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ASSESSMENT OF THE PHYSICAL AND SOCIO-ECONOMIC POTENTIAL OF THE GRASSLANDS IN BANAT, ROMANIA IN A HOLISTIC APPROACH

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Abstract

Grasslands, the main natural resources of rural areas, are open systems, which are functionally and structurally linked with other geomorphological, climatic and/or socio-economic components. The purpose of the research was the diagnostic analysis of the grasslands in Banat, based on several criteria from: (i) the physical environment; (ii) the sphere of biodiversity and (iii) the socio-economic environment. For the analysis - diagnosis, 8 indicators were established: relief; reduction of livestock; the variation in the number of inhabitants; the area of grasslands /inhabitant; accessibility; overlap with protected areas; high biodiversity; touristic potential. Each experimental site was rated with a score according to the characteristics, later the final "grade" was established, and the spatial analyzes were done in the GIS environment. The obtained results show that the grasslands located in the hilly and mountainous areas had the highest scores for the predetermined indicators.They are grasslands restricted by climatic conditions and infrastructure, but they have a High Natural Value, they are located in protected areas and are considered areas with great touristic potential.

Key words: *grasslands, anthropogenic impact, socio-economic analysis, Banat, Romania*

INTRODUCTION

The grasslands cover approximately one third of the Earth's surface [7], distributed in varying proportions across all continents. These ecosystems fulfill multiple functions. In addition to their economic function, grasslands provide a series of services such as: environmental services, like maintaining the balance of greenhouse gases and the carbon cycle [2, 10, 6), biological control, protection of water and soil quality [17, 18]. Additionally, grasslands offer tourist services [8], cultural and social services [25, 34] and landscape elements [45].

Given the complexity of the pastoral space, a multicriteria analysis is necessary for its evaluation, serving as a support for decision-making or for advancing forecast scenarios.

Specialized literature presents numerous studies applying multicriteria spatial modeling using Geographic Information Systems (GIS), based on a differentiated approach to the involved factors, thus allowing for controlled determination of the weight of each factor [24, 22].

Spatial modeling can be applied in any type of study involving multifactorial approaches [46, 26], such as land stability [36], spatial modeling of carbon [11], hydrological risk [4, 38], spatial prediction of fire danger or natural hazard modeling [33].

Based on the spatial modeling techniques applicable to grasslands, the idea behind this study is based on the question: *"What is the physical and socio-economic potential of the grasslands in Banat?"* After analyzing studies in the specialized literature, it was found that in most cases, the evaluation and classification of grasslands are done unidirectionally: from a physico-geographical perspective, considering vegetation and land use, or as entities of the land fund. The working hypothesis of the study was formulated based on these findings, namely: a multicriteria approach, involving as many natural and anthropic factors as possible, spatialized, which provides the answer to the initial question. The necessity of such a holistic approach stems from the fact that grasslands are complex ecosystems and resources with multifunctional roles, especially within rural communities, which depend on them.

In this context, the aim of the research was the analysis-diagnosis and classification of the grasslands in Banat, based on several criteria of different aspects: (i) physico-geographical; (ii) biodiversity/subsidies; (iii) socio-economic environment, as well as to develop a spatial analysis model that integrates these factors for a holistic analysis of the pastoral space.

MATERIALS AND METHODS

The study area

Within this study, the grasslands in the southwestern region of Romania, specifically in Timiș and Caraș-Severin counties, were taken into consideration. The study area extends over a very wide altitudinal range, between 60 – 2,275 meters, encompassing a great variety of relief unitsabd landforms [41, 42], representing a complex territory from a geographical perspective. This is the first clue to the variability of grasslands in the area, identified based on Corine Land Cover (CLC) [15] datasets, covering an area of 238,866 hectares.

The working methodology

Within the study, 8 indicators were considered for the analysis of grasslands, with the final result being the map of grassland distribution, classified according to their potential.

With ArcGIS 10.4 software [5], the data selected and processed are shown in Figure 1.

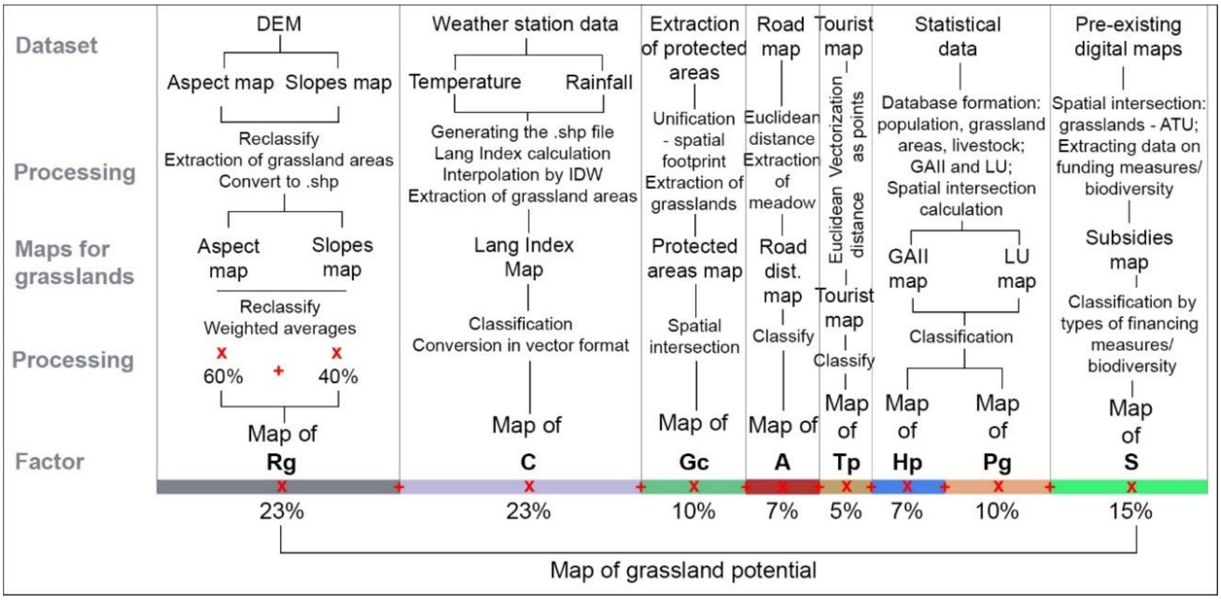


Fig. 1. The working methodology
Source: Original workflow.

- CLC data from the 2018 edition were used for identifying grasslands; cadastre maps, satellite images, and orthophoto plans were utilized for updating the geometries of the grasslands [1, 16];
- The Digital Elevation Model (DEM) with a spatial resolution of 25 meters, freely available through the Copernicus program [20], was utilized. From the DEM, slope maps (in degrees) and aspect maps were generated, necessary for determining the relief factor of grasslands (Rg);
- Climatic data including monthly average temperatures and monthly precipitation amounts were recorded at 13 meteorological stations in the area of interest for the year 2022 [12]. These data were used to calculate

the Lang Rainfall Index (R) used for the Climatic Factor (C);
- the natural protected areas boundaries [37] were used to determine the Grassland Conservation Factor (Gc);
- the road network in shapefile format [20] was utilized to determine the Accessibility Factor (A), while the tourist map of Banat [29] was used for spatializing the Tourism Potential Factor (Tp);
- Administrative-Territorial Units (ATU) boundaries and statistical data regarding the total population [30] and livestock numbers [19] were used to generate the Human Potential Factor (Hp) and the Potential for Animal Grazing Factor (Pg);
-the map showing the distribution of eligible areas for Measure 10 (M10) – Agri-environment and climate (with different Packages – P) and Measure 13 (M13) – Payments for areas facing natural constraints (ZM) or other specific constraints (SEMN) [3] was used to generate the Grassland Subsidies Factor (S) - to preserve biodiversity, without considering the amount (vary from year to year).

The indicators, expressed as thematic maps, analyzed within the spatial model for grassland analysis, were classified and quantified according to Table 1. The ratings for each indicator were awarded based on the degree of impact, ranging from 1 (no or weak impact) to 5 (very high impact).

Table 1. The quantification of indicators for grassland evaluation

Factor	Rg		C	Gc	A	Tp	Hp	Pg	S[4]
Data used for indicators	Slope map(40)	Aspect map(60)	Lang index(R)[1]	Map of protected areas(Pa)	Distance to roads (km)	Distance to landmarks(km)	GAII[2] (ha/ inhabitant)	Pg[3] (LU/ha)	-
Impact on grasslands									
1 - Null or very low	0–5	E - SE	100-160	Pa Present	0-5	0-5	0.71-1	0.7-1	A
2 - Low	5.1–10	S - SV	>160		5.1-10	5.1-10	1.1-4	0.41-0.7	B
3 - Moderate	10.1-20	V	60-100		10.1-15	10.1-15	0.51-0.7	1.1-3	C
4 - High	20.1–35	NV – NE	40-60		15.1-20	15.1-20	0.1-0.5	0-0.4	D
5 –Very high	35.1-58	N	20-40	Pa Absent	20.1-25	20.1-25	4.1-8	4.1-12	E

Legend

1	R = P / T P – Annualprecipitation(mm); T – annual average temperatures(ºC)Climate: 20-40 – steppe; 40-60 – semiarid; 60-100 – warm temperate; 100–160 – temperatehumid; >160 – humid (Satmari, 2010) [43]	3	Pg = LU / grassland area LU – livestock units; LU/ha LU = No. of animals x conversion coefficient: 1 – cattle; 0.14 – goats, sheep (Iacob et al., 2015) [28]
2	GAII = The area of grasslands/ inhabitant GAII - Grassland Anthropic Impact Index Ha/inhabitant (Cojocariu et al., 2024) [14]	4	The classification applies to differentiated subsidy categories: Category a - M10-P1, P2.1, P2.2, M13-ZM; Category b - M10-P1, P2.1, P2.2, M13-SEMN; Category c - M10-P1, P2.1, P2.2; Category d – M10-P11.2.1, P11.2.2, P11.2.3, P3.2.1, P3.2.2, M13-SEMN; Category e - Grasslands without subsidies from M10

Source: Original workflow based on literature data.

The class boundaries were established based on obtained data, field data, experiences, and specialized literature, adapted to the proposed grassland analysis model.

After obtaining ratings for each indicator, a weighted average was calculated in the GIS environment according to Figure 1.

The resulting grassland map was reclassified, and the grassland potential classes were obtained using the Natural Breaks classification method (Figure 2).

The grasslands of Banat have been divided into five classes: very high potential; high potential; moderate potential; low and very low potential.

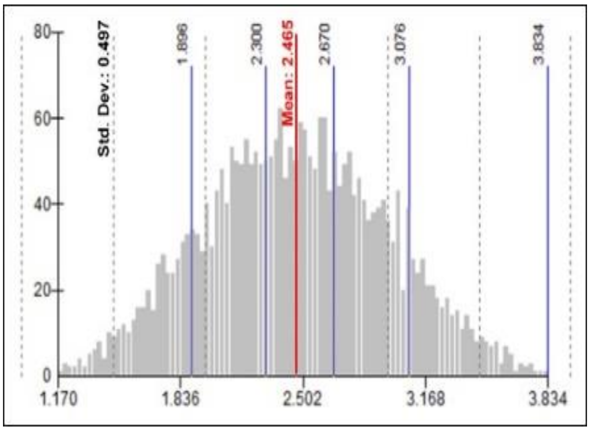


Fig. 2. The histogram of the dataset ”Grasslands”
Source: ArcGIS 10.4 [5].

RESULTS AND DISCUSSIONS

Relief Factor (Rg)

Previous research has demonstrated the direct and/or indirect influence of relief on the distribution and constitution of vegetation cover. Relief acts on vegetation both through the slope of the terrain [9, 23, 31] and through the aspect of the slopes [32, 35]. The design of the Rg factor was based on the following hypothesis: the impact of relief on grasslands is minimal on gentle slopes and southern aspects (highest-rated grasslands) and very significant on steep slopes and northern aspects (lowest-rated grasslands). Relief has null or weak impact on 19% (43,960 ha) of grasslands (rating 1), which are located in all component subzones (Figure 3). Grasslands with slopes ranging from 5-10º and southern, south-western aspects received a rating of 2, covering a mosaic area of 92,714 ha (40% of total grasslands).

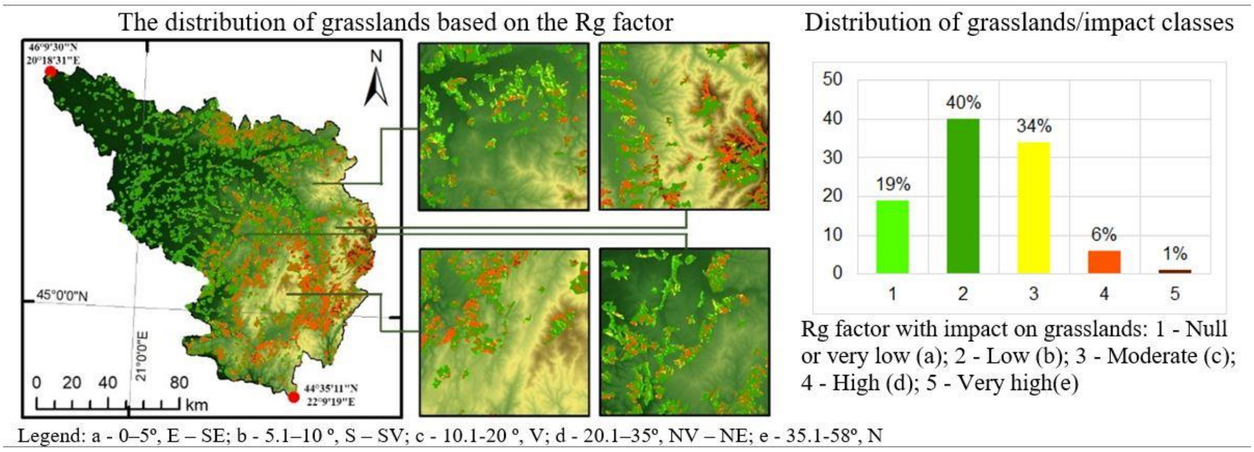


Fig. 3. The Rg factor in the study area
Source: Processing after: EEA, 2023; CLC, 2023; Geospatial, 2023 [20, 15, 21].

The relief has a moderate impact (rating 3) on 34% of grasslands (79,896 ha - slope between 10-20º and aspect west).

Grasslands with high (rating 4), 17,399 ha, and very high (rating 5), 552 ha, geomorphological risk, totaling 7% of the total, have slopes ranging from 20-58º and north-facing aspects; they are found in hilly and mountainous areas.

The climatic factor(C)

In this study, C was expressed through the Lang Rainfall Index, widely used in various climatic studies [43, 48] or phytological studies [44], to assess the precipitation-temperature relationship.

Depending on the requirements of grassland plants, we considered that the highest-rated grasslands are located in the temperate humid climate (rating 1), while the lowest-rated are the grasslands in the steppe climate (rating 5). Based on the C values, the grasslands in the analyzed area were classified according to Figure 4.

From Figure 4, it can be observed that 44% (104,459 ha) of the grassland areas are located in the temperate humid climate zone, which is beneficial for their vegetation and received a rating of 1. These are located in hilly areas and, with moderate temperatures and high precipitation levels. Among the analyzed grasslands, 31% (73,429 ha) fall into the humid climate zone (rating 2), in mountainous areas with low temperatures and high precipitation levels.

The remaining 26% of the total grasslands fall into the warm temperate (rating 3), semiarid (rating 4), and steppe (rating 5) climates, typical of plain regions with high temperatures and low precipitation levels.

The Grassland Conservation Factor(Gc)

In recent decades, both internationally and in Romania, there has been increasing emphasis on conserving grassland habitats. After Romania's accession to the European Union, the areas included in protected areas of various categories have significantly increased [13, 40, 47].

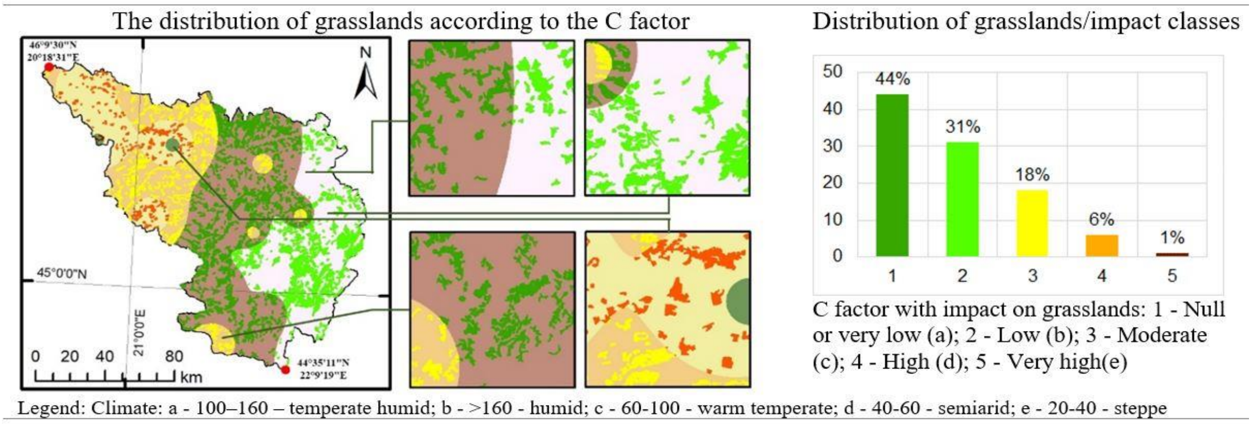


Fig. 4. C factor in the study area
Source: processing after: CLC, 2023; Climatic databases, 2023; Geospatial, 2023 [15, 12, 21].

In the study area, protected areas have a territorial "footprint" of 396,028 ha. Grasslands included in natural areas are aimed at preserving biodiversity and conserving genetic resources. Protected areas overlap with 21% of grasslands (50,691 ha) and have been rated with 1 (maximum value), while grasslands not within protected areas have been rated with 5.

The Accessibility Factor (A)

Studies in the field have shown that grasslands are exploited differently depending on accessibility, especially those near settlements and roads with immediate access are more intensively used [35]. The A factor is an indirect factor in grassland management, and we considered that its impact increases as they move away from access roads (Figure 5).

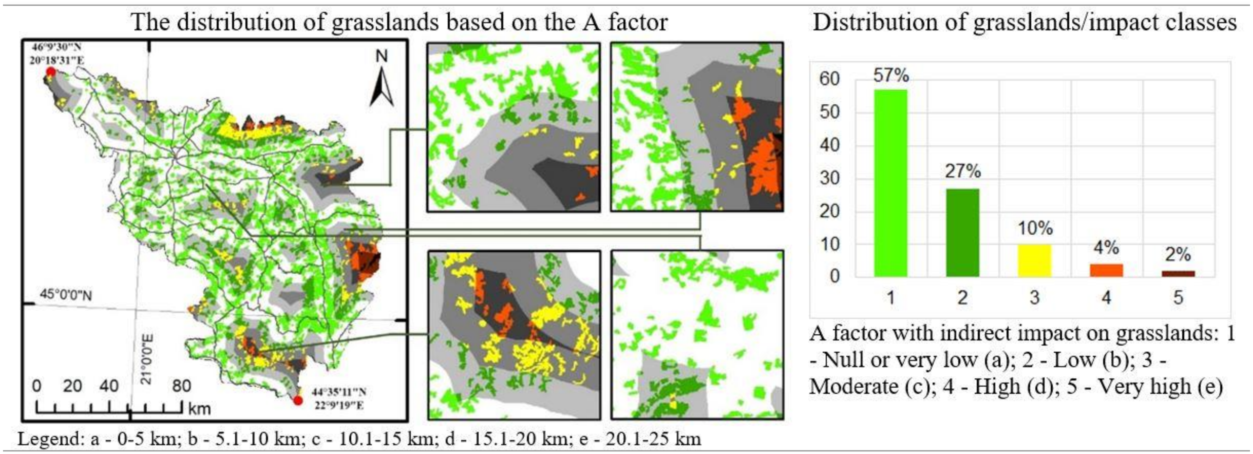


Fig. 5. A factor in the sudy area
Source: processing after: CLC, 2023; Geospatial, 2023 [15, 21].

Among the grasslands, 57% (136,509 ha) are located at distances less than 5 km from access routes (rating 1); 37% of grasslands (64,224 ha) were classified with a rating of 2, being located at distances between 5–10 km from the main access routes. Out of the total grassland area, 16% are located at distances between 10–25 km from the main roads, which classifies them with a lower score (in the high mountain area). Accessibility, broadly understood (transport infrastructure, water sources), plays an important role in the lives of livestock breeders and in the marketing of products. In plain areas, easily accessible, milk sales are daily, even twice a day. This explains the concentration of animals (sheep) in plain areas, which are more easily accessible, even though the grasslands occupy smaller areas and have a lower production potential.

The Tourism Potential Factor (Tp)

In Banat, there are many tourist and cultural attractions, natural and man-made (Figure 6).

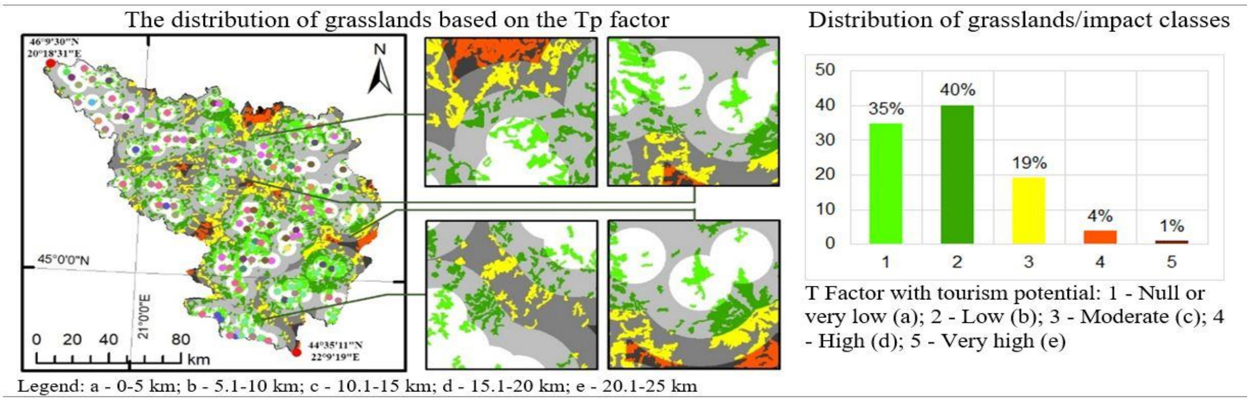


Fig. 6. Tp factor in the study area
Sourc: processing after: CLC, 2023; Geospatial, 2023; Intercultural Institute, 2023 [15, 21, 29].

In this study, the analysis of the tourist potential of grasslands was done based on their proximity to various attractions: balneoclimatic resorts, water mills, castles, industrial heritage, etc.

Additionally, the location of grasslands in areas with specific traditions (German, Hungarian, Serbian etc.) was taken into account, many of which are carried out in grasslands (rural festivals) or have connections to pastoral space, such as sheep measuring rituals [27].

Grasslands located close to tourist attractions were rated with maximum scores, on the principle that they can be easily integrated into tourist circuits.

Thus, 35% of the analyzed grasslands (83,348 ha) are located within 5 km of tourist attractions (Figure 6), being included in the class with the highest potential (rating 1).

The Human Potential Factor (Hp)

One of the most important resources of a territory is the human population, and in relation to grasslands, people direct the mode of exploitation and valorization, the dynamics of areas, or the role of these resources in the local economy.

In Banat, the anthropogenic potential in the exploitation of grasslands, appreciated through the GAII index [14], varies territorially (Figure 7).

Based on Hp, grasslands were rated as follows (Figure 7): with rating 1, accounting for 13% (30,240 ha), grasslands where GAII had optimal values (0.71 - 1.0 ha/inhabitant); with rating 2, accounting for 33% (78,686 ha), GAII values ranging between 1.1 - 4.0 ha/inhabitant; with rating 3, respectively 15% (36,634 ha), with GAII values between 0.51 - 0.70 ha/inhabitant; with rating 4, accounting for 33% (79,897 ha), with reduced GAII values, between 0.01 - 0.5ha/inhabitant; with rating 5, accounting for 6% (13,311 ha), with GAII ranging between 4.1-8.0ha/inhabitant.

In calibrating this indicator, we considered that low GAII values may indicate overexploitation of grasslands, while high values may indicate underutilization.

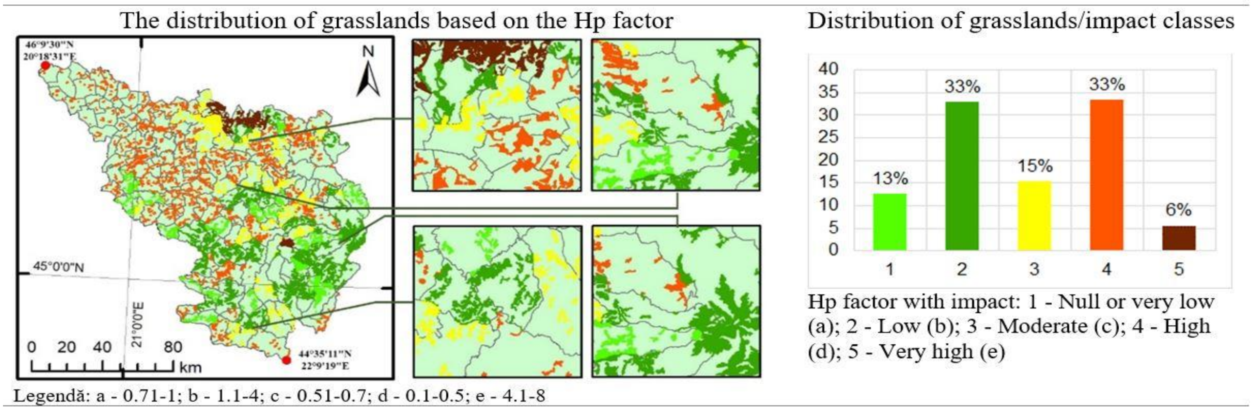
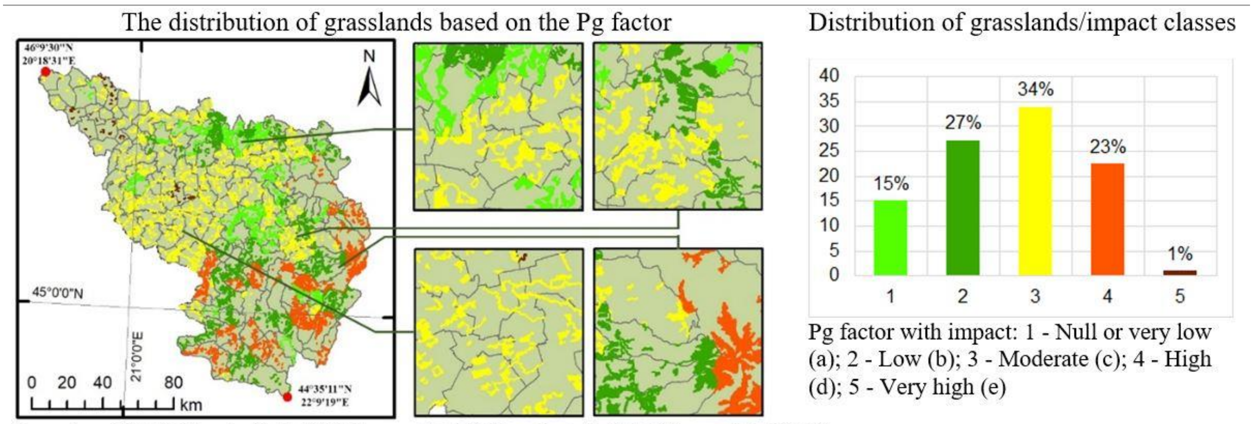


Fig. 7. Hp factor in the study area
Source: processing after: CLC, 2023; Geospatial, 2023; INS, 2023 [15, 21, 30].

Potential for Animal Grazing Factor (Pg)

In the case of grasslands, one of the modes of exploitation is their use with animals (Figure 8).

The current situation in our country shows that in the plain areas there are many animals and a small area of grasslands, while in the hilly areas where there are many grassland areas, the number of animals is reduced (INS, 2023)[30]. This situation is also reflected at the level of the study area (Figure 8).



Legend: a - 0.7-1 LU/ha; b - 0.41-0.7 LU/ha; c - 1.1-3 LU/ha; d – 0.01-0.4 LU/ha; e - 4.1-12 LU/ha

Fig. 8. Pg factor in the study area
Source: processing after: CLC, 2023; Geospatial, 2023; data.gov, 2023 [15, 21, 19].

In this context, we considered Pg as a factor for quantifying the 'density' of animals (LU) per unit area (ha). To enable integrated analysis, we quantified all categories of animals (cattle, sheep, goats) in LU.

From Figure 8, it can be seen that 15% of the total grassland area in the analyzed area (36,131 ha) received a rating of 1, with values ranging from 0.7 to 1.0 LU/ha (considered optimal for grassland exploitation). Of the total grasslands, 27% (65,200 ha) were rated 2, with values between 0.41 and 0.7 LU/ha, mainly in depressions or hilly areas, accessible areas with more intense agricultural activities. A percentage of 34% (81,043 ha) of the grasslands were quantified with a rating of 3, with values between 1.1–3.0 LU/ha, in the plain areas with a large number of animals and reduced grassland areas (risk of overexploitation).

In contrast, the grasslands rated 4, with values between 0.01 and 0.4 LU/ha, are found in mountainous areas (risk of underutilization and abandonment).

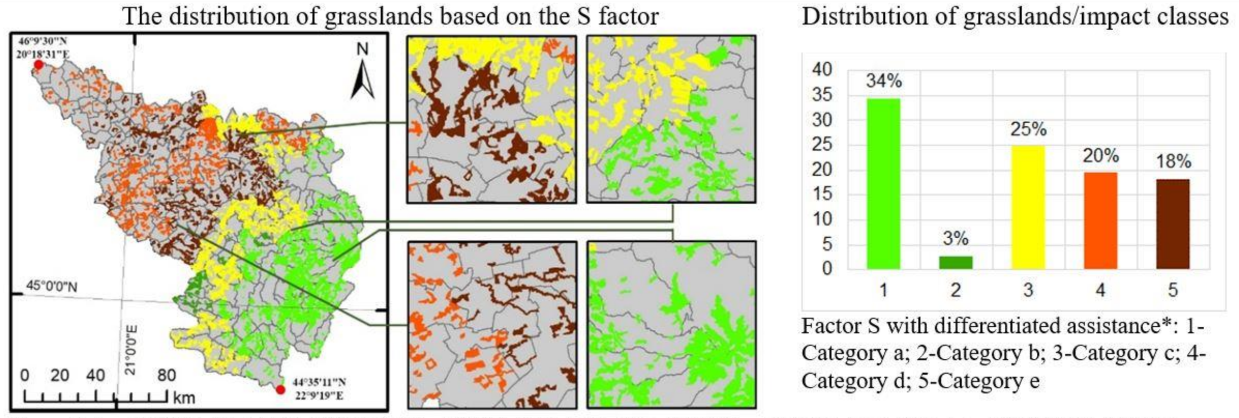
The Subsidies Factor for Grasslands(S)

At the EU level and implicitly in Romania, through the Common Agricultural Policy (CAP) and/or national programs (PNDR) [38], grasslands benefit from subsidies for exploitation. Measure 10 for Agri-environment and climate (M10) protects the biodiversity of grassland habitats and at the same time ensures the protection of soil, water, and carbon sequestration, in accordance with the principles of sustainable development.

In conceiving Factor S (Figure 9), the amount of subsidies was taken into account.Thus, M10 provides subsidies for forage losses, for High Nature Value Grasslands (used in traditional systems), and for Grasslands Important for Birds (used in extensive systems, with the protection of bird species nesting there).

Depending on the area, additional subsidies are added for initial packages through Measure 13, which includes areas located in mountainous regions (ZM) or areas with significant natural constraints (SEMN). The measure also provides subsidies for animals from traditional breeds, but this is not the subject of studies in this work, strictly referring to grassland areas.

The spatialization of factor S, at the level of Banat, showed that 34% of grasslands (82,150 ha) are under the incidence of M10 (HNV grasslands, in packages P1, P2, with the related variants) and M13-ZM, being located in mountainous areas and included in the maximum subsidy category (grade 1). In the second subsidy category, grasslands under the incidence of M10 (HNV grasslands), but located in SEMN, represent 3% of the total (6,627 ha). Category 3 funding includes only HNV grasslands (M10), located in hilly areas and depressions, accounting for 25% of total grasslands (59,505 ha). Looking strictly from a biodiversity perspective, grasslands included in category 3 are the most valuable, being complex ecosystems with a large number of species, grasslands unaffected by restrictive environmental conditions. Category 4 includes Grasslands Important for Birds, accounting for 20% of the total, located in plain areas and in the Lipova Hills. The minimum score (grade 5) was assigned to semi-natural grasslands that do not benefit from subsidies from M10, accounting for 18% (43,714 ha), located in the plain and hills.



*Legend: 1 a - M10-P1, P2.1, P2.2; M13-ZM; 2 b - M10-P1, P2.1, P2.2, M13-SEMN;3 c - M10-P1, P2.1, P2.2; 4 d –M10-P11.2.1, P11.2.2, P11.2.3, P3.2.1, P3.2.2, M13-SEMN; 5 e –grasslands without subsidies fromM10

Fig. 9. S factor in the study area
Source: processing after: CLC, 2023; Geospatial, 2023; PNDR, 2020; APIA, 2023 [15, 21, 38, 3].

Multicriterial analysis of grasslands

From the analysis depicted in Figure 10, it can be observed that the grasslands in Banat are classified into five classes based on their physical-geographic and socio-economic potential. Out of the total grassland area, 11% (24,558 ha) were categorized into Class 1, indicating very high potential. These grasslands are primarily located in the mountainous area, on plateaus, and in intramontane depressions; they are not restricted by relief factors and have minimal impacts regarding exploitation factors (Hp and Pg) and accessibility. These grasslands exhibit a high degree of biodiversity, overlap with protected areas, benefit from subsidies, and can be utilized for agrotourism purposes. Grasslands with high potential have been identified on 24% (55,155 ha) of the total area considered. They are mainly found in mountainous areas, depressions, and high hills.

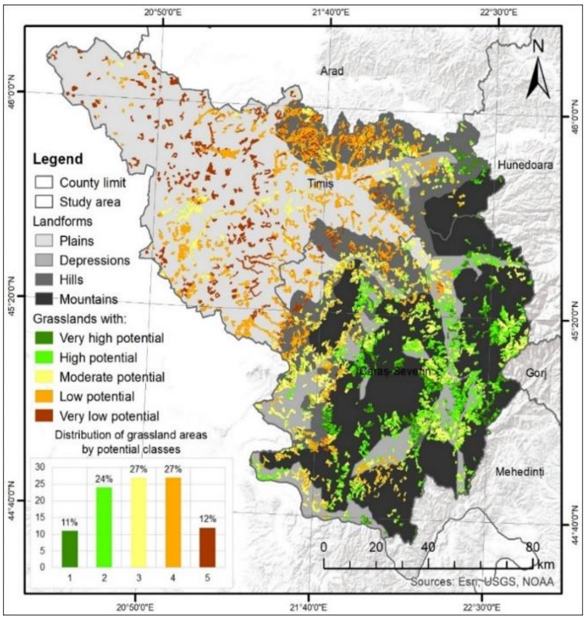


Fig. 10. The distribution of grasslands by potential
Source: processing after: CLC, 2023; Geospatial, 2023. [15, 21].

In their case, factors such as Rg, Hp, and Pg have a weak to moderate impact, while the other considered factors remain within optimal parameters. Grasslands with moderate potential (Figure 10), identified on 27% (62,097 ha) of the total area, are scattered from the lower mountain ranges to lowland areas.

In the case of these grasslands, the impact of the Rg factor is felt, most do not overlap with protected areas, the GAII index has lower values in certain areas, leading to a reduced number of animals. However, there is a high potential regarding climatic conditions, accessibility, and the fact that over 70% are HNV grasslands benefiting from subsidies.

Grasslands with low potential represent 27% (62,055 ha) of the total and are located in lowland and low hill areas. They are negatively impacted by factors such as Rg, C, Gc, Hp, and Pg. However, these are grasslands that benefit from subsidies to the extent of 80%, of which 60% are for HNV grasslands and 20% for important bird areas.

Grasslands with very low potential represent 12% (28,791 ha) of the analyzed grassland area. They are generally located in the lowland and Lipova Hills area and are disadvantaged by climatic conditions and exploitation factors (high population and large animal stocks relative to small grassland areas). Most of these grasslands are degraded due to overgrazing and lack of care.

CONCLUSIONS

The grasslands in Banat are located in different geographical conditions (plain, hill, mountain), which create territorial differences in their physical and socio-economic potential. Some grasslands are situated in subzones more favorable for harmonious development on multiple levels, while others face various degrees of difficulty (risk and/or impact factors).

The spatial variability of grasslands has been demonstrated through the eight indicators analyzed in this study. Their values differ both horizontally and vertically.

Based on the multicriteria analysis model applied in this study, it is evident that out of the total grassland area, 11% have very high potential, 24% have high potential, 27% have moderate potential, 27% have low potential, and 12% have very low potential.

According to the evaluation indicators established in the study, grasslands with the highest physical and socio-economic potential in Banat are located in mountainous areas, intramontane depressions, and hilly zones.

Spatial analysis models of grasslands based on individual and spatialized indicators in the form of thematic maps provide both the opportunity to use the results obtained separately for each indicator and to create an integrated overview considering all indicators. Such studies are useful in rural development strategies, spatial organization and territorial planning, regional economic development plans, pastoral management plans, and/or protected area management plans.

REFERENCES

[1]ANCPI.National Agency of Cadastre and Real Estate Advertising, 2023, Geospacial database, https://geoportal.ancpi.ro/portal/home/, Accessed on 15.02.2022.

[2]Ali, I., Cawkwell, F., Dwyer, E., Barrett, B.,Green, S., 2016, Satellite remote sensing of grasslands: From observation to management. J. Plant. Ecol, 9, 649–671

[3]APIA, Payment and Intervention Agency for Agriculture, 2023, Maps for the distribution of the eligible zones at the county, local center level, https://apia.org.ro/materiale-de-informare/materiale-de-informare-anul-2019/, Accessed on 20.04.2022.

[4]Allamano, P., Claps, P., Laio, F., 2009, Global Warming Increases Flood Risk in Mountainous Areas. Geophys. Res. Lett, 36, L24404

[5]ArcGIS Documentation, 2022, https://desktop.arcgis.com/en/documentation/, Accessed on 25.03.2022.

[6]Bai, Y., Cotrufo, F., 2022, Grassland soil carbon sequestration: current understanding, challenges, and solutions. Știință, 6606, 603 – 608 . https://doi.org/10.1126/science.abo238

[7]Bangira, T., Mutanga, O., Sibanda, M., Dube, T., Mabhaudhi, T., 2023, Remote Sensing Grassland Productivity Attributes: A Systematic Review. Remote Sens., 15, 2043.

[8]Bengtsson, J., Bullock, J.M., Egoh, B., Everson, C., Everson, T., O’Connor, T., O’Farrell, P.J., Smith, H.G., Lindborg, R., 2019, Grasslands—More important for ecosystem services than you might think. Ecosphere, 10, e02582

[9]Bennie, J.J., 2003, The ecological effects of slope and aspect in chalk grassland. Doctoral thesis, Durham University, http://etheses.dur.ac.uk/4017/, Accessed on 12.12.2023.

[10]Bernués, A., Alfnes, F., Clemetsen, M., Eik, L.O., Faccioni, G., Ramanzin, M., Ripoll-Bosch, R., Rodríguez-Ortega, T., Sturaro, E., 2019, Exploring social preferences for ecosystem services of multifunctional agriculture across policy scenarios. Ecosystem Services, 39, 101002.

[11]Canaza, D., Calizaya, E., Chambi, W., Calizaya, F., Mindani, C., Cuentas, O., Caira, C., Huacani, W., 2023, Spatial Distribution of Soil Organic Carbon in Relation to Land Use, Based on the Weighted Overlay Technique in the High Andean Ecosystem of Puno—Peru. Sustainability, 15, 10316

[12]Climatic databases, 2023, https://rp5.ru/Weather_in_Romania, Accessed on 17.01.2024.

[13]Cojocariu, L., Copăcean, L., Popescu, C., 2019, Conservation of grassland habitats biodiversity in the context of sustainable development of mountain area of Romania. APPL ECOL ENV RES 17 (4), 8877-8894, 10.15666/aeer/1704_88778894.

[14]Cojocariu, L.L., Copăcean, L., Ursu, A., Sărăţeanu, V., Popescu, C.A., Horablaga, M.N., Bordean, D.-M., Horablaga, A., Bostan, C., 2024, Assessment of the Impact of Population Reduction on Grasslands with a New "Tool": A Case Study on the "Mountainous Banat" Area of Romania. Land, 13, 134. https://doi.org/10.3390/land13020134

[15]Copernicus Land Monitoring Service-Corine Land Cover - CLC., 2022, https://land.copernicus.eu/pan-european/corine-land-cover, Accessed on 11.11.2023

[16]Copernicus Open Access Hub.(2023). https://scihub.copernicus.eu/dhus/#/home, Accessed on 10.11.2023.

[17]Craine, J.M., Ocheltree, T.W., Nippert, J.B., Towne, E.G., Skibbe, A.M.,Kembel, S.W., Fargione, J.E., 2012, Global diversity of drought tolerance and grassland climate-change resilience. Nature Climate Change, 3, 63–67. https://doi.org/10.1038/nclimate1634

[18]Cresswell, C.J., Cunningham, H.M., Wilcox, A., Randall, N.P., 2018, What specific plant traits support ecosystem services such as pollination, bio-control and water quality protection in temperate climates? A systematic map. Envir. Evidence, 7, 2–13.

[19]Data. Romania's Government, 2023, Data sets, https://data.gov.ro/, Accessed on 22.03.2022.

[20]European Environment Agency (EEA), 2023, Digital Elevation Model (EU-DEM), https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem, Accessed on 11.02.2022.

[21]Geospatial, 2023, Romania: Sets of general vectorial data, http://geo-spatial.org/vechi/download/romania-seturi-vectoriale, Accessed on 21.05.2023.

[22]Girard, L.F., Cerreta, M., De Toro, P., 2008, Integrated spatial assessment: A multidimensional approach for sustainable planning. In Proceedings of the MTISD 2008—Methods, Models and Information Technologies for Decision Support System, Lecce, Italy; pp. 277–280.

[23]Gonga, X., Brueck, H., Giese, K.M., Zhang, L., Sattelmacher, B., Lin, S., 2008, Slope aspect has effects on productivity and species composition of hilly grassland in the Xilin River Basin, Inner Mongolia, China. J ARID ENVIRON, 72(4); 483 - 493, https://doi.org/10.1016/j.jaridenv.2007.07.001

[24]Hailegebriel, S., 2007, Irrigation Potential Evaluation and Crop Suitability Analysis Using GIS and Remote Sensing Technique in Beles Sub Basin, Beneshangul Gumez Region. Master's Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

[25]Hartel, T., Fagerholm, N., Torralba, M., Balázsi, A., Plieninger, T., 2018, Forum: social-ecological system archetypes for European rangelands. Rangeland Ecology & Management, 5, 536–544.

[26]Herbei, M., Sala, F., 2022, Model for monitoring and estimating the production of alfalfa crop based on remote sensing, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22(4), 287-294.

[27]Hoancea, L., Copacean, L., Bordean, D.M., Cojocariu, L., 2017, Analysis of pasture vegetation in the west of Romania in correlation with pastoral traditions, SGEM 2017 Conference Proceedings, 29, Vol. 17(52), 33-40, DOI: 10.5593/sgem2017/52/S20.005

[28]Iacob, T., Vîntu, V., Samuil, C., Dumitrescu, N., 2015, Grassland- Characteritics- Improvement, Utilization (In Romanian), Ion Ionescu de la Brad Publishing House, Iasi, pp. 76.

[29]Intercultural Institute Timisoara, 2023, Culture and cross-border cooperation, Developing cultural tourism in Banat – A cross-border challenge, Map of Banat Region, https://www.intercultural.ro/wp-content/uploads/2020/05/Banatul-cultural.pdf. Accessed on 02.02.2024.

[30]Institutul Naţional de Statistică, National Institute of Statistics, INS, 2023, Tempo online, Statistical data bases, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on 01.02.2024.

[31]Lieffering, M., Newton, P.C.D., Brock, C.S., Theobald, W.P., 2019, Some effects of topographic aspect on grassland responses to elevated CO_2, Plant Production Science, 22(3), 345-351.

[32]Lieffers, V., Larkin-Lieffers, P., 2011, Slope, aspect, and slope position as factors controlling grassland communities in the coulees of the Oldman River, Alberta. CAN J BOTANY. 65. 1371-1378.

[33]Ma, Z., Mei, G., 2021, Deep learning for geological hazards analysis: Data, models, applications, and opportunities. Earth-Sci. Rev, 223, 103858.

[34]Martínez-Paz, J. M., Albaladejo-García, J. A., Alcon, F., 2023, When cultural services and biodiversity matter most: Gaining a deeper insight into badlands ecosystem services preferences. Land Degradation & Development, 34(2), 545–557

[35]Maruşca, T., 2017, Items d gradientics and mounatin ecology (Elemente de gradientică şi ecologie montană), In Romanian. Universitatea Transilvania Publishing House, Braşov, pp.30-45.

[36]Mehrnoor, S., Robati, M., Kheirkhah Zarkesh, M.M., Farsad, F., Baikpour, S., 2023, Land subsidence hazard assessment based on novel hybrid approach: BWM, weighted overlay index (WOI), and support vector machine (SVM). Nat Hazards 115, 1997–2030.
[37]Ministry of Environment, Water and Forests, 2023, GIS limits of the natural protected areas, https://www.mmediu.ro/articol/date-gis/434, Accessed on 23.04.2023.
[38]Ministry of Agriculture and Rural Development, 2018, National Programme of Rural Development (PNDR) 2014 – 2020, version December 2018, https://madr.ro/docs/dezvoltare-rurala/2018/PNDR-2014-2020-versiunea-VIII-aprobata-10-decembrie-2018.pdf, Accessed on 11.02.2023.
[39]Nguyen, H., 2022, Spatial modeling of flood hazard using machine learning and GIS in Ha Tinh province, Vietnam. Journal of Water and Climate Change. 14
[40]Nita, A., Hartel, T., Manolache, S., Ciocanea, C.M., Miu, I. V., Rozylowicz, L., 2019, Who Is Researching Biodiversity Hotspots in Eastern Europe? A Case Study on the Grasslands in Romania. PLOS ONE, 14 (5), e0217638.
[41]Posea, G., Badea, L., 1984, România. Relief units. Geormorphological regions (Unităţile de relief. Regionarea geomorfologică), In Romanian. Scientific and Enciclopaedic Publishing House, Bucharest, pp. 28-73.
[42]Rusu, R., 2007, Organization of the geopgraphic space in Banat (In Romanian), Mirton Publishing House, Timişoara, pp.23-52.
[43]Satmari, A., 2010, Practical works in Biogeography (Lucrări practice de biogeografie). In Romania. Eurobit Publishing House. Timişoara, 85 pp.
[44]Sărățeanu, V., Cotuna, O., Paraschivu, M., Cojocariu, L.L., Horablaga, N.M., Rechiţean, D., Mircov, V.D., Sălceanu, C., Urlică, A.A., Copăcean, L., 2023, Features of Natural Succession of Ex-Arable Forest Steppe Grassland (from Western Romania) under the Influence of Climate. Plants, 12, 1204. https://doi.org/10.3390/plants12061204
[45]Seppey, C.V.W., Lara, E.,Broennimann, O., Guisan, A., Malard, L., Singer, D., Yashiro E., Fournier, B., 2023, Landscape structure is a key driver of soil protist diversity in meadows in the Swiss Alps. Landsc Ecol 38, 949–965.
[46]Simon, M., Popescu, C.A., Copăcean, L., Cojocariu, L., 2020, Complex model based on UAV technology for investigating pastoral space. PESD, 14(2), 139 – 150. https://doi.org/10.15551/pesd2020142011
[47]Ursu, A., Stoleriu, C.C., Ion, C., Jitariu, V., Enea, A., 2020, Romanian Natura 2000 Network: Evaluation of the Threats and Pressures through the Corine Land Cover Dataset. Remote Sens. 12, 2075
[48]Vlăduţ, A., Nikolova, N., Licurici, M., 2017, Influence of climatic conditions on the territorial distribution of the main vegetation zones within Oltenia region, Romania. Oltenia. Studies and communicationsi. Ştiinţele Naturii. 33. 154-164.