PRELIMINARY RESULTS OF RAINFALL EROSIVITY MAPPING FOR POLAND

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INTRODUCTION
WHAT IS RAINFALL-RUNOFF EROSIVITY FACTOR?

Proposed by Wischmeier and Smith rainfall runoff erosivity factor (R-factor) is generally considered as a useful tool for regional climatic condition description in respect to soil erosion by water.

1) It is a basic input parameter for popular soil-loss equations, like: USLE (Universal Soil Loss Equation) and RUSLE (Revised Universal Soil Loss Equation).

2) It is important parameter for real and potential soil erosion hazard mapping.

HOW TO CALCULATE R-FACTOR?

Longtime, at least 22-year rainfall registrations and their detail analysis are necessary for the calculation of R-factor:

$$Rr_j = \frac{Ek \cdot I_{30}}{100}$$

where:

Rr_j – single rainstorm erosivity [$1 \cdot EU = 1 \cdot MJ \cdot ha^{-1} \cdot cm \cdot h^{-1}$],

Ek – rainstorm kinetic energy [$J \cdot m^{-2}$],

I_{30} – maximal 30-min intensity [$cm \cdot h^{-1}$].

The rainstorm kinetic energy has to be calculated as a total of kinetic energy values for different periods of the storm having different constant intensities:

$$Ek_i = (206 + 87 \log_{10} I_i) P_i$$

where:

Ek_i – kinetic energy for a single i period of the rainstorm [$J \cdot m^{-2}$],

I_i – storm intensity for i period [$cm \cdot h^{-1}$],

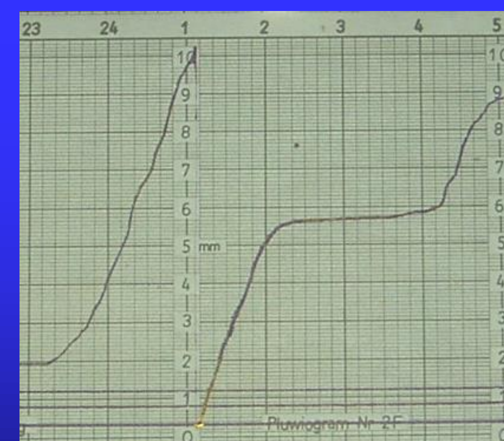
P_i – precipitation total for i period [cm].

WHAT DO WE KNOW ABOUT R-FACTOR IN POLAND?

1) R-factor values were originally calculated from the long-lasting recording-rain-gage records for only about 10 meteorological stations.
2) Only the proposal of isoerodents map of Poland based on approximated Fournier index method was published in 1985. However this map was not introduced into a widespread practical use.

Fournier index method:

$$R = \sum_{i=1}^{12} \frac{p_i^2}{P}$$



R – annual rainfall erosivity factor [EU],
pi –monthy precipitation total for i-th month [mm],
P – annual precipitation total [mm].

STUDY AIM

Elaboration of new updated rainfall erosivity map of Poland.

The study was concentrated on plotting of the map on the base of already calculated average annual rainfall erosivity factor values for a network of gauging stations in Poland.

STUDY MATERIAL

The formerly elaborated database of average annual R-factor values for 67 stations in Poland, estimated by means of artificial neural network was used as a base for this study.

Average annual R-factor values were calculated by means of previously successfully trained double hidden layer perceptron ANN of the following architecture: MLP 12:12-13-13-1:1. As an input for ANN average monthly precipitation totals from years 1951-1970 were used.

Estimated by ANN average annual R-factor values for analyzed 67 stations were at the range of 35,2 - 142,1 EU

LOCATION OF ANALYZED GAUGING STATIONS:

METHODS

Geographical Information Systems (GIS) techniques (GRASS system) and statistical methods (regression analysis associated with statistical hypothesis testing) were introduced for average annual R-factor spatial distribution estimation. A digital elevation model (DEM) GTOPO30 characterized by 1-km spatial resolution was the base for the relationship describing R-factor spatial variability development.

The following parameters were derived from DEM and used as independent variables at regression analysis:

- elevation above see level,
- slope,
- aspect,
- distance to the see,
- parameters describing the influence of surrounding analyzed point terrain's relief, calculated as the average of all the surrounding to the set up distance raster cells' elevations and assigned to the central raster cells (wide range of neighbourhood was analyzed from 1 km up to 30 km).

RESULTS

Important for the final model form parameters, characterized by significant correlation with R-factor values were identified by means of progressive step regression (made with use of Statistica 6.0 software):

1) normalized average elevation of surrounding at 2 km radius from central raster cell - $H_{avg2.N}$,
2) normalized average elevation of surrounding at 20 km radius from central raster cell - $H_{avg20.N}$,
3) normalized elevation of raster cell in question - H_N .

Other tested parameters were not statistically significant for average annual R-factor variability.

RESULTS – MODEL OF R-FACTOR VARIABILITY

Model describing average annual R-factor variability in Poland:

$$\mathbf{R = 0{,}69355\, H_{avg.2.\mathit{N}} - 0{,}10249\, H_{avg20.\mathit{N}} - 0{,}46106\, H_{\mathit{N}} + 52{,}23.}$$

where:

R - average annual rainfall erosivity factor,

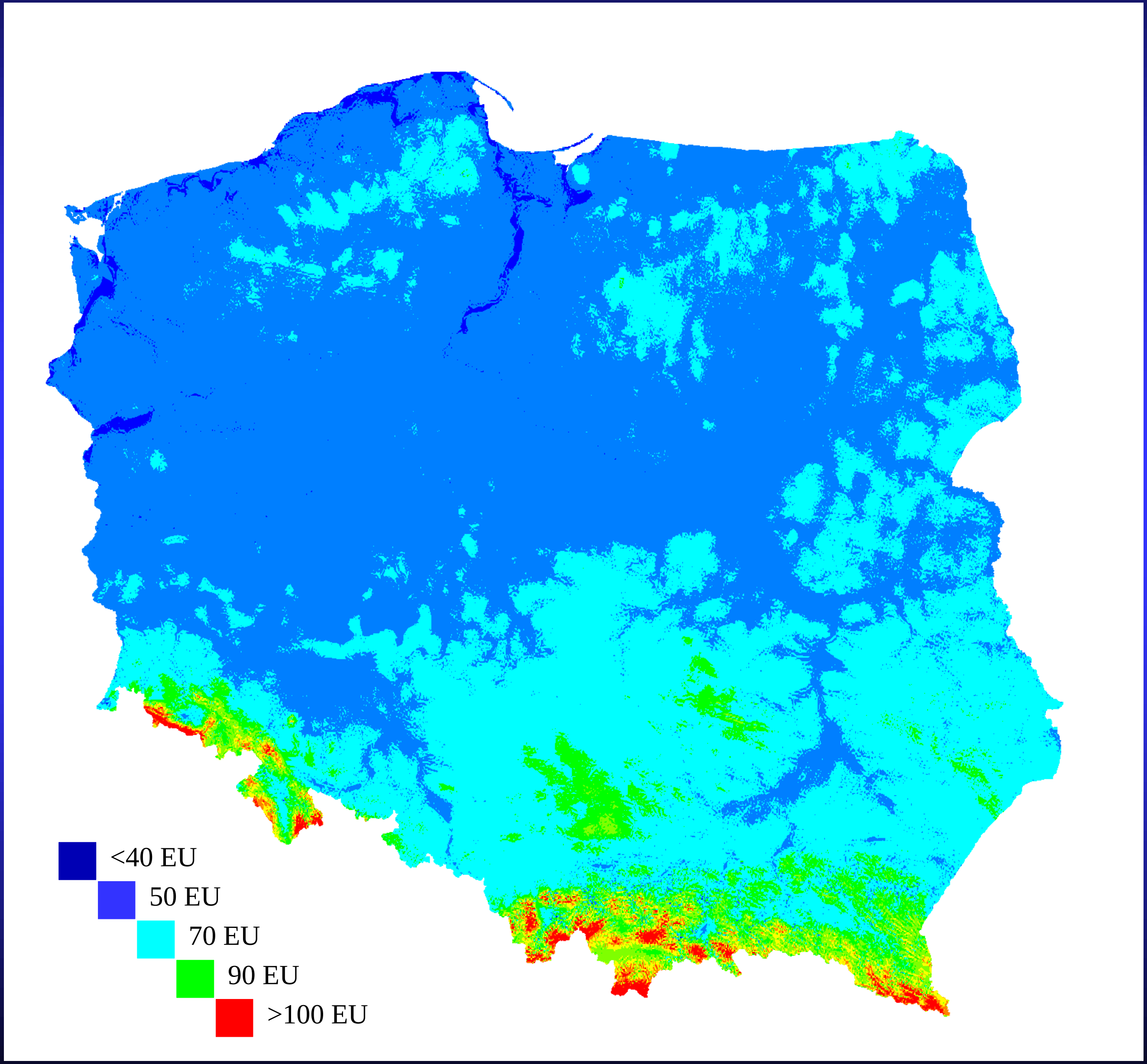
$H_{avg.2.N}$, $H_{avg.20.N}$, H_N - parameters derived from DTM.

Model was characterized by:

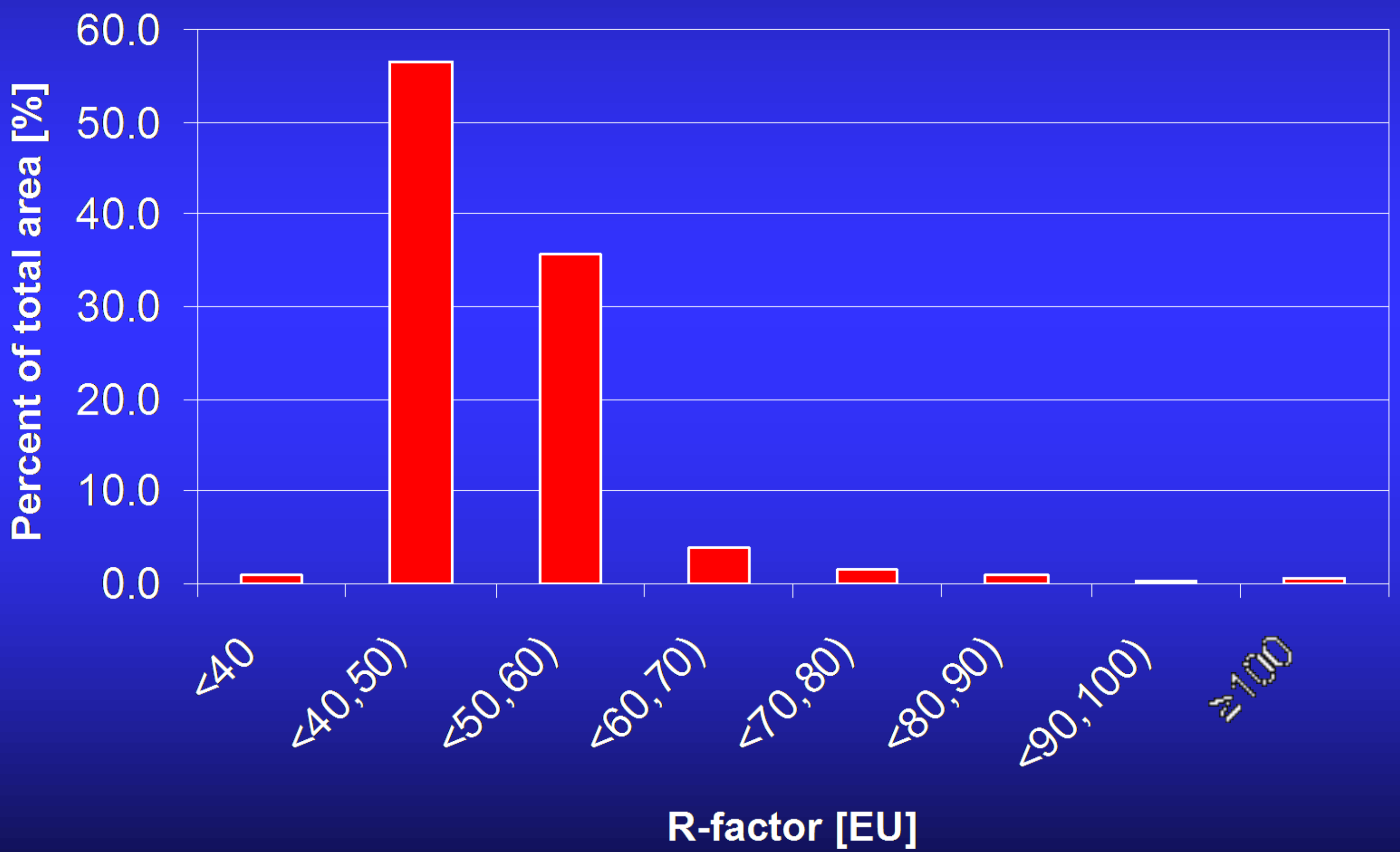
1) determination coefficient R^2=0,90;
2) F-statistic equal to 185,3;
3) standard deviation of errors for the output variable (STE) equal to 5,6 EU,
4) was statistically significant at $p<0{,}0000$.

Model evaluation showed that the regression rests distribution was close to normal one and only in case of 4 stations (Raciborz, Sniezka, Lebork i Aleksandrowice) exceeded 2 STE.

RESULTS –R-FACTOR MAP FOR POLAND



RESULTS –PERCENT OF AREAS UNDER DIFFERENT MAGNITUDE OF AVERAGE ANNUAL R-FACTOR VALUES IN POLAND



CONCLUSIONS

1) Developed average annual R-factor map can be practically used as an important information source for soil conservation service in Poland.
2) Most of Polish territory is under low or moderate values of R-factor at the range from 40 to 60 EU. Elevated, exceeding 100 EU R-factor values are observed for mountainous areas of southern Poland, being the heads of the two biggest Polish rivers: Wisla and Odra.
3) For better erosion prediction accuracy, presented map needs to be verified and updated in the future, especially for mountainous regions of southern Poland. Moreover as an attachment to the map, rainfall erosivity annual distribution curves for different regions of country should be developed and added in the future.

CONCLUSIONS

4) The study has proved that DEM should be used to aid mapping of rainfall erosivity. Implementation of GIS techniques allows to use DEM as a cheap source of vast topographic information.