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THE POTENTIAL IMPACT OF THE EXTREME VOLUME AND INTENSITY OF RAINFALL ON THE NATURAL DISASTER RISK LEVELS OF HYDROLOGICAL ORIGIN IN HUNGARY IN THE PERIOD FROM FALL 2017 TO SPRING 2018

AZ EXTRÉM MENNYISÉGŰ ÉS INTENZITÁSÚ CSAPADÉKHULLÁS HATÁSA MAGYARORSZÁG HIDROLÓGIAI EREDETŰ KATASZTRÓFA VESZÉLYEZTETETTSÉGÉRE 2017. ŐSZÉTŐL 2018. TAVASZÁIG

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Abstract

This article is intended to demonstrate the risks of disasters of hydrological origin in Hungary and – through the presentation of a number of extreme weather event – in other countries in the light of the extreme volume and intensity of rainfall during the period from September 2017 to April 2018.
The purpose of the paper is to highlight that objective substantiation of the correlation between the changes in the patterns of precipitation and the increased risk of occurrence of disasters of hydrological origin can only be achieved by long term empirical research and recoding the data and damage events.

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Keywords: *disasters of hydrological origin, extreme rainfall*

Absztrakt

Cikkemben Magyarország – és néhány szélsőséges időjárási esemény bemutatásán keresztül más országok - hidrológiai eredetű katasztrófa veszélyeztetettségét mutatom be a 2017. szeptemberétől 2018. áprilisig tartó időszakban hulló extrém mennyiségű és intenzitású csapadékhullás tükrében.
Célom rávilágítani arra, hogy a csapadék jellemzők megváltozása és a hidrológiai eredetű katasztrófák bekövetkezése kockázatának növekedése közötti összefüggések, hosszú távú empirikus kutatás, illetve adat- és káresemény rögzítés segítségével támaszthatóak alá objektíven.

Kulcsszavak: *hidrológiai eredetű katasztrófák, extrém csapadékhullás,*

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CORRELATIONS BETWEEN EXTREME RAINFALL, DOMESTIC CLIMATE CHANGE AND DISASTERS OF HYDROLOGICAL ORIGIN

The adverse impacts of unfavourable meteorological and environmental events are substantial even when expressed in monetary terms. There are significant annual fluctuations. The total annual amount of damages and control measures in the average of multiple years ranges up to HUF 150–180 billion, thus reaching nearly 1% of the GDP. Global climate change may be associated with the increased frequency and intensity of certain extreme phenomena and the extent of losses may increase significantly. Additionally, there are losses which are difficult to be expressed in monetary terms, primarily in human health care and the natural environment. [1]

Based on the experiences of the past years, it can be concluded that extreme, immoderate weather events – which can be associated with the global climate change – have become more and more frequent, intensive and bear ever more striking features, such as the fall of sudden, torrential precipitation in great volumes or the appearance of a form of precipitation previously not characteristic for the season (such as snowfall in April 2017 or the deluge rainfall in May 2017 in Budapest).

"An extreme weather or climatic event is characterised as the occurrence of such a value of a climatic/meteorological variant which is below or above the threshold values determined on the basis of the probability distribution range of the variant under consideration, in other words such values are encountered only infrequently and with a low level of probability as concluded from the climatic data series."[2]

In my view, a clear and close correlation can be revealed based on the experiences gained from the past years and decades between the changes in these features of precipitation and the increased risk of the occurrence of disasters of hydrological origin. Hydrological disasters are understood as floods, inland excess water, flash floods, drought and extraordinary events which develop as the result or consequence of sudden high volume rainfall (for instance a chaotic state of traffic, damage incidents due to problems with water drainage).

I think that drought, as a disaster caused by a long standing lack or shortage of precipitation is of hydrological origin just like a calamity caused by sudden high volume precipitation. This concept was raised by several other authors studying the field.[3] My hypothesis is that in spite of the position statements related to climate change calling the attention of the reader to the reduced amount of the precipitation as a result of the overall global warming, the occurrence of the sudden high volume rainfall incidents will increase the risk of developing disasters of hydrological origin, irrespective of the actual season.

In my opinion we better acknowledge and admit that the extreme traits of weather are less and less dependant on the seasons of the year, therefore preparations to counter disasters of hydrological origin must be a continuous exercise.

The primary threatening impacts of disasters of hydrological origin in Hungary are represented by damages caused by excess/surplus water. [4]

I think my research is related to the preparation of a complex emergency situation forecast for the disaster management corps, and that my results may contribute to the preparation of a long term forecast with respect to disasters of hydrological origin. I think the strength of my research is that observation and recording of the same parameters can be accomplished in a time horizon of several decades. In 5-, 10-, 20-year cycles a more comprehensive conclusion can also be drawn from the data. The timeliness of this approach is underpinned by the fact that the first professional position statements dealing with global climate change – published more than ten years ago, even in consideration of the impacts in Hungary – outlined long term scenarios. A kind of "test for provenness" of these forecasts and predictions can be carried out already nowadays.

For instance the summary report of the VAHAVA project was published in 2005, where the following was formulated for the hydrological disasters in terms of disaster management aspects of the climate change for the coming decades: You have to reckon with the occurrence of low or medium significance, significant, and extreme floods in this country in every two to three years, five to six years and 10 to 12 years, respectively.

As a matter of fact, I think, looking back from a distance of the past 13 years, we can draw some conclusions from the predicted and actually ensued events. “In the past 20 years, the highest historical flood level fell on 21 rivers, three times on the Danube and 5 times on the Tisza, but record water levels occurred on the Sajó, Hernád, Mura and a number of other lesser watercourses as well.”[5]

OVERALL PRECIPITATION PATTERNS TYPICAL FOR THIS COUNTRY IN THE LIGHT OF CLIMATE CHANGE

The average figure of the annual volume of precipitation nationwide was 612 mm in the period from 1961 to 1990. The decline of rainfall reached 11% during the 1901 to 2004 period. [3] Having regard to the fact that precipitation has very diverse characteristics both in terms of space and time, the ten years averages are characterised more by fluctuations than by a certain kind of trend. As for the multiple years averages, the areas with high annual rainfall (at least 700 mm/year) have diminished, and the areas characterised by low rainfall (less than 500 mm/year) have increased. Our annual precipitation falls on 120 to 160 days, in other words approximately in every third day of the year you can reckon on precipitation of some kind.[3]

Most days with precipitation are typical at the end of autumn and the beginning of winter, originating from several rainfalls of lesser intensity. A part of the precipitation falls in the from of snow. In average, there are 20 to 30 snowy days at lower elevations, while in higher mountains you can anticipate 50 to 60 days with snowfall. Having regard to the fact precipitation basically is a lot more changeable parameter of the climate than temperature, it is difficult to draw regionally applicable general conclusions from the changing qualitative and quantitative properties of the precipitation and the climate change. It is particularly difficult to draw objective conclusions in Hungary, since the country lies on the borderline of climate zones with different signs: while the overall amount of precipitation increases in the temperate latitudes, it is on the decline in the subtropical areas, that is in the Mediterranean in Europe.[3] It can be stated in general, however, that the annual amount of precipitation in our country is diminishing, while the hydrological cycle has become more intensive due to the higher temperature, indicated by an ever growing amount of precipitation falling in the form of heavy rains. The extent of reduction in the autumn and winter precipitation is 12 to 14% [3], you may say it would not have any serious effect on the annual total precipitation figures. It is true mainly for the reduced amount of precipitation in the winter months, since the amount of precipitation in this season is the least compared to the other seasons of the year.

In comparison to the beginning of the twentieth century, the drop of the annual precipitation characterises mainly the spring months. The annual accumulated precipitation level typical for the season is only 75% of that at the beginning of the century[3]. No significant changes are shown in the summer precipitation, while the increased number of hot summer days has deteriorating effects on the quality of both water and arable land.

Fundamental correlations between rainfall and the occurrence of disasters of hydrological origin

Type and characteristics of precipitation	Typical season	Predictability	Extent	Accompanying phenomenon	Disaster of hydrological origin	Other disaster management complication	Damages caused	Example from the past 5 years
Sudden downpour of large quantities of rain	Summer, autumn, spring,	The exact location, the amount and intensity of the precipitation cannot be predicted in advance	As a rule, it has a local scope	Fierce rainstorm, large (with a diameter of minimum 2 centimetres) hailstones, Strong windstorm (wind gales exceeding 90 km/h) Violent tempest (exceeding a speed of 119 km/h)	Flash flood in low rate of flow streamlets, inland excess water, flood	Risk of landslide in mountain areas, risk of mudslides, panic at mass events, wounded persons and casualties, increased probability of the occurrence of road traffic accidents, soaking walls of residential buildings – quicker depreciation – becoming uninhabitable	Both in natural and built environments	Approximately 44 millimetres of precipitation fell on downtown Budapest within an hour on 23 May 2017, equalling three quarters of the monthly aggregate precipitation in May [6])
Extreme snowfall	Winter (spring)	The exact location, the amount and intensity can not be predicted in advance	As a rule, it has a local or regional scope	Strong windstorm (wind gales exceeding 90 km/h) Violent tempest (exceeding a speed of 119 km/h)	Inland excess water, flood as a result of snowmelt	Roads become impenetrable due to snow drift (in extreme cases cars may get trapped by the snow), some settlements cannot be accessed, increased probability of the occurrence of road and railway traffic accidents,	Both in natural and built environments	Snowfall on the long weekend holiday of 15 March 2013: snowfall and stormy winds on 15 March, reaching a 165 km/ hour speed on higher lying elevations.
Extreme hailstorm	Winter, spring, (summer)	The exact location, the amount and intensity can not be predicted in advance	As a rule, it has a local or regional scope	Extreme rainstorms, windstorms,	Flash floods in low rate of flow streamlets accompanied by heavy rains, inland excess water, flood	Increased probability of the occurrence of road traffic accidents, roof structure of residential buildings destructed – they may become uninhabitable.	Both in natural and built environments (substantial losses in agriculture, significant damages to roof of buildings, etc.)	A hailstorm occurred in Megyaszó on 21 June 2017 (B-A-Z. county), hailstones the size of a walnut fell destructing everything in the community
Long term shortage of precipitation	Summer	Can be predicted based on the temperature and anticipated precipitation levels	As a rule, it has a national scope and impact, but certain regions are affected more seriously (for instance the Great Hungarian Plain)	Extreme hot temperature	Drought	Open surface of lakes and rivers is reduced, water quality impaired	In natural environments, wearing down both wildlife and vegetation	Appears on a continuous basis to a lesser or greater extent

Table 1 Basic correlation between the fall of precipitation and the occurrence of disasters of hydrological origin, Prepared by the author

THE CHARACTERISTICS OF PRECIPITATION IN THE AUTUMN AND WINTER MONTHS OF 2017 AND THE SPRING MONTHS OF 2018

The Fall of 2017 was more humid in Hungary than the multiple years' average. The total amount of precipitation reached 190 mm as a national average. Compared to the average figure of the autumn seasons from 1981 to 2010 this means approximately 30% more.
However, individual autumn months have shown substantial differences in terms of the characteristics of the precipitation.

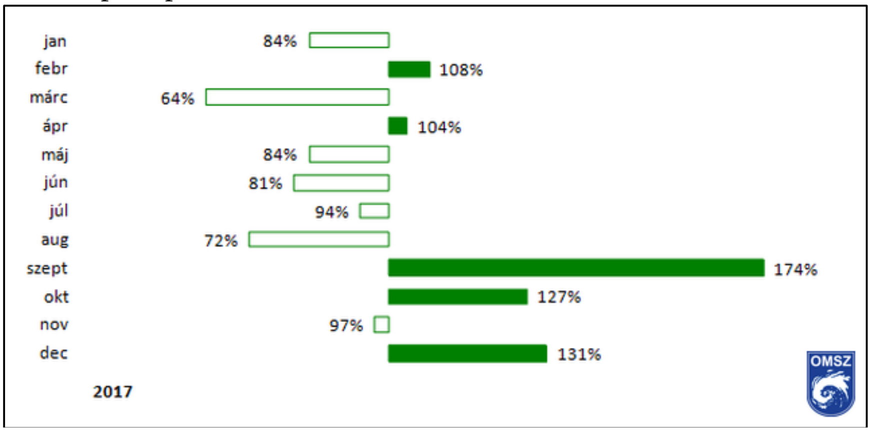

Figure 1 Monthly aggregate precipitation figures in 2017 expressed as normal percentage of the 1981-2010 period
(Source: https://www.met.hu/omsz/OMSZ_hirek/index.php?id=2079&hir=A_2017-es_ev_globalisan_a_2.,_a_hazai_rangsorban_a_13._legmelegebb downloaded on: 23 January 2018)

September was very humid. One hundred and seventy four per cent of the 1981-2010 September standard fell down.[7]

Precipitation in the month of October exceeded the customary level by 27%, which, however fell within a couple of days. Most of them on 22 and 23 October.[7]

On the other hand, there was less precipitation in November compared to the commonly observed amount in this month.

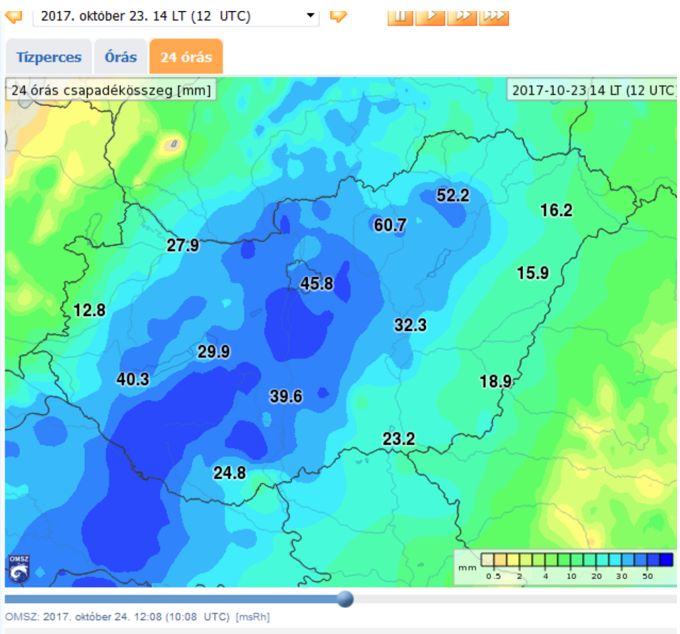

Figure 2 24-hour total aggregate precipitation in Hungary on 23 October 2017
Source: www.met.hu/idojaras/aktualis_idojaras/megfigyeles/csapadek downloaded on: 23 October 2017

DISASTERS OF HYDROLOGICAL ORIGIN AND CASES OF DAMAGE IN THE AUTUMN AND WINTER PERIOD OF 2017 AND SPRING 2018 IN HUNGARY

16 September 2017: a super cell entered the country at Barcs, resulting in a storm arriving to Pécs from the south, just at the time the Pécs Carnival was organised. The tempest stroke suddenly, accompanied by sudden downpour of large volumes of heavy rain and hailstones. Thousands of people had to flee from the tempestuous weather. Rainwater drains could not cope with the large volume of water which thus inundated the streets.

29 October 2017: Narcissus, the intensive cyclone swept across Hungary. Winds at a speed of more than 100 km/hour were measured in the great part of the country, which reached 130 km/hour at Lake Balaton and 125 km/hour in Budapest. Most affected areas and regions included Pest county, Győr- Moson- Sopron county, Bács- Kiskun county and Fejér county.

Most typical damages were as follows: dismantled roof structures, tumbled down fences, fallen trees, destroyed assets, leaking houses. In many cases, trees fall on residential buildings, power lines or telecommunication transmission lines. At some parts, the storm also triggered blackouts.

It was quite common on a national level that in the days following the storm disaster management units had to carry out recovery operations. Nationwide, approximately 3,700 incidents were reported to the disaster management headquarters and fallen trees, poles had to be cleared, damages caused by them cleaned up, rainwater had to be pumped from residential buildings, etc.[8]

First stage of flood control alertness was in place on 17 December 2017 in the respective areas of two different water management directorates along a 230–km-long section.[9]

The size of land inundated by inland excess water on 18 December 2017 reached. 14,930 hectares. The administration transferred 6.4 million m^3 excess water into the rivers.[9]

Flood control alertness and preparedness were ordered on 19 December 2017 in the area of four water management directorates on a total river section length of 566 kilometres, 68 km of them being second stage preparedness and 498 km first stage alertness.[9]

Inland excess water preparedness was ordered in the area of 8 water management directorates along 42 sections.

On the 20th December 2017, flood control alertness and preparedness were ordered within the respective areas of a total of 4 water management directorates, in a length of 654 km. Second stage preparedness affected a 68 km long section and first stage alertness applied to a length of 577 km. Watercourses concerned included the River Bodrog, Csincse streamlet, Eger streamlet, Eastern Main Canal, Laskó stream, Lónyay Main Canal, Ronyva stream, River Sajó and River Tisza. Watercourses below could be characterised with the features as follows[9]:

Túr: The flood wave travelling on the River Túr peaked at Garbolc on 17 December 2017 with a water level of 425 centimetres, followed by a slow recession.

Szamos: Only minor level increase could be observed. The highest water level was seen at Csenger on 17 December 2017, but did not the reach alertness level.

Kraszna: The flood wave peaked on 18 December 2017 at Ágerdőmajor with a water level of 422 centimetres, which still fell short of the flood control stage one alertness level.

Bodrog: the river peaked on 20 December 2017 with a water level of 698 centimetres at Felsőberecki, nearly hitting the third stage, i.e. the state of emergency.

Tisza: the river peaked at Záhony with 552 centimetres on 19 December 2017, which did not reach the second stage, state of preparedness.

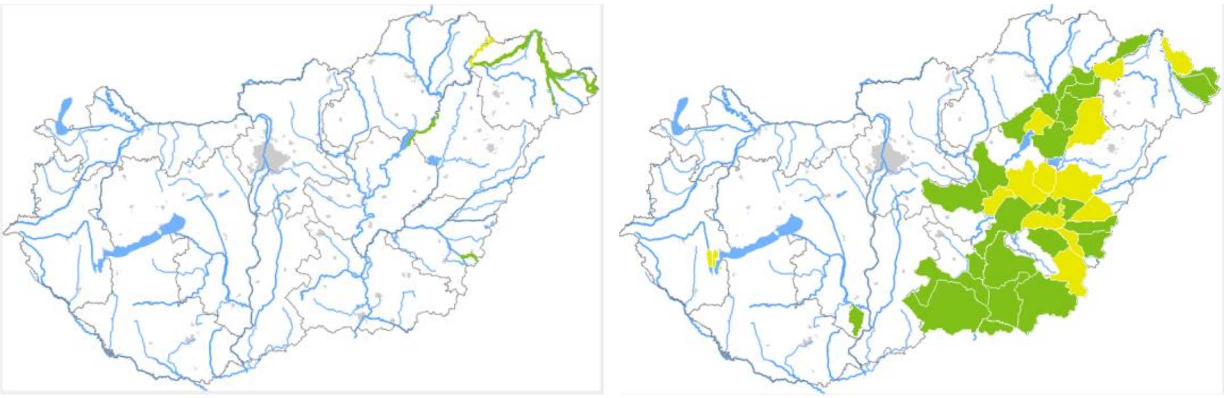

Figure 3 Stages of alertness in case of floods (left side figure) and in case of inland excess water (right hand side figure) in our country on 19 December 2017
Source: https://www.vizugy.hu/index.php?module=content&programelemid=1&id=1446 downloaded on: 22 January 2017

2018

17 March 2018: The same wayit happened on 15 March 2013 with the snow, an air mass of polar origin reached our country, resulting in wind gales of a speed of 70 km/hour, intensive, heavy precipitation in the eastern part of the Great Hungarian Plain and snowfall, snow drift to the east from the Danube.

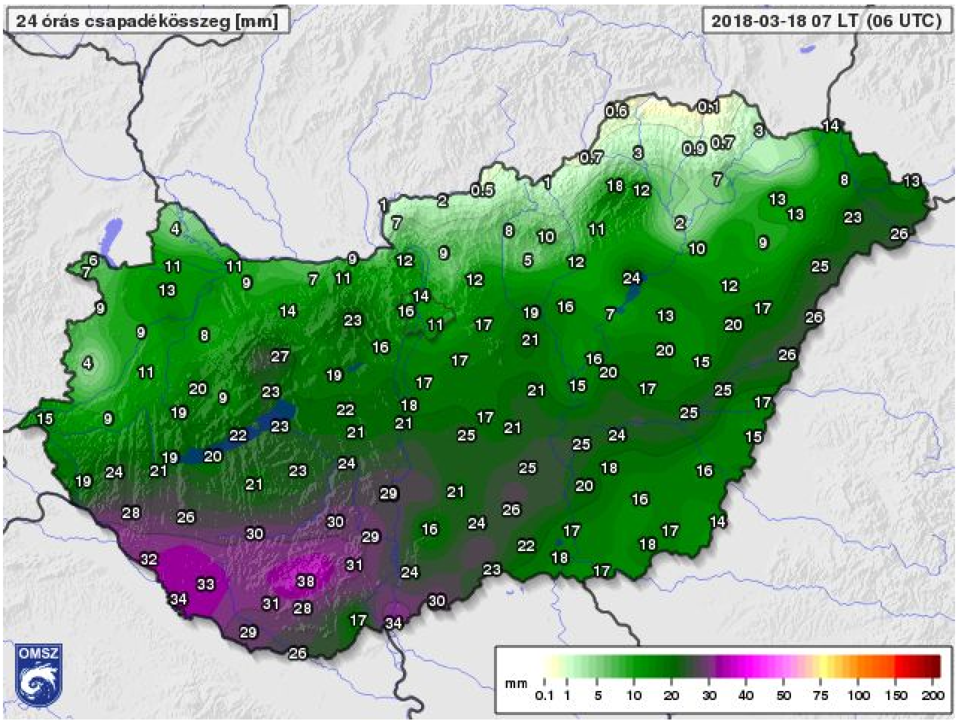

Figure 4 Aggregate 24-hour precipitation on 18 March 2016
(source: http://www.met.hu/ismeret-tar/erdekessegek_tanulmanyok/index.php?id=2151&hir=Hidegbetores_marciusban#t6 downloaded on: 6 April 2018)

In addition to the snowfall, freezing rain and drizzle was also formed, aggravating traffic problems and the disturbances of utility services nationwide at several locations. (Most of the problems focused on the areas of Hajdú-Bihar county, Jász- Nagykun- Szolnok county, Békés county.) Snow banks due to snowfall and slippery roads due to freezing drizzle were common. Due to the adverse weather conditions, vehicles slid into ditches at several locations and even the Hungarian Defence Forces took part in the rescue operations on Highway M3.

Highway M3 had to be closed off at several places due to snow removal, and in the next stage the icing of the road surfaces caused risks to road traffic.

CORRELATION BETWEEN THE CHARACTERISTICS OF PRECIPITATION AND THE FLOOD CONTROL EVENTS ENCOUNTERED

In mid-December 2017, strong and heavy precipitation activities were observed in the Sub-Carpathian area of the upper Tisza catchment. An average of 50 mm rain fell but locally extreme levels were also recorded. The amount of runoff was increased by the melting and runoff of snow from the mountains. The aggregate precipitation could be divided up to approximately 2/3 of rainfall and approximately 1/3 snowfall. In the area, average 2.3 mm (maximum 6.1 mm), 1.6 mm (maximum 9.6 mm), 0.8 mm (maximum 2.2 mm) of precipitation were measured in the basin of the river Sajó, the Hernád and of the Bódva, respectively.[10] With respect to the inland excess water, it can be noted that an amount of precipitation exceeding 50 millimetres occurred in the Bereg inland water system through several days starting with 12 December 2017, this is why water levels increased significantly in the inland water draining canal system.

SUMMARY

This article intended to demonstrate the risks of disasters of hydrological origin in Hungary and – through the presentation of a number of extreme weather event – in other countries in the light of the extreme volume and intensity of rainfall during the period from September 2017 to January 2018.

All in all, it can be concluded that during the period under investigation a relatively low number and small extent of incident of damage of hydrological origin occurred (flood, inland excess water, flash flood, drought). Storms accompanied by sudden downpour of large volumes of precipitation in the months of September and October entailed heavy destruction. The large amount of precipitation falling onto the catchment areas of our rivers caused rising water levels and flood in the second half of December, but no serious flood situations occurred in the country nevertheless.

In my opinion, it can be highlighted that from a disaster management perspective – both domestically and abroad – the impact of adverse weather conditions and extreme precipitation levels encountered resulted, in most of the cases, in the same patterns of typical damage events: streets with rolling water due to saturation of rainwater drainage systems, fallen trees, bursting overhead lines, impediments in traffic, disrupted power supply. These are the instant consequences of the sudden downpour of heavy rains and other types of precipitation locally, as opposed to the disasters of hydrological origin taken in the conventional sense which do not develop immediately (except flash floods) and do not necessarily cause problems locally, at the same place where the precipitation fell.

I think typical interdependencies between the formation of disasters of hydrological origin and the sudden downpour of heavy rains and other types of precipitation can be drawn up objectively in the light of the domestic impacts of global climate changed on the *long term* only. After a long-term analysis, my research can be seen as a kind of "test for provenness" of the climate change scenarios prepared 10-20 years ago, that records the amount of precipitation falling onto this country and the hydrological events encountered.

Considering that my long term goal is to investigate the correlations between the incidents observed and the characteristics of precipitation, it seems to be properly justified that the hydrological incidents observed and the characteristics of precipitation in the upcoming years be recorded.

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