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Economic evaluation of conservation grassland as a measure to control soil erosion in the Czech Republic

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Abstract: Conservation grassland significantly reduces soil erosion risk in agricultural landscapes, as shown by a nationwide analysis of over 1.9 million Farmer's blocks (DPBs) records from the Czech Republic (2016–2022). A logit regression model revealed that grassland establishment lowers the likelihood of erosion events by about 64%, with erosion risk strongly influenced by altitude, land use, and management practices. Spatial mapping and soil suitability classification identified nearly 240 00 hectares – mainly along 33 000 concentrated runoff pathways – as suitable for targeted grassland conversion. Despite its soil-protective function, high opportunity costs hinder uptake in economically productive regions. Cluster analysis across EU Member States confirmed a strong link between low permanent grassland share and high erosion exposure. The findings underscore the need for regionally tailored policies, long-term financial support, and flexible land management options to enhance soil resilience and promote sustainable agriculture.

Keywords: cluster analysis; conservation grass management; logit regression analysis; opportunity cost; water erosion

Soil erosion remains a critical form of land degradation, severely affecting agricultural productivity, nutrient cycles, and essential ecosystem services. Inadequate land management and weak conservation practices exacerbate the depletion of nutrients such as calcium and organic carbon (Tenberg et al. 1998). In erosion-prone regions of South America and the EU, annual productivity losses average 0.43%,

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imposing costs of approximately EUR 1.25 billion (Panagos et al. 2018). While Italy faces the greatest impact, Central and Eastern European countries also suffer regionally significant effects due to distinct geomorphological conditions.

In the Czech Republic, agricultural land still accounts for over 53% of total area (Ministry of Agriculture 2021). The intensification and homogenization of agricultural practices have accelerated soil degradation processes, notably erosion-induced organic matter loss, compaction, contamination, diminished microbial activity, waterlogging, runoff, and reduced infiltration (Žalud et al. 2020). Water erosion has intensified due to recent extreme hydrological events. Surface runoff during heavy rains transports valuable topsoil into settlements, damaging property and entering water systems, where it becomes contaminated and must be landfilled as toxic waste (Laflen et al. 1985; Dumbrovský 2013).

To counteract water and wind erosion, and mitigate runoff, the Ministry of Agriculture introduced agri-environmental and climate measures such as "Grassing of concentrated runoff paths" and "Grassing and greening of valley bottoms" (Vejvodová 2016; MZE 2025). However, these initiatives remain marginal due to limited research on ecosystem service valuation and weak integration into practice.

Over 80 % of erosion events in the Czech Republic occur on land lacking conservation measures (Kapička et al. 2023). Although financial subsidies are available, high opportunity costs and maintenance requirements reduce farmers' motivation—especially in economically productive areas (Giger et al. 2018; Horák & Marada 2023). Despite the EU Green Deal's growing focus on erosion control, escalating climate pressures may soon surpass the capacity of current strategies. Adaptive measures – like land consolidation, green infrastructure, and flexible policy tools – will likely become necessary (Šarapatka & Bednář 2022).

Among nature-based solutions, conservation grasslands offer multifunctional benefits such as erosion control, carbon sequestration, and habitat provision (Lehmann & Hediger 2004). Although they involve productivity trade-offs, their long-term ecological value is well established (Benisiewicz et al. 2021; Horák & Marada 2022, 2023). In the Czech Republic, over half of all agricultural land –particularly in South Moravia – is threatened by erosion, especially ephemeral gully (EG) erosion (Dumbrovský et al. 2020). Research from 2012 to 2017 demonstrated a strong correlation between gully morphology and sediment load, offering predictive value for targeting erosion control.

This article evaluates the economic feasibility of conservation grassland as a soil protection strategy in Czech agricultural landscapes. Utilising datasets (2016–2022) from the Ministry of Agriculture and the Czech Statistical Office, a regression model identifies key natural and anthropogenic erosion drivers (e.g., altitude, land use, conservation practices). A cluster analysis of EU Member States places Czech data in a broader policy and ecological context.

A particular focus is placed on the Vysočina Region, a highland agricultural area comparable in terrain to the Harz Mountains (Germany), Massif Central (France), southern Poland, and eastern Austria. Such upland zones often combine slope-related production constraints with high ecological and water-quality potential.

By integrating biophysical and economic factors, this study identifies conditions conducive to effective grassland implementation. Regionally adaptive support schemes are proposed to enhance uptake, especially in high-yield regions where opportunity costs hinder adoption. Findings provide evidence-based guidance for future land use and subsidy policy, supporting sustainable, erosion-resilient agriculture in the Czech Republic. The main purpose of this study is to quantify the effect of conservation grassland on the probability of officially recorded erosion events and to evaluate its economic feasibility under regional opportunity costs.

MATERIAL AND METHODS

The authors applied land-block regression models with ecological and management controls, complemented by spatial suitability mapping, EU clustering, and an opportunity-cost analysis. Building on Horák and Marada (2023), this study employs data from 2016–2022 (Table 1), provided by the Ministry of Agriculture, detailing agricultural land characteristics and erosion vulnerability. A cost-benefit analysis assessed the value of anti-erosion ecosystem services and opportunity costs for farmers establishing conservation grasslands. Czech Statistical Office (2020) data enabled regional comparisons of agricultural profitability and the economic value of grassland-based erosion control.

Horák and Marada (2023) categorised Czech farmland into ten erosion hazard classes (TEO), with TEO 10 comprising roughly 103 000 ha at the

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Table 1. Number of evaluated DPBs per year

Year	Units
2016	270 785
2017	269 892
2018	271 610
2019	274 332
2020	279 093
2021	286 088
2022	287 996
Total	1 939 796

DPB – Farmer's block

highest risk. This typology underpins the unique dataset used to assess erosion risk during 2016–2022. The dataset covers approximately 280 000 land units annually over seven years, subject to structural changes (e.g., plot splits or mergers; Table 1). These units – Farmer's blocks (DPBs) – are separately registered as part of a land block in the land parcel identification system (LPIS), with a single user and uniform agricultural use. They are the basic spatial reference in the LPIS for monitoring, subsidy administration, and erosion assessment. Though lacking an exact English counterpart, DPBs function as agricultural management units.

The complete national dataset was obtained from the Ministry of Agriculture through a formal request under Act No. 123/1998 Coll. It includes data on erosion risk classification, conservation measures, altitude, and land use for each DPB. Each record is one DPB, a homogeneous agricultural land unit used for administration and monitoring, tracked in a given calendar year. The number of records varies slightly across years due to various legislative, administrative and changes in user reasons. Over 1.9 million observations were processed, covering the entire Czech Republic for 2016–2022. This full-population dataset enabled a high-resolution, spatially explicit statistical analysis of erosion trends and conservation grassland effectiveness. Using actual data (rather than estimates or samples) significantly enhanced the accuracy and representativeness of the results.

To fully examine the potential threat of an erosion event to happen, selected variables were examined to estimate the likelihood of an erosion event to happen. To estimate the probability of erosion events, we have employed the following empirical strategy using logit regression model:

$$p(EE_{i,t} = 1) = \beta_0 + \beta_1\text{Altitude}_i + \beta_2\text{TEO}_{i,t} + \beta_3\text{EKO}_{i,t} + \beta_3\text{Grass}_{i,t} + \beta_n\text{BPEJ}_{i,t} + \beta_m\text{Culture}_{i,t} + \nu_t + \varepsilon_i$$

where:

EE – a dummy for erosion event occurring in a specific plot *i* in year *t*;

β_0 – a constant of the regression;

β_x – parameters of the regression;

Altitude – the average altitude of the plot *i* in meters above sea level;

TEO – the average value of erosion hazard class in the area;

EKO – the dummy that has a value of 1 if the organic farming is applied in the given area;

Grass – a dummy for conservation grassland, main variable of interest;

BPEJ – a set of dummies for nine different climatic categories of the land according to the official registry (0–1 very warm, dry to warm and dry; 2 – warm, dry; 3 – warm, slightly humid; 4 – mildly warm, dry; 5 –mildly warm, slightly humid; 6 –mildly warm to warm, considerably humid; 7 – mildly warm, humid; 8 – mildly cool, humid; 9 – cool, humid; Novotný et al. 2013);

Culture – a set of dummies for different crop cultures (standard arable land; fallow; grassland (on arable land); other permanent crop; fast-growing woody plants; wooded land);

ν_t – time fixed effects;

ε_i – the error term.

The construction of this model was inspired by previous empirical research applying regression approaches to erosion prediction, such as the work by Ge et al. (2023), who used a similar econometric logic to quantify the effects of land characteristics and farming practices on erosion risk across China. While there is no universally accepted erosion prediction model combining administrative DPB data and environmental classifications, our framework is designed to reflect the specific structure and availability of Czech datasets, such as LPIS and TEO classification. The model thus builds on established methodological foundations but is in itself unique in its scope and structure, particularly in its application to over 1.9 million geo-referenced land observations and the integration of both natural and policy-relevant variables. It may serve as a methodological reference for future erosion risk studies in similarly structured agricultural landscapes.

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Descriptive statistics are presented in Table 2. As mentioned before, our dataset contains almost 2 million observations, and the descriptive statistics can be interpreted as follows. The first variable, *EE* (erosion event), can be 0 if no event occurred, and 1 if an event occurred in the respective year. As seen from the mean value, the events are relatively rare, with 0.16% of the observations experiencing such an event. A similar interpretation can be seen in the EKO and Grass variables. Altitude is a continuous variable; as seen, the lowest land in the dataset is 129 meters above sea level, the highest is 1 120 m high, while the average value is 373 m a.s.l. The last variable, TEO, can have values ranging from 1 to 10, according to the erosion threat level (10 is the highest), with the average value being 4.3. These variables align with existing literature that supports conservation grassland as a key measure for soil erosion mitigation.

Key variables include Altitude, which correlates with an increased likelihood of erosion events, and TEO, indicating the average erosion risk class, with higher values signifying greater soil loss potential. The EKO variable identifies land managed under organic farming, providing insights into regional erosion risks. Most critically, the Grass variable represents the presence of conservation grassland, a crucial factor in erosion prevention. This variable was analysed to assess its influence on erosion rates and its potential role in shaping soil protection strategies.

The study examines both natural and anthropogenic factors influencing soil erosion. Natural conditions, such as BPEJ, Altitude, and TEO, remain fixed, while human interventions, including organic farming (EKO) and conservation grassland (Grass), can actively reduce erosion risks. Modifiable factors, particularly EKO and Grass, play a significant role in erosion control. However, the study is limited by its relatively short timeframe, as long-term data were unavailable due to the lack of historical records from institutions such as the Research Institute for Soil and Water Conservation and the Ministry of Agriculture. This limitation underscores the need for extended research to explore broader correlations and long-term trends using the available variables.

In addition to the statistical estimation of erosion probability, a spatially explicit assessment of where conservation grassland is technically and environmentally feasible is essential. While the regression model identifies areas of high erosion risk (particularly TEO 8–10), not all high-risk DPBs are physically suitable for grassland establishment due to slope, soil depth, or water retention characteristics. For this reason, we complemented the probabilistic approach with a soil suitability analysis based on the main soil unit (MSU) classification, as used in Czech pedological and agro-ecological mapping systems.

The following table presents MSU types most relevant for targeted grassland implementation. These include steep slopes, shallow soils, or waterlogged areas that not only suffer from erosion but also limit conventional arable use. Their identification allows for a practical match between modelled erosion risk and ground-based technical feasibility – thus translating model outputs into actionable conservation planning.

Conservation grassland is primarily implemented on arable land with steeper slopes. Criteria for identifying suitable soils include slopes exceeding 20%, shallow soils (up to 30 cm, MSU 37–38), moderately skeletal soils on slopes of 10–20% (MSU 40–41), as well as permanently or periodically waterlogged, heavy to very heavy soils (MSU 65–76) and saline soils. MSU 64 and 65 represent cultivated hydromorphic soils, while MSU 66–69 are associated with plain units and depressions. Hydromorphic soils of alluvial areas (MSU 70–72), slopes (MSU 73–74), and catenas on shorter or lower slopes (MSU 75–76) are also

Table 2. Descriptive statistics

Variable	Observed	Mean	SD	Min	Max
EE	1 939 796	0.0016	0.040	0	1
Altitude	1 939 796	373.14	131.9	129.37	1120.41
TEO	1 924 523	4.315	1.975	1	10
EKO	1 939 796	0.058	0.239	0	1
Grass	1 939 796	0.0081	0.090	0	1

SD – standard deviation; *EE* – erosion event; Altitude – the average altitude; TEO – erosion hazard classes; EKO – organic farming; Grass – conservation grassland

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Table 3. Areas of main soil units (MSU) suitable for grassing in the Czech Republic

MSU	Area (ha)
37	157 465.01
38	32 045.37
40	115 374.26
41	72 527.15
65	5 061.06
66	2 120.55
67	78 666.05
68	54 750.57
69	15 143.13
70	11 376.61
71	15 733.30
72	18 764.21
73	21 228.91
74	4 800.74

included (Table 3). Typical representatives of these soil types include gleys, which develop in long-term water-saturated zones, and stagnogleys, which experience prolonged surface waterlogging.

These soil types represent the core spatial targets for grassland conversion, particularly where the statistical model has confirmed elevated erosion risk and where permanent grass cover may offer the highest return in terms of erosion control and land functionality.

RESULTS AND DISCUSSION

Comparison to EU states. To compare erosion conditions in the Czech Republic with broader patterns across Europe, we conducted an exploratory cluster analysis using data from all 27 EU Member States. The purpose of this analysis was to identify groups of structurally similar countries based on their agricultural land use and exposure to soil erosion, thereby situating the Czech Republic within a wider European context. The analysis focused on a consistent set of indicators expressed as shares of the utilised agricultural area: (*i*) percentage of land affected by moderate erosion, (*ii*) percentage of land affected by severe erosion, (*iii*) proportion of arable land, (*iv*) proportion of permanent grassland, and (*v*) proportion of permanent crops.

Data on soil erosion were obtained from the publicly available Eurostat database (EC Eurostat 2025), provided in cooperation with the Joint Research Centre of the European Commission (JRC–Ispra), which is a partner in the development of agri-environmental indicators under the existing Memorandum of Understanding. For the classification, we applied the k-means clustering algorithm, which groups countries with similar multivariate profiles by minimising within-cluster variance. According to Meloun and Militký (2006), this method is well-suited for datasets that combine continuous and discrete variables, as it classifies observations based on their similarity in multidimensional space. Prior to clustering, raw values were standardised into z-scores (mean-centred and scaled by standard deviation) to ensure comparability across indicators with different units. All computations were carried out using Statistica 13 software.

The results of the k-means analysis are summarised in Table 4. In particular, Cluster 2 contains EU Member States with the highest proportion of agricultural land affected by erosion. The clustering is based on Euclidean distance, where each distance measures the straight-line dissimilarity between a country's profile and the centroid of its cluster. Smaller distances indicate greater similarity, whereas larger distances signal divergence. In Table 4, distances are reported as dimensionless values and sorted in descending order relative to individual clusters, rounded to three decimal places. The main factor driving the separation of Cluster 2 from the other clusters is the low share of permanent grassland, which is among the lowest observed across EU Member States.

The inclusion of EU-wide erosion data reflects the fact that the Common Agricultural Policy (CAP) incorporates measures promoting sustainable land management practices to mitigate soil erosion. However, the success of implementing these measures varies considerably among Member States. By applying this exploratory analysis of land-use criteria, our study highlights the specific structural position of the Czech Republic relative to other EU countries, underlining both common challenges and distinctive weaknesses in soil protection.

Significance of the conservation grassland. The regression analysis confirms that conservation measures, particularly conservation grassland (Grass), are highly effective in reducing soil erosion risk. Table 5 reports the results of the logistic regressions. In the baseline model (first column), which excludes anti-erosion measures, the variable Altitude has a statistically significant positive coefficient, implying that erosion risk rises by 0.3% with each meter increase in altitude.

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Table 4. Members of the identified clusters, including respective Euclidean distances over all employed criterions

Cluster 1	Distance	Cluster 2	Distance	Cluster 3	Distance
Ireland	1.452	Malta	0.804	Finland	0.820
Slovenia	1.340	Cyprus	0.796	Slovakia	0.658
Portugal	0.972	Greece	0.724	Netherlands	0.590
Romania	0.702	Italy	0.614	Denmark	0.577
Croatia	0.522	Spain	0.608	Bulgaria	0.530
Luxembourg	0.519			Sweden	0.376
Austria	0.462			Belgium	0.361
				Latvia	0.353
				Hungary	0.314
				Estonia	0.312
				France	0.306
				Czechia	0.279
				Lithuania	0.239
				Germany	0.145
				Poland	0.116

The variable TEO (erosion hazard class) also exhibits a significant positive association with erosion risk, whereas the variable EKO (organic farming) shows a significant negative coefficient, indicating that ecological farming practices mitigate erosion. When anti-erosion measures are added, results remain highly

Table 5. Logit regression model

	EE					
	1	2	3	4	5	6
Altitude	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)
TEO	0.213*** (0.000)	0.214*** (0.000)	0.225*** (0.000)	0.207*** (0.000)	0.218*** (0.000)	0.242*** (0.000)
EKO	–1.084*** (0.000)	–1.066*** (0.000)	–1.081*** (0.000)	–1.068*** (0.000)	–1.083*** (0.000)	–0.971*** (0.000)
Grass		–0.898*** (0.003)	–0.954*** (0.002)	–0.917*** (0.002)	–0.972*** (0.001)	–0.416 (0.176)
Constant	–8.808*** (0.000)	–8.809*** (0.000)	–9.096*** (0.000)	–9.120*** (0.000)	–9.400*** (0.000)	–10.876*** (0.000)
Year FE	no	no	yes	no	yes	yes
BPEJ FE	no	no	no	yes	yes	yes
Culture FE	no	no	no	no	no	yes
Observations	1 924 523	1 924 23	1 924 523	1 920 774	1 920 774	1 920 774
F-test *P*-value	0.000	0.000	0.000	0.000	0.000	0.000
R^2	0.030	0.030	0.033	0.036	0.039	0.048

EE – erosion event; Altitude – the average altitude; TEO – erosion hazard classes; EKO – organic farming; Grass – conservation grassland, Constant – constant of the regression; year FE – fixed effects of respective years; BPEJ FE – fixed effects of climatic categories of the land according to the official registry; Culture FE – fixed effects of different crop cultures; R^2 – coefficient of determination; *P*-values in brackets; $^{***}P < 0.005$

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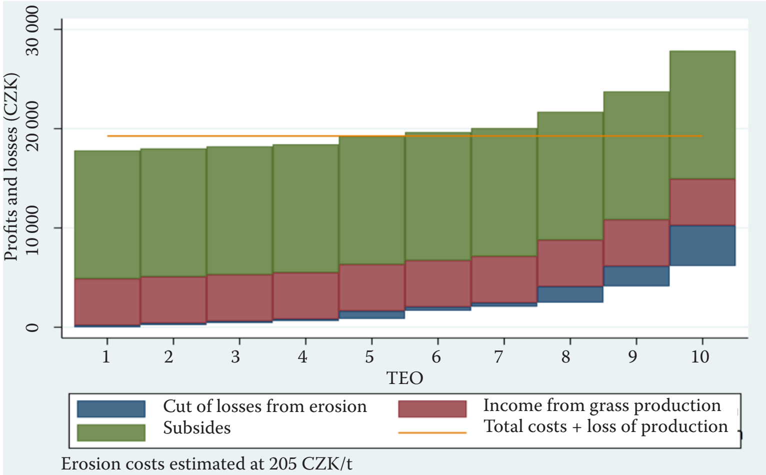

Figure 1. Total cost-benefit economic modelling of conservation grassland on Czech agricultural land
TEO – erosion hazard classes

consistent, underscoring the robustness of the estimates. Conservation grassland (Grass) emerges as the most influential factor, with a statistically significant negative coefficient corresponding to an approximate 64% reduction in erosion risk (Horák 2024). Year fixed effects and BPEJ dummies were included to control for variability, with negligible changes in parameter estimates. Adjusting for different crop cultures shifts part of the significance from Grass to the crop control variable, which reflects the expected substitution of effects.

To examine the feasibility of conservation grassland, we build on the cost-benefit analysis by Horák and Marada (2023), which integrates ecosystem services and opportunity costs. Figure 1 displays plots located below the cost and production-loss threshold, i.e. land where conservation grassland is financially unviable for both farmers and the state. On such DPBs, the reduction of erosion losses is less pronounced than on land above the threshold.

Erosion loss reduction, as a central anti-erosion ecosystem service, is crucial for the success of conservation grassland. Yet administrative frameworks often overlook this variable, concentrating instead on agrotechnical or organisational measures. As a result, areas where long-term solutions like conservation grassland would be more effective are insufficiently recognised and supported in practice.

The financial viability of conservation grassland depends heavily on subsidies and revenues, which are regulated by subsidy schemes. Non-productive areas generate nearly no direct income for farmers, creating economic barriers to adoption. Figure 2 compares opportunity costs across Czech administrative regions using data from the Czech Statistical Office.

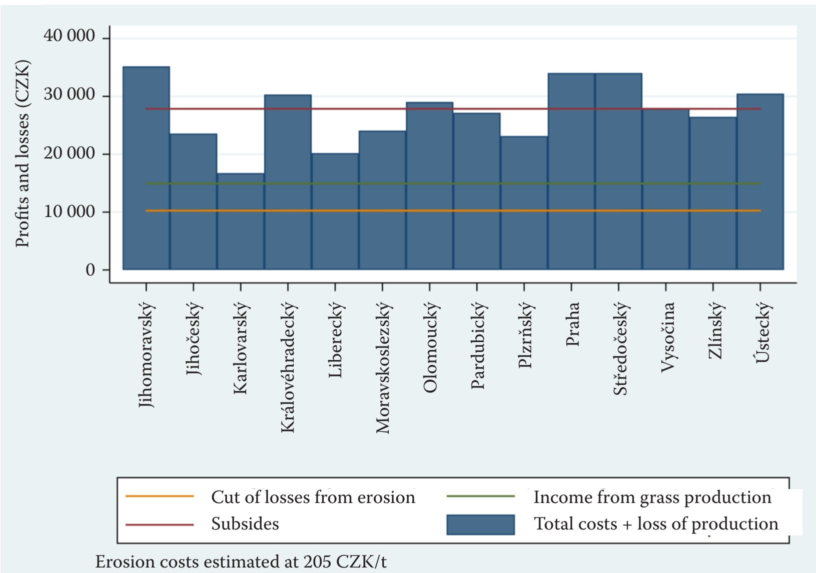

Figure 2. Conservation grassland modelling taking into account the opportunity cost in Czech regions

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While Horák and Marada (2023) applied average opportunity costs to assess the economic feasibility of agricultural land protection (with methodology from Konečná et al. 2014), strong regional variation reveals the importance of both economic and environmental heterogeneity in conservation planning.

In high-productivity regions such as South Moravia, Hradec Králové, Olomouc, Prague, Central Bohemia, and Ústí nad Labem, the opportunity cost of conservation grassland exceeds its erosion-control benefits due to high per-hectare yields. By contrast, in regions with the highest recorded erosion events, particularly South Bohemia and Vysočina (28.1% and 25.9% of erosion events in 2023, respectively – according to data obtained from Research Institute for Soil and Water Conservation and Ministry of Agriculture), the economic benefits of conservation grassland equal or exceed its costs when erosion mitigation effects are properly valued. These insights should inform subsidy policy, suggesting higher rates, tax reliefs, or other incentives to encourage adoption. Figures 1 and 2 further support prioritising conservation grassland on high-risk DPBs classified as TEO 8–10 (Horák & Marada 2023), where the return on investment is most significant. Nevertheless, because agricultural performance varies widely across regions, subsidy schemes must explicitly recognise the value of anti-erosion ecosystem services.

Farmers also require flexibility in hay management to adapt to local conditions and maximise utility. Rugged terrain and fragmented land blocks complicate implementation, especially on small, scattered high-risk plots. A broader spatial strategy is therefore needed, combining erosion class layers and erosion source mapping. For example, erosion-prone areas could be reorganised into new DPBs dedicated to conservation grassland or less erosion-sensitive crops. High-risk areas (TEO 8–10) should be prioritised (Horák 2024) for conservation grassland, while lower-risk land can remain under conventional crops such as maize or oilseed rape, given an appropriate land management. Approval procedures for conservation grassland should align with this strategy, enabling farmers to participate effectively in erosion mitigation.

A differentiated approach that considers land characteristics, regional disparities, and ecosystem service values is essential for effective implementation. Landscape planning must integrate ecosystem services, particularly erosion control, into land use strategies to achieve environmental and societal benefits (Fürst et al. 2014). Erosion suppression should be treated as a priority for national, regional, and local authorities. Policymakers need to balance the opportunity costs of non-conventional crop production with the erosion-control benefits of conservation grassland. Current subsidy policies do not sufficiently account for these opportunity costs and undervalue the full ecosystem service contribution of grassland. Tailored evaluations of farms and regions are therefore necessary, as profitability varies (Figure 2). Farmers should also gain more autonomy in managing conservation grassland, including the option to use hay for on-farm consumption or sale, since current rules limit such flexibility and undermine viability. Results of the *k*-means clustering

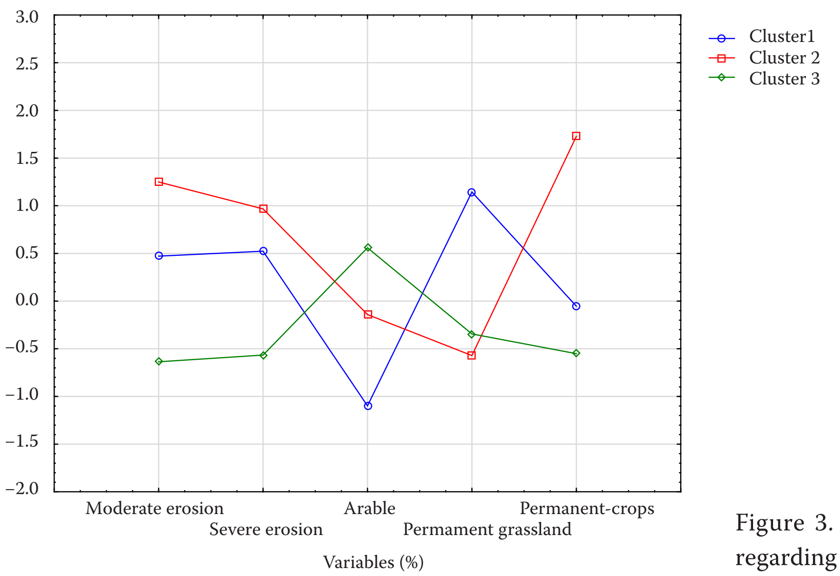

Figure 3. Plot of means for identified clusters regarding 27 EU Member States

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Figure 4. Example of the effectiveness of PCR stabilisation by grassing for sediment trapping
PCR – concentrated runoff paths

in Figure 3 additionally demonstrate that countries with the lowest share of permanent grassland experience the greatest erosion exposure.

Permanent grassland is further recommended to stabilise concentrated runoff paths (PCR) and buffer zones along watercourses and reservoirs. The source data for estimating potential grassland areas were derived from the national LPIS, where concentrated runoff paths were identified for the Ministry of Agriculture. Delineation relied on modelling runoff accumulation from catchments, terrain analysis, and orthophotomap interpretation. Over 33 000 concentrated runoff pathways were identified, covering nearly 12 000 km. Catchment areas were delineated through digital terrain modelling, automated runoff analysis, and manual corrections using topographic rasters, aerial imagery, and runoff direction maps. The identification of PCR outfalls was an additional indicator, with outcomes categorised by discharge type: 33% into water bodies, 14% into forests, 19% into ditch systems, and 16% into built-up areas. The potential area for 20 m grass strips is estimated at about 240 000 ha. Besides reducing deep erosion rills, these strips trap sediment within the catchment. Maintaining sufficient grass height is essential, as grass lying flat under heavy rain allows faster runoff compared to shorter cover. Properly managed grassed PCR therefore serve as natural filters, reducing sediment and nutrient runoff into watercourses and protecting downstream areas up to the design rainfall event. Figure 4 illustrates the effectiveness of such PCR.

The valuation of erosion-control ecosystem services delivered by conservation grassland must be based on detailed erosion risk data. Integrating erosion risk classifications with farmers' opportunity costs ensures that financial support offsets real costs and provides incentives for adoption. Continuous farmer education remains vital, as awareness of erosion's harmful impacts alone does not guarantee uptake (Fučík et al. 2016). Finally, sustainable erosion control requires policies that extend beyond five-year project cycles. Conservation grassland measures must be embedded as permanent or indefinite commitments to secure long-term protection on high-risk soils.

CONCLUSION

This study confirms the essential role of conservation grassland as an effective erosion control measure and as a provider of key ecosystem services, including carbon sequestration, landscape stability, and biodiversity preservation. Using a comprehensive, population-wide dataset of over 1.9 million Czech Farmer's blocks (DPBs) obtained from the Ministry of Agriculture, the research applied a logit regression model to quantify the impact of various natural and management factors on erosion risk. The results demonstrate that the implementation of conservation grassland reduces the probability of erosion events by approximately 64%, validating its strategic importance in agricultural land protection.

A major strength of this study lies in its use of nationwide, high-resolution data integrated with detailed soil-ecological and land use characteristics. The erosion risk model is grounded in the structure of Czech agricultural land administration and inspired by existing international methodologies, yet it is methodologically unique in its scope and transferability. In addition to statistical modelling, the analysis incorporates soil suitability through the MSU classification, which helps identify land where conservation grassland is both environmentally necessary and technically feasible.

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At the same time, the study reveals persistent economic barriers to broader adoption, particularly in high-productivity regions where opportunity costs often outweigh the short-term financial benefits. These disparities point to the need for regionally differentiated policy tools, including targeted subsidies, long-term support schemes, and flexible land management options that take into account both environmental risk and economic viability.

The study also extends the analysis to the EU level through a cluster-based comparison of 27 member states, which confirms that countries with the lowest proportion of permanent grassland tend to experience the highest rates of moderate and severe erosion. This reinforces the importance of maintaining and expanding permanent grassland areas as part of a broader erosion mitigation strategy, both nationally and across the EU.

Finally, the identification of over 33 000 PCRs across the Czech Republic further supports the implementation of conservation grassland in specific hydrologically exposed areas. These areas, covering nearly 240 000 ha, represent critical points for intercepting sediment and nutrient loss. The integration of biophysical erosion modelling, spatial soil classification, and economic feasibility assessment provides a complex yet practical framework for sustainable land management and future agricultural policy development.

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