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Original Research Article

ANALYSIS OF THE LOCAL PRECIPITATION TRENDS IN THE PODKARPACKIE AND LUBUSKIE VOIVODESHIPS

Katarzyna KUBISZYN[1]
Faculty of Civil Engineering, Architecture and Environmental Engineering, Institute of Environmental Engineering, University of Zielona Góra, Zielona Góra, Poland

A b s t r a c t

The type of precipitation is one of the factors taken into consideration when deciding on the most optimal drainage system. Drainage systems are used to prevent the landslides caused by water erosion. Rainfall affect the rate of infiltration and the intensity of surface runoff and thus the occurrence, course and effectiveness of erosion processes [1, 2, 3]. Knowledge of local precipitation trends will help to apply precautions and thus minimise the risk of adverse events such as landslides. What is more it can help more effectively manage projects risks and costs.

The aim of this study was to analyse more than 30 years of data from daily rainfall measurements from the Podkarpackie Voivodeship and to check whether the occurrence of precipitation is a random event or whether it indicates long-term trends that may affect changes in ground stability. The non-parametric Mann-Kendall test and correlation test were used for the analysis.

Keywords: local precipitation trends, Mann-Kendall test, decision-making process map, risk management

1. INTRODUCTION

The observation of the weather's news' from last couple of years seems to indicate the changes in their intensity. The negative effects are visible both in the cities, which usually are flooded, and in rural areas, where occur the grounds erosions. Precipitation is one of the main reasons causes surface, linear and landslide erosion. The influence of rains on erosion processes is determined by frequency, amount, duration and intensity of rainfall. These features affect the rate of infiltration and the intensity of surface runoff, and thus the occurrence, course and effectiveness of erosional processes [1, 2, 3]. The decision-

[1] Corresponding author: Faculty of Civil Engineering, Architecture and Environmental Engineering, Institute of Environmental Engineering, University of Zielona Góra, ul. prof. Z. Szafrana 15 65-516 Zielona Góra, Poland, e-mail: k.kubiszyn@iis.uz.zgora.pl

making map of choosing the most optimal drainage system is presented in Fig. 1. We can see there, that among the all factors in selection of the system, one of the first is conditions of precipitation [11].

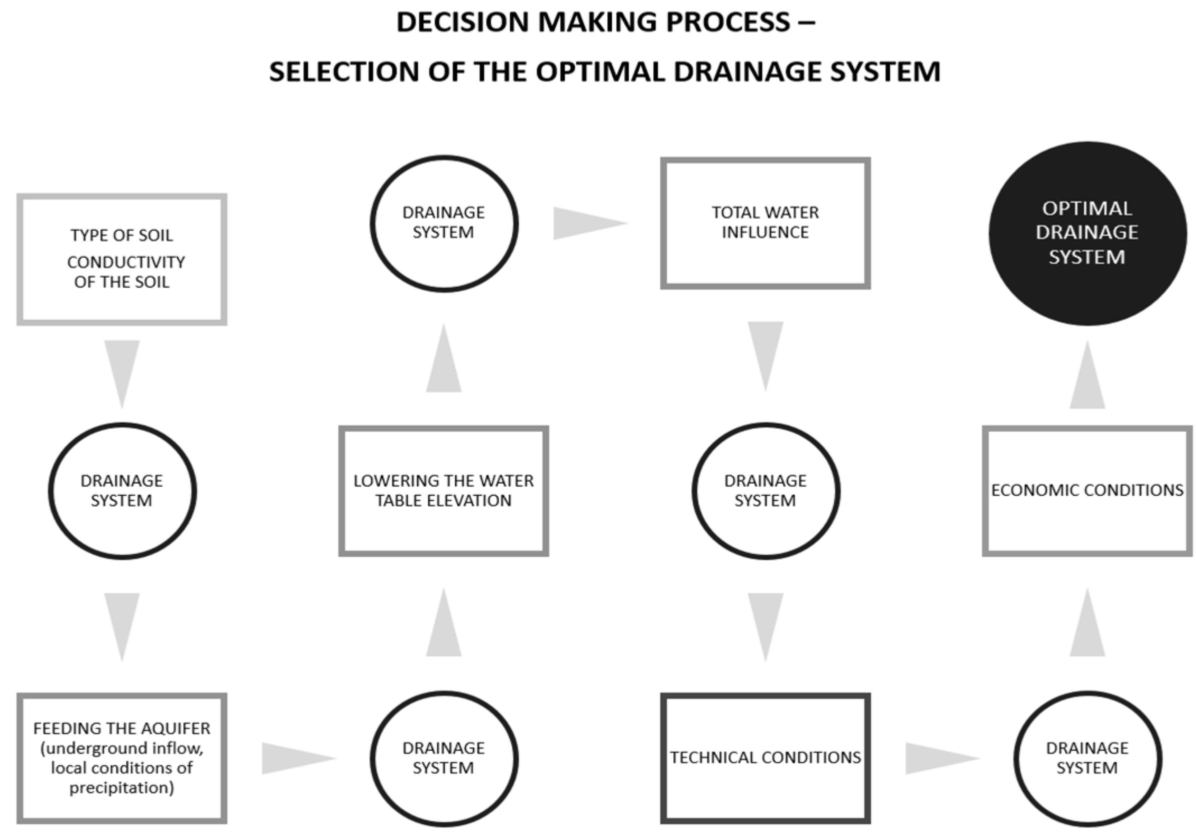

Fig. 1. Decision-making map of choosing the most optimal drainage system. Source: [11]

Knowledge of local precipitation trends will help to apply precautions and thus minimise the risk of adverse events such as landslides. Analysis of changes in local rainfall trends can help more effectively managing projects risks and costs.

To better understanding how precipitations affect the environment, scientists have created a number of classifications relating to this meteorological phenomena. One of such classification is Chomicza's classification, which refer to heavy and torrential rains [4]. This classification was based generally on two factors – amount of rainfall and duration. The other type of classification was presented in the paper '*[Natural disasters and the internal security of the country]*' published by Institute of Meteorology and Water Management (IMGW). It is based on the analysis of empirical data regarding the intensity of daily rainfalls and its effects. Due to the level of risk for environment, society and economy, precipitation was divided into four groups, which are presented in the Table 1 [5].

Table 1. Criteria of precipitation according to [5]

No.	Name	Amount of rainfall [mm/day]	Kind of risks
1	Minor flooding	30 - 50	– local flooding of low located areas and basements/spaces, – on streets arise stagnate layer of water formations, – in places where terrain is diverse occur the quick surface runoff, – ground erosions, – can be noticed problems with pedestrian and road traffic.
2	Flood-dangerous	50 - 70	– water from rainfall creates "rivers/streams" in undeveloped and urban areas, – occur bigger infrastructure destructions, – eroding of tree roots – possible of occurring mudslides
3	Flood	70 -100	– absorption of water by the ground is limited, – storm drains and sewage pipes cannot get back such amount of water, – the streets become water channels. – in areas with slopes, are created rushing streams destroying everything on their way. – the roads and railway are washed out, and the level of water in rivers suddenly increase. – landslides and mudslides are formed, – help of rescue organisations is needed.
4	Catastrophic flood	above 100	in addition to the events listed in point 3, it occurs: – uncontrolled runoff of water into rivers as a consequence of high intensity of precipitation, – rainfall occurring in shorter periods may be classified as torrential rain, – water in rivers exceed the level of riverbanks, – catastrophic destructions of all infrastructure including bridges, – humans' death – help of local as well as national and even international rescue organisations is required, – physical, medical, psychological, and financial assistance is essential for affected population

According to this classification, risk for the environment, society and economy may cause the precipitation at the level of 30 mm/day. Analysis of local, regional, and global changes of trends are provided by many researchers around the world. Results of studies shows that in the XX century average level of yearly precipitation increased. However, there are also studies indicating that increasing trend is not typical for each place. For example in Poland it was found increasing trend in south-east part but in the same time decreasing trend was noticed in the west [4, 6, 7, 5, 8, 9, 2].

Taking account above and the information about climate changing, the author of this paper is trying to find the answer for the question about the scale of changes in the structure of local precipitation. The paper contains the results of analysis a daily precipitation data from 23 stations located in Podkarpackie voivodeships, and 17 stations from Lubuskie Voivodeships, which were collected at least over the last 30 years.

In the climatology, time series tests for finding trends can be categorized as parametric and non-parametric methods. In the paper non-parametric trend tests were used to examine trends. This kind of tests require only independent data [10]. Statistical techniques such as Mann-Kendall test and Sen's slope estimator were used for examination the trends directions. The author has tried to find out the answer on the questions: does the structure of precipitation on the south-east part of Poland is changing, and what is the difference compering to western part?

2. RESOURCES AND STUDIE METHODS

The analysis of changes in the precipitation structure was limited to the area of southern part of Podkarpackie Voivodeship and Lubuskie Voivodeship. The data of daily precipitation gathered by IMGH over the last 30 years were analysed at both localisations.

Podkarpackie Voivodeship is located in south-east part of Poland and covers an area of approx. 18 000 km^2. Capital of voivodeship is Rzeszów. Podkarpackie has three different physiographic regions. In the northern part it is the Sandomierska Valley, in the middle - Carpathian Foothills, and in the south - mountains – the Low Beskids and Bieszczady. This region is under the influence of maritime climate of north-western Europe and eastern European continental climate. The local climate is also affect by regional surface relief and physiographic division. There occur three climate regions: lowland, foothill, and mountain. The average amount of precipitation depends on localisation and is from 565 mm (north part) to 1200 mm (Bieszczady Mountains). The average yearly temperature in the northern part is 8 ^oC and in the southern part 6 ^oC. The voivodeship is both agricultural and industrial region. In the Podkarpackie Voivodeship are areas of special natural values and vast forest complexes. The forest cover 38,3% of voivodeship [12].

In central-western part of Poland is located Lubuskie Voivodeship. Lubuskie cover an area of approx. 14 000 km^2. Characteristic for this region is lots of wooded areas and little industrialization. The climate is one of the warmest in Poland. The average air temperature in the region is 8.5 ° C, and the typical annual precipitation totals are between 500-600 mm. Although in the last decades in Zielona Góra (located in the centre of Lubuskie Voivodeship,) amount of worm seasons increased compere to cold, level of yearly participation has not change a lot. The lack of variability in the average annual rainfall results from the fact, that the intensity of rainfall changed [19].

The studies data come from website of IMGW, where can be find the measurements of daily precipitation from all meteorological stations located in Poland. Twenty-three stations located in Podkarpackie and 17 stations located in Lubuskie, which have been carrying out measurements continuously at least 30 years or more, were selected as a data source. The location of the meteorological stations shows Fig. 2 and Fig. 3.

In this paper, author analysed changes in seasonal and annual trends in local daily precipitation for individual stations and whole Podkarpackie region. Trends were checked in two groups of data. First group considered the number of measurements indicating no precipitation. The range of data for second group met the assumption showing the number of measurements indicating the rainfalls of no less than 30 mm per day. Precipitation above 30 mm/d may have influence on ground and slope stability [5]. To verify whether in those two groups are some trends, there were used non-parametric statistical methods.

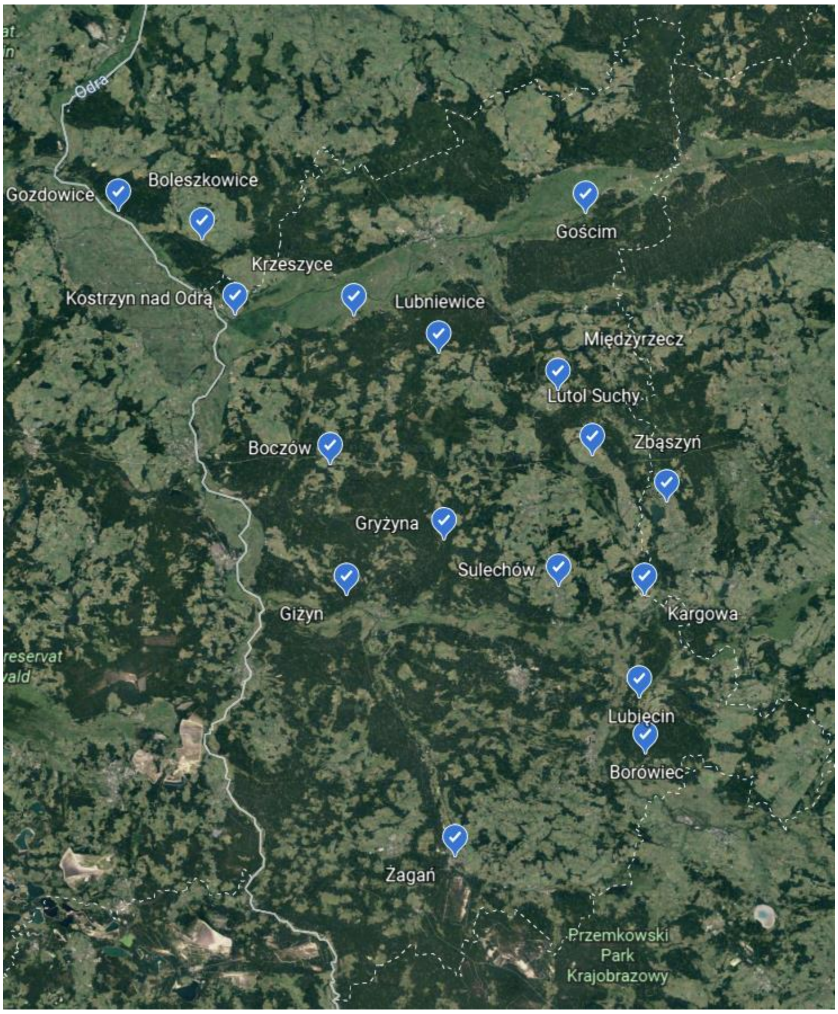

Fig. 2. Localisation of stations in Lubuskie Voivodeship. Source: [11]

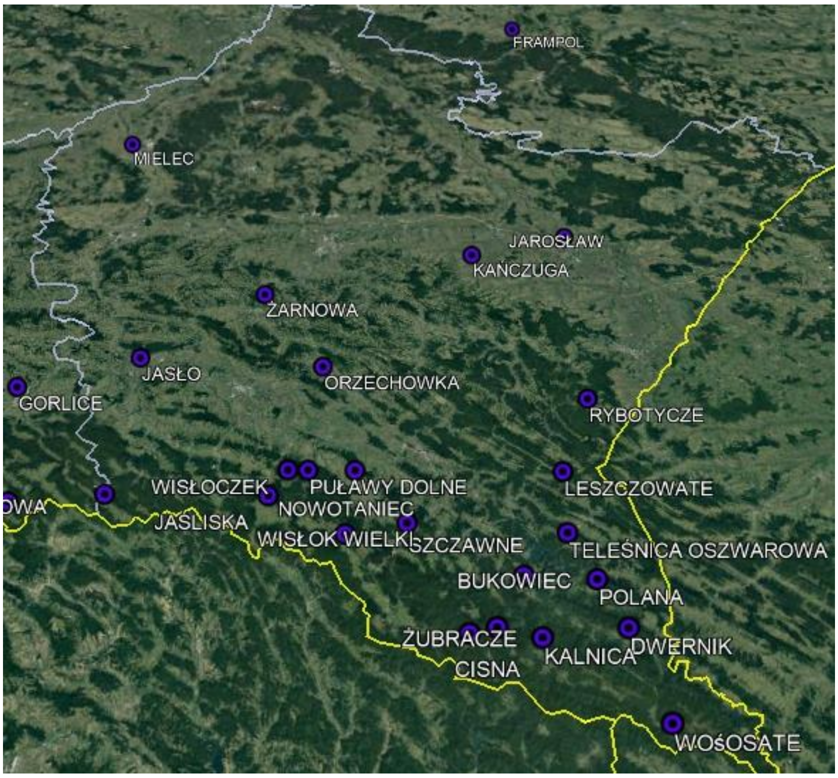

Fig. 3. Localisation of stations in Podkarpackie Voivodeship

The Mann-Kendall test statistic S is used to determine whether a time series has a monotonic upward or downward trend. Data for this test do not have to be linear or normally distribute. The null hypothesis for Mann-Kendall test assumes no trend, on the other hand, the alternative hypothesis indicates on a trend in the two-sided test or that there is an upward trend (or downward trend) in the one-sided test [13]. The S is calculated as [10, 7]:

$$\mathrm{S} = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_j - x_i) \tag{2.1}$$

where:
n – number of data points,
x_j, x_i – data values in time series i and j (j > i),
$sign(x_j - x_i)$ – sign function in accordance with formula (2.2):

$$sign(x_j - x_k) = \begin{cases} 1\, for\; x_j - x_i > 0 \\ 0\, for\; x_j - x_i = 0 \\ -1\, for\; x_j - x_i < 0 \end{cases} \tag{2.2}$$

A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a negative trend [10, 7]. As in studies n above 10 means that distribution of S is like normal distribution, with mean zero and variance. The variance of S can be calculated as in (2.3) [14, 13, 10]:

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i\,(t_i-1)(2t_i+5)}{18} \tag{2.3}$$

where:
m – number of tied groups
t_i – the number of ties of extent i.
The tied group is a set sample data with the same value.
The standard normal test statistic (Z_S) count by using formula (2.4) can be used to determine whether the time series data exhibits a significant trend [14, 10]:

$$Z_S = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}, if\ \ S > 0 \\ 0, \qquad\quad if\ S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}, if\ \ S < 0 \end{cases} \tag{2.4}$$

Positive value of Z_S point at increasing trends, while negative show decreasing trends. What is more, when $|Z_S| > Z_{1-\alpha/2}$, the null hypothesis is rejected, and significant trend exist in the time series. Testing trends is done at the specific α significance level, which in this paper is 0.05 [14, 10].
Non-parametric correlation coefficient is a statistic (τ) defined by a relationship (2.5) which takes values in the range [-1;1] [10]:

$$\tau = \frac{2S}{n(n-1)} \tag{2.5}$$

Positive values of τ indicates upward tendency, negative - downward tendency, and values near zero indicates lack of tendency [10].
Changes of analysis tendency can be described by correlation coefficient (β) expressed by the Sen's slope defined as [10]:

$$\beta = median\left(\frac{x_j - x_i}{j - i}\right) \tag{2.6}$$

where: i < j and (i = 1, 2, …, n-1, and j = 2, 3, …, n).

Analysis was done for four seasonals (winter, spring, summer, and autumn) and yearly data and for two groups (no precipitation, precipitation ≥ 30mm/day). In this paper value of significance level is interpret according to following scale [7]:

- p > 95% (<0.05) - significant change
- p = 90 - 95% (0.05-0.10) - near significant change
- p = 75-90% (0.10-0.25)- tendency to change

Results of statistic test for Podkarpackie are presented in the tables 4 to 8. What is more in those tables are presented also results for Lubuskie Voivodeship.

3. RESULTS OF ANALYSIS

Data were tested in 5 different time periods, annual, winter, spring, summer, and autumn. According to [11] in Lubuskie, the biggest number of trends for seasonal periods occur in first data group – 'no precipitation'. For whole area of Lubuskie Voivodeship trend in first group increase in winter, while in summer and spring the trends decrease. For second group of data – 'precipitation ≥ 30 mm/day' – there is no trends. Annual results for Podkarpackie as in Lubuskie, shows that only in one analyzed group – 'no precipitation' occurs increasing trend. Looking at the results of studies in seasonal time periods, it can be noticed that the biggest increasing trend for first group occur in autumn. In the group for precipitation above 30 mm/day no trends is observed. The biggest influence on the general trend has the southern part of region. This conclusion is also confirmed by the results of studies from stations located in the mountain region e.g., Cisna, Jaśliska, Kalnica, Zboiska. The results of studies were compiled in the tables 4 - 8, and Fig. 4.

Correlation between two data groups in Podkarpackie as well as correlation between Podkarpackie and Lubuskie were also studied in relation to the annual period. Results of analysis are presented in tables 3, and Fig. 5-6. We can see that in Podkarpackie Voivodeship correlation between 'No precipitation' and 'Precipitation ≥ 30 mm' has small relationship. What is more correlation between time series (years) and data from 'No precipitation' is much higher than correlation between time series and the second group data.

Looking on the result of correlation test for Podkarpackie and Lubuskie, it can be noticed that there is moderate correlation between the data for 'no precipitation' group.
In both voivodeships trends was not found in group called 'precipitation ≥ 30 mm/day'. However, in Podkarpackie voivodeship it was found the increasing trend of the periods without precipitations. Tendency for such weather was found also in Lubuskie.

Summing up the result of research for Lubuskie and Podkarpackie voivodeship, it can be said, that level of daily precipitation with intensity above 30 mm in the last years has not shown any tendency. However there is much more days without precipitation. This can result in changes of pore water pressure, increasing the water permeability, and lowering the stability of ground and thus the formation of landslides when torrential rain will occur [8, 15, 16, 17]. Another conclusion is that regional climate condition may be different even for close localizations. From project risk management point of view, knowledge about local climate help assess the level of precautions which has to be apply. This let to evaluate the propel costs and lower the risks of occur the harmful event.

Table 2. Results of correlation analysis for annual period in Podkarpackie

	Year	No precipitation	Precipitation ≥ 30 mm
Year	1,00		
No precipitation	0,63	1,00	
Precipitation ≥ 30 mm	0,11	-0,15	1,00

Table 3. Results of correlation analysis for annual period in Podkarpackie and Lubuskie Voivodeships

	Precipitaion ≥ 30 mm Lubuskie	No precipitation Lubuskie	Precipitaion ≥ 30 mm Podkrapackie	No precipitation Podkarpackie
Precipitaion ≥ 30 mm - Lubuskie	1			
No precipitation - Lubuskie	0,31	1		
Precipitaion ≥ 30 mm - Podkrapackie	0,09	-0,18	1	
No precipitation - Podkarpackie	0,24	**0,58**	-0,15	1

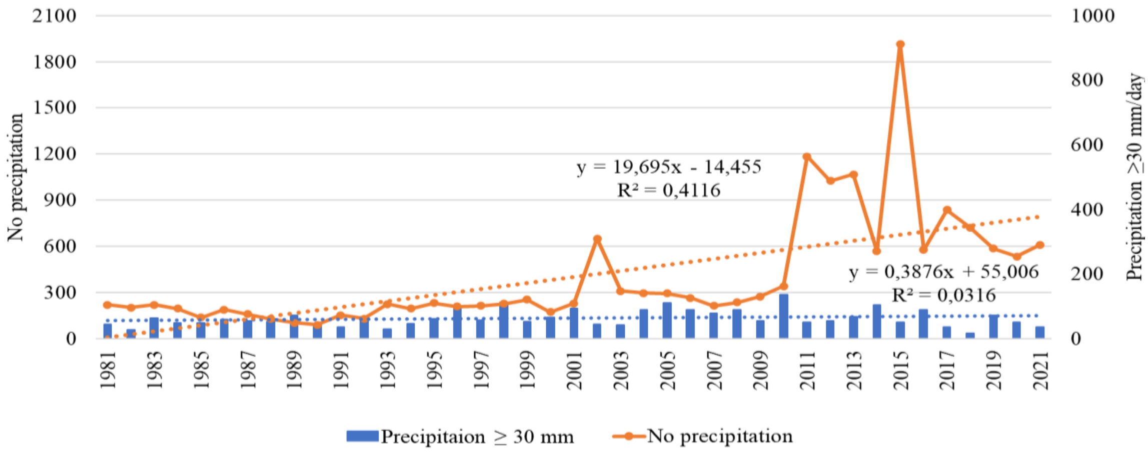

Fig. 4. Number of measurements per year - 1982-2022 in Podkarpackie. Source: author's compilation based on [18]

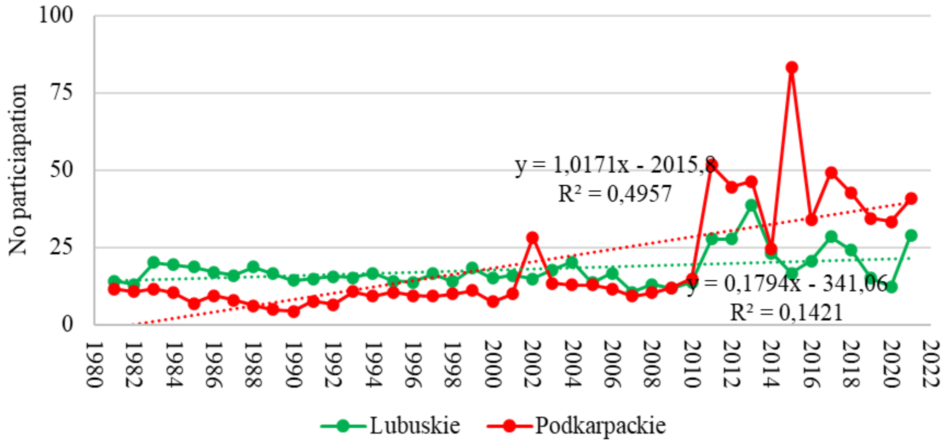

Fig. 5. Mean number of days without precipitation in Lubuskie and Podkarpackie Voivodeships. Source: author's compilation based on [18]

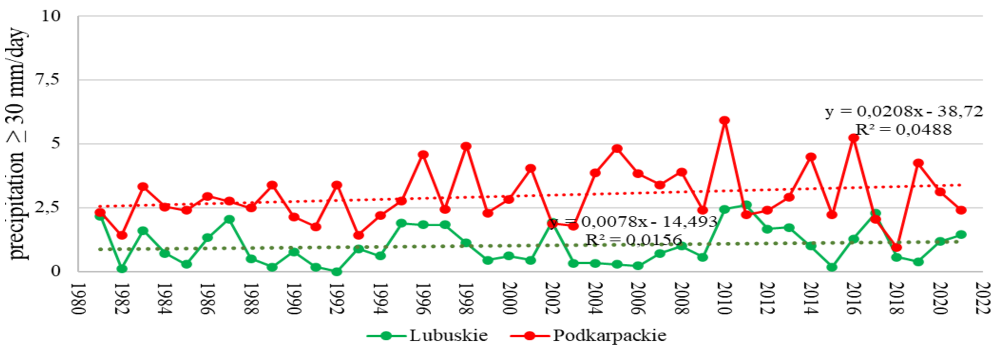

Fig. 6. Mean number of days with precipitation above 30 mm/day in Lubuskie and Podkarpackie Voivodeships. Source: author's compilation based on [18]

Table 4. The trend of changes in the number of measurements indicating no precipitation and precipitation ≥ 30 mm / day in the years 1982-2022

Annual	No precipitation				Precipitation ≥30 mm/day			
	S	τ	β	p	S	τ	β	p
CISNA	490,0	0,60	1,69	0,00	155,0	0,21	0,10	0,06
DWERNIK	263,0	0,32	0,56	0,00	-70,00	-0,09	-0,03	0,43
FRAMPOL	19,0	0,02	0,00	0,84	-62,00	-0,08	0,00	0,46
GORLICE	264,0	0,32	0,68	0,00	-20,00	-0,02	0,00	0,83
JAROSŁAW	130,0	0,16	0,16	0,15	-36,00	-0,04	0,00	0,68
JAŚLISKA	417,0	0,51	0,99	0,00	76,00	0,09	0,00	0,39
KAŃCZUGA	38,00	0,05	0,00	0,68	-70,00	-0,09	0,00	0,42
KREMPNA	261,0	0,32	0,75	0,00	72,00	0,09	0,00	0,41
LESZCZOWATE	97,00	0,12	0,10	0,28	-197,0	-0,24	-0,06	0,02
LUTOWISKA	34,00	0,04	0,00	0,71	-171,0	-0,21	-0,06	0,05
NOWOTANIEC	494,0	0,60	0,97	0,00	51,00	0,06	0,00	0,57
PILZNO	189,0	0,23	0,30	0,03	60,00	0,07	0,00	0,48
POLANA	462,0	0,56	0,76	0,00	-63,00	-0,08	-0,03	0,48
PUŁAWY DOLNE	519,0	0,63	0,90	0,00	131,0	0,16	0,04	0,14
RYBOTYCZE	-137,0	-0,17	-0,23	0,12	3,00	0,00	0,00	0,98
SZCZAWNE	260,0	0,32	0,33	0,00	14,00	0,02	0,00	0,88
TELEŚNICA OSZWAROWA	257,0	0,31	0,55	0,00	-23,00	-0,03	0,00	0,80
WISŁOCZEK	402,0	0,49	1,08	0,00	239,0	0,29	0,08	0,01
WISŁOK WIELKI	135,0	0,16	0,29	0,13	134,0	0,16	0,03	0,13
WYSZOWADKA	-268,0	-0,33	-0,20	0,00	-153,0	-0,19	-0,05	0,08
KALNICA	493,0	0,60	1,38	0,00	332,0	0,40	0,14	0,00
ZBOISKA	563,0	0,69	1,71	0,00	265,0	0,32	0,06	0,00
ŻARNOWA	333,0	0,41	0,50	0,00	153,0	0,19	0,00	0,08
PODKARPACKIE VOIVODESHIP	491,0	0,60	12,44	0,00	63,00	0,08	0,11	0,49
LUBUSKIE VOIVODESHIP	48	0,059	1,215	0,598	51	0,062	0,14	0,574

Table 5.The trend of changes in the number of measurements indicating no precipitation and precipitation ≥ 30 mm / day in the years 1982-2022 in Winter

Winter	No precipitation				Precipitation ≥30 mm/day			
	S	τ	β	p	S	τ	β	p
CISNA	522,0	0,64	0,93	0,00	-91,0	-0,11	0,00	0,19
DWERNIK	275,0	0,34	0,35	0,00	-71,0	-0,09	0,00	0,23
FRAMPOL	87,00	0,11	0,00	0,31	0,00	0,00	0,00	1,00
GORLICE	247,0	0,30	0,26	0,01	9,00	0,01	0,00	0,74
JAROSŁAW	223,0	0,27	0,11	0,01	0,00	0,00	0,00	1,00
JAŚLISKA	400,0	0,49	0,57	0,00	34,00	0,04	0,00	0,47
KAŃCZUGA	11,00	0,01	0,00	0,91	0,00	0,00	0,00	1,00
KREMPNA	271,0	0,33	0,45	0,00	5,00	0,01	0,00	0,92
LESZCZOWATE	151,0	0,18	0,11	0,09	17,00	0,02	0,00	0,69
LUTOWISKA	-27,0	-0,03	0,00	0,77	-35,0	-0,04	0,00	0,39
NOWOTANIEC	434,0	0,53	0,48	0,00	-57,0	-0,07	0,00	0,16
PILZNO	283,0	0,35	0,23	0,00	0,00	0,00	0,00	1,00
POLANA	381,0	0,46	0,33	0,00	-7,00	-0,01	0,00	0,80
PUŁAWY DOLNE	415,0	0,51	0,47	0,00	11,00	0,01	0,00	0,84
RYBOTYCZE	0,00	0,00	0,00	1,00	9,00	0,01	0,00	0,74
SZCZAWNE	281,0	0,34	0,14	0,00	-88,0	-0,11	0,00	0,06
TELEŚNICA OSZWAROWA	305,0	0,37	0,33	0,00	46,00	0,06	0,00	0,17
WISŁOCZEK	369,0	0,45	0,51	0,00	71,00	0,09	0,00	0,16
WISŁOK WIELKI	180,0	0,22	0,32	0,04	34,00	0,04	0,00	0,54
WYSZOWADKA	-172,0	-0,21	0,00	0,04	49,00	0,06	0,00	0,29
KALNICA	506,0	0,62	0,69	0,00	115,0 0	0,14	0,00	0,07
ZBOISKA	517,0	0,63	0,70	0,00	36,00	0,04	0,00	0,29
ŻARNOWA	301,0	0,37	0,24	0,00	-28,0	-0,03	0,00	0,41
PODKARPACKIE VOIVODESHIP	436,0	0,53	6,41	0,00	-24,0	-0,03	0,00	0,78
LUBUSKIE VOIVODESHIP	211	0,257	1,77	0,018	24	0,029	0,0	0,648

Table 6. The trend of changes in the number of measurements indicating no precipitation and precipitation ≥ 30 mm / day in the years 1982-2022 in Spring

Spring	No precipitation				Precipitation ≥30 mm/day			
	S	τ	β	p	S	τ	β	p
CISNA	368,0	0,45	0,19	0,00	-75,0	-0,09	0,00	0,39
DWERNIK	-8,00	-0,01	0,00	0,93	-23,0	-0,03	0,00	0,80
FRAMPOL	-19,0	-0,02	0,00	0,81	-59,0	-0,07	0,00	0,42
GORLICE	275,0	0,34	0,10	0,00	-105	-0,13	0,00	0,21
JAROSŁAW	-194	-0,24	-0,07	0,03	-75,0	-0,09	0,00	0,34
JAŚLISKA	173,0	0,21	0,05	0,05	-17,0	-0,02	0,00	0,85
KAŃCZUGA	-14,0	-0,02	0,00	0,88	-22,0	-0,03	0,00	0,80
KREMPNA	-100	-0,12	0,00	0,25	-56,0	-0,07	0,00	0,51
LESZCZOWATE	54,0	0,07	0,00	0,53	-218	-0,27	-0,03	0,01
LUTOWISKA	-16,0	-0,02	0,00	0,86	-72,	-0,09	0,00	0,40
NOWOTANIEC	382,0	0,47	0,17	0,00	-34,0	-0,04	0,00	0,69
PILZNO	-198	-0,24	-0,03	0,02	-87,0	-0,11	0,00	0,29
POLANA	202,0	0,25	0,04	0,02	-25,0	-0,03	0,00	0,78
PUŁAWY DOLNE	298,0	0,36	0,05	0,00	51,00	0,06	0,00	0,55
RYBOTYCZE	-278	-0,34	-0,08	0,00	-6,00	-0,01	0,00	0,95
SZCZAWNE	-9,00	-0,01	0,00	0,90	-6,00	-0,01	0,00	0,95
TELEŚNICA OSZWAROWA	-31	-0,04	0,00	0,73	-125	-0,15	0,00	0,14
WISŁOCZEK	255,0	0,31	0,09	0,00	124,0	0,15	0,00	0,15
WISŁOK WIELKI	-220	-0,27	-0,06	0,01	41,00	0,05	0,00	0,64
WYSZOWADKA	-290	-0,35	-0,06	0,00	-204	-0,25	0,00	0,02
KALNICA	318,0	0,39	0,15	0,00	200,0	0,24	0,00	0,02
ZBOISKA	474,0	0,58	0,30	0,00	196,0	0,24	0,00	0,02
ŻARNOWA	135,0	0,16	0,00	0,10	101,0	0,12	0,00	0,18
PODKARPACKIE VOIVODESHIP	323,0	0,39	0,95	0,00	-44,0	-0,05	-0,19	0,63
LUBUSKIE VOIVODESHIP	-177	-0,22	-0,50	0,05	-8	-0,01	0	0,94

Table 7. The trend of changes in the number of measurements indicating no precipitation and precipitation ≥ 30 mm / day in the years 1982-2022 in Summer

Summer	No precipitation				Precipitation ≥30 mm/day			
	S	τ	β	p	S	τ	β	p
CISNA	165,0	0,20	0,04	0,06	148,0	0,18	0,03	0,09
DWERNIK	-70,00	-0,09	0,00	0,40	-64,0	-0,08	0,00	0,46
FRAMPOL	18,00	0,02	0,00	0,81	-77,0	-0,09	0,00	0,34
GORLICE	247,0	0,30	0,06	0,00	-6,00	-0,01	0,00	0,95
JAROSŁAW	-80,00	-0,10	0,00	0,36	-15,0	-0,02	0,00	0,86
JAŚLISKA	-44,00	-0,05	0,00	0,61	55,00	0,07	0,00	0,53
KAŃCZUGA	-120,0	-0,15	-0,03	0,17	-108	-0,13	0,00	0,18
KREMPNA	-24,00	-0,03	0,00	0,75	135,0	0,16	0,00	0,11
LESZCZOWATE	17,00	0,02	0,00	0,85	-131	-0,16	0,00	0,13
LUTOWISKA	-28,00	-0,03	0,00	0,75	-139	-0,17	0,00	0,10
NOWOTANIEC	183,0	0,22	0,06	0,04	132,0	0,16	0,00	0,13
PILZNO	-212,0	-0,26	0,00	0,01	57,00	0,07	0,00	0,50
POLANA	280,0	0,34	0,04	0,00	-61,0	-0,07	0,00	0,49
PUŁAWY DOLNE	222,0	0,27	0,00	0,00	142,0	0,17	0,00	0,10
RYBOTYCZE	-173,0	-0,21	0,00	0,04	-20,0	-0,02	0,00	0,82
SZCZAWNE	-14,00	-0,02	0,00	0,83	29,00	0,04	0,00	0,75
TELEŚNICA OSZWAROWA	-90,00	-0,11	0,00	0,29	43,00	0,05	0,00	0,62
WISŁOCZEK	91,00	0,11	0,00	0,29	211,0	0,26	0,04	0,01
WISŁOK WIELKI	-277,0	-0,34	-0,05	0,00	132,0	0,16	0,00	0,13
WYSZOWADKA	-150,0	-0,18	0,00	0,08	-122,	-0,15	0,00	0,15
KALNICA	188,0	0,23	0,05	0,03	262,0	0,32	0,04	0,00
ZBOISKA	418,0	0,51	0,16	0,00	210,0	0,26	0,00	0,01
ŻARNOWA	107,0	0,13	0,00	0,16	92,00	0,11	0,00	0,27
PODKARPACKIE VOIVODESHIP	181,0	0,22	0,36	0,04	85,00	0,10	0,12	0,34
LUBUSKIE VOIVODESHIP	-281	-0,34	-0,79	0,002	80	0,1	0,09	0,37

Table 1. The trend of changes in the number of measurements indicating no precipitation and precipitation ≥ 30 mm / day in the years 1982-2022 in Autumn

Autumm	No precipitation				Precipitation ≥30 mm/day			
	S	τ	β	p	S	τ	β	p
CISNA	445,0	0,54	0,39	0,00	97,00	0,12	0,00	0,25
DWERNIK	320,0	0,39	0,14	0,00	4,00	0,00	0,00	0,97
FRAMPOL	14,00	0,02	0,00	0,87	3,00	0,00	0,00	0,95
GORLICE	277,0	0,34	0,20	0,00	71,00	0,09	0,00	0,23
JAROSŁAW	117,0	0,14	0,00	0,19	76,00	0,09	0,00	0,10
JAŚLISKA	402,0	0,49	0,27	0,00	85,00	0,10	0,00	0,21
KAŃCZUGA	25,00	0,03	0,00	0,79	0,00	0,00	0,00	1,00
KREMPNA	234,0	0,29	0,15	0,01	101,0	0,12	0,00	0,13
LESZCZOWATE	185,0	0,23	0,11	0,03	27,00	0,03	0,00	0,52
LUTOWISKA	113,0	0,14	0,00	0,20	-97,0	-0,12	0,00	0,10
NOWOTANIEC	376,0	0,46	0,24	0,00	13,00	0,02	0,00	0,84
PILZNO	144,0	0,18	0,08	0,10	-11,0	-0,01	0,00	0,67
POLANA	424,0	0,52	0,20	0,00	19,00	0,02	0,00	0,80
PUŁAWY DOLNE	446,0	0,54	0,20	0,00	31,00	0,04	0,00	0,66
RYBOTYCZE	-211,0	-0,26	-0,11	0,02	28,00	0,03	0,00	0,55
SZCZAWNE	316,0	0,39	0,13	0,00	45,00	0,05	0,00	0,47
TELEŚNICA OSZWAROWA	336,0	0,41	0,17	0,00	8,00	0,01	0,00	0,92
WISŁOCZEK	392,0	0,48	0,22	0,00	62,00	0,08	0,00	0,37
WISŁOK WIELKI	215,0	0,26	0,10	0,01	89,00	0,11	0,00	0,22
WYSZOWADKA	-117,0	-0,14	0,00	0,17	7,00	0,01	0,00	0,92
KALNICA	467,0	0,57	0,34	0,00	252,0	0,31	0,00	0,00
ZBOISKA	495,0	0,60	0,50	0,00	63,00	0,08	0,00	0,28
ŻARNOWA	259,0	0,32	0,11	0,00	87,00	0,11	0,00	0,03
PODKARPACKIE VOIVODESHIP	491,0	0,60	3,58	0,00	93	0,11	0,06	0,30
LUBUSKIE VOIVODESHIP	-46	-0,06	0	0,61	93	0,11	0	0,09

4. CONCLUSIONS

Summarizing the above considerations, the following can be concluded:

1. In the article were analysed occurrence of trends in the data series for number of days without precipitation and precipitation above 30 mm/day in 1982-2022 in the Podkarpackie Voivodeship for annual and seasonal period. Data to analysis was taken from 23 meteorological stations located in Podkarpackie Voivodeship.
2. The Mann-Kendall test and linear correlation test were used to find trends and the correlation between two groups of data.
3. Correlation between dry spells and occurrence of more intensity precipitation has not been found for Podkarpackie voivodeship.
4. Results of data analysis for Lubuskie and Podkarpackie show the increasing trend of occurring the days without precipitation. What is more, the trend is larger in the Podkarpackie voivodeship.
5. Scientific publications indicate dependency between dry spell periods, rains, and increasing number of landslides episodes,
6. Dewatering systems are one of protection methods against landslides. To choose the optimal drainage system, many factors must be taken under consideration, especially local hydrogeological and atmospheric conditions, as well as technical and economic factors.
7. Local condition of precipitation may be different in nearby area, if is only possible the trends of local precipitation should be analysed, instead of taking account indicators form books for large areas.
8. Knowledge about of local precipitation trends is helpful in the process of assessment the risks of projects realisation in the construction and environmental engineering sectors.

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