Journal of Energy and Natural Resources
2023; 12(4): 38-46
http://www.sciencepublishinggroup.com/j/jenr
doi: 10.11648/j.jenr.20231204.11
ISSN: 2330-7366 (Print); ISSN: 2330-7404 (Online)

Multifunctionality of Grasslands - Permanent Way of Sustainable Utilization of Regional Resources in Romania

Neculai Dragomir[1], Vasile Mocanu[1, *], Nicoleta Dragomir[2]

[1]Research Department, Research-Development Institute for Grasslands, Brasov, Romania
[2]"FERMA" Magazine, Timisoara, Romania

Email address:
vasmocanu@yahoo.com (Vasile Mocanu)
[*]Corresponding author

To cite this article:
Neculai Dragomir, Vasile Mocanu, Nicoleta Dragomir. (2023). Multifunctionality of Grasslands - Permanent Way of Sustainable Utilization of Regional Resources in Romania. *Journal of Energy and Natural Resources*, *12*(4), 38-46. https://doi.org/10.11648/j.jenr.20231204.11

Received: October 28, 2023; **Accepted**: November 21, 2023; **Published**: November 30, 2023

Abstract: Generally speaking, the grasslands are an essential element of sustainable farming systems represented by animal welfare, providing fodder, soil quality and optimal use of land less productive, especially for biomass production, renewable energy source. In addition to the decisive role of providing fodder for animals, grasslands have an important role in rural development and the environment, reflected through: carbon sequestration in soils, symbiotic nitrogen fixation, landscape quality, biodiversity conservation, soil fertility improvement and flood prevention and landslides, the richness of medicinal herbs, honeydew potential, important cultural heritage and a good management of water. By revegetation are biologically consolidated the road sides, mining, industrial and domestic deposits, skiing areas and other land with no vegetation to be protected from destructive external factors, stimulated pedogenesis and beautify the landscape. These features reflect and define grassland multifunctionality. Following the studies carried out on the multifunctional management of permanent grasslands in Romania, the estimated economic value of some services and functions, specific to these ecosystems, was determined at the total amount of 29,265 million lei/year, or 5,853 million euros/year, with an average annual of 6,097 lei/ha, or 1220 €/ha.

Keywords: Permanent Grasslands, Multifunctionality, Services, Resources, Economic Value

1. Introduction

Globally, permanent grasslands occupy an area of about 3.4 billion hectares, representing 25% of the Earth's surface (13.4 billion hectares). The total phytomass production of these areas is about 1000 million tons, ensuring, directly (through animal breeding) or indirectly (through the services and products offered), a large part of the resources necessary for the life of at least 2 billion people. In this context, according to the FAO, *"a world without animals is humanitarian, multifunctional, agronomic and ecological nonsense"*.

Within the European Union, permanent grasslands occupy an area of 63 million hectares and represent 15% of the territorial area and 39% of the agricultural area. According to the data of the Council of Europe, this area has an annual rate of decrease of 10%, reaching an area of only 50 million hectares in 2030 (20% less). Romania, with its 4.8 million hectares (7.6% of the EU area) of permanent grasslands, has committed to maintaining this area at 4.7 million hectares.

The concept of agricultural multifunctionality appeared in 1992 at the UN Conference on sustainable development, held in Rio de Janeiro, and in the period 1995-1998, the European Commission integrates this concept within rural policies, focusing on the environment and the territorial approach.

In the case of grassland areas, the concept of multifunctionality was the theme of the 19th Congress of the European Grassland Federation (EGF), held in France (La Rochelle), with the title *"Multi-function grasslands: Quality Forages, Animal Products and Landscapes"*.

According to Lemaire "multifunctionality, as a concept, is a new paradigm of grassland research" [1]. The evaluation of the multiple functions of grasslands requires a reconsideration of scientific objectives, methods and models of investigation and a multidisciplinary approach to research [1-5, 7-10].

The year 2013 was devoted to the multifunctional system of agriculture, in general, and the herbaceous system, in particular (FAO).

Grasslands in Romania, representing 33% of the agricultural area, is a national patrimony of major importance by the size and quality of forage resources, as well as other functions with beneficial effect on environmental protection and landscape beauty.

In our country, from an economic point of view, grasslands are better known and appreciated due to their fodder value, which provides the necessary food for animals, and therefore the production function was and will remain a priority for these ecosystems. Today, however, to grasslands is given much greater importance due to their multifunctional value, which provides not only food and shelter for animals, but the existence in their structure of real plant treasures, make these lands become more important both for the field science as well as for the social, ecological and economic value generated by services and functions of these ecosystems.

2. Research Methods

The grassland characterizes the Romanian space and ensures its permanence over time, both through the multitude of natural species existing in the vegetal carpet, and through the safety of life offered to people, through the breeding of animals and the diversity of species. The marginal territories, on one side and the other of the Carpathian Mountains, have always been pastures for animal breeding, under the conditions of maintaining their multifunctional character and a synergistic balance between the main components of this natural ecosystem (soil-plant-animal- environment) [13].

Compared to other fields of agriculture, the concept of multifunctionality of grasslands is given by their semi-natural character of utilization and the nature of the functions and services of particular value, both from an economic point and an ecological and social point of view.

The notion of services applies to ecological and agronomic benefits, as a result of the realization of functions considered to achieve the intended ecosystem service [6]. According to FISHER et TURNER service is a set of ecosystem properties that allow the production of "good" for humans and nature [24].

DUFRENE classifies grassland ecosystem services into 4 categories: production, regularization, cultural and support services. Each of these services comprises several functions, with a specific structure of processes and resources [25].

The paper presents the value dimension of economic, social, ecological and cultural services, predictable at the level of the 4.8 million hectares in Romania, related to the following resources and processes: phytomass production, phytodiversity of plant species, multifunctional use value of flora, the honeydew value, the phytotherapeutic potential of grasslands, the value of fixed nitrogen, carbon sequestration and storage, the economic value of services.

3. Results

3.1. Area, Productivity and Forage Balance of Permanent Grasslands in Romania

In this paper, based on the concept of multifunctionality, the production potential of the grassland ecosystem is highlighted, as support for the evaluation of the other functions and services, specific to these ecosystems.

The recorded data, statistically processed and introduced in this paper, are substantiated by the scientific results of some studies carried out, for almost a century, in Romanian grassland science and some technical and economic information communicated by various government institutions.

In order to evaluate the phytomass production of permanent grasslands in Romania, the results of some scientific studies were taken into consideration, over a period of 90 years, divided into 3 stages:

1. 1930-1960, the first experimental pratological research and the identification and establishment for the first time of the types and formations of grasslands, on altitudinal differences;
2. 1960-1990, laborious, interdisciplinary research, at the level of the soil-plant-animal relationship, by realization of special technologies for improving and using the permanent grasslands;
3. 1990-2022, studies and research on forage quality, the ecology and biodiversity, technological solutions and the use of grasslands.

In the first stage of extensive use of grasslands, the natural potential of green mass production, according to bibliographic data, had values between 2-8 t/ha, depending on the type of grasslands and stationary area conditions.

In the second stage, the carried out experimental research by applying a complex of fertilization and use technologies, the production level was 7-20 t/ha of green mass. In the last stage, although the grassland area has increased, on average by 30%, an advanced state of degradation of the vegetal carpet can be found, in the conditions where the improvement measures are applied sporadically and on small areas, and the limits of the variation of the production of green mass is between 3-10 t/ha, close to the production potential of the first stage.

Table 1. *Surface of permanent grasslands, by vegetation areas, green mass production and forage balance.*

Vegetation area	Surface		Green mass estimated production		Total LU *)		The forage balance, reported to the grasslands production and No. of LU (mil. tons of green mass)		
	mil. ha	%	mil. tones	%	mil. LU	%	Required	Deficit **)	Surplus
Plain	0.6	13	3	13	1.18	38	13	-10	-
Hill	2.5	52	16	67	1.39	45	17	-1	-
Mountain	1.7	35	5	21	0.52	17	3	-	+2

Vegetation area	Surface		Green mass estimated production		Total LU *)		The forage balance, reported to the grasslands production and No. of LU (mil. tons of green mass)		
	mil. ha	%	mil. tones	%	mil. LU	%	Required	Deficit **)	Surplus
Total	4.8	100	24	100	3.09	100	33	-11	+2

*) According to the Institute of Statistics (2018)
**) The green mass deficit is provided from the annual forage crops production

The production function of permanent grassland ecosystems, by its complex nature, contributes to the economic performance of agricultural holdings, has a direct and beneficial impact on the environment, has an important role in regulating nutrient cycles and increasing the level of soil fertility, in reducing emissions of greenhouse gases (GHG), in biodiversity conservation [9, 27]. The services that provide the production function of these ecosystems contribute directly, not only to the production of phytomass, but also include the provision of food for animals, ensure the nutritional value of fodder and make the entire technical-economic system more efficient [6, 24]. Under the conditions in Romania, permanent grasslands have a total area of 4.8 million hectares (representing 20% of the country's area and 34% of the agricultural area) and occupy the 4th place at the EU level (8.4% of the total area of grasslands). At the same time, this area, by the production of green mass, contributes 73% of the food required for feeding ruminants.

The relief of Romania determines an altitudinal structuring of grassland surfaces, depending on stationary area conditions, on the following vegetation zones: 0.6 million ha in the plain area (13%), 2.5 million ha in the hill area (52%) and 1.7 million ha in the mountain area (35%). These conditions determine the existence of a great diversity of species in the floristic composition of the vegetation cover, which consists of a multitude of types and formations of grasslands [14].

The green mass production of permanent grasslands, determined as a multi-year weighted average of specialized data, amounts to an estimated total value of 24 million tons (3 million t in the plain area, 16 million t in the hill area, 5 million t in mountain area). From the data presented in Table 1, it follows that the fodder balance, related to the production of grasslands and the number of LU (total 3.62 million), is negative, the difference of 11 million tons of green mass being covered by other fodder sources (forage crops sown in arable land).

3.2. Biodiversity and Multifunctional Use Value of Permanent Grasslands in Romania

The concept of multifunctionality has become, in recent decades, a paradigm of agricultural policies, based on the integration of productive and non-productive functions in an ecological, technical and social system. In the case of permanent grasslands, this multifunctional integration refers to a series of natural resources existing within these ecosystems: fodder resources, honeydew resources, medicinal and aromatic plant resources, ornamental and aesthetic species resources, energy resources. This diversity of species ensures the functionality, efficiency and resilience of the ecological balance within these natural ecosystems.

The ability of the vegetal carpet to satisfy, more or less, a series of criteria specific to the functions of the production system is the most important indicator that defines the multifunctional use value of the grasslands. From this point of view, the economic value of grasslands is given by the phytodiversity of the vegetal carpet, constituted by numerous botanical species, which ensure the productivity and quality of fodder production for animal breeding.

Table 2. *Phytodiversity of permanent grasslands, depending on the feeding value of species (proportion of species by botanical families,%).*

Vegetation area	Poaceae		Fabaceae		Various Species	
	Limits	Ponderal average	Limits	Ponderal average	Limits	Ponderal average
Plain	38-57	46	7-14	11	34-54	43
Hill	42-68	54	6-15	12	27-48	34
Mountain	62-78	74	2-10	5	16-24	21

*) Average results of some scientific papers from the Romanian grassland management literature

Floristic studies carried out in our country have highlighted the existence of a great diversity of species, structured on the three economic components of botanical families: *Poaceae* (Gramineae), *Fabaceae* (Leguminae) and other *families* (various). From this point of view, in the lowland area, species from the *Poaceae* family are dominant (between 38-57% and a weighted average of 46%), followed by species from other families (between 34 and 54% and an average of 43%) and those from the *Fabaceae* family (7-14% and an average of 11%).

In the grasslands in the hill area, the contribution of *Poaceae* species increases (42-68% with an average of 54%), the proportion of diverse species decreases (27-48% and an average of 34%) and the participation rate of *Fabaceae* species is maintained (6-15% and an average of 12%).

In high altitudinal (mountainous) areas, the presence of *Poaceae* species is the highest (between 62-78%, with a weighted average of 74%), the proportion of *Fabaceae* species decreases (2-10%, with an average of 5%) and of various species (16-24% and an average of 21%) (Table 2).

Table 3. *Multifunctional use value of the flora from the permanent grassland vegetation (proportion of species in the botanical composition,%).*

Vegetation area	F + MF **)		F + M **)		F + MF + M **)		VE **)	
	Limits	Ponderal average	Limits	Ponderal average	Limits	Ponderal average	Limits	Ponderal average
Plain	20-28	25	27-36	31	40-51	44	65-80	74
Hill	16-26	22	20-30	24	47-62	54	85-96	92
Mountain	22-33	27	27-38	31	34-48	42	75-87	80

*) Average results of some scientific works from the Romanian grassland management literature

**) F=forage species; MF= melliferous species; M=medicinal species; VE=aesthetic value species

Pastures, by their floristic structure, constitute an important reservoir of honeydew resources for the economy of each area where these surfaces are located. Thus, in the floristic structure of these grasslands there is an important melliferous flora, which ensures the realization of important productions of honey and bee products, at a high level of quality. Also, in the spontaneous flora of Romania there are over 3,700 species, recognized as having special curative properties, of which over 300 species are cataloged with pharmacodynamic properties. However, the rich flora of medicinal plants does not correlate with a greater degree of valorization of this national wealth, existing in a preponderant rate in the vegetation of permanent grasslands.

The results obtained from the studies on the floristic diversity of the permanent grasslands in Romania have resulted in the grouping of species in the following categories: with fodder value (F), with honey value (MF), species with medicinal value (M) and species with aesthetic value (VE). Because almost all honey and medicinal species also have a fodder value, in order to express the general value of multifunctional use, these species have in turn been classified into mixed use groups: F+MF, F+M, F+MF+M. Thus, stationary area conditions (climate, soil, altitude, etc.) and the way of use determine a mixed utilization of the flora from the botanical composition of the meadows in Romania, as follows: 22-27% F+ MF, 24-31% with F+M use, 42-54% with F+MF+M use (Table 3).

3.3. The Honeydew Potential of Permanent Grasslands in Romania

Bee honey is among the oldest foods used by humans for thousands of years ago, being a product with multiple benefits for maintaining the health of human body. According to its origin, honey has several names: monofloral honey, polyfloral honey, manna honey, honey with names of plants, trees etc. Honey can be considered monofloral when it comes from a single botanical species and when the pollen potential is greater than 45% [29]. The difference between monofloral and polyfloral honey is the floristic structure of the natural or cultivated vegetation and the natural conditions specific to each geographical region. Thus, in Estonia, honey is mainly polyflora, and in the other northern European countries (Baltic countries) there is no differentiation between the other categories of honey [30].

Table 4. *Estimated melliferous potential of permanent grasslands in Romania.*

Vegetation area	Area of grasslands used for melliferous value *) (mil. ha)	Average number of melliferous species in grasslands	Melliferous species average degree of coverage (%)	The average amount of honey for 1% degree of coverage (kg)	Honey production (kg/ha/year)	Total quantity of honey (t/year)
Plain	0.15	60	40	0.80	32	4800
Hill	0.63	80	60	0.90	54	34020
Mountain	0.42	40	20	0.50	10	4200
Total/Average	1.20	60	40	2.20	32	43020

*) Of the grasslands total area, about 25% is considered hayfield, which can also be used for the melliferous value (DRAGOMIR 2009)

The quality of honey, evidenced by analyzes carried out in specialized laboratories, is not a determining factor in differentiating one type of honey from another. Thus, the results of analyzes performed on a sample of honey, originating from 72 species of plants (polyfloral honey) were close to those originating from a single species (clover, rapeseed, fruit trees) [28]. The total production of honey worldwide was, in 2021, 1771000 tons, and China, with a production of 472,700 tons, occupied the first place (27%). This year (2021), Romania recorded the highest production in recent years, of 25,269 tons, ranking 2nd in Europe and 15th in the world, being overtaken by Spain, with a production of 30,000 tons. From the total amount produced, Romania exports about 500 tons annually, mainly to England (FAO, EUROSTAT).

Due to the high degree of phytodiversity of natural and cultivated vegetation Romania still has honeybee potential, not fully exploited. As a result, in our country, all types of honey demanded by the market are produced, including organic honey, which represents 18% (4,500 t) of the total.

Among the agroecosystems in Romania, the permanent grasslands represent, because of the great diversity of honeydew species, an unexplored reservoir at its optimal capacity, regarding the increase of honey production, especially of an ecological nature, with superior qualitative characteristics.

The studies carried out in the last decades regarding the diversity of species existing in the vegetation of permanent grasslands, highlight the presence of an important number of honeydew species in the floristic structure, between 40-80, with a degree of coverage between 20-60%, depending on the vegetation area (Table 4).

The honeydew potential of permanent meadows was evaluated as a weighted average of several studies carried out in the country and [10, 16-20, 31]. Thus, an estimated amount between 0.3-0.9 kg/ha of honey resulted, for a degree of coverage of honeydew species of 1%, with a weighted average of 0.7 kg/ha.

If only the area of 1.2 million ha (25% of the total) of grasslands, representing the area intended for haymaking, would be taken into account, the following productions of polyfloral honey could be achieved: 32 kg/ha /year in the plain area, 54 kg/ha/year in the hill area and 10 kg/ha/year in the mountain area. The total amount of honey will be 43,020 t/year, of which: 4,800 t in the plain area (9%), 31,500 t in the hill area (59%), 16,800 t in the mountain area (32%). In recent years, the drastic decrease in cattle herds has also led to a sharp decrease in the areas of grasslands used by animal grazing. This situation favors the growth of abandoned grassland areas, which, through specific works to maintain floristic diversity, will be able to be used as potential melliferous areas.

3.4. The Phytotherapeutic Potential of Permanent Grasslands in Romania

The diversity of species, existing in the floristic composition of permanent grasslands in Romania, also includes numerous medicinal species, with pharmacodynamic properties in folk and allopathic medicine. This rich flora of medicinal plants (over 300 species) is not exploited at an optimal level of efficiency, given that between 500-1000 tons are harvested annually, of which over 50% is exported. In worldwide more than 2000 medicinal species are recognized, used in human and veterinary medical phytotherapy.

Table 5. *Estimated phytotherapeutic potential of permanent grasslands in Romania.*

Vegetation area	Area of grasslands used for phytotherapeutic value *) (mil. ha)	Average no. of medicinal species in grasslands	Medicinal species average degree of coverage (%)	Average amount of medicinal herb **) (kg/ha DM)	Total quantity of medicinal herb (t/year)
Plain	0.15	60	40	0.80	32
Hill	0.63	80	60	0.90	54
Mountain	0.42	40	20	0.50	10
Total/Average	1.20	60	40	2.20	32

*) Of the grasslands total area, about 25% is considered hayfield, which can also be used for the phytotherapeutic value (DRAGOMIR 2009)

**) For 1% degree of coverage with medicinal plants, the amount of medicinal herb is about 2 kg/ha DM (DRAGOMIR, 2009)

The permanent grasslands can be considered an important source of medicinal plants, but, in the natural conditions in Romania and the utilization way of these surfaces, it is considered that the richest medicinal flora is found in the grasslands used for haymaking, which represents about 25% of the total area of Romanian grasslands. In this context, the research carried out by DRAGOMIR et al. (2009) showed that for 1% degree of coverage with medicinal plants, the amount of medicinal herb is about 2 kg/ha SU (Table 5) [11].

The studies carried out on the distribution of medicinal species, on vegetation areas and altitudinal differences, showed that in the hilly area, with more favorable climatic conditions for the vegetation of grasslands, the average number of medicinal plants is 60, with a coverage of 25% of surface, compared to plain and mountain areas. In this area the average amount of medicinal herb is 50 kg/ha SU, compared to only 30 kg/ha SU in the lowland area and 40 kg/ha SU in the mountain area. If the entire grassland surface were harvested, the total amount of dry substance of medicinal plants would increase to an amount of 52,800 t/year, distributed as follows among the three vegetation zones: 9% in the plain area; 60% in the hill area; 31% in the mountain area.

3.5. The Carbon Balance, by Vegetation Area, of Permanent Grasslands in Romania

Today, more than ever, Planet Earth is facing a general situation, unprecedented in its history, generated by the increase of greenhouse gases (GHGs) as a result of all human activities. Thus, it is estimated that, in the period 1900-2020, the amount of GHGs emitted globally increased from 2 billion tons of CO_2 to 35 billion tons of CO_2, respectively more than 17 times and with an average annual rate of 8 billion tons. Depending on the structure of the gases, CO_2 has a contribution of 56%, followed by CH_4 with 16%. By origin, the agricultural and forestry sector contributes 24% to the total amount of GHG emissions. According to SCHINDLER, the development of agriculture was the main cause of the increase of CO_2 in the atmosphere, to which was added, in the current period, the combustion of fossil C (6.5 Gt) in industry and transport [32]. However, under the conditions of a conservative agriculture, soil protection, by application of limited agrotechnical operations for soil preparing, the amounts of C sequestered in the soil consist of 0.5-1.0 t C/ha/year in temperate humid areas, between 0.2-0.5 t C/ha/year in humid tropical areas and 0.1-0.2 t C /ha/year in semi-arid areas [21, 33].

In the soils of permanent grasslands, studies conducted at global level have shown that these ecosystems are large reservoirs of atmospheric C storage: globally between 62-340 kg/ha/year [34]; in Europe, on average 740 kg/ha/year [35]. Also, a good grassland management contributes substantially to the increase of sequestered C depending on the type of applied technological operations, respectively between 0.30-3.04 t C/ha/year [36].

Table 6. *Annual quantitative estimation of C flow in permanent grasslands of Romania.*

Vegetation area	Permanent grasslands surface (mil. ha)	Phytomass amount, DM, thousand tones			Total amount of C captured by photosynthesis and sequestered in aerial, stubble and underground phytomass				The total amount of C stored in soil organic matter **)	
		aerial	stubble and underground	total	C			CO_2*)	thousand t/an	t/ha/year
					thousand t/an	%	t/ha/year	thousand t/an		
Plain	0.6	613	392	1005	462	12	0.77	1695	339	0.56
Hill	2.5	3390	2170	5560	2613	68	1.05	9590	1918	0.77
Mountain	1.7	1075	688	1763	793	21	0.47	2910	582	0.34
Total/Average	4.8	5078	3250	8328	3868	100	0.76	14195	2839	0.56

*) After SOUSSANA et al, 2004: 1 t C = 3,67 t CO_2

**) Center for Climate and Energy Solutions (C_2ES). Biosechestration: 20% of atmospheric CO_2, fixed by plants, is stored in the soil organic matter.

The results presented in Table 6 highlight the estimated annual amount of C captured, sequestered and stored in permanent grasslands in Romania. In this context, the average values of C content in the aerial and underground phytomass of grasslands existing in the specialized literature were taken into account. Also, the number of roots in the rhizosphere was estimated at an average value of 46% of the total amount of phytomass [9, 10, 15, 31].

At the level of the total area of Romanian permanent grasslands of 4.8 million hectares, the total amount of C captured by photosynthesis and sequestered in aerial phytomass, stubble (vegetation remaining after harvesting or grazing), rises to 3868 thousand t/year, of which, on vegetation zones: 462 thousand t/year (12%) in the lowland area; 2,613 thousand t/year (68%) in the hill area; 793 thousand t/year (20%) in the mountain area. In this sense, the studies carried out by JANSSENS et. al., regarding the balance of C in European countries, highlights in the case of permanent grasslands in Romania a C sequestration level of 11.1 g/m^2/year (111 kg C/ha/year) [37].

The total amount of C stored in soil organic matter is estimated at 20% of the amount of CO_2 sequestered by plants (C2ES). Thus, in the permanent grasslands in Romania, a total amount of stored C of 2839 thousand tons/year, respectively on average 0.56 t/ha/year, is estimated.

3.6. Bioaccumulation of Biologically Fixed N in Permanent Grassland Soils

Permanent grasslands, characterized by a very diverse flora, also include numerous leguminous species, with a different potential for symbiotic fixation of atmospheric N. In plant nutrition more than half of the Terra permanent grasslands is based on N fixed by legumes and transferred to other species in the floristic structure [12].

In grasslands, the fixation of atmospheric nitrogen is carried out within wide limits from one country to another, depending especially on the proportion of legumes existing in the vegetal carpet: between 55-268 kg/ha in England; between 83-296 kg/ha in Ireland; between 15-660 kg/ha in New Zealand [38].

Also, in grassland older than 20 years, a lower amount of N is fixed (45 kg/ha/year), compared to younger grasslands (88-142 kg/ha/year) [39]. At the same time, the studies carried out by JACOT et al., (2000) showed that there is a sharp decrease in the amount of N fixed with the increase of altitudinal level at which the pastures are located, as a result of the proportional decrease of legumes in the botanical composition [49]. Much of the N requirement for grass species or other non-N-fixing species in temporary and permanent grassland ecosystems is provided by the transfer of part of the N fixed by legumes. Thus, the estimated amount transferred varies a lot, ranging between 0-68% of the amount of fixed N [40-42].

Table 7. *Annual quantitative estimation of N flux in permanent grasslands in Romania.*

Vegetation area	Grassland surface	Phytomass amount (thousands tones DM)	Average Fabaceae species (%)	Total amount of Fabaceae (thousands tones DM)	Nt from Fabaceae species (%)	Ndfa *) (%)	Nfixed from Nt (%)	Total amount of Nfixed (t)	Quantity of N fixed and transferred to non-leguminous species from rhizosphere (t)
Plain	0.6	609	11.0	67	3.37	80	2.70	1809	326
Hill	2.5	3272	12.0	393	3.42	70	2.39	9393	1691
Mountain	1.7	1029	5.0	51	2.78	40	1.11	566	102
Total/Average	4.8	4910	9.3	511	3.19	63	2.07	11768	2119

*) Ndfa – N derivate from atmosphere (average values from: BROWMAN et. al., 1996; JACOT et. al., 2000; ROSS et. al., 2008; YANG et. al., 2011; DRAGOMIR, 2012)

Legume species in the floristic composition of permanent grasslands represent an important source of N supply to these natural ecosystems, through the amount of biologically fixed N (BFN). In this direction, in order to estimate the biological fixation capacity of N in the 4.8 million hectares of permanent grasslands in Romania, the results obtained by DRAGOMIR and collaborators, over a period of 40 years and presented in the paper entitled "N fixation in grassland and perennial leguminous ecosystems, 2012". For the quantitative estimation of fixed N, the N difference method was applied (proposed by ROSS et al., 2008 with the modifications made by DRAGOMIR, 2012), based on the indirect determination of the proportion of N originating from the atmosphere (% Ndfa) and the difference of Nt between the Nt content of the legumes and the Nt of the grasses in the vegetal carpet.

Analyzing the data presented in table 7, based on the average values obtained, it results that, in the botanical composition of permanent grasslands in Romania, the proportion of *fabaceae* species varies between 5-12%, depending on the vegetation area and altitude, and the quantitative value of these species it is 67,000 t SU in the plain area (13%), 393,000 t SU in the hill area (77%) and 51,000 t SU (10%) in the mountain area. The total amount of symbiotically fixed N in permanent grasslands, by vegetation zones, is as follows: 1809 t (15%) in the plain area, 9393 t (80%) in the hill area, 566 t (5%) in the mountain area.

3.7. The Economic Value of Services and Resources of Permanent Grasslands in Romania

The functions and services of natural ecosystems determine, directly and indirectly, a series of benefits for human populations, estimated by CONSTANZA et al., in the 17 ecosystem categories, respectively: regulation of greenhouse gases (GHGs), climate regulation, ecosystem regulation, water regulation, water storage, erosion control, soil formation, nutritional cycles, waste treatment, pollination, biological control, refuge habitats, food production, material production, genetic resources, services recreational, cultural services [22]. The economic value of these services and resources, at worldwide level, has been estimated at $16-54 trillion ($10^{12}$)/year, with an average of $33 trillion/year.

The studies carried out by LIU et. al., (2022), on natural grassland ecosystems at Earth level, estimated a total value of the services of these surfaces of $2.76 trillion/year [46]. Depending on the type of grasslands, the value of ecosystem services varies as follows: tropical grasslands have an economic value of $5464/ha/year, Mediterranean grasslands a value of $4600/ha/year, temperate grasslands a value of $4254/ha/year, semi-desert grasslands a value of $3955/ha/year and other types of grasslands a value of $4436/ha/year.

Romanian permanent grasslands, structured altitudinally, in three vegetation zones (13% in the plain area, 52% in the hill area, 35% in the mountain area), represent, after the forests, the most important natural ecosystem. Both in terms of biodiversity and economic value. Following the grassland studies carried out in our country, it can be appreciated that this ecosystem produces more than 25 ecosystem services and functions, less evaluated and known from an economic, ecological and social point of view.

Table 8. *The economic, social, ecological and cultural value of some services and resources offered by permanent grasslands in Romania.*

Structure of services and resources	Euro/year			Lei/year		
	Tarif	€/ha	Total mil. euro	Tarif	lei/ha	Total mil. lei
Value of phytomass production (green mass)	14 €/t	70	336	10 lei/t	350	6
The value of animals	404 €/ha	404	1938	2002 lei/ha	2002	32
The melliferous value	6 €/kg	192	230	30 lei/kg	960	4
Phytotherapeutic value	2 €/kg	80	96	10 lei/kg	400	2
Sequestered C value	50 €//ha	50	240	250 lei/ha	250	4
The amount of C stored in soil organic matter	320 €/ha	320	1536	1600 lei/ha	1600	26
N fixed value (NFB)	1.11 €/kg	3	13	5.5 lei/kg	14	1
Pollination service	70 €/ha	70	336	350 lei/ha	350	6
Water storage and regulation service	100 €/ha	100	480	500 lei/ha	500	8
Cultural value	60 €/ha	60	288	300 lei/ha	300	5
Educational and scientific value	15 €/ha	15	72	75 lei/ha	75	1
Aesthetic and recreational value	60 €/ha	60	288	300 lei/ha	300	5
TOTAL	x	x	5853	x	x	100
Average (€/ha, lei/ha)	x	x	1220	x	x	x

In order to carry out this study, personal research was taken into consideration, as well as some results obtained in the country and abroad

Thus, in order to estimate the economic value of the services and resources of grasslands, in addition to those presented previously, the following reference scientific papers were also consulted: [23, 26, 43-45, 47, 48].

Thus, taking into account the existing natural conditions in the area of permanent grasslands and their productive potential, the economic value of phytomass production, the value of animals in grassland habitats, the melliferous value, the phytotherapeutic value, the sequestered C value, the cultural value, the educational value and scientific, aesthetic and recreational value was determined.

The calculated results and presented in table 8 show that at the level of the 4.8 million hectares of permanent grasslands, a total value of ecosystem services and resources, taken in the study, was estimated at 29265 million lei/year, or 5853 million euros/year. On average, per surface unit, the economic value of ecosystem services and resources of permanent grasslands was estimated at 6097 lei/ha/year, or 1220 euros/ha/year. Among the 12 service categories, the largest share in the total economic value is given by: livestock value with 32%, stored C value with 26%, water storage service with 8% and pollination service with 6%.

4. Conclusions

1 Multifunctional management is based on the knowledge and assessment of the many functions, services and processes specific to each agroecosystem, including permanent grasslands;

2 Sustainable utilization of farmland by use of grassland multifunctionality, can be achieved by adapting the technologies of permanent and temporary grasslands and livestock for promoting sustainable agricultural systems, with minimal effects of climate changes.
3 The economic quantification of some ecosystem services and functions of permanent grasslands in Romania estimated a total value of 29265 million lei/year, or 5853 million euros/year, with an annual average of 6097 lei/ha, or 1220 euros/year;
4 In perspective, the development of the concept of multifunctionality opens up new horizons in grassland research that necessarily involves the application of multidisciplinary and transdisciplinary research, carried out in complex teams of researchers, from related research fields.

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] LEMAIRE G., 2007, Research priorities for grassland science; the need of long-term integrated experiments networks. Revista Brasileira de Zootechinia, SCIELO Brasil.

[2] HOPKINS A., HOLZ B., 2006, Grassland for agriculture and nature conservation: production, quality and multi-functionality. Agronomy Research, 4 (1), 3-20.

[3] JEANGROS B., THOMET P., 2004, Multi-functionality of grassland systems in Switzerland. Grassland Science in Europe, vol. 9, 11-23.

[4] BUGALHO N. M., ABREU M. J., 2008, The multifunctional role of grasslands. CIHEAM/FAO/ENMP/SPPF, 25-30, serie A.

[5] BUCHMANN N. et. al., 2019, Multifunctionality of permanent grasslands: ecosystem services and resilience to climate change. Grasslands Science in Europe, vol. 24, 19-26.

[6] AMIAUD B., CARRERE., 2012, Grassland multifunctionality in providing ecosystem services. Forages, no. 211, 229-238.

[7] RICHTER F., et al., 2021, A guide to assess and value ecosystem services of grasslands. Ecosystem Services, no. 52, 1-17.

[8] JARCHOW M., SWANSON D., KERBY J., 2020, North American grasslands as multifunctional landscapes. Life and Land, 744-763.

[9] DRAGOMIR N: et al., 2008, Multifunctionality structure of permanent pastures in Romania. Scientific Papers: Animal Science and Biotechnologies, 41 (1), 283-287.

[10] DRAGOMIR N: et al., 2009, Multifunctionality and sustainability of the utilisation of permanent pastures in Romania under condition of alternative utilisation. Proceeding of the 15 th European Grassland Federation Symposium Brno, pp. 87-90.

[11] DRAGOMIR N. şi cclab., 2009, Multifunctional utilisation of pastures in Romania. Scientific Papers: Animal Science and Biotechnologies, 42 (1), 191-194.

[12] DRAGOMIR N. et al., 2012, Energetic potential of Romania's grasslands. Scientific Papers: Animal Science and Biotechnologies, 45 (1), 387-389.

[13] DRAGOMIR N., 2005, Pajişti şi plante furajere. Ed. Eurobit Timişoara, 501 pag.

[14] MOCANU V. şi colab., 2021, Pajiştile României – resurse, strategii de îmbunătăţire şi valorificare. Ed. Universităţii Transilvania, Braşov, 289 pag.

[15] SOUSSANA J. F. et al., 2004, Carbon cycling and sequestration opportunities in temperate grasslands. Soil Use and Management, 20, 219-230.

[16] ION NICOLETA, 2008, Cercetări asupra valorii melifere a laminaceelor din pajiştile xerofite din Lunca Dunării. Lucrări stiinţifice Zootehnie şi Biotehnologii, vol. 41, Timişoara.

[17] MOTCĂ GH., 2010, Experimental results concerning grasslands multifunctional exploitation. Romanian Journal of Grasslands and Forage Crops, 2, 27-36.

[18] DECOURTYE A., MADER E., DESNEUX N., 2010, Landscape enhancement of floral resources for honeybees in agro – ecosystem. Apidologie, 41, 264-277.

[19] CIOBANU I., 2010, Honey potential of grasslands in Subcarpathian Ialomiţa. The annals of "Valahia" University of Târgovişte, 80-82.

[20] DINCĂ N., BARBU I., DUNEA D., 2014, An inventory of floristic composition in permanent grasslands of Rucăr – Bran corridor: application and perspectives of melliferous potential. Scientific Papers, Series A, Agronomy, vol. LXII, 157-162.

[21] LAL R., KIMBLE J., FOOLET R., COLE C. V., 1998, Potential of us cropland for carbon sequestration and greenhouse effect mitigation. Chelsea, Michigan, USA, Sleeping Bear Press.

[22] COSTANZA R. et al., 1997, The value of the world's ecosystem services and natural capital, Nature 387, 253-260.

[23] HȌNIGOVA I. et al., 2012, Survey on grasslands ecosystem services. Report to the EEA – European topic centre on biological diversity. Prague: Nature Conservation Agency of the Czech Republic, pp 78.

[24] FISHER B., TURNER R. K., 2008, Ecosystem services: classification for valuation. Biological Conservation, vol. 141, no. 5, 1167-1169.

[25] DUFRÈNE M., 2013, Quelle est la valeur de la biodiversite? ULg. Gembloux Agro- Bio-Tech.

[26] TOL R., 2008, The social cost of carbon: trends, outlines and catastrophes. Economics, vol. 2, 25, 1-24.

[27] HUYGHE C., 2009, La multifonctionnalité des praires en France II. Conciliation des fonctions de production et de préservation de l`environnement. Cahiers Agricultures, 18 (1), 17-16.

[28] BIRGE T., 2019, Report to the grassLIFE project, Latvian Fund for Nature.

[29] LOUVEAUX et al., 1978, Methods of Mellisapolynology, Bee World, 59, 139-157.

[30] POUSEPP L. and KOFF T., 2014, Pollen analysis of honey from the Baltic region, Estonia, Grana, 1-8 pp.

[31] VĂCARIU E. D., 2014, Multifuncţionalitatea pajiştilor permanente din judeţul Caraş-Severin, în contextul dezvoltării durabile. Teză de doctorat, USAMVB Timişoara, 224p.

[32] SCHINDLER D. W., 1999, The mysterious missing sink. Nature, 398, 105-107.

[33] LAL R., 1999, Global C pads and fluxes and the impact of agricultural intensification and judicious land use. World Soil Resources Report, 86, Rome.

[34] SIMS P. L., and BRADFORD J. A., 2002, Carbon dioxide fluxes in a southern plains prairie. Agricultura land Forest Meteorology, 109, 117-134.

[35] CIAIS P. et al., 2010, The greenhouse gas balance of European grasslands. Bio geosciences Discuss, 7, 5997-6050.

[36] CONANT R. T. et al., 2001, Grassland management and conversion into grassland: effects on soil carbon. Ecological Applications, 11, 343-355.

[37] JANSSENS I. A. et al., 2005, The carbon budget of terrestrial ecosystems at country-scale-European, case study. Bo geosciences, 2 (1), 15-26.

[38] CRUSH J. et al., 1983, Nitrogen fixation during 1979-1981 in 2 pastures on the Manawatu Plains. N. Z. J. Exp. Agric., 11, 17-20.

[39] EDMEADES D. C. and GOH K. M., 1978, Symbiotic nitrogen fixation in a sequence of pastures of increasing age measured by a15 N dilution technique. N. Z. J. Agric., 21, 623-628.

[40] LEDGARD S. F., 1991, Transfer of fixed nitrogen from white clover to associated grasses in swards grazed by dairy cows, estimated using 15N methods. Plant Soil, 131, 215-223.

[41] HOGH- JENSEN H. and SCHJOERRING J. K., 2000, Below-ground nitrogen transfer between different grassland species: Direct quantification by 15N leaf feeding compared with indirect dilution of soil 15N. Sol Biology and Biochemistry, 33, 439-448.

[42] RASMUSSEN J. et al., 2007, In situ carbon and nitrogen dynamics in ryegrass-clover mixtures: transfers deposition and leaching. Soil Biology and Biochemistry, 39, 804-815.

[43] DAHLIN S. and STENBERG M., 2010, Transfer of N from red clover to perennial ryegrass in mixed stand sunder different cutting strategies. Europ. J. Agronomy, 33, 149-156.

[44] PUYDARRIEUX P. and DEVAUX J., 2013, Quelle evaluation economique pour les services écosystémique rendus par les prairies en France métropolitaine? (Report no. 92). Colection "Etudes et documents".

[45] HUNGATE A. B. et al., 2017, The economic value of grassland species. Sci. Adv., 3, 1-8.

[46] LIU H. et al., 2022 The economic value of grassland ecosystem services: A global meta-analysis. Grassland Research, vol. 1, no. 1, 63-74.

[47] WILIAMS I. H., 1994, THE dependences of crop production within the European Union on pollination by honey bees. Agricultural Zoology Reviews, 6, 229-257.

[48] GALLAI N. et al., 2009, Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics, 68, 810-821.

[49] JACOT A. et. al., 2000, Symbiotic N2 fixation of various legume species along an altitudinal gradient in the Swiss Alps, Soil Biology and Biochemistry, Volume 32, Issues 8–9, Pages 1043-1052.