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ANALYSIS OF PEDOCLIMATIC RESOURCES AND AGRICULTURAL LAND SUITABILITY FOR WHEAT CULTIVATION IN ȘIRIA COMMUNE, ARAD COUNTY

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Abstract. *This study examined pedoclimatic resources and agricultural land suitability for wheat cultivation in Șiria Commune, Arad County, Romania. The research integrated pedological and geomorphological descriptions, climatic records, and agricultural land use statistics from official territorial documents. Soil characteristics were assessed in relation to the ecological requirements of wheat, while climatic and agricultural indicators were analyzed using descriptive statistics. Particular attention was given to rainfall distribution during critical wheat growth stages. The territory includes chernozems, alluvial soils, and areas affected by excess moisture or salinity, reflecting differences in conditions for crop development. The climatic analysis revealed a mean annual temperature of 10.98°C and a long-term mean annual precipitation of 582 mm. Arable land covered 8,292.03 hectares, accounting for 60.65% of the administrative territory. Agricultural census data recorded 1,825.32 hectares cultivated with common wheat and spelt, equivalent to 39.28% of the area devoted to grain cereals. The integrated assessment indicated favorable conditions for wheat cultivation on deep, well drained lowland soils, whereas localized salinity, waterlogging, and erosion susceptibility represent potential constraints. The findings emphasize the importance of considering the combined effects of soil properties, water availability, and climatic variability when adapting agronomic practices and promoting sustainable nutrient management in wheat production systems.*

Keywords*: wheat; pedoclimatic conditions; agricultural land suitability; soil characteristics; sustainable agriculture*

INTRODUCTION

Common wheat (*Triticum aestivum* L.) is among the principal cereal crops and plays an essential role in food supply and the productive use of agricultural land. Although wheat can be cultivated under a wide range of ecological conditions, its yield level and stability depend on the correspondence between crop requirements and the characteristics of the growing environment. Assessing agricultural land suitability therefore provides a basis for identifying appropriate land uses and supporting site-adapted farming practices (TUĞAÇ et al., 2023; SIMÃO et al., 2024).

Suitability for wheat cultivation reflects the combined influence of pedological, geomorphological and climatic conditions rather than any single soil attribute. Topography, soil depth and texture, drainage and moisture regime contribute to spatial variation in agricultural potential. Recent suitability studies have emphasised the relevance of analysing these factors together, although the methods and data requirements differ according to the purpose and geographical scale of assessment (MAKAR et al., 2024; TUĞAÇ et al., 2023).

Temperature and water availability regulate wheat development throughout the growing cycle. In particular, heat and drought stress during reproductive stages may impair flowering and grain filling (SHOKAT et al., 2023). From an agrochemical perspective, soil moisture also affects nutrient mobility and root uptake, making water availability an important determinant of nutrient-use efficiency (LI et al., 2024). The interaction between environmental constraints and crop response supports the interpretation of pedoclimatic resources in relation

to mineral nutrition, without treating climatic or agrochemical characteristics in isolation (BHOITE et al., 2024).

Șiria Commune, in Arad County, occupies a transitional area between the Arad Plain and the Zarand Mountains. The association of lowland, piedmont and upland landforms creates contrasting pedological and hydrological conditions. Its soils include chernozems, alluvial soils and units locally affected by waterlogging or salt accumulation, which differ in their agricultural management requirements (ȘIRIA LOCAL AUTHORITY, 2014; URBIS GEOPROIECT, 2016).

This study aims to analyse the pedoclimatic resources of Șiria Commune and to assess the suitability of its agricultural land for wheat cultivation through a combined examination of soil and terrain characteristics, general climatic conditions and agricultural land-use structure. Particular attention is paid to favourable and restrictive factors, their territorial differentiation and their implications for sustainable land and nutrient management.

MATERIAL AND METHODS

The study focused on Șiria Commune, Arad County, comprising the settlements of Șiria, Galșa and Mâsca. The territory extends from the Arad Plain towards the Zarand Mountains, encompassing contrasting landforms and soil-forming conditions. The local development strategy reports an administrative area of 13,673 ha, of which 10,582.53 ha were classified as agricultural land in the territorial records reproduced from the 2011 General Urban Plan (ȘIRIA LOCAL AUTHORITY, 2014).

The documentary analysis combined information from the Local Development Strategy 2014–2020, the General Urban Plan explanatory report (2016), agricultural census statistics and recent administrative records. Territorial descriptions were complemented by the pedological survey synthesis published by ȚĂRĂU et al. (2023), including the distribution of major soil groups, arable-land quality classes, the reported weighted mean land-rating score and the occurrence of land limitations. The 2023 article compiles earlier pedological records and should not be interpreted as a field survey conducted entirely in that publication year.

Agrochemical interpretation focused on how documented soil characteristics may influence nutrient availability and crop mineral nutrition. Soil reaction, organic matter and moisture conditions were considered as factors affecting nutrient mobility and uptake, using established agronomic literature for the interpretation of mechanisms. No new soil sampling, laboratory analyses or fertiliser trials were undertaken, and no measured nutrient concentrations were assigned to the local soil units.

The climatic overview retained the mean annual air temperature and mean annual precipitation reported in the local strategy, identifying the corresponding reference period where available. The temperature value refers to 2002–2012, whereas the precipitation mean is presented in the local document without a directly comparable annual series. Recent national meteorological assessments were used exclusively as wider context, not as measurements for Șiria Commune (NATIONAL METEOROLOGICAL ADMINISTRATION, 2025).

Land-use categories were expressed in hectares and as percentages of the relevant administrative or agricultural reference area. Cereal areas were derived from the 2010 General Agricultural Census data reproduced in the local strategy. Soil-type and quality-class shares were calculated from the area totals provided by ȚĂRĂU et al. (2023). As these sources use different reference datasets and dates, comparisons were descriptive and were not interpreted as measured changes over time. Land suitability was considered qualitatively by relating

terrain, soil and moisture constraints to the ecological requirements of wheat; no new numerical land-rating scores or crop-specific suitability classes were calculated.

RESULTS AND DISCUSSIONS

Pedological and geomorphological characteristics of the study area

The natural setting of Șiria Commune is characterised by a transition from nearly level lowland terrain to the slopes of the Zarand Mountains. The western sector is dominated by relatively gentle landforms and sedimentary deposits, whereas the eastern piedmont and mountain sectors display distinct lithological, drainage and topographic conditions. This variability affects soil formation and the spatial organisation of agricultural land (ȘIRIA LOCAL AUTHORITY, 2014; URBIS GEOPROIECT, 2016).

The General Urban Plan describes cambic and argic chernozems, hydromorphic soils, alluvial soils and soil associations affected by salinity in the lower sectors. Brown and other forest-related soils are reported in the upland areas. A quantitative pedological synthesis for the commune is available in ȚĂRĂU et al. (2023), based on an agricultural reference area of 12,107 ha and on information compiled from historical pedological documentation.

Table 1

Distribution of major soil types within the agricultural reference area of Șiria Commune

Soil type	Area (ha)	Share (%)
Chernozems	7,033	58,09
Preluvosols	1,768	14,60
Phaeozems	1,114	9,20
Eutric Cambisols	654	5,40
Fluvisols	569	4,70
Gleysols	424	3,50
Solonetz	85	0,70
Other soil types	460	3,80
Total	12,107	100,00

Source: recalculated from Țărău et al. (2023), Table 2. "Other soil types" combines Leptosols, Vertisols and Anthrosols. Values refer to the source study's agricultural land base.

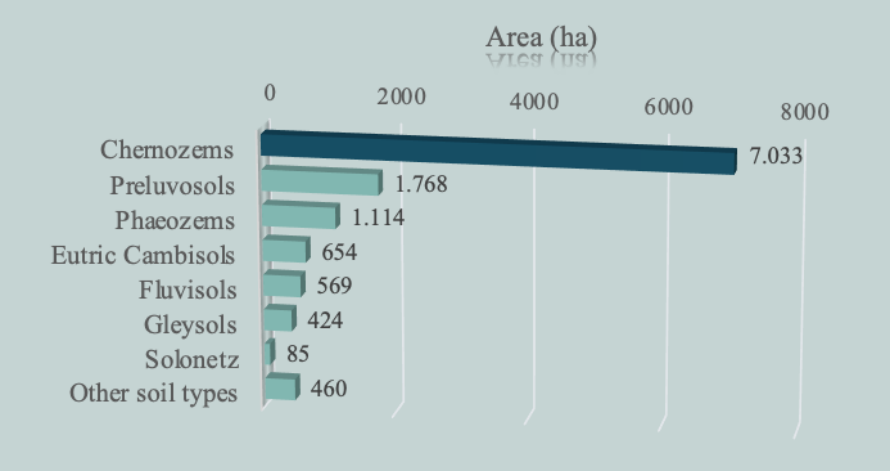


Figure 1. Area of major soil types in Șiria Commune, according to the pedological reference dataset of ȚĂRĂU et al. (2023).

Chernozems cover 7,033 ha (58.09%) and represent the largest reported group. Preluvosols account for 1,768 ha (14.60%), and Phaeozems for 1,114 ha (9.20%); collectively, these three groups comprise 81.89% of the agricultural reference area. Their distribution indicates substantial agricultural resources, but soil taxonomy alone does not determine the degree of suitability for a particular crop.

On deep chernozems with an adequate water regime, the rooting environment and the capacity to store and supply water can favour wheat cultivation. In contrast, textural differentiation within Preluvosols may affect water movement through the profile. Conditions also vary across alluvial and groundwater-influenced areas. Local differences in depth, drainage and root-zone conditions should therefore be considered alongside the broader distribution of soil groups (MAKAR et al., 2024).

Gleysols and Solonetz indicate specific potential constraints related to groundwater influence and sodicity. Salt-affected soil associations are also documented near Galșa (URBIS GEOPROIECT, 2016). Salt accumulation may restrict plant water uptake through osmotic effects, while exchangeable sodium can affect soil structural behaviour; these processes are not interchangeable and should be evaluated separately (KRAMER and MAU, 2023; LINDBERG and PREMKUMAr, 2024). Upland terrain adds limitations associated with slope, possible erosion and access for agricultural machinery. Consequently, agricultural suitability varies among local land units rather than following a uniform pattern across the commune.

Climatic conditions and implications for wheat cultivation

The local climatic setting is broadly temperate continental, with influences from westerly and south-westerly atmospheric circulation. The local development strategy reports a mean annual air temperature of 10.98°C for 2002–2012 and a long-term mean annual precipitation of 582 mm. It also indicates mean June precipitation of 88.6 mm and approximately 58% of annual rainfall during the warm season (ȘIRIA LOCAL AUTHORITY, 2014). These figures provide historical climatic reference points, rather than an updated climatological normal.

The National Meteorological Administration reported that 2024 was the warmest year in Romania in its national reference series and 2025 ranked fourth, with predominantly deficient precipitation nationally during 2025. These observations provide recent national context but cannot be interpreted as site-specific temperature or rainfall values for Șiria (NATIONAL METEOROLOGICAL ADMINISTRATION, 2025).

For winter wheat, the agronomic relevance of these conditions lies chiefly in how soil water availability and temperature affect crop development. Water deficit during stem elongation, heading and grain filling can constrain physiological activity and productivity. Recent studies highlight the importance of soil-water conservation for rainfed wheat systems and show that temperature and moisture stress around reproductive development can be especially damaging (ADIL et al., 2024; SHOKAT et al., 2023).

Soil moisture also affects nutrient transport towards roots and the efficiency of nitrogen uptake. Excessive wetness, conversely, can impair root functioning and increase the potential for nitrogen losses. Therefore, climatic suitability is best interpreted jointly with soil depth, texture, drainage and nutrient-management conditions; mean climatic indicators by themselves are insufficient to predict field-level crop performance (LI et al., 2024; HE et al., 2024).

Agricultural land use and the role of wheat

The land-use records reproduced in the local strategy describe a predominantly agricultural commune. Of the reported 13,673 ha of administrative territory, 10,582.53 ha

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(77.40%) were classified as agricultural land according to the underlying 2011 General Urban Plan records (Șiria Local Authority, 2014).

Table 2

Land-use structure of Șiria Commune in the earlier territorial records

Land-use category	Area (ha)	Share (%)
Arable land	8,292.03	60,65
Pastures and hayfields	1,252.34	9,16
Vineyards	1,037.72	7,59
Orchards	0.44	<0,01
Total agricultural land	10,582.53	77,40
Non-agricultural land	3,090.47	22,60
Total administrative area	13,673.00	100,00

Source: Șiria Local Authority (2014), based on 2011 General Urban Plan records. Agricultural and administrative totals are not independent categories.

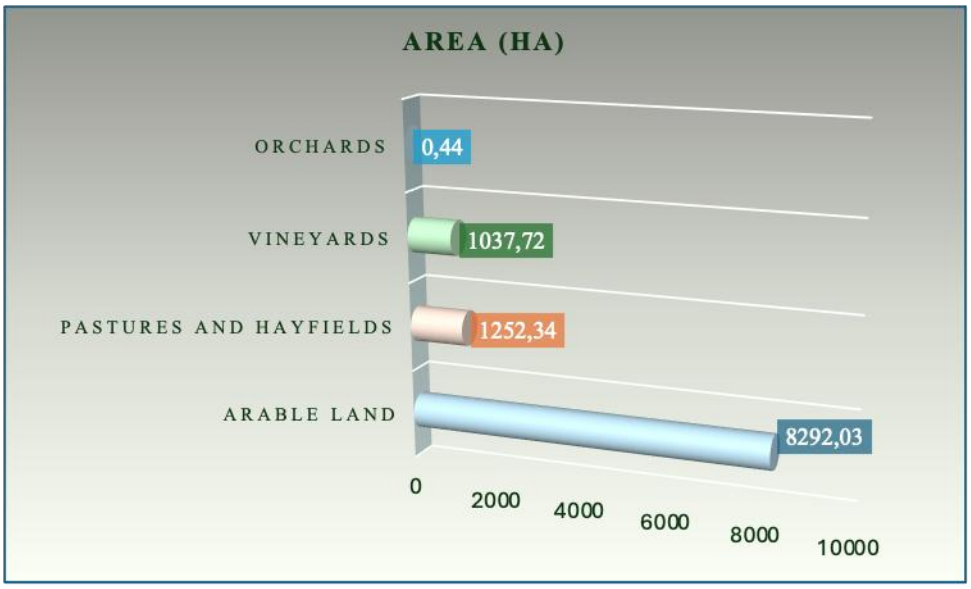


Figure 2. Distribution of agricultural land by land-use category in Șiria Commune.
Source: The figure was developed using data reported by Șiria Local Authority (2014)

Arable land comprised 60.65% of the territory and 78.36% of agricultural land. Vineyards accounted for 7.59% of the administrative area, reflecting the differentiated use of lower and sloping terrain within the local agricultural landscape. Another dataset, reproduced by ȚĂRĂU et al. (2023), gives 8,502 ha of arable land; the same value is reported by the local authority in its report for 2025. The sources are not directly comparable in definition and reference period, however, and these figures cannot establish a measured increase in arable land (ȘIRIA LOCAL AUTHORITY, 2026).

The local strategy also reproduces 2010 General Agricultural Census figures for grain cereals. The documented cereal area was 4,646.73 ha, including 1,825.32 ha of common wheat and spelt and 2,291.26 ha of maize. The source values and their shares are presented in Table 3.

Table 3

Area of grain cereal crops in Șiria Commune (2010 agricultural census)

Crop	Area (ha)	Share (%)
Common wheat and spelt	1,825.32	39.28
Maize	2,291.26	49.31
Barley	333.69	7.18
Oats	194.76	4.19
Other grain cereals	1.70	0.04
Total	4,646.73	100.00

Source: 2010 General Agricultural Census, as reproduced in Șiria Local Authority (2014), Figure 17.

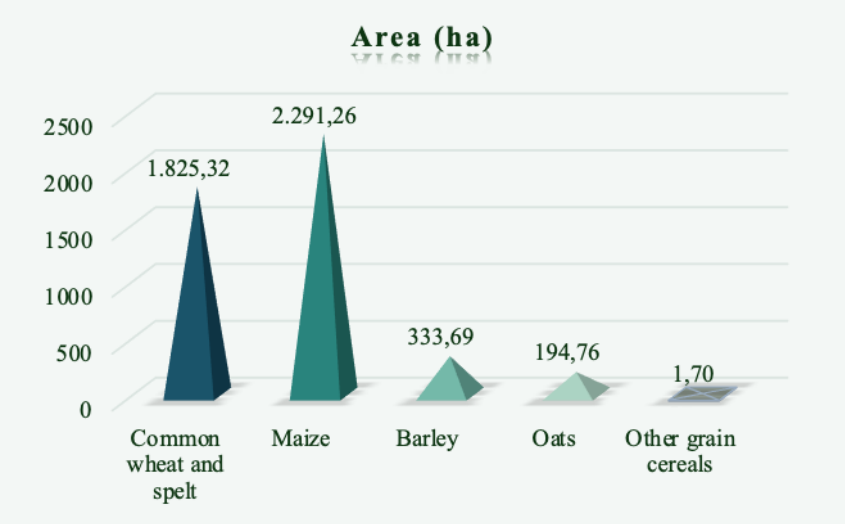


Figure 3. Reported areas of the principal cereal crops in Șiria Commune, 2010.
Source: Data reproduced in Șiria Local Authority (2014).

Common wheat and spelt represented 39.28% of the cereal area, ranking second after maize (49.31%); the area difference was 465.94 ha. Together, these two cereal categories accounted for 88.59% of the reference cereal area. These figures demonstrate the importance of cereals in the documented cropping structure, without establishing the commune's current crop allocation.

The inclusion of autumn- and spring-sown crops in the agricultural system offers opportunities for organising field operations and managing water and nutrient demand. Longer and more diverse rotations, including non-cereal crops, can also support resource-use efficiency and help moderate biological pressures. The value of diversification and the role of previous crops in nitrogen-use efficiency have been emphasised in recent research (SIMÃO et al., 2024; VAZIRITABAR et al., 2024).

Assessment of agricultural land suitability for wheat cultivation

The pedological and topographic evidence indicates that the agricultural potential of Șiria is unevenly distributed. A quantitative basis for this interpretation is provided by the arable-land quality classes compiled by ȚĂRĂU et al. (2023). These ratings concern general arable use; they should not be interpreted as crop-specific wheat suitability scores.

Table 4

Arable-land quality classes in Șiria Commune

Quality class	Area (ha)	Share (%)
Class I (81–100 points)	3,460	40,70
Class II (61–80 points)	2,500	29,40
Class III (41–60 points)	1,046	12,30
Class IV (21–40 points)	697	8,20
Class V (0–20 points)	799	9,40
Total	8,502	100,00

Source: Țărău et al. (2023), Table 3; the reported weighted mean rating for arable land is 64 points.

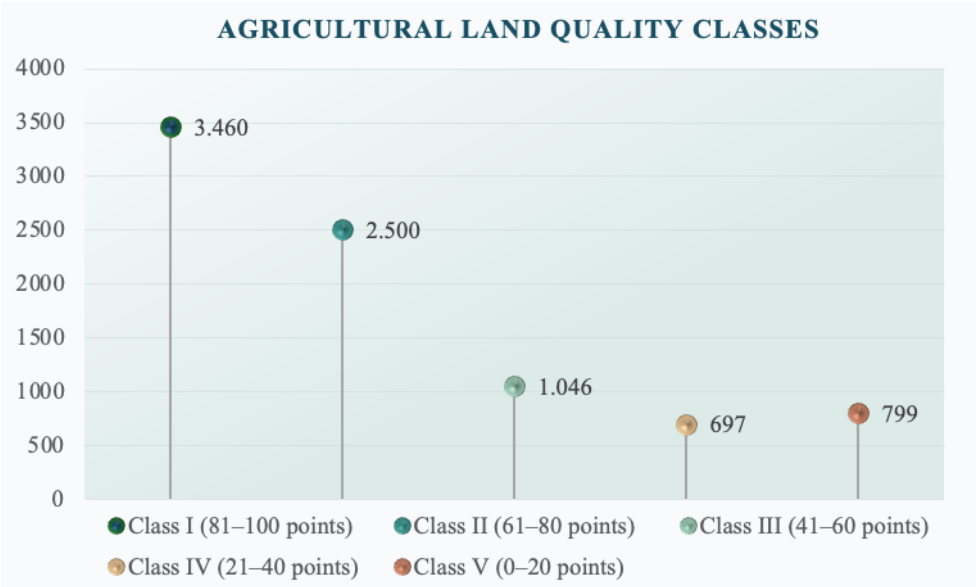


Figure 4. Distribution of arable land across quality classes I–V in Șiria Commune.
Source: Țărău et al. (2023).

Classes I and II together represent 5,960 ha, or 70.10% of the reported arable area, whereas Classes IV and V total 1,496 ha (17.60%). The weighted mean rating of 64 points indicates a substantial land resource but also points to differences among the component land units. These general arable ratings offer relevant context for wheat cultivation, although an evaluation of wheat-specific suitability would require appropriate crop-specific criteria and field-level information.

Excess groundwater moisture is a notable limitation in the compiled pedological dataset. For Șiria, ȚĂRĂU et al. (2023) report 2,603 ha affected by strong to excessive groundwater-related wetness, equivalent to approximately 21.50% of the 12,107 ha agricultural reference area. Such conditions can restrict root aeration and alter nutrient cycling. Experimental studies of winter wheat under waterlogging have documented changes in root functioning and nutrient losses, while water-table and nitrogen management have been shown to interact in determining crop response (LUO et al., 2024; HE et al., 2024).

The same pedological synthesis reports 7,143 ha in the weak soil-acidification category and 3,015 ha in the moderate category. These data identify differences in chemical

soil constraints but do not provide field-specific pH values or prescribe amendment requirements. Soil acidity may influence phosphorus behaviour and nutrient availability, with crop effects depending on the local soil environment and interactions with other limitations (BHOITE et al., 2024).

Sodicity and local salinity form another group of constraints. The presence of Solonetz in the soil inventory and salt-affected associations near Galșa warrants attention to the distinction between soluble salt concentration and exchangeable sodium. Increased salinity can impose osmotic and ionic stress on plants; high sodicity can also affect aggregate stability and infiltration. These mechanisms have been described in recent reviews on wheat and salt-affected agricultural systems (KRAMER and MAU, 2023; FAROOQ et al., 2024; KOTULA et al., 2024; ZHANG et al., 2024). Determining the severity of these local limitations would require appropriate field measurements, including electrical conductivity and indicators of exchangeable sodium.

Piedmont and sloping land introduces additional constraints related to surface runoff, soil loss and mechanisation. Conserving soil cover and adapting field operations to slope conditions are therefore relevant management directions. On lowland land with deep soils and adequate drainage, wheat cultivation has a more favourable natural basis; where groundwater excess, salt accumulation or erosion is present, management must respond to the particular limitation rather than relying solely on the soil type.

From an agrochemical standpoint, effective use of the commune's agricultural resources requires nutrient management that is responsive to soil reaction, drainage and moisture conditions. Fertiliser decisions should be supported by local agrochemical testing and crop nutrient demand, rather than inferred directly from a general soil category or an arable-land quality score. Research on winter wheat also shows that water management, previous crops, soil operations and nitrogen inputs may interact in determining nutrient-use efficiency (LI et al., 2024; WU et al., 2024; VAZIRITABAR et al., 2024).

Taken together, the predominance of chernozems and the high share of arable land in Classes I and II indicate favourable agricultural resources within Șiria Commune. This conclusion remains a territorial appraisal, not a newly calculated wheat-specific land-rating exercise. The spatially variable hydrological, topographic and agrochemical constraints justify differentiated land use and crop management in order to sustain wheat cultivation while protecting soil resources.

CONCLUSIONS

The pedoclimatic assessment of Șiria Commune indicates spatially differentiated agricultural potential associated with contrasting terrain and soil distributions. Chernozems cover 7,033 ha, corresponding to 58.09% of the agricultural reference area, and constitute an important soil resource for arable production. Their presence in lowland sectors, together with locally favourable topographic conditions, supports the cultivation of wheat where the soil-water regime is adequate.

The published arable-land assessment places 5,960 ha (70.10%) in quality Classes I and II and reports a weighted mean land-rating score of 64 points. These results describe the general capacity of the land for arable use rather than a quantitative rating for wheat alone. Historical agricultural census records also indicate the crop's local importance: common wheat and spelt occupied 1,825.32 ha, representing 39.28% of the recorded cereal area.

The local strategy reports a mean annual temperature of 10.98°C for 2002–2012 and long-term mean annual precipitation of 582 mm, which provide historical climatic context.

Important limitations arise from local soil-water conditions: strong to excessive groundwater-related wetness is reported on 2,603 ha, or approximately 21.50% of the agricultural reference area. Salt-affected and sodic soils, soil acidification and erosion susceptibility contribute further to territorial variation in agricultural potential.

For wheat production, these differences call for management practices adapted to the characteristics and restrictions of each land unit. Agrochemical management should be linked to soil reaction, water availability and the processes controlling nutrient uptake, supported by field-specific assessment. Such an approach can promote the effective use of pedoclimatic resources, maintain soil quality and support sustainable wheat production in Șiria Commune.

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