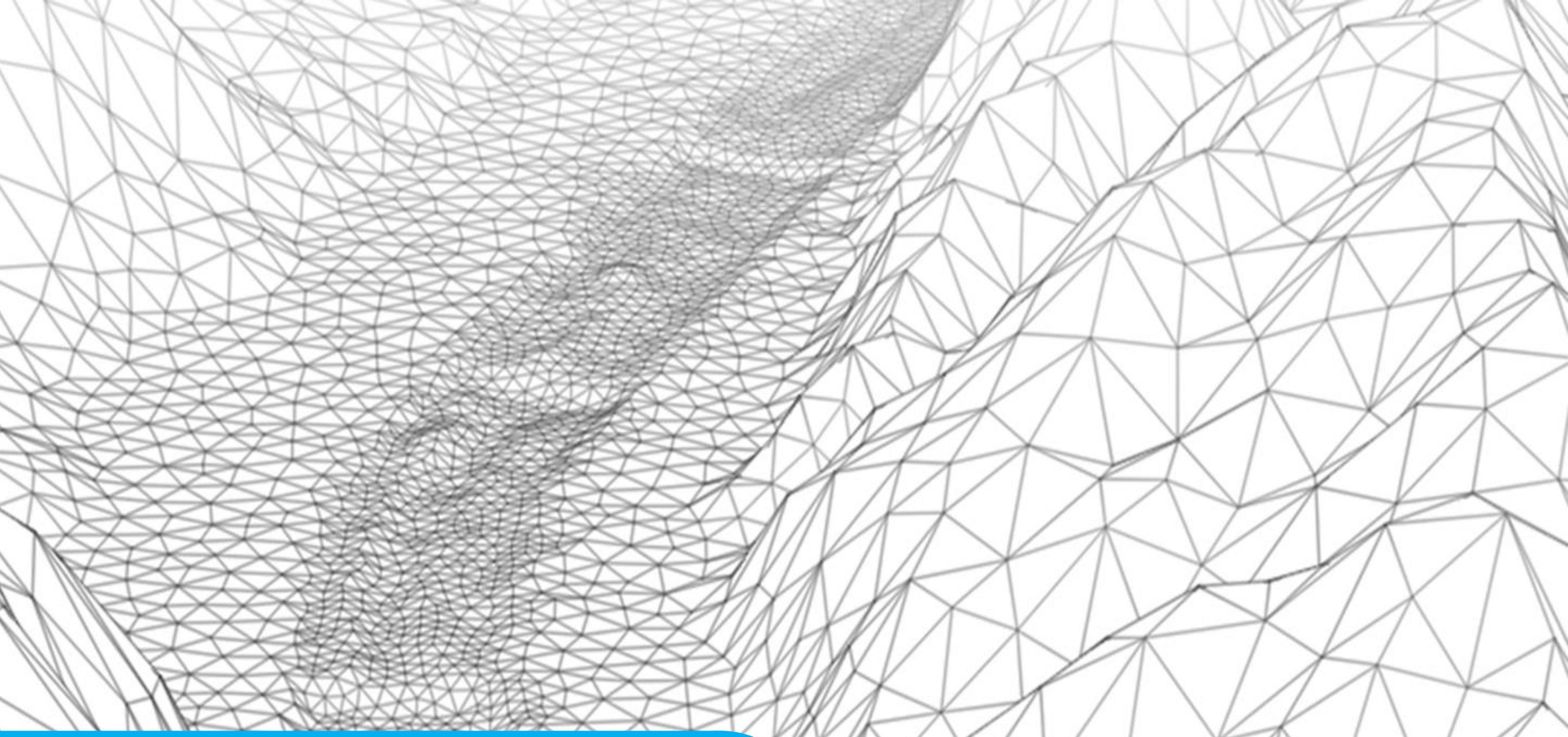

Impact of restoration on runoff formation

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Case Study Skawa Catchment (Poland)

Analysis of the impact of catchment restoration on runoff formation

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1 Introduction

1.1 Study area

Urbanisation processes relate to various aspects (demographic, economic, social, spatial-architectural and technical) and can be observed throughout Poland. As a result of these processes, the local land cover is often changed in a way that increases the area of impervious surfaces. This phenomenon can have a significant impact on hydrological processes in the catchment area and lead to an increased risk of flooding. The changes in land cover resulting from urbanisation processes are mainly associated with civil engineering structures. The construction of buildings, roads and artificial surfaces are the main factors responsible for the increase in impervious areas.

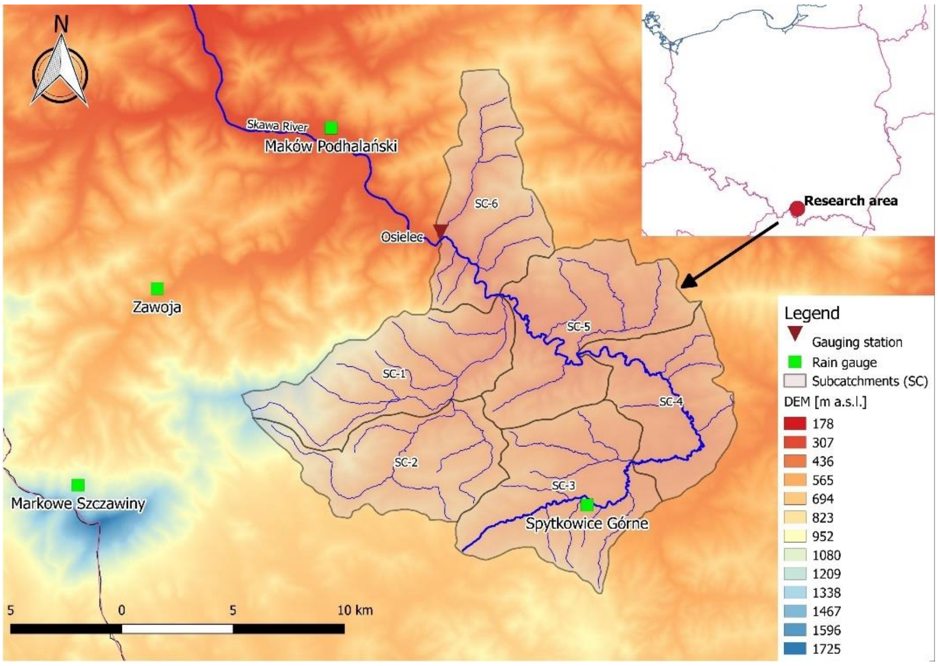

Figure 1. Research area —the Upper Skawa River catchment.

The mountainous catchments are naturally characterised by a rapid hydrological response, which is one of the main causes of flooding, but this effect is expected to be exacerbated by the expansion of impervious areas. The study area was a small mountainous catchment of 240.4 km^2, the Upper Skawa, located in southern Poland. Within the catchment six sub-catchments can be identified. Due to its mountainous landform and frequent heavy rainfall events, this region suffers from flash floods every year.

1.2 Hydrological model and CLC processing

Based on the previous exercise “Investigation of uncertainties related to hydrological modeling in the Skawa catchment, Poland”, prepare a hydrological model of the catchment area. It will be used to carry out simulations related to climate change mitigation.

For processing of the CLC data it is suggested to use QGIS software.

2 Analysis of land cover change

2.1 Download and visualize the Corine Land Cover Data

The Corine Land Cover (CLC) database is one of the most widely used databases in this field in Europe. Based on satellite measurements and ground validation, spatial maps of land use have been produced.

Download vector data for the years 1990, 2012 and 2018. Note: Vector data are characterised by large size, so it is recommended to crop the entire CLC vector layer to the catchment area.

Using the land use forms received, prepare a comparative map. As there may be many forms of land use in the layers of marginal importance, only the main ones with the following codes should be selected for further analysis: 112, 121, 131, 211, 231, 242,243, 311, 312, 313, 321, 324.

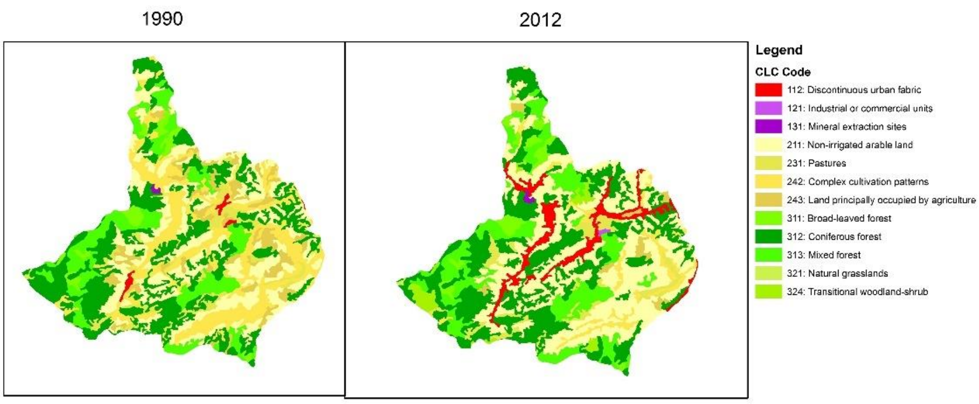

Figure 2. An example of a site comparison map for 1990 and 2012.

2.2 Prepare tables with data

Based on the vector data, calculate the areas for each CLC code and their % share of the catchment area (without sub-catchment area division). Compare 2018 with 1990 and 2012. Identify whether there is an upward (↑) or downward (↓) pattern.

Table 1. Sample table to be filled in.

CLC Code	Land cover	1990		2012		Pattern
		Area [km^2]	%	Area [km^2]	%	
112	Discontinious urban fabrics					
121	Industrial or commercial units					
131	Mineral extraction sites					
211	Non-irrigated arable land					
231	Pastures					
242	Complex cultivation patterns					
243	Land principally occupied by agriculture					

311	Borad-leaved forest					
312	Coniferous forest					
313	Mixed forest					
321	Natural grasslands					
324	Transitional woodland-shrub					

Comment on the results obtained. Analyse how the form of land use has changed and whether there is evidence of progressive urbanisation.

2.3 Surface runoff estimation

The Soil Conservation Services Curve Number (SCS-CN) developed by the United States Department of Agriculture in 1972 is one of the most popular methods for estimation of surface runoff knowing the amount of rain.

If the total rainfall is greater than initial abstraction, then the surface runoff in SCS-CN method is described as:

$$P_e = \frac{[P - I_a]^2}{P - S_p + R} \tag{1}$$

where:

P_e - runoff [mm], P - total rainfall [mm], I_a - initial abstraction [mm], R - potential maximum retention of soil [mm].

The maximum potential retention of soil (R) is related to the estimated CN value (CN):

$$R = 254\,(\frac{100}{CN} - 1) \tag{2}$$

The amount of initial abstraction (I_a) is expressed as a fraction of the potential maximum retention of soil:

$$I_a = \mu R \tag{3}$$

where: μ - empirical coefficient based on the CN value (CN < 70, μ = 0,075; 70 ≤ CN < 80, μ = 0,100; 80 ≤ CN < 90, μ = 0,150; 90 ≥ CN, μ = 0,200).

Taking into account eq. (2) and eq. (3) we can notice that the estimated surface runoff eq. (1) significantly depends on the estimated CN value.

2.4 Identification of Curve Number values

The Curve Number (CN) indicates the proportion of rainfall that contributes to surface runoff. Its value is estimated according to the relationship between the land cover and the hydrological soil group. The curve number is estimated between 0 and 100. The higher the CN value, the higher the proportion of surface runoff. Table 2 shows the CN values according to land cover and hydrological soil group.

Table 2. Curve Number values according to the land cover and hydrological soil group

CLC Code	Curve numbers for hydrologic soil group			
	A	B	C	D
112	54	70	80	85
121	85	90	92,5	94
131	77	86	91	94
211	65	76,5	84	88
231	30	58	71	78
242	30	58	71	78
243	78	83	86	88
311	30	55	70	77
312	36	60	73	79
313	30	55	70	77
321	39	61	74	80
324	30	55	70	77

Using the provided Excel file fill in the values of areas of different CLC corresponding to sub-catchments. The areas must be expressed in km^2. Once these values are provided in the next table in Excel file the CN values will be automaticly calculated. Identify how the CN values have changed over time according to CLC from different years (1990, 2012 and 2018).

3 Application of the hydrological model

3.1 Verification of calculated CN values

Compare the CN results determined using the Excel file with the initial values used in the model and with the results after calibration.
Select one version of the model (after calibration) for radar data and one for IMERG GPM data. This will be used in further analyses.

3.2 Impact of catchment restoration on catchment discharge

Renaturalisation can be an important tool to allow the catchment area to adapt to climate change. The issue here is not only what the impact will be from a land-use perspective, but also how it will affect the formation of surface runoff and, consequently, runoff in the catchment.

- recommend which forms of restoration can be applied in the analysed catchment area. Assess their technical complexity and potential costs.
- analyse the impact of these solutions on the formation of surface runoff,
- carry out hydrological simulations for different restoration scenarios to verify how much impact they will have on the formation of runoff in the catchment.