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Forest Shelterbelts between Potential and Reality - A Case Study in the Romanian Plain and Dobrogea Plateau, Romania

Elena Mihaila[1*], Adrian Tudora[1,2*], Mihaita Bitca[1,3*], Dorina Dragan[1], Marius Petrila[1], Bogdan Apostol[1], Cristiana Marcu[1], Elena Achim[1]

[1]National Forestry Research-Development Institute "Marin Dracea", 128 Eroilor Blvd, 077190 Voluntari, Ilfov County, Romania
[2]Faculty of Silviculture and Forest Engineering, Transilvania University of Brașov, 29 Eroilor Blvd, 500036 Brașov, Brașov County, Romania
[3]Forestry Faculty, "Ștefan cel Mare" University of Suceava, 13 Universității Str, 720229 Suceava, Suceava County, Romania
[*]Corresponding authors. E-mail: lilianmihaila@gmail.com; bitcamihaita@gmail.com; tudoraadrian197@gmail.com

ABSTRACT

This paper analyzes the development and current necessity of forest shelterbelts in the southern and southeastern regions of Romania (the Romanian Plain and Dobrogea Plateau) over the past three decades. These regions are characterized by extreme climatic conditions and a low forest cover (approx. 8%), making them particularly vulnerable to desertification, wind erosion, and soil degradation. The study reviews the transition from the stagnation of the communist era to the current legislative framework (Law No. 289/2002), which facilitates the establishment of shelterbelts for both infrastructure protection and agricultural benefit. The study highlights a dual implementation approach: state-led initiatives by the Romanian Forest Administration and the Romanian Academy, and private efforts by farmers. Technical specifications for shelterbelt design using GIS systems are detailed, emphasizing species composition and spatial arrangement. In addition, the paper synthesizes international and local data on agricultural yields, demonstrating that protected fields can achieve production increments between 10% and 30%, particularly for winter wheat (+23%) and maize (+12%), by mitigating wind speed and conserving soil moisture. We conclude that while funding remains a primary obstacle, the large-scale restoration of forest shelterbelts is imperative for Romania's climate change adaptation and long-term food security.

Keywords: forest shelterbelts, agricultural yield, climate change, agroforestry systems, soil conservation.

INTRODUCTION

In the Romania, the concept of agroforestry entered into specialized terminology starting in 2006, following the funding of the first research projects dedicated to agroforestry (Mihaila, 2006-2010), and its subsequent inclusion in national strategic documents (Ministry of Agriculture and Rural Development - MARD, 2013; Ministry of Environment, Waters and Forests - MEWF, 2022). However, the association of forest species with crops has ancient roots in the Romanian rural landscape. Among these, forest shelterbelts (or windbreaks) represent the most widespread and recognized agroforestry systems, with a history of approximately 150 years in protecting agricultural land, pastures, and transport infrastructure (Lupe, 1952; Lupe et al., 1959; Lupe, 1981, 1985; Nesu, 1999; Musat and Guiman, 2006; Vasilescu and Teresneu, 2006; Mihaila et al., 2010; Giurgiu, 2012; Vasilescu, 2015). The evolution of these systems has not been linear, marked by periods of significant development followed by decline, largely influenced by political shifts and economic crises. Shelterbelts are formations with forest vegetation, of different lengths and relatively narrow widths (from 10 m to 30 m), located at a certain distance from each other, performing both protective (mainly by reducing the harmful effects of wind) and productive functions (increasing agricultural production and wood material) (Lupe, 1952).

Knowing the history of the establishment of forest shelterbelts and their development

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over the last three decades aims to promote this type of agroforestry system, encouraging farmers to establish it in the largest possible areas, especially in the current climate change conditions (MEWF, 2019), and may convince national or European authorities to support their establishment through agroforestry system financing programs.

The history of shelterbelts development in Romania can be summarized in three major stages, which are outlined in the following sections.

The first stage in the evolution of shelterbelts development began *in the early 20th century and lasted until the 1960s,* when forest shelterbelts were established on approximately 10000 ha (Popov et al., 2018). It was the most prolific period in this issue.

The second stage in the evolution of forest shelterbelts development runs from *1960 to 1990,* and it is characterized by their destruction when 6300 ha of forest shelterbelts were completely cut (Popov et al., 2018). The communist authorities of that period decided to expand the area occupied by agricultural lands and to practice extensive agriculture. The forest shelterbelts created by Romanian foresters between the two world wars in southern Dobrogea (Cadrilater), a territory ceded to Bulgaria in 1940, remain as a testimony. Here, the forest shelterbelts were maintained and expanded.

Starting from 1990, when major political changes took place in Romania, also important in terms of the nature of property (reverse transfer of land from state ownership to legal owners), public debates on the need to create forest shelterbelts were relaunched (Giurgiu and Lupe, 1995; Ianculescu, 2005; Marusca, 2012; Vasilescu, 2008). It is important to note that in this last stage, the Forest Shelterbelts Law No. 289 (Romanian Parliament, 2002) was promulgated, which is the basis for the implementation of projects to establish forest shelterbelts. The Institute for Forestry Research and Development (IFRD) has designed projects for the establishment of forest shelterbelts to protect agricultural land in the southern and southeastern areas of the country and for all road and railway sections affected by snow accumulation during winters with heavy snowfalls and snowstorms. Therefore, in the last three decades, there have been two directions for the establishment of forest shelterbelts: one supported by central public authorities (Romanian Forest Administration - RFA and the Romanian Academy - RA) and the other by private entities through farmers. The forest shelterbelts established by RA were realised based on technical and economic documentation in which the composition of the shelterbelts took into account the need to use indigenous species, while those realised by farmers used fast-growing exotic species like black locust to obtain the fastest possible effect of these shelterbelts.

MATERIAL AND METHODS

This study is based on a qualitative bibliographic analysis of the development and functions of forest shelterbelts in Romania over the last three decades. The research methodology consisted of a systematic review of scientific literature, legislative documents, technical reports, and institutional publications concerning the establishment, management, and ecological and agricultural importance of shelterbelts.

The research was conducted in four successive stages: (i) identification and collection of relevant scientific and technical sources, (ii) selection and classification of information according to thematic relevance, (iii) comparative analysis of data regarding the ecological, agricultural, and socio-economic role of shelterbelts, and (iv) synthesis and interpretation of the results in relation to the Romanian environmental and agricultural context.

Particular attention was given to studies addressing the relationship between shelterbelts and key variables such as: agricultural productivity, climate resilience, soil protection, and landscape restoration. The analysis particularly focused on southern and southeastern Romania, regions where climatic stressors and land degradation processes make shelterbelt systems especially relevant for sustainable land management.

RESULTS AND DISCUSSION

The natural setting

The Romanian Plain, located in the south of Romania, and the Dobrogea Plateau, in the south-east, are the main agricultural areas of the country, occupying an area of 21% and 6.5% of the country's area (Grecu, 2010; NIS, 2018) (Figure 1). Due to the geographical location, but also due to the small percentage of areas occupied by forests, around 8%, these are the most exposed areas in the country from a climatic point of view, so the areas most affected by climate change.

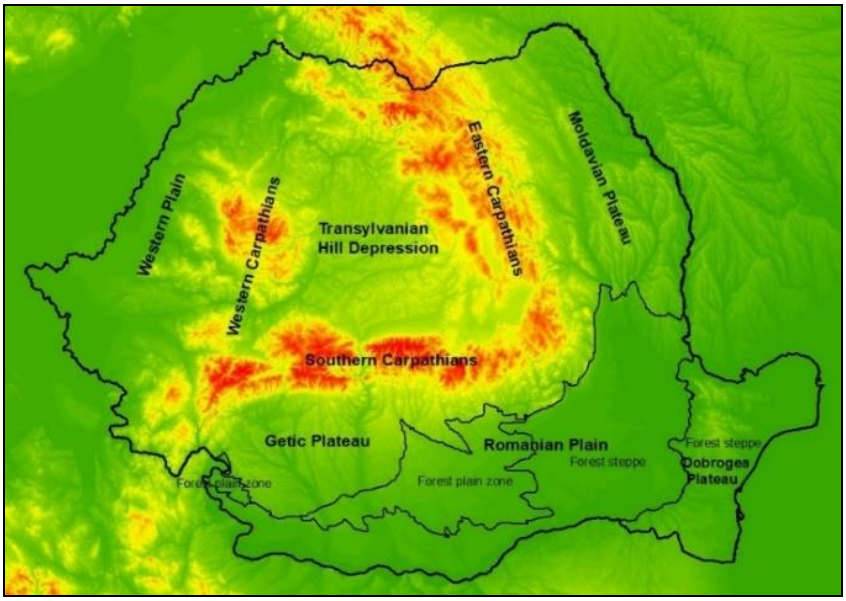

Figure 1. Map of Romania with the Romanian Plain and the Dobrogea Plateau

Therefore, the need for forest shelterbelts was imposed primarily due to climate conditions and the lack of area covered by forest vegetation.

The main climatic elements that impose the need to install forest shelterbelts, especially in this area, are: air temperature, precipitation and winds. The average annual air temperatures are for the Romanian Plain 10-11.5°C and Dobrogea 9-11°C (Posea, 2006). From a pluviometric point of view, the analyzed area is under the influence of continental air. Here, on average, 500 mm of precipitation is recorded annually, less in the extreme eastern part, where 400-450 mm are recorded and a little more to the west, where up to 550 mm are recorded (Posea, 2006). As for precipitation, it is unevenly distributed throughout the year, with months with high amounts of precipitation (over 200 mm), but also months without precipitation, especially in the summer season. In the Romanian Plain, the dominant winds are from east and north (in the eastern and northeastern part of the plain) and west and northwest (in the west), with speeds that progressively increase from 3 to 4 m/s in the Romanian Plain (Posea, 2006). The maximum average speeds are from March to April when the soil is relatively bare. In the eastern Romanian Plain and Dobrogea, up to 1600 hours/year (66.7 days) can accumulate when the wind speed reaches speeds of 10-12 m/s. In addition to the dominant ones, in the Romanian Plain and Dobrogea, there are also local winds that have a seasonal or daily periodicity, such as the Crivăț, a cold and dry wind that blows predominantly in winter from the NE-SW direction and brings frost, snowstorms, knock down trees, etc., and the Suhovei, a hot and dry wind that causes storms, dust, drought. These climatic elements have excessively manifested themselves in recent years, so that, for example, in 2023 the average annual temperature for the area under discussion is 12-14°C, and on certain surfaces even more (National Meteorological Administration - NMA, 2024). Regarding the annual amount of

precipitation, amounts between 400 and 500 mm were recorded, on certain surfaces even below 400 mm (National Meteorological Administration - NMA, 2024)

Climatic extremes and human activities have gradually reduced the productive potential of some lands in the Romanian Plain and the Dobrogea Plateau, leading to the desertification of these areas (UNCCD, 1994; MEWF, 2023). Here, processes of land, soil, vegetation and hydrological resources degradation have been observed. As a result, areas with unstable sandy soils have emerged, which tend to expand in the absence of forest vegetation (Figure 2). This phenomenon has spread to Romania (Pravalie et al., 2017), finding that the areas affected by it increased from 16.3% to 43.7% over approximately 10 years. Also, by expanding the areas affected by this phenomenon, the sensitivity desertification index, calculated in 2017, for Romania, corresponds to class 4, meaning high sensitivity of land to degradation (Pravalie et al., 2017).

Figure 2. Sandy soil area in the southwest of the Romanian Plain

Regarding the lack of forest vegetation in the analyzed area, it is important to mention that the areas occupied by forests vary, according to the National Institute of Statistics (NIS), 2018, from 2.9% (plain area of Buzău County) to 12 (Dolj County) - 12.4% (Tulcea County), with an average of 7.5% (Figure 3).

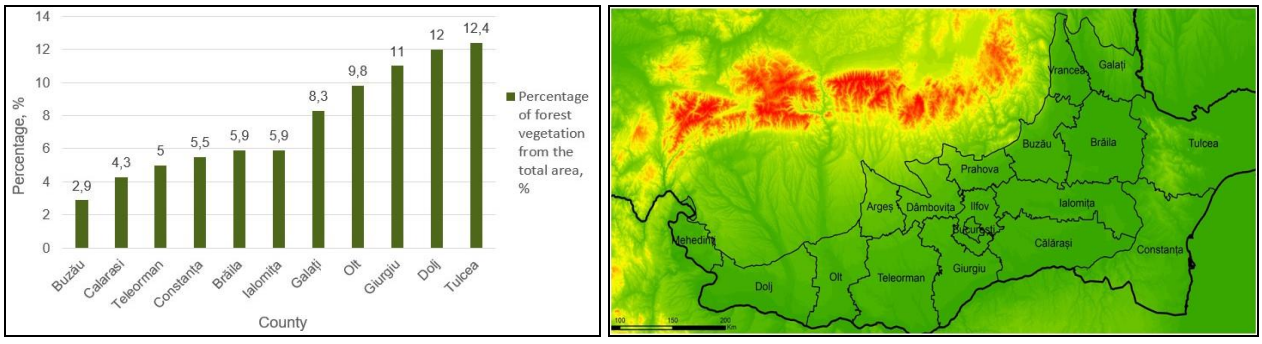

Figure 3. Percentage of forest vegetation in the total area of the county (a), in the counties of the Romanian Plain and the Dobrogea Plateau (b) (all delimited portions on the map represent the counties in the analysed area).

Forest shelterbelts design

Since 1990, the Institute for Forestry Research and Development (IFRD), later reorganized as the National Institute for Research and Development in Forestry (NIRDF), has conducted numerous studies

and technical projects supporting the establishment of forest shelterbelts in Romania, particularly in the southern and southeastern agricultural regions of the country (Danescu et al., 2007; Costachescu et al., 2010; Adam et al., 2012; Greavu et al., 2012; Costachescu et al., 2018; Mihaila et al., 2022).

The design of forest shelterbelt networks for agricultural land protection was carried out in a GIS approach at the commune level, using high-resolution geospatial data to determine the location, length, and area of the proposed shelterbelts. Soil information was obtained from scanned and georeferenced soil maps at a scale of 1:200000, allowing afforestation solutions to be adapted to local site conditions. The geospatial database integrated several categories of information, including vector data (roads, rivers, and administrative boundaries) (Figure 4a), georeferenced cadastral plans at a scale of 1:10000 (Figure 4b), and orthophotoplans derived from aerial imagery with a spatial resolution of 0.5 m (Figure 4c).

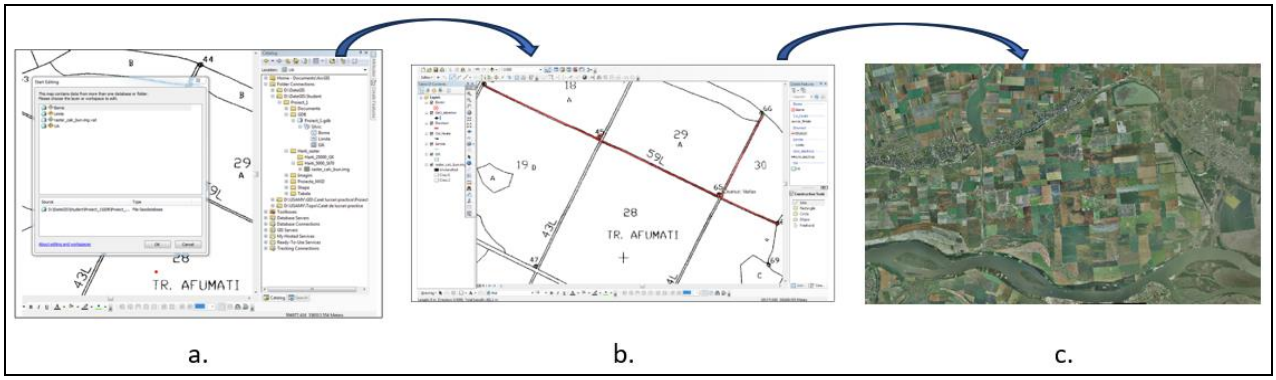

Figure 4. The successive layers of diverse information (geographical, hydrographical, pedological, administrative) over which the network of forest shelterbelts was placed

Once the geospatial database has been created, another stage follows, namely: the location of forest shelterbelts on the edges of the fields using the information from the created database (Figure 5).

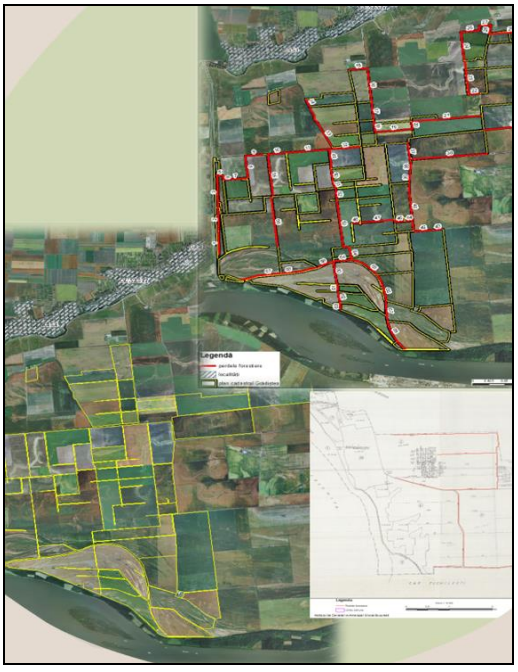

Figure 5. Location of the network of forest shelterbelts by vectorization on maps after database creation

The positioning of forest shelterbelts was based on previously developed technical documentation, generally using rectangular grid systems. For large farms (with typical plot dimensions ranging between 500 × 1000 m and 600 × 1200 m), shelterbelts were recommended along plot margins to avoid excessive fragmentation of agricultural land and to facilitate mechanized farming operations (Danescu et al., 2007; Costachescu et al., 2010; Danescu and Costachescu, 2014).

Although an optimal shelterbelt width of approximately 20 m was considered desirable (Giurgiu, 2012), widths of around 10 m were recommended in the initial stage, corresponding to a land occupation rate of about 2% (Mihaila et al., 2022), a compromise more acceptable to farmers. Once established, the GIS database could be further used to extract statistical data, generate thematic maps, and integrate updated information. Feasibility studies and technical projects were also developed for shelterbelts protecting roads and highways, their location being established under Government Decision No. 994/2004 in areas frequently affected by snow accumulation during severe winters.

Specialists from IFRD and NIRDF have conducted feasibility studies and technical projects for forest shelterbelts designed to protect road and rail infrastructure along roads, highways, and railways. Their placement was regulated by Government Decision No. 994/2004 (Ministry of Justice, 2004), targeting sections prone to snow accumulation during severe winters (Greavu et al., 2012; Constandache et al., 2013). In eastern and southeastern Romania, the Crivăț winter wind frequently causes traffic disruptions by drifting snow onto transport corridors, which justifies the implementation of these shelterbelts in such areas.

The shelterbelts are located 20-30 m from the infrastructure, parallel to it, on the windward side, and are designed to trap snow within a 10-15 m zone, preventing its deposition on the roadway. They consist of approximately 15 rows of trees and shrubs, with 2 m spacing between rows and 1 m between individual plants, forming a dense, largely impermeable structure for effective snow retention.

Forest shelterbelts for protection of road and rail communications consist of 15 rows of different species of trees and shrubs, with a 2 m distance between rows and a 1 m distance between trees/shrubs in a row. They have an impenetrable structure to accumulate snow inside and in their immediate vicinity.

Depending on the ecological requirements of the species and the microsite conditions, different afforestation compositions and planting schemes were adopted, all containing (Figure 6):

- *main species* that reach the largest sizes (long-lived species such as grayish oak, pedunculate oak and other oaks species, field elm, European white elm, silver lime or fast-growing species such as black locust, honey locust), usually installed in the middle of the forest vegetation strip.

- *accessory (helping) species*, less tall, that stimulate the growth in height of the main species, which complete the density of the forest shelterbelts in the longitudinal section, like: field maple, Turkish maple, wild pear, flowering ash, mulberry, cherry plum, mahaleb cherry, Siberian elm, oleaster, Osage orange, European black pine. They are installed either among the main species, on either side of the rows with the main species, or mixed with shrubs.

- *shrubs* are used for shading and soil protection, to ensure the density of the forest shelterbelts in the longitudinal section, and to prevent the entry of animals that can cause damage to trees. The following species are used: common hawthorn, wild privet, dog rose, blackthorn, and smoketree. As a rule, they are installed on the marginal rows.

Road/Highway	20-30 m wide strip	4 m	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Agricultural land
		Permanent access lane	Shr	Shr	Shr	Ac	Shr	Ac	M	M	M	M	Ac	Ac	Shr	Ac	Shr	
			Shr	Shr	Ac	Shr	Ac	Ac	M	M	M	M	Ac	Shr	Ac	Shr	Shr	
			Shr	Shr	Shr	Ac	Shr	Ac	M	M	M	M	Ac	Ac	Shr	Ac	Shr	
			Shr	Shr	Ac	Shr	Ac	Ac	M	M	M	M	Ac	Shr	Ac	Shr	Shr	

R1 … R15 – rows of trees/shrubs
SHR – shrubs: *Crataegus monogyna*, *Ligustrum vulgare*, *Rosa canina*, *Prunus spinosa*, *Cotinus coggygria*
Ac – accessory (helping) species: *Acer campestre*, *A. tataricum*, *Pyrus pyraster*, *Fraxinus ornus*, *Morus sp.*, *Prunus cerasifera*, *P. mahaleb*, *Ulmus pumila*, *Eleagnus angustifolia*, *Maclura pomifera*, *Pinus nigra*
M – main species: *Quercus pedunculiflora*, *Q. cerris*, *Q. pubescens*, *Ulmus minor*, *U. laevis*, *Tilia tomentosa*, *Robinia pseudoacacia*, *Gleditschia triacanthos*

Figure 6. The way to place the species in forest shelterbelts to protect road and railway communications

As for *forest shelterbelts designed to protect agricultural land*, their width is smaller, typically consisting of 5-7 rows of trees and shrubs. The spacing is 2 m between rows and 1 m between individual plants within a row. They include 2-3 main and auxiliary tree species, together with shrub species that may sometimes be absent (Figure 7), resulting in a semi-permeable structure. The species composition is similar to that used for shelterbelts protecting roads, but in this case they primarily serve to delimit agricultural fields.

	R1	R2	R3	R4	R5	R6	R7	3m	
Agricultural land	Shr	Ac	M	M	M	Ac	Shr	Exploitation road	Agricultural land
	Ac	Ac	M	M	M	Ac	Ac		
	Shr	Ac	M	M	M	Ac	Shr		
	Ac	Ac	M	M	M	Ac	Ac		

Figure 7. The way to place the species in forest shelterbelts that protect agricultural land

Establishment of forest shelterbelts

At the national level, important steps have been taken toward the establishment of forest shelterbelts, particularly after the promulgation of Forest Shelterbelt Law No. 289/2002 (Romanian Parliament, 2002). This law aimed to create a national system of shelterbelts across major agricultural regions of Romania (the Romanian Plain, Tisza Plain, Dobrogea Plateau, Subcarpathian hills) and along transport corridors, with the purpose of mitigating drought, desertification, and climate change impacts. However, implementation has been hindered by land ownership issues and the need for landowners' consent, particularly for shelterbelts along transport infrastructure. Subsequent amendments (Romanian Parliament Law No. 213/2011 and Law No. 150/2017) introduced the classification of such works as being of public utility, allowing expropriation with compensation according to legal provisions. This was somewhat easier to do, as these categories of forest shelterbelts represent a small share compared to forest shelterbelts to protect agricultural land and, therefore, cost less (Greavu and Greavu, 2014). Despite this legal framework, the establishment of agricultural shelterbelts has remained limited compared to scientific recommendations, mainly due to financial constraints related to land acquisition, compensation payments, and establishment costs (Nitescu, 2023; Enescu, 2024). An additional limiting factor is the loss of agricultural subsidies on land converted to forest vegetation.

At the institutional level, the RFA has played a central role in implementing

shelterbelt programs, including on its own agricultural lands, through its forestry and land management structures. Since 1993, following Law No. 83/1993 (Romanian Parliament, 1993), which supported an anti-drought afforestation program, a legal framework was established for both agricultural and transport protection shelterbelts. Between 1993 and 2014, RFA established approximately 2033 ha of shelterbelts, followed by an additional 329 ha between 2014 and 2023 (Iacob et al., 2014; Nitescu, 2023) (Figure 8).

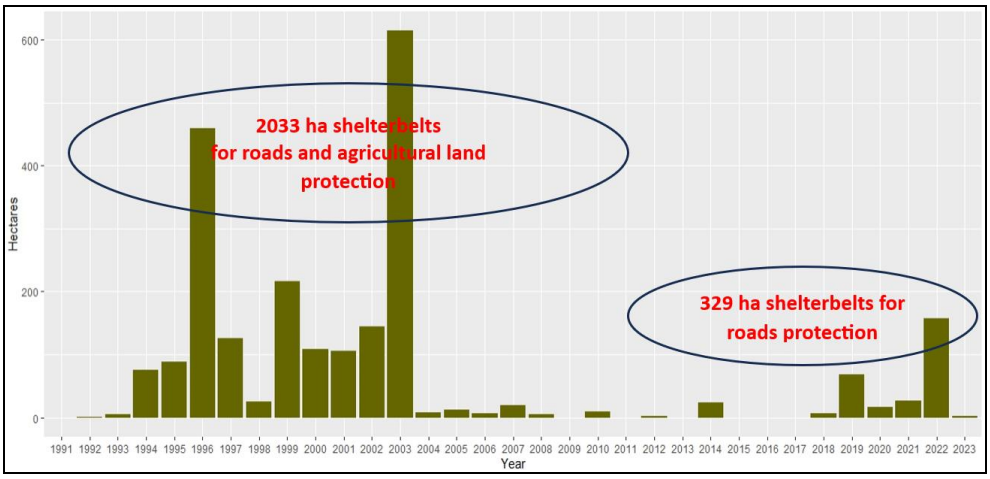

Figure 8. Forest shelterbelts established by the Romanian Forestry Administration from 1990 until 2023

A second important national authority is the RA, which, through its Patrimoniu Foundation, has implemented a program on its agricultural lands in southern and southeastern Romania. Since 2014, this initiative has aimed to establish around 170 ha of shelterbelts, reaching 165.3 ha by the end of 2024 (Dolocan et al., 2022).

Forest shelterbelts established by farmers

Aware of the benefits of forest vegetation in improving microclimatic conditions, soil fertility, and crop productivity, some farmers have established forest shelterbelts on their own farms, through private initiative and funding. At the national level, the total area occupied by such privately established shelterbelts is not precisely known, but is estimated, based on Google Earth interpretation, at approximately 2500 ha. More clearly documented examples exist at county level; between 2006 and 2022, over 600 ha were established in Dolj and Olt Counties and more than 350 ha in Constanța County, located in the Romanian Plain and Dobrogea Plateau (Grigoriev, 2023). However, these values remain significantly below the estimated requirements of approximately 37857 ha for southern and southeastern Romania (Mihaila et al., 2022). Compared with shelterbelts designed by IFRD/NIRDF, farmer-established systems show several structural and functional differences. They are generally composed of 2-4 rows (occasionally up to 7) and are predominantly based on black locust (*Robinia pseudoacacia* L.), selected for its rapid growth and low establishment costs. In some cases, reduced planting spacing (1 × 1 m instead of the standard 2 × 1 m) is used to minimize agricultural land loss. Moreover, these shelterbelts are often of limited length and are not organized in a rectangular grid system, which reduces their capacity to generate large-scale microclimatic effects, although they may still contribute locally to biodiversity enhancement in agricultural landscapes. Differences are also evident in terms of management. Shelterbelts integrated into the forest fund are subject to silvicultural regulations and management plans, whereas most farmer-established shelterbelts lack systematic maintenance and do not follow forestry standards. This leads to several limitations, including the use of black locust on unsuitable soils (e.g., high carbonate content), which may result in growth

stagnation and decline after 10 years (Tudose, 2023-2026), reduced efficiency due to discontinuous spatial configuration, and progressive degradation in some cases.

Considering ongoing climate change trends and the historical underdevelopment of shelterbelt systems, the need for large-scale implementation remains evident. However, the estimated cost of approximately 32000 euros per county (Mihaila, 2022) represents a significant financial constraint, making access to European funding mechanisms essential for future expansion.

The Impact of Forest Shelterbelts on Agricultural Yield Increments

The most compelling argument for private investment in shelterbelt establishment remains the substantial increase in agricultural yields observed in protected areas. The efficiency of forest shelterbelt networks in enhancing crop production has been widely documented in international literature. A landmark synthesis by Baldwin (1988) and Kort (1988) demonstrates that these agroforestry systems improve agricultural performance by reducing wind velocity, conserving snow cover, limiting evapotranspiration, and moderating local microclimatic conditions.

At the global level, reported yield increases associated with shelterbelt systems generally range from 5% to 25%, while in conditions of severe drought, particularly in semi-arid environments, benefits may exceed 30-50%. Climatic conditions represent a key determinant of shelterbelts' efficiency. In regions characterized by cold winters and seasonal snow cover (conditions comparable to those of the Romanian Plain and the Dobrogea Plateau), average yield increases of approximately 20.8% have been reported, significantly higher than the 12.5% average observed in snow-free regions.

Crop-specific studies also indicate differentiated responses to shelterbelt protection. Among the most responsive crops are winter wheat, with average yield increases of approximately 23%, barley with around 25%, maize with approximately 12%, and soybeans with about 15%. In addition to higher yields, shelterbelts contribute to greater production stability, reduced soil erosion, improved soil moisture retention, and enhanced resilience to climatic extremes.

These data are consistent with local observations from Dolj, Olt, and Constanța Counties, where similar positive effects of forest shelterbelts on agricultural productivity have been recorded. In these regions, it was found that agricultural production increases by up to 30% on lands protected by forest shelterbelts compared to exposed fields (Grigoriev, 2023). This performance is explained by the fact that the maximum protective effect of shelterbelts extends over a distance of approximately 5 to 20 times their height (H) in the leeward direction, effectively reducing the effects of dominant winds such as the *Crivăț* and *Suhovei*.

Although the installation of shelterbelts requires the allocation of a small proportion of arable land, approximately 2% in the current design model, aggregated studies show a net increase of about 3.5% at the whole-plot level, after deducting losses caused by the occupied area and root competition. In conclusion, for the arid and semi-arid zones of Romania, where precipitation deficits and strong winds constantly affect crops, forest shelterbelts represent not only a protective barrier but an essential tool for improving agricultural profitability through enhanced soil moisture, reducing soil erosion, and increased yield stability.

CONCLUSIONS

Due to its geographical position, which determines a temperate continental climate with excessive nuances, Romania has had constant concerns over the last 150 years about protecting agricultural lands, localities, and transport infrastructure with the help of forest shelterbelts, even though during the communist regime, their development stagnated. The manifestation of climate extremes in the last three decades has intensified concerns about the restoration of forest shelterbelts, on the one hand,

agricultural production being affected by the lack of precipitation, droughts, and strong winds, and on the other hand, road blockages due to snowfall in winters with snowstorms. In response, research institutions such as IFRD and NIRDF, through specialists concerned with this issue, have conducted research studies on the need to create forest shelterbelts and have designed agricultural land and road and railway communications forest shelterbelts for the entire south and south-east of the country. Unfortunately, the lack of funding and constant political support has blocked the effective establishment of these forest shelterbelts. However, in the last three decades, both agricultural land forest shelterbelts and especially for road and railway communications have been installed, even if not on all surfaces requiring protection. This progress was mainly facilitated by the adoption of the law for the establishment of forest shelterbelts in 2002 and the successive amendments made to it. The actual establishment was done through the involvement of central authorities such as the Romanian Forest Administration, which installed forest shelterbelts for road protection and, to a small extent, forest shelterbelts for agricultural land protection, and the Romanian Academy, which installed forest shelterbelts for agricultural land protection. In parallel with the efforts of the mentioned authorities, some farmers, faced with the effects of climate extremes, set up forest shelterbelts to protect agricultural land; most of them only used black locust and did not install forest shelterbelts in the form of a network.

Improving climatic conditions can be achieved by establishing networks of forest shelterbelts in as large areas as possible in the Romanian Plain, but this is possible for Romania only if financing ways from European funds are identified. Such networks would not only reduce the adverse effects of drought, wind, and soil erosion but would also contribute to improving the stability and productivity of agricultural crops through the mitigation of climatic stress, consistent with results reported for Romania and findings from other countries.

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