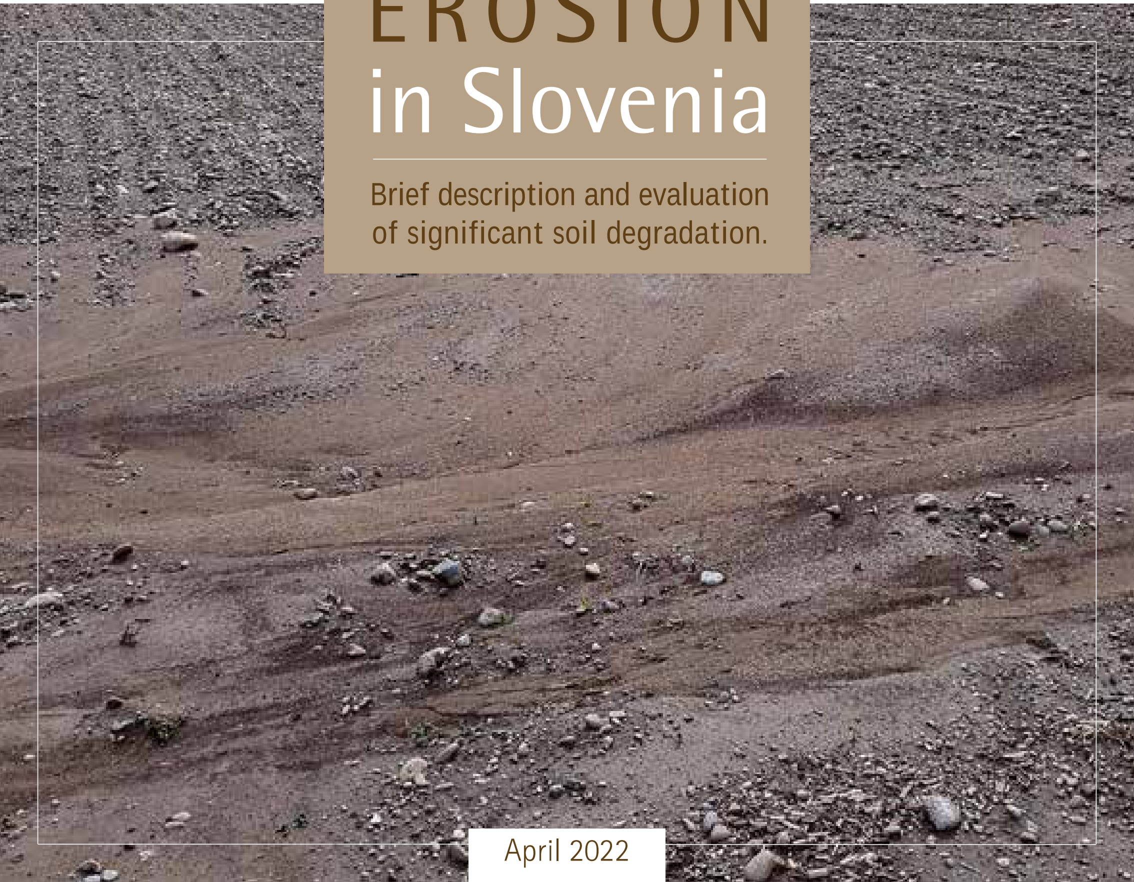
Kmetijski inštitut Slovenije

Agricultural Institute of Slovenia

EROSION in Slovenia

Brief description and evaluation of significant soil degradation.



April 2022

Acknowledgements

This publication is an ad hoc translation of the Slovenian brochure *Erozija v Sloveniji* - a simplified publication for the general public. It contains a brief interpretation of the comprehensive report on the 2020 National Soil Erosion Assessment Project.

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA KMETIJSTVO, GOZDARSTVO IN PREHRANO

PROGRAM RAZVOJA PODEŽELJA

Evropski kmetijski sklad za razvoj podeželja: Evropa investira v podeželje

The authors would like to thank the Ministry of Agriculture, Forestry and Food for funding the project.

About the publication

Authors: Dr Borut Vrščaj, Janez Bergant, Peter Kastelic, Marjan Šinkovec

Editor: Dr Borut Vrščaj

Contributions: Dr Sašo Petan, Msc Tomaž Poje and Geza Grabar

Cover photo: Geza Grabar

Design: JR design

Produced by: GEAart, 2022

The electronic publication is available at: www.kis.si

From the Agricultural Institute of Slovenia, Ljubljana, 2022

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani

COBISS.SI-ID 106676739

ISBN 978-961-6998-55-0 (pdf)

DID YOU KNOW THAT...

- EROSION is a natural process that can be greatly accelerated by unsustainable soil management?
- EROSION is the most important form of soil degradation on five of the seven continents?
- EROSION directly and significantly reduces/degrades soil ecosystem services?
- successful measures against erosion are quite simple?
- in Slovenia erosion is highest on permanent crops, significantly lower on arable land and lowest on grassland?

Figure 1: Erosion in the field after spring rain (photo B. Vrščaj)

Erosion in the field in Hoče near Maribor occurred in the spring after short but intense rains in March 2013. Trenches formed on heavy, silty, poorly permeable, and partially hydromorphic soils (Planosol on a slight slope) that were up to 40 cm deep in some places. Fine soil particles were carried away by surface water flow into the drainage ditches and then into the Hočki potok.

ABOUT EROSION

Soil erosion is a natural geomorphological process of soil detachment and displacement. It can be greatly accelerated by human activities and can be many times greater than under natural conditions.

Erosion (water, wind, and soil erosion) remains the greatest threat to soil in several regions of the world. Measuring erosion is a time-consuming, costly, and organizationally complex process, so erosion risk and its intensity are usually estimated using computer models. Global and regional erosion estimates vary widely depending on the method used. General estimates of soil erosion in field areas are significantly higher (from 8 to nearly 50 t ha^{-1} $year^{-1}$) than estimates from regional and global models (2 to 4 t ha^{-1} $year^{-1}$). Any erosion assessment should be evaluated based on an acceptable level of soil loss.[1]

Estimates of the impact of erosion show a 0.4% decrease in crop yields, which is not insignificant given a growing global population. Importantly, soil erosion also leads to a reduction or degradation of ecosystem services and causes economic damage across multiple sectors. Thus, erosion is not only an agricultural problem, but also an environmental problem with significant economic consequences.

This booklet mainly focuses on erosion on agricultural land. It is known that erosion of agricultural soils can be reduced through adapted tillage, changes and improvements in soil structure, land use adaptation or, if severe, land use change. Measures such as soil conservation, ground cover, planting trees and shrubs, terracing, and several others have been shown to be effective. Yet, we pay too little attention to erosion in Slovenia. This publication presents a first nationwide assessment of erosion in Slovenia using the RUSLE method and selected examples of erosion in our agricultural areas.

Borut Vrščaj

[1] *FAO. 2019. Soil erosion: the greatest challenge to sustainable soil management. Rome. 100 pp.*

RUSLE EQUATION

The Revised Universal Soil Loss Equation (RUSLE) is the mathematical model most commonly used to evaluate erosion in the absence of accurate, and long-term measured data on the amount of soil eroded from standard test plots.

RUSLE evaluates erosion intensity based on key erosion factors: Rainfall frequency, intensity, and duration; soil susceptibility to erosion; slope and length of slopes; land use and land cover; protective/anti-erosion control measures and agricultural practices.

Equation 1: Basic equation for a group of RUSLE models:

$$RUSLE: Er = Rf * Kf * Lf * Sf * Cf * Pf$$

Where:

Er = erosion – average annual amount of eroded soil per unit area ($t\ ha^{-1}\ year^{-1}$)

Rf = rainfall erosivity factor ($MJ\ ha^{-1}\ mm\ h^{-1}\ year^{-1}$)

Kf = soil erodibility factor ($t\ ha^{-1}\ h^{-1}\ MJ^{-1}\ ha^{-1}$ *mm-1)*

Lf = slope length factor (no units)

Sf = slope inclination factor (no units)

Cf = land cover and land use factor (no units)

Pf = protection factor (no units)

RUSLE

The Universal Soil Loss Equation (USLE, 1965) is an empirical model for estimating soil loss from water erosion ($t\ ha^{-1}$) on land with known precipitation regime, land use (land cover/vegetation/agricultural crops), soil type, relief, and soil management practices. The model was developed at the U.S. National Runoff and Soil Loss Data Center based on several 10,000-year erosion measurements on standardized plots at 49 experimental sites under a variety of soil conditions across the United States. The USLE and more modern models are the primary tool for evaluating erosion and establishing erosion control and protection measures in the United States and other countries.

The Revised Universal Soil Loss Equation (RUSLE, 1978) is a group of related erosion models (RUSLE2, MUSLE) that is an evolution of the original Universal Soil Loss Equation (USLE). RUSLE is based on the same equation with some erosion factors improved. RUSLE2015 (Panagos, 2015) is a modified version of the RUSLE model used to produce soil loss estimates for Europe for the reference year 2010. Input factors (rainfall erodibility, soil erodibility, land cover and land use, topography, and soil treatment practices) are modelled using the latest available pan-European data at 100 m resolution (Figure 2).

The results of RUSLE2015 have significantly improved previous EU erosion estimates that were uncertain due to the lack of highly separable pan-European data, inconsistencies and input data of erosion factors, missing information on agricultural practices and soil treatments, and missing data on precipitation intensity. RUSLE2015 is a useful source of information for simulating the impacts of various development policies at the EU level.

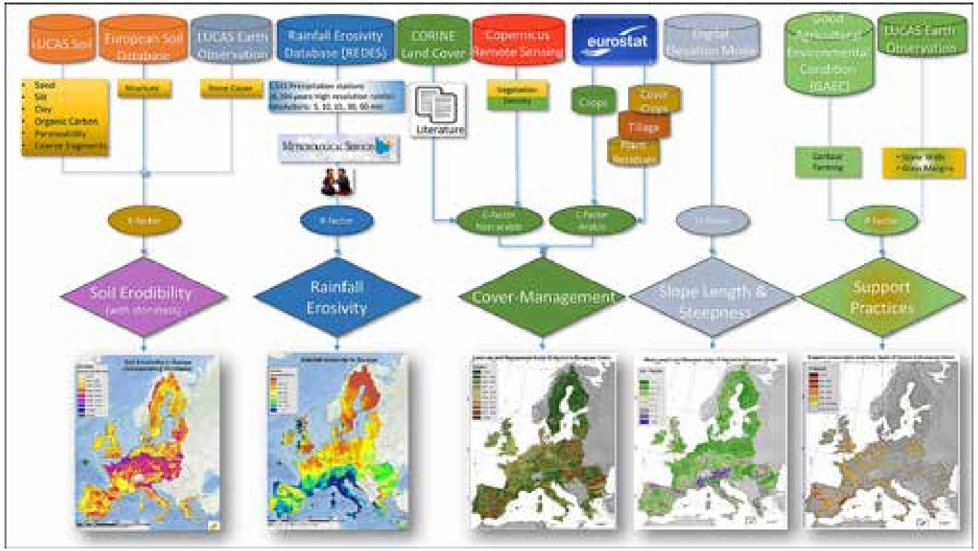


Figure 2: Erosion assessment model for the EU country area (Panagos Et Al., 2015)

The RUSLE15 erosion assessment (JRC ESDAC), is based on a complex and diverse data model and is a good example of the integration of large European databases. The main data on soil properties (soil texture, soil organic matter content, soil permeability and stoniness) were included in the LUCAS databases, soil structure in the Soil Map of Europe (European Soil Database 1: 1 M), different uses or land use in Corine Land Cover 1: 100,000. Data from remote sensing (Copernicus) were integrated to determine vegetation and different statistics on agricultural crops, tillage type, crop residue management, etc. were used.

ASSESSMENT OF SOIL WATER EROSION IN THE EU AND SLOVENIA BY RUSLE METHOD

Under the Joint Research Centre (JRC) EC, the European Soil Data Centre (ESDAC) conducted erosion modelling and published a comprehensive erosion assessment for most EU countries in 2015 (Panagos et al., 2015).

The erosion modelling results show that Slovenia ranks second among EU members in annual erosion, with an average of 7.43 t/ha/year of eroded soil across all land use types. The publication explains that the erosion rate in Slovenia is high due to high precipitation erosivity and steep topography. Only Italy has a higher average annual erosion rate (8.46 t/ha), while Austria ranks third with 7.19 t/ha. For arable land in Slovenia, it is estimated at 4.63 t/ha per year. The regions: Obalno-Kraška, Southeast Slovenia and Savinjska have an average annual erosion rate of 10-20 t/ha - also one of the highest in the EU. Five regions in western Slovenia have estimated erosion of 5-10 t/ha and Posavska, Podravska and Pomurska 2-5 t/ha. In any case, these are figures far above the estimates of the Slovenian profession and the general opinion about the intensity of erosion in Slovenia.

In view of these values, it should be borne in mind that it is difficult to take into account the peculiarities of erosion factors in individual countries in the continental scale model. The peculiarities in Slovenia include relatively erosion-resistant loamy but permeable Eutric Cambisols, a high proportion of forest (about 61%), extreme fragmentation of agricultural land, and other factors. For such and similar reasons, some Slovenian experts are sceptical of EU erosion estimates. However, since no other comparable erosion data are available, the ESDAC erosion estimates are published in some official EU documents and publications.

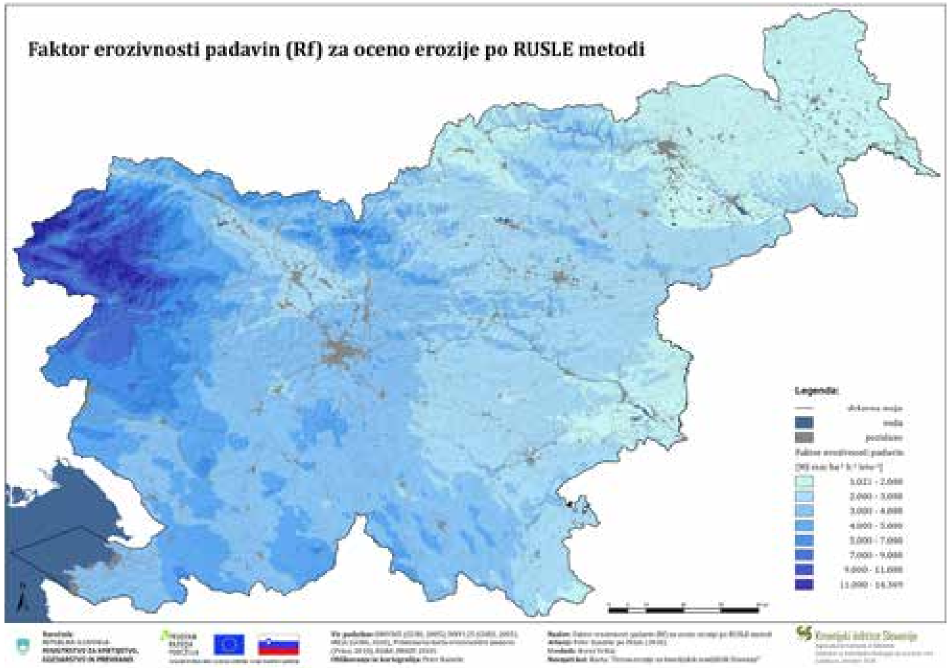


Figure 4: R factor (Rf) map - rainfall erosivity of Slovenia (data source: Petan, 2010)

The map shows the average amount, kinetic energy, and duration of precipitation represented as precipitation erosivity-a key factor leading to water erosion in all types of land use.

Rf – Rainfall erosivity factor

Precipitation erosivity is the kinetic energy of the impact of raindrops on the ground and the magnitude of the associated surface water runoff. It is generally determined by (a) the intensity of the precipitation event [mm h^{-1}], (b) the kinetic energy of the raindrops, their distribution, and the size and velocity of the precipitation, and (c) the duration of the precipitation event. The erosivity of precipitation is a key factor in erosion because it directly affects the separation of soil particles (the destruction of soil structural aggregates) and the washing away of soil particles.

The factor R [MJ mm ha^{-1} h^{-1} $year^{-1}$] is the multi-year average erosivity index of precipitation, which measures the kinetic energy required to separate these particles from soil structure aggregates, as well as the intensity of precipitation. It describes the effects of precipitation and thus the frequency and abundance of sheet and rill erosion. Rainfall erosivity is calculated by multiplying the kinetic energy by the maximum rainfall intensity in 30 minutes of a daily rainfall event. Therefore, the RF gives the multi-year averages of the cumulative rainfall values of individual rainfall events. Rf can be credibly estimated if rainfall is accurately recorded at short intervals (1-60 minutes) over at least a few years.

In creating a map of soil erosion in Slovenia, we used data from the preliminary map of precipitation erosivity (Petan, 2010). The map was created based on measurements from 31 ARSO pluviographic monitoring stations with at least a 10-year record between 1999 and 2008, and supplemented with data from 13 ARSO precipitation stations with daily precipitation records.

The minimum Rf factor in Slovenia is 1.021, the average is about 3.390, and the maximum is 14.369 MJ mm ha^{-1} h^{-1} $year^{-1}$.

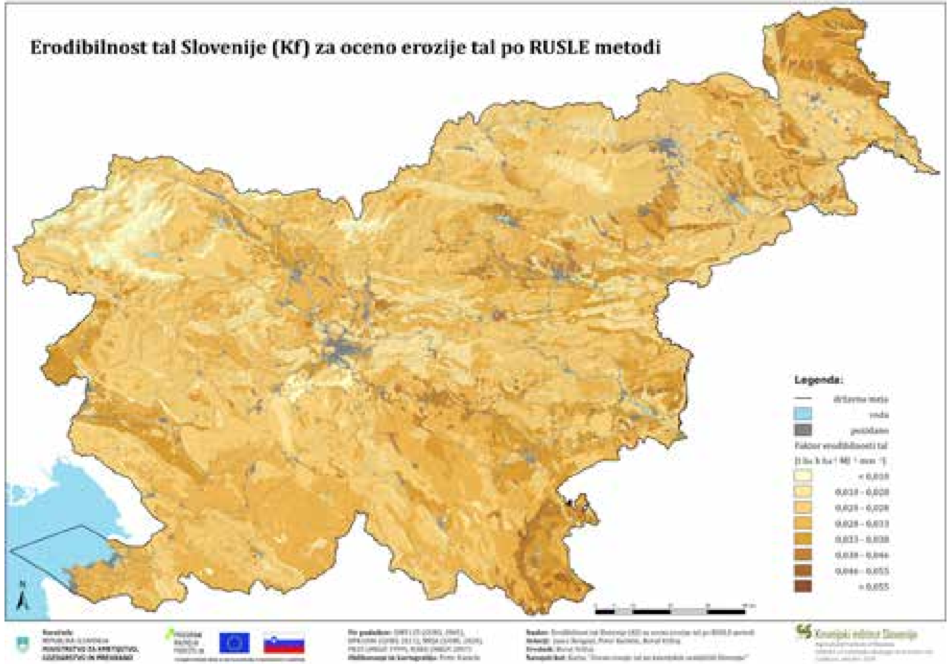


Figure 2: Soil erodibility (Kf) in Slovenia

The map of soil erodibility factor K shows the areas where the soil is more/less resistant to erosion. Higher soil erodibility is found in areas of Calcaric Cambisols of Goriška brda, Vipava valley, Slovenian Istria, Goričko, Slovenske gorice, Kozjansko, on slightly leached Chromic, Luvic and Eutric Cambisols of Dolenjska and Bela krajina, and Dystric Cambisols of the hills of Škofja Loka, in the Pohorje mountains and partly in the Savinja valley and in the Koroška region.

Kf – Soil erodibility factor

Kf is the resistance factor of soil to water erosion, i.e. the erosion of topsoil and washing away of particles smaller than 2 mm with water. Erosion means the disintegration of the aggregates of the soil structure, which is usually accompanied by poor permeability of the soil, resulting in increased surface runoff and drifting of soil particles. Kf depends mainly on soil texture, soil structure, soil organic matter content, basic cations, and other soil properties that determine the cohesion and stability of soil structure aggregates and soil permeability. Kf [t ha h ha^{-1} MJ^{-1} mm^{-1}] was measured on standard test fields (length 22.1 m, 9% slope) under standard conditions (bare soil, conventional tillage). Kf measurements are expensive and lengthy.

Erosion-resistant and low-erodibility soils have lower Kf values. These are clayey soils with greater cohesion (Kf ~ 0.007 - 0.020) and sandy soils that otherwise have lower cohesion but higher permeability (Kf ~ 0.007 - 0.026). Clay soils are moderately susceptible to erosion (Kf ~ 0.033 - 0.53). Soils with high silt content are most susceptible to erosion (Kf ~ > 0.053), harden quickly and have high surface runoff.

Since Kf is not systematically measured in Slovenia, we calculated Kf for the soil types of the Soil Map of Slovenia 1:25,000 (PK25) from the measured data of the corresponding representative soil profiles based on the average soil organic matter content (som), texture factor (tf), clay, sand, to a depth of 20 cm of the soil, soil structure class (ssc) and soil permeability class (sp).

$$Kf = [\{2.1 \times 10^{-4}\ tf^{1.14}\ (12 - som) + 3.25\ (ssc - 2) + 2.5\ (sp - 3)\} / 100] * 0.1317$$

(After Wischmeier and Smith (1978) and Renard et al. (1997))

Kf was spatially defined within the boundaries of the PK25 soil mapping units.

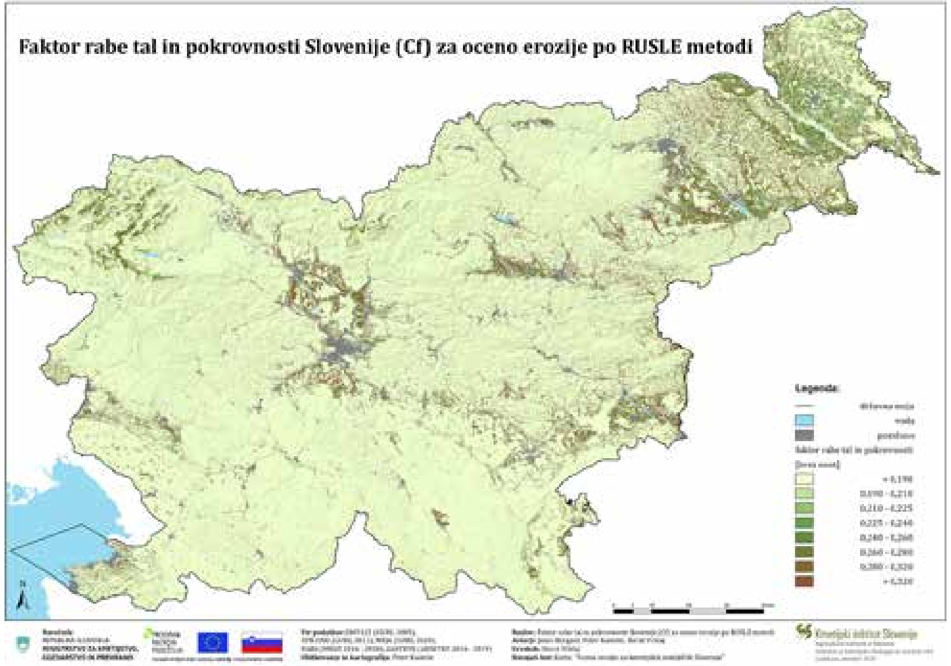


Figure 3: Distribution of C-factor (Cf) of land use and land cover in Slovenia.

The Cf map of the territory of Slovenia follows land use and established agricultural practices that contribute to the reduction of erosion. The values range from 0 to 0.38 with an average value of 0.039, with the lowest values found in forested areas (Cf = 0.001), while larger and smaller areas with different agricultural use and higher values are clearly visible. For example, in Brda mainly permanent crops are cultivated, in Vipava valley and Slovenian Istria different types of agricultural use are interwoven, in Drava region, Ptujsko polje and Prekmurje medium Cf values dominate due to predominant use of arable land. In Slovenske gorice, the Cf value is also high due to the high proportion of vineyards.

Cf – Land use and land cover factor

The C-factor (without unit) defines the impact of land use, land cover, and related agricultural practices on the (partial) reduction of soil erosion and the severity, frequency, and incidence of soil erosion processes. Cf is a quantitative indicator of the combined effects of land cover/use and agricultural practices compared to reference conditions (land with bare soil, ploughed along the slope, value Cf = 1). The higher the value of the factor, the more pronounced the impact of erosion.

Cf is the most important factor in terms of possible measures to reduce erosion because it can be regulated by good agricultural practices and agricultural policies that influence the extent of erosion.

The most common arable crops from the "Requirements" data set (ARSKTRP, 2016-2019) were assigned Cf reference values from the literature. This was implemented for all land use types (MAFF, 2016-2019). Total Cf was combined from crop Cf (Cfplant) and land use Cf (Cflanduse) factors. Agricultural practices that contribute to erosion reduction were also considered and integrated.

The final Cf was calculated as the average Cf for 2016 - 2020.

Due to extensive forests, most of Slovenia has a low Cf with a value of 0.001. On agricultural land, the lowest Cf values are achieved on grassland (0.049). On arable land, the Cf value varies greatly depending on the crop (e.g. from 0.123 in orchards to 0.225 in vineyards.

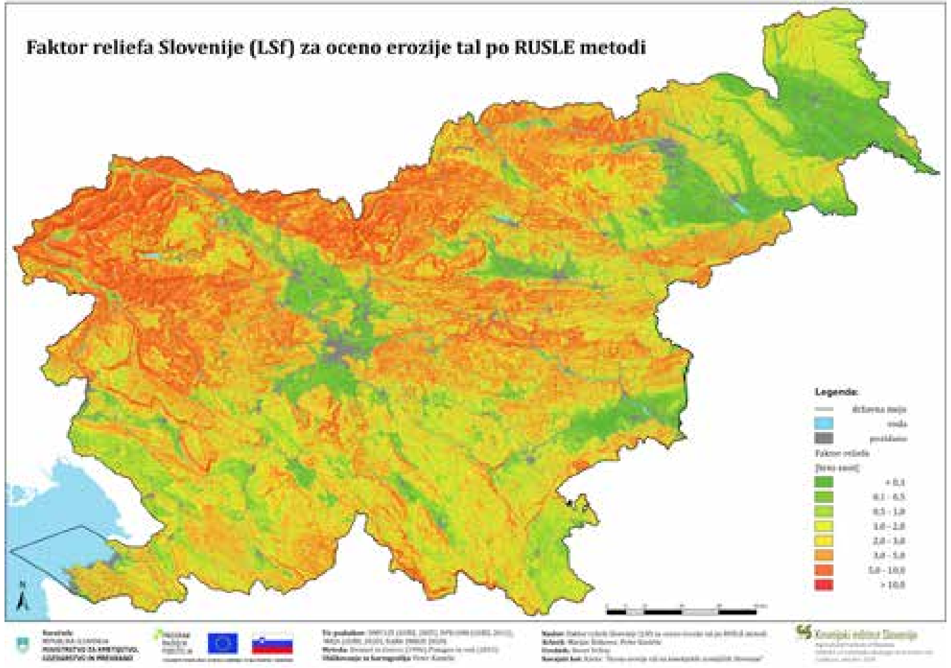


Figure 4: The map of the LSf factor of Slovenia shows the hilly location of Slovenia.

The source of the LSf data is a digital elevation model with a resolution of 12.5 m: Green areas are flat areas and areas with gentle slopes, yellow are slopes with medium LSf (~ 2 - 5), and red are long and steep or very steep slopes with high LSf values (> 5). The map also shows areas with slopes > 26 ° (high mountains and steep slopes), where LSf is not quite relevant.

LSf – Relief factor

In RUSLE, the factors of slope length (Lf) and slope gradient (Sf) are usually combined into a factor LS, which represents the overall effect of topography on the degree of erosion (Van Remortel et al., 2004). Thus, the factor LS consists of the length of the slope (L), i.e., the distance from the starting point of surface flow to the point where the slope (S) decreases to such an extent that (a) deposition of eroded material begins or (b) flow begins to concentrate in surface channels (equation 19). Lf was calculated using the method presented by Desmet and Govers (1996).

Equation 2: Calculation of the LSf factor by Wischmeier and Smith (1978).

$$A_i = A \frac{\tan \beta_i * W_i}{\sum_{j=1}^{k} \tan \beta_j * W_j}$$

where: λ = slope length (m); θ = slope steepness; m = (depends on the slope); 0,5: slope > 5 %; 0,4: slope between 3,5 % and 4,5 %; 0,3: slope between 1 % and 3 %; 0,2: slope < 1 %

The calculation of slope steepness (Sf) in each cell of the DMV grid plane for the study area was based on the algorithm of Zevenbergen and Thorne (1987):

Equation 3: $G_{i,j} = \sqrt{G_x^2 + G_x^2}$ *, where Gx= slope in direction x (m/m); Gy slope in direction y (m/m)*

Lf and Sf were combined in LSf with an algorithm according to Desmet and Govers (1996):

$$LS_j = \frac{S_j \, x \, (\lambda_j^{m+1} \; \lambda_{j-1}^{m+1})}{(\lambda_j - \lambda_{j-1}) * (22,13)^m}$$

Kjer je -L = faktor dolžine pobočja; Sj = faktor naklona pobočja za j-segment;
λj = razdalja od spodnje meje j-segmenta do meje na vrhu hriba in m = eksponent dolžine faktorja USLE LS

Based on the above and other equations, we created a uniform grid layer of LSf with a resolution of 10 m for the entire area of Slovenia (Figure 7).

Figure 8: Erosion in the vineyard area (photo by Tomaž Poje).

Minimal erosion in a vineyard covered with grass despite the slope. The only eroded areas are in the ruts of the road.

Figure 9: Erosion on terraces (photo by Borut Vrščaj).

Terraces effectively reduce the intensity and consequences of erosion processes. Nevertheless, it is necessary to ensure proper design of terraces, prevention of erosion hotspots and consolidation of terrace edges.

Pf – Factor of agricultural practice and tillage

The agricultural practises factor (Pf) was set to a default value of Pf = 1 in our RUSLE model because detailed data on terraces, boundaries, ploughing direction, etc., which correspond to fragmented land use in Slovenia and would be suitable for nationwide soil erosion modelling, are not available. Agricultural practises that protect soil from erosion are partially included in the Cf factor because some information is available on agricultural practices that reduce erosion (e.g., soil conservation treatments, winter cover crops, etc.).

Figure 9: Severe erosion and a devastated crop in a field near Strehovci (photo by Tomaž Poje).

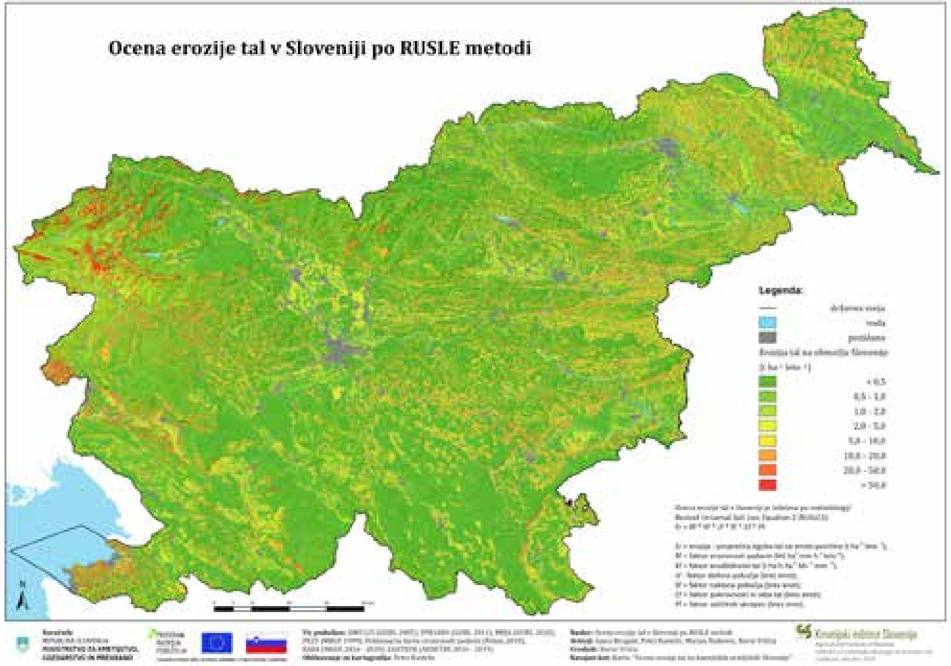


Figure 10: Estimation of soil erosion in Slovenia using the RUSLE method.

The map shows the distribution of estimated erosion values in Slovenia. Goriška brda and Slovenian Istria stand out due to land use (vineyards and olive groves), highly erodible soils and relief; 'wreath' of vineyards in Bela krajina, Vipava valley, Trška gora, Slovenske gorice, Haloze and individual slopes in NW Slovenia. According to RUSLE, forests have much lower or even marginal degree of erosion.
The results of RUSLE erosion estimates on slopes > 50% are not meaningful enough, although they are marked on the map. In addition to very steep slopes, there are also high mountains and lithosols (very thin skeletal soils, bare rocks).

Evaluation of soil erosion of agricultural land in Slovenia

The high erosivity of precipitation strongly contributes to the fact that there are places with higher erosion rates in the west and northwest of Slovenia. High erosion is observed in the Goriška brda and, to a lesser extent, in the Posočje, due to the combination of tillage on gentle and steeper slopes and the high erodibility of some soil types. Highly erodible Calcaric and Eutric Cambisols are the cause of high erosion estimates in the Vipava Valley and Slovenian Istria. Terraces supported by stone walls are typical forms of the cultural landscape in this area. They are clear evidence that centuries ago, and in some places millennia ago, measures were taken to protect them from erosion. Since there were no sufficient spatial records of terraces in Slovenia, they are not included in the model. Therefore, we can conclude that soil water erosion in these areas is overestimated in our model. But the data on terraces exist, so the modeling should be updated.

In NE Slovenia, the Eutric Cambisols (silty and often poor in topsoil organic matter) are very susceptible to soil erosion. Despite lower precipitation, high levels of erosion are estimated, especially in vineyards and fields in Slovenske Gorice, Kozjansko and Goričko. In the plains (Dravsko Ptujsko polje, Prekmurje) there are very susceptible Dystric Cambisols in the valleys of Pesnica and Ščavnica moderately erodible Gleysoils. On these areas RUSLE-SI is not observed more severe erosion, which is otherwise common on the surrounding hills.

In Dolenjska, Notranjska, Karst and partly in Bela Krajina, Eutric and Chromic Cambisols develop mainly on hard limestones and dolomites. Higher clay contents and the presence of Ca are important factors for a good, stable polyhedral structure and sufficient water permeability throughout the profile. Stable and erosion-resistant terraces that are not supported by walls have been constructed over the centuries primarily to shape farmland on slopes rather than as erosion control measures. The extent of soil erosion on Rendzic Leptosols (the most common soil type in Slovenia) is probably overestimated by the RUSLE-SI method. These soils are often characterized by high soil organic matter content, friable structure, and frequently thicker humus or even organic A horizons. Rendzic Leptosols occur on hard limestones and dolomites, which are predominant on steeper slopes and at higher elevations in Slovenia.

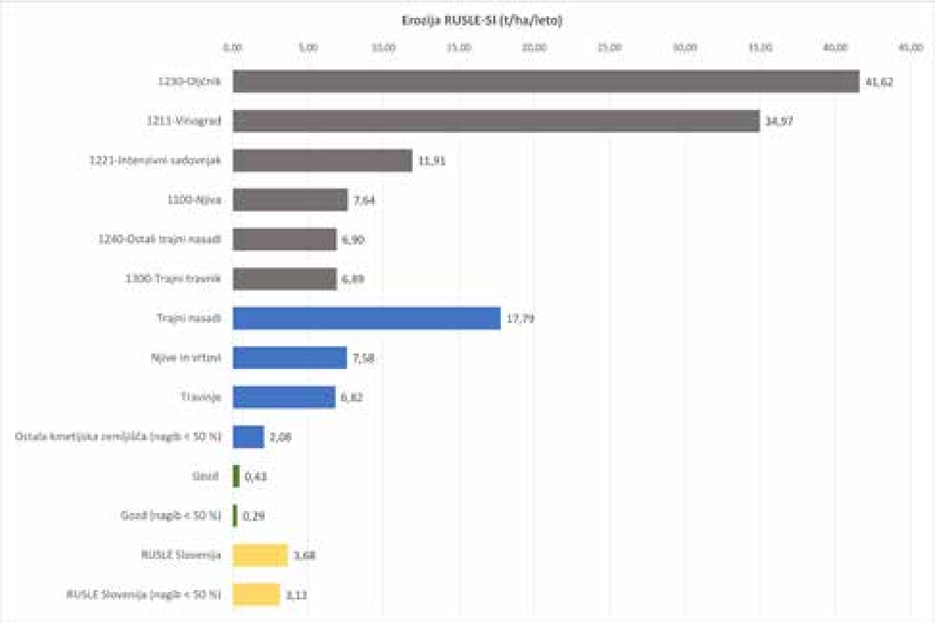


Figure 11: Erosion rates by selected categories of agricultural land use, by land use groups, and for the entire Slovenia.

Both field observations and calculations show that erosion is highest for permanent crops covering 2.62% of Slovenia's land area, of which olive groves (0.12% of Slovenia's land area) and vineyards (0.88%) are the most important. The share of arable land (8.95%) and meadows (17.93% of the area) is significantly smaller. Depending on the climatic conditions (erosivity and amount of precipitation) and the different relief, forest cover (59.0%) contributes to the relatively low erosion in Slovenia.

Soil erosion in Slovenia in figures

The RUSLE method reliably estimates erosion rates on reliefs with slopes less than 50% (< 26.6°). However, the estimate for higher slopes is less reliable. Therefore, estimates for a large portion of the Slovenian area (17.1%) with steep/steep slopes are less reliable, but still useful.

Broken down by groups of agricultural land use, erosion is calculated to be highest for permanent crops (17.79 t/ha on average), on land with intensive tillage, i.e. fields and gardens (7.58 t/ha), while total erosion on all grassland is somewhat lower (6.82 t/ha).

Calculations by type of agricultural use should show that erosion is most pronounced in uses with bare and cultivated soil. It is highest in olive groves (41.62 t/ha), vineyards (34.97 t/ha), much lower in intensive orchards (11.91 t/ha) and even lower in fields (7.64 t/ha). We assume that the RUSLE values for olive groves and vineyards, and to a lesser extent for intensive orchards, are exaggerated because a significant part of these land uses in Slovenia consists of terraces. Terraces were not included in the calculations because accurate data on selected terraced agricultural land in Slovenia were not known or available at the time of modelling. Repeated modelling that would consider data on terraces would significantly reduce erosion estimates for these areas.

For permanent grassland, erosion is estimated to be quite high (6.89 t/ha) given the permanent land cover, but this is understandable given the higher proportion of permanent pasture on (steep) slopes.

As expected, the estimate of the degree of erosion in forests is by far the lowest. Erosion in forests throughout Slovenia is estimated to be much higher (0.37 t/ha) than erosion in forests on slopes < 50% and in the plain (0.25 t/ha).

The average annual erosion in Slovenia is estimated at 3.68 t/ha. For 82.9% of Slovenian land with slopes < 50% on slopes erosion is estimated at 3.13 t/ha. A relatively large proportion of forests (59%) contributes to the low rating of the Slovenian erosion rate.

Figure 12: Severe erosion in the field (photo by Tomaž Poje).

Proper tillage can significantly limit erosion. Ploughing along the slope in this case contributed significantly to severe erosion. Transverse ploughing, while not desirable on Planosols, would significantly limit the negative effects of the rain event.

Figure 13: Erosion in the vineyard (photo by Tomaž Poje).

On the soil where the grass grows, there is almost no sign of erosion. On the other hand, there are signs of severe erosion on the bare soil.

Land use susceptible to erosion

In addition to rainfall (Rf), soil (Kf), and relief (LSf), the intensity of erosion is highly dependent on land use (Cf) and land management practises (Pf). The most sensitive types of agricultural land use are vineyards, fields, and orchards. Less sensitive are grasslands and orchards. Even within the same land use types, there are large differences due to cultivation practices or differences in land cover.

Figure 14: Severe erosion in arable land with high silt content in Prekmurje (photo by Geza Grabar).

Lower humus content, texture (predominant silt) and treatment method resulted in severe erosion, runoff into watercourses and accumulation in the flatter part of the field.

Figure 15: Agricultural practices or measures on the same land use can well limit the occurrence / erosion - the case of the fields (photo by Tomaž Poje).

The picture shows a pronounced ~ 30-40 cm deep and in some places ~ 1 m wide erosion ditch formed on a field ploughed in autumn, but not sown / covered with overwintering crops. It is located between fields where overwintering crops with similar slope and soil characteristics have successfully reduced erosion.

Adaptation and erosion control measures

The main guidelines for limiting erosion in the world are primarily related to land-use change, i.e., primarily preventing the conversion of forests to agricultural land and of grasslands to fields (FAO, 2019). In Slovenia, such guidelines are unlikely to be useful due to the (very) modest amount of agricultural land, low self-sufficiency and strategic security, high proportion of grassland, and especially the 59% forest area.

The second and third groups of erosion control measures should be introduced on a larger scale. The second group includes protecting the soil surface, limiting the rate and amount of surface runoff (terraces, grazing, etc.), ensuring good soil absorption capacity and deeper and better soil permeability (tillage, avoiding soil compaction, etc.). The third group of measures focuses on improving the quality of surface soil horizons. Agrotechniques that increase humus content are important because they improve the shape and stability of soil structure aggregates and ensure adequate soil porosity. It is the conservation tillage adapted to the soil type, the sound soil fertilisation, the maintenance of an adequate soil acidity (liming) and a better condition of the soil biota. However, the most important measure is to ensure soil cover. This is especially important during summer storms and prolonged and heavy rains in spring and fall.

The RUSLE-SI method does not apply to wind erosion, which is becoming increasingly common. The bora wind in the Vipava Valley has significantly thinned the soil of bare fields and vineyards in winter in some places. According to farmers, wind erosion is also occurring more frequently in Prekmurje. In such areas, planting linear structures of trees and shrubs is a useful measure to protect against soil erosion while increasing biotic and landscape diversity.

More attention must be paid to the good condition of agricultural soils and protection against erosion in all its forms. The new programme period should focus on maintaining soil quality, preventing soi erosion, integrating erosion indicators, and promoting erosion control measures, among others.

Figure 16 (left) and Figure 17 (right): gully erosion on cropland.

These figures show the effects of advanced erosion that can occur on cropland after heavy rains. The left image shows a gully on soil with a silty texture on a gentle slope. The right image shows gully erosion on a flat field on poorly permeable soils with unstable soil structure (photos by Tomaž Poje).

If we come to the conclusion

Erosion is very important, in some countries even the most important form of soil degradation. Both visible erosion and erosion that is difficult to detect cause great economic damage that does not only affect the agricultural sector. By reducing the ecosystem services provided by soil, erosion causes broader environmental damage that affects everything from biodiversity to climate change.

Slovenia is vulnerable to erosion due to frequent heavy and intense rainfall (870 - 3600 mm/year) and a large proportion of steep topography. On the other hand, a fine-grained structure of agricultural land (average farm size 6.52 ha in 2016), 54.2% share of grassland in agricultural land and 59.0% forest cover suggest that erosion cannot be a serious problem. Unfortunately, long-term and systematic measurements are not performed in Slovenia, so the estimates cannot be verified.

Nevertheless, we cannot ignore the fact that Slovenia has only a small amount of good agricultural land, that we are at the bottom of Europe in terms of the percentage of fields and gardens per capita (856.8 m2 / inhabitant in 2020), and that we are not self-sufficient in food supply.

It should also be noted that this brochure is mainly about erosion of agricultural land and less about other types of land use where erosion also occurs.

This confirms the consensus that soil must be protected from erosion in all types of land use, not just those where erosion occurs frequently. Agricultural production guidelines and policies in the agricultural development plan must adequately address the problem of erosion. Reducing and preventing soil erosion is a fundamental element of soil conservation and environment protection, and thus sustainable agricultural production.

Figure 18: Erosion in the olive grove after heavy rains (photo by Peter Kastelic).

The Calcaric Cambisols of Slovenian Istria, Goriška brda, Kozjansko, Goričko and other parts of Slovenia are prone to erosion, especially when freshly ploughed, deeply tilled, backfilled or filled.

Figure 19 (left) and Figure 20 (right): Consequences of erosion in permanent crops.

Both images show well the effect of advanced erosion that can occur when establishing or restoring permanent crops. In the olive grove of Slovenian Istria (photo Janez Bergant) there is a heavy downpour or longer intense rainfall deep eroded soils that were backfilled and unconsolidated; thus, in a very sensitive, erodible phase. In a felled vineyard in Vipava Valley (photo Borut Vrščaj) erosion is expected to accelerate at the site of the rut and due to poor structure, compaction of the soil and non-maintenance. Both cases are very erodible eutric brown soils and dictate preventive measures in the restoration / establishment of permanent crops.

Photo: Geza Grabar (a), Janez Bergant (b), Tomaž Poje (c, d, f),

Kmetijski inštitut Slovenije
Agricultural Institute of Slovenia

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA KMETIJSTVO, GOZDARSTVO IN PREHRANO

PROGRAM RAZVOJA PODEŽELJA

Evropski kmetijski sklad za razvoj podeželja: Evropa investira v podeželje