)
D.25.a.	Cutting and gathering wood	< 33	ha	a 8-a	30.496/5.92	0.227	70.46	2148.75/417.23
D.25.b.		34 - 66	ha	a 8-a	30.496/5.92	0.156	102.81	3135.29/608.79
D.25.b.		> 66	ha	a 8-a	30.496/5.92	0,120	133.33	4066,03/789.31

T.O.[1] - hourly rate, N.P.[2] - production rate, N.T.[3] - time rate, T.U.[4] - unit rate. Conversion level used 1€ = 5.15 lei

Table 2. Elements related to manual uprooting of softwood and resinous hardwood stumps (processing after Unified time and production standards for forestry work (1997))

Norm symbol	Diameter of the stump (cm)	Unit of measurement	Framing grid	T.O. (lei/hour)/(€/oră)	N.P. (pcs./8hours)	N.T. (hours-man/pcs.)	T.U. (lei/buc.)/(€/pcs.)
C.5.a	11-20	piece	a 2-a	25.685/4.99	20.18	0.40	10.27/2.00
C.5.b	21-30	piece	a 2-a	25.685/4.99	8.48	0.94	24.14/4.69
C.5.c	31-40	piece	a 2-a	25.685/4.99	6.35	1.26	32.36/6.29
C.5.d	41-50	piece	a 2-a	25.685/4.99	4.02	1.99	51.11/9.93
C.5.e	51-60	piece	a 2-a	25.685/4.99	3.31	2.42	62.16/12.08
C.5.f	61-70	piece	a 2-a	25.685/4.99	1.92	4.17	107.11/20.81
C.5.g	> 70	piece	a 2-a	25.685/4.99	1.56	5.13	131.76/25.60

Table 3. Elements related to the works of filling holes and leveling the land following the uprooting of stumps (processing after Unified time and production standards for forestry work (1997))

Norm symbol	Average pit volume (m^3)	Unit of measurement	Framing grid	T.O. (lei/hour)/(€/hour)	N.P. (buc./8hours)	N.T. (hours-man/ pcs.)	T.U. (lei/pcs.)/(€/pcs.)
C.7.a	până la 0.25	piece	heavy work	25.126/4.88	109	0.07	1.76/0.34
C.7.b	0.26-0.40	piece	heavy work	25.126/4.88	79	0.10	2.51/0.49
C.7.c	0.41-0.60	piece	heavy work	25.126/4.88	36	0.22	5.53/1.07
C.7.d	Peste 0.60	piece	heavy work	25.126/4.88	26	0.30	7.54/1.46

To achieve the necessary crops, the soil will be plowed with a three-furrow plow at a plowing depth of 29-31 cm (Table 4), since it has been experimentally proven that the largest carbon reserves in the soils of agrosilvopastoral systems are found at a depth of 0-15 cm (Salazar et al., 2024). The plowing work will also be carried out with a harrow pulled by a tractor (Table 5).

A particularly important work is represented by the fertilization of the areas intended for crops and grazing, respectively (Maruşca, 2022). Recent research has shown that on the land areas exploited in the agrosilvopastoral system, the application of chemical fertilizers has been limited to the point of total elimination (Tsufac, et al., 2022). Consequently, organic fertilizer represented by manure will be used, or where possible, mulching will be carried out.

Manure fertilization can be carried out with specialized trailers of the MIG type (Figure 7a), of different capacities, depending on the topography of the land and the surface being worked. In areas relatively difficult to access for mechanized means, animal-drawn means can also be used successfully, especially those with hypotraction.



Figure 7a. Fertilization with manure, using the MIG trailer

Table 4. Elements related to soil plowing works with a plow, with three furrows, in medium-textured soils, at a plowing depth of 29-31 cm (processing after Unified time and production standards for forestry work, 1997)

Norm symbol	Furrow length (m)	Unit of measurement	Framing grid	T.O. (lei/hour)/(€/hour)	N.P. (ha./8hours)	N.T. (hours-man/ha)	T.U. (lei/ha)/(€/ha)
D.7.III.b.17	100-200	ha	a 7-a	29.184/5.67	0.85	9.41	274.62/53.35
D.7.III.b.18	201-400	ha	a 7-a	29.184/5.67	0.92	8.70	253.90/49.33
D.7.III.b.19	401-600	ha	a 7-a	29.184/5.67	0.96	8.33	243.10/47.23
D.7.III.b.20	Peste 600	ha	a 7-a	29.184/5.67	0.98	8.16	238.14/46.27

Table 5. Elements related to the work of disc ploughing with a tractor-drawn harrow (processing after Unified time and production standards for forestry work, 1997)

Norm symbol	Disc harrow type	Working depth	Unit of measurement	Framing grid	T.O. (lei/hour)/(€/hour)	N.P. (ha/8hours)	N.T.(hours-man/ha)	T.U. (lei/ha)/(€/ha)
D.9.a	G.D -2.5	10-15	ha	a 7-a	29.184/5.67	4.37	1.83	53.41/10.38
D.9.b	G.D -3.2	10-15	ha	a 7-a	29.184/5.67	5.69	1.41	41.15/7.99
D.9.c	G.D -4.0	10-15	ha	a 7-a	29.184/5.67	6.79	1.18	34.44/6.69

The use of manure spreading at present, in the studied location, is currently reported on relatively small areas, due to the low number of cattle and sheep, but it can be expanded in the context of establishing associations between livestock breeders, and submitting financing projects for the development of these activities.
The increasing complexity of agrosilvopastoral systems, as a result of the way the soil is worked, with direct implications on enzymatic activities, nutrient availability, texture, fertility and implicitly on production diversification, actively contributes to optimizing synergies between the nutrient cycle and soil organic carbon storage (Steinfeld et al., 2023; Ngaba et al., 2024).
Fertilization works are also assimilated to those in the forestry sector, carried out in nurseries and plantations, and respectively on areas intended for obtaining complementary food for fauna of hunting interest. The incorporation of seeds into the previously processed soil, for the crops to be installed, can be done manually or mechanically, depending on their specifics. To ensure peace and protection of the crops grown, temporary or permanent fences can be made, depending on the way the land is exploited and the available material possibilities. Currently, a modern variant of making fences is represented by the electric fence (Maruşca, 2022).
The provision of complex ecosystem services, such as diversified fruit production, resistant to diseases and pests, will be of particular importance in the future, given climate change and the growing interest in food security (Špulerová et al., 2025). The specific works for fruit tree cultivation refer to the maintenance of traditional orchards, which are partially or totally abandoned, and to the restoration of some that have been destroyed, or which are at the upper limit of longevity, being dry or in the process of drying (Figure 7b).



Figure 7b. Orchard of local plum varieties in the process of drying, in which specimens of common juniper *Juniperus comunis* L. have been installed, and which needs to be restored

As a result, these works explicitly refer to maintaining optimal tree vegetation conditions and, respectively, to the appropriate management of their crowns, in order to obtain optimal fruit production. In this context, it is necessary to clear the biogroups of woody, shrubby and subshrubby species (Figure 8; Table 1), remove and utilize them, if possible, as well as administer natural fertilizers, namely manure, over the entire surface, with a periodicity of 3-5 years, depending on the soil type.



Figure 8. Apple orchard where black locust specimens *Robinia pseudacacia* L. are being installed, and where crown pruning is required

For the proper management of the crowns, regeneration, management and formation works are necessary, depending on the age, growth and development vigor and respectively the phytosanitary condition of the trees (Figure 9). These works will be assimilated to those related to the formation, maintenance and correction cuts of the crowns in the plantations and seed orchards related to deciduous species (Table 6).



Figure 9. Example of a local apple variety that was grown in a traditional orchard, requiring specific pruning of the crown and removal of surrounding tree vegetation

Also, if the orchards are totally or partially destroyed, they will be restored by planting some fruit tree specimens, if possible, from the original species, or from other local species, which are successfully acclimatized and naturalized in the area. It is preferable to promote in culture trees grafted on freely generative rootstocks, from the apple and pear species. These rootstocks are obtained from seeds, and are optimal for vigorous, long-lived and frost and drought-resistant trees, developing a deep taproot, presenting high adaptability to less fertile soils, representing the perfect solution for the creation of traditional orchards (https://pomfruct.ro/blog/informatii-privind-caractéristiques-portaltoiului/), and present an increased resistance to diseases and pests.

In this situation, the work of obtaining planting material by grafting (Table 7) and respectively its planting (Table 8) can be assimilated to those in the forestry sector, carried out in nurseries, plantations and forest seed orchards.

Consequently, the rehabilitation and preservation of classic (traditional) orchards is very important, because in addition to producing high-quality, organic fruits, it contributes to the preservation of regional traditions and identity, attractive places for recreation, aesthetic appreciation, inspiration for artists, for locals as well as for potential tourists, from the country and abroad (Špulerová et al., 2025).

The works related to the forestry component of agrosilvopastoral systems (Figure 10) refer to:

- ensuring an appropriate phytosanitary condition of the biogroups formed by trees belonging to the fundamental natural forest type;
- appropriate regulation of intraspecific and interspecific competition,
- artificial pruning and trimming works for trees that present an excessive crowning process;
- controlling the succession process of pioneer and invasive species;
- regeneration of tree biogroups that have reached their physiological limit.

Table 6. Elements related to crown formation, maintenance and correction pruning in deciduous tree seed plantations and orchards (processing after Unified time and production standards for forestry work, 1997)

Norm symbol	Species group	Time since planting (years)	Unit of measurement	Framing grid	T.O. (lei/hour) (€/hour)	N.P. (pcs./8hours)	N.T. (hours-man/pcs.)	T.U. (lei/pcs.) (€/pcc.)
C.48.a	hardwood	2-3	pieces	a 7-a	29.184/5.67	42.33	0.19	5.54/1.08
C.48.b	hardwood	4-6	pieces	a 7-a	29.184/5.67	29.74	0.27	7.88/1.53
C.48.c	hardwood	7-10	pieces	a 7-a	29.184/5.67	21.51	0.37	10.80/2.10
C.48.d	hardwood	>10	pieces	a 7-a	29.184/5.67	16.03	0.50	1459/2.84

Table 7. Elements related to grafting works for deciduous forest saplings
(processing after Unified time and production standards for forestry work, 1997)

Norm symbol	Specifications	Unit of measurement	Framing grid	T.O. (lei/hour)/(€/oră)	N.P. (1000 pcs./8hours)	N.T. (hours-man/buc)	T.U. (lei/1000 pcs.) (€/1000 pcs.)
B.83.I.b.1	Prepared rootstock and scion, grafted and tied with raffia	(1000 pieces)	a 7-a	29.184/5.67	0.12	65.57	1913.59/371,78
B.83.I.b.1	Glue graft with mastic	(1000 pieces)	a 7-a	29.184/5.67	0.53	15.24	444.76/86,41

Table 8. Elements related to the planting works of seedlings grown or transplanted in polyethylene bags (processing after Unified time and production standards for forestry work, 1997)

Norm symbol	Pit dimensions (cm)	Working conditions[1]	Unit of measurement	Framing grid	T.O. (lei/hour)/ (€/hour)	N.P. (buc./ 8hours)	N.T. (hours-man/ 100seedlings)	T.U. (lei/100 seedlings)/ (€/100 seedlings)
C.40.I.a	30x30x30	light[2]	100 seedlings	a 6-a	28.407/5,51	2.06	3.88	99,89/21.38
C.40.I.b	30x30x30	medium[3]	100 seedlings	a 6-a	28.407/5,51	1.28	6.24	160,66/34.38
C.40.I.c	30x30x30	heavy[4]	100 seedlings	a 6-a	28.407/5,51	0.91	8.75	225,28/48.21
C.40.II.a	40x40x40	Light	100 seedlings	a 6-a	28.407/5,51	1.09	7.35	189,23/40.50
C.40.II.b	40x40x40	Medium	100 seedlings	a 6-a	28.407/5,51	0.66	12.06	310,50/66.45
C.40.II.c	40x40x40	Heavy	100 seedlings	a 6-a	28.407/5,51	0.48	16.84	433,56/92.79

[1]Working conditions are determined by soil texture and moisture, skeletal content, degree of weed and woody species coverage, and terrain slope. [2]Light conditions 5-7 points. [3]Medium conditions 8-11 points. [4]Heavy conditions 12-15 points.

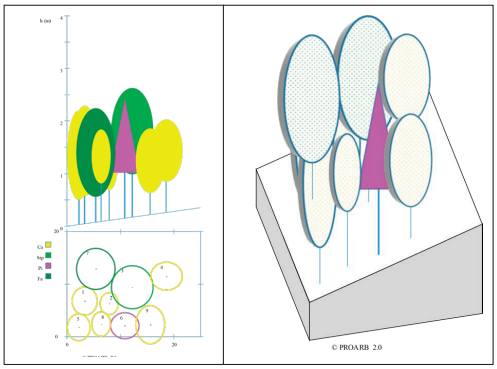


Figure 10. Tree biogroups within an agrosilvopastoral system in Vârfurile locality, Arad county.
The identified species are: Ca - *Carpinus betulus* L., Stp - *Quercus robur* L., Pi - *Pinus sylvestris* L., and Fa - *Fagus sylvatica* L.

The regeneration of tree biogroups, which build the fundamental natural type of forest bordering agrosilvopastoral systems, can be achieved naturally, from certified seed, coming from seed reserves (Crainic et al., 2023b), or mixed, also using bare-root forest seedlings (Dorog & Crainic, 2015). As a result, the tree species of *Quercus robur*, *Quercus ceris*, *Quercus petraea*, *Acer campestre*, *Fagus sylvatica*, *Carpinus betulus*, *Prunus avium*, and *Alnus glutinosa* will be regenerated, which are native species and have a very important role in improving and maintaining soil fertility and in the efficient functioning of the land exploitation system (Cheruto et al., 2025). Also, the wood that will be obtained from these tree species can be valued differently, depending on the needs of the owners. The aforementioned interventions will comply with the recommendations of the technical norms related to activities in the forestry sector, as well as some technical solutions offered by local experience, which have been shaped over decades of exploitation (activity).

It is also aimed at removing biogroups of shrubs and subshrubs that cannot be exploited, and which frequently colonize considerable areas.

The wood resulting from the application of the interventions mentioned above can be exploited

in compliance with the regulations in force regarding forest vegetation outside the national forest fund (Forestry Code - Law 331/2024), and the cultivation of some fruit tree species, such as walnut and cherry. Agrosilvopastoral systems have a high potential to store more carbon and improve the physical and chemical characteristics of the soil, compared to conventional pastoral systems (Salazar et al., 2024). Consequently, at present, the zootechnical component, namely animal husbandry, must be maintained and rehabilitated in these complex land use systems in the studied area, and for this reason.

The works related to the zootechnical component mainly refer to the partial redevelopment of animal shelters, watering places and, last but not least, the design of modern enclosures and electric fences, activities that can be carried out relatively easily by the owners, given the current logistical possibilities. To make the process of monitoring the exploitation and health of agro-forestry systems, and carbon sequestration more efficient on a large scale, remote sensing applications can be used with high efficiency (Sirimalle et al., 2025).

Although the elements related to the specifics and cost of the mentioned works have been assimilated to those in the corresponding activity sectors, however, currently the economic evaluation of the activities presented is carried out through direct negotiation between the owner and the provider, or they can be carried out by the owner himself, including a series of expenses determined by various materials, fuels, taxes, etc.

For the plains and low hills, the value of the works related to the installation of oat crops is approximately 2100 lei (407.76 euros) per hectare of land, and in the high hills area, where the case study was conducted, the value of these works is currently estimated at 2600 lei (504.85 euros) per hectare.

These aspects, regarding the method used to evaluate the works, are relevant for the correct quantification of all expenses and obviously for establishing an efficient financing approach.

It is known that at the European level, for example in Switzerland, the valorization of the productions of meadows and orchards related to agroforestry systems is declining, although these are managed within the framework of extensive agri-environmental schemes (SAE) (Nishizawa et al., 2022).

At the national level, although part of the areas exploited in the agrosilvopastoral system are declared for APIA subsidies (www.agroinfo.ro, www.agrointel.ro, Table 9), their amount can only finance (financially support) a relatively small percentage of the works necessary for their rehabilitation and introduction into the productive circuit.

Table 9. General summary of APIA support (€/ha), for hill and mountain areas (www.apia.org.ro)

Use category	Estimated payment range (€/ha)
Permanent grassland (simple)	120 - 180
Mountain/alpine grassland	200 - 300
Agri-environmental grassland	250 - 350
Traditional orchards	150 - 300

The revival of activities in this type of exploitation requires an efficient strategy for the valorization of the products obtained.

Although the production of animal and plant-based foods related to agro-silvopastoral systems is of superior quality, with some products being organic, in some situations production costs are higher, which may influence market competitiveness.

But the quality of the products, namely the taste, healthy character, naturalness, flavor, seriously attract the attention of consumers, who are interested in these essential characteristics. Consequently, consumers, through the actions of purchasing products, can support the activity in these systems (Philipp & Zander, 2023).

In this context, the creation of a modern, efficient system for the valorization of animal products, especially a series of dairy products from cattle, (represented by milk, cream, fresh cheese) which are sold locally, through a vending machine and a retail store, respectively, was initiated. As a result, the companies Lazurana Lact SRL and Lazurana Ferm Lact Agricultural Cooperative represent a local producer located in Lazuri Village, Vârfurile ATU, Arad County, which processes milk from local farms within the Vârfurile ATU, Arad County, and which exploits the lands in an agrosilvopastoral system, producing a wide range of organic dairy products.

Also, to capitalize on the fruits obtained from traditional orchards that are exploited in agro-

forestry systems, a complete line with industrial capacity was purchased for processing fruits and obtaining various types of pasteurized and unpasteurized, organic juices in the locality of Măgulicea, UAT Vârfurile, Arad County.

Agrosilvopastoral systems are characterized by a high level of biodiversity and superior production capacity, but their related activities require considerable time and financial effort, in order to optimally and sustainably capitalize on the productive potential of the land (Philipp & Zander, 2023).

The climatological analysis presented above shows that the period 1990-2025 was very warm, with 2/3 of the years analyzed having positive thermal deviations from normal. The 2007-2025 interval was the warmest, recording only positive annual temperature deviations. That caused the linear trend of annual thermal deviations to be strongly upward. The precipitation analysis highlighted that the negative annual deviations were greater than the positive ones, but the rainy periods were longer than the dry ones. However, the rainfall extremes were very well highlighted in the analyzed period 1990-2025: there were very rainy and excessively rainy years interspersed with very dry or excessively dry years. As a result, the very high temperatures and long droughts in the dry years negatively influenced the plant and animal yield in the studied area, and the excessive rains in the rainy years favored obtaining rich yields.

The necessary works for the rehabilitation and introduction into the productive circuit of the abandoned agrosilvopastoral systems have to be carried out in an integrated manner, for each of their components, depending on the objective reality on the ground. The specifics of the works and the way they are carried out have to be correlated with the technical and financial possibilities of the owners. Also, the way of valorizing the products of plant and animal origin obtained have to be optimal, in order to efficiently support the expenses related to the production process, with a view to sustainable management of these complex systems. The financing options that can be accessed through various projects or non-refundable payments and interventions, constitute an important support for the owners of agrosilvopastoral systems. According to the aspects presented above, it follows that the objectives of the study have been achieved.

The results obtained in this study contributed to the advancement of scientific knowledge in the addressed field, by the fact that for the rehabilitation and introduction into the productive circuit of the abandoned agrosilvopastoral systems, an integrated approach to the necessary works is required, depending on the specifics of the system component, in direct correlation with the vegetation conditions and the yield obtained, making it possible to predict the expenses and income obtained, with high accuracy.

The extension of research to other locations in Vârfurile Commune, Arad County, is mainly limited by the way in which agrosilvopastoral systems are exploited, which differs from one owner to another, with several differences regarding the exploitation of the productive potential of each component of the systems. Research may also be limited by the refusal of owners to facilitate the access to information from the agricultural register and to information relating to the plant and animal yields obtained.

Research and studies on agrosilvopastoral systems can be continued in the future for each village in the Vârfurile commune, in order to analyze their condition and the real possibilities for their rehabilitation and introduction into the productive circuit.

CONCLUSIONS

The period 1990-2025 was a very warm one, the 2007-2025 interval being the warmest. Most years of the period 1990-2025 had positive deviations of the annual average air temperature from normal. Compared to the precipitation recorded in the period 1966-2025, the period 1990-2025 was relatively rich in precipitation, but in which the rainfall extremes were highlighted (there were very rainy and excessively rainy years interspersed with very dry or excessively dry years). Thermal and rainfall extremes are very damaging to forests, representing a major stress for them, weakening the resistance of trees and favoring the emergence of diseases and pests.

Agro-silvopastoral systems in uncultivated areas of medium and high hills were exploited differently over time, and after 1989, interest in

productive activities gradually decreased, some of them being abandoned, even today.

The work required to rehabilitate these complex land valorization systems has specific features for their functional components, requiring considerable financial support.

Although the measures that need to be adopted are relatively easy for owners, in order to make them more efficient, it is necessary to achieve an ownership, at least at the village level.

The initiation of the valorization of animal and plant products resulting from productive activities, mostly locally, in an organized manner, given the facilities that are currently available, represents for the studied area a definite possibility of rehabilitation and reintegration into the productive circuit of agro-silvopastoral systems.

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