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Floods in the Context of Natural Hazards and Risks

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Abstract

The worldwide methodology for gathering data about natural disastrous processes is still missing. Consequently it is hard to confirm the theory about increase of natural hazards due to the global warming. Nevertheless data about impact on human lives and property exist. Several specific statements about time and space distribution of floods, effects on different groups of the society allow us to evaluate the risk. The possition of floods among various natural hazards is discussed from the point of view of predictibility or occurrence regularity. Internal links between different types of hazardous processes and the role of complexity help to understand the fundaments of floods.

Key words: natural hazards and risks, floods

1. Introduction

With respect to increasing consequences of individual types of natural hazards and risks, the physical-geographical research has started to focus more on the study of these phenomena, too. The main aim of this rewiev article is to advance a broader overview of natural hazards with special regard to the position of floods among a large variety of hazardous processes. Individual types of natural disasters do have their specifics following from the essence of natural processes, nevertheless there are many common signs, as well, especially in relation to the human society. Floods occupy a significant position among natural disasters, both concerning their frequency as well as consequences. They represent a problem in developed as well as the third world countries. From the viewpoint of protection against floods, awareness of their dangerous nature in the population is important.

2. Natural Hazards and Risks

The term natural hazard generally means a potentially destructive process of natural origin, which may lead to losses in human lives, injuries, economic or social damages and/or to the environment degradation. A general definition of the natural hazard was presented already by Burton – Kates (1964): "Those elements in the physical environment (which are) harmful to man and caused by forces extraneous to him".

While sometimes it may be very difficult to distinguish the purely natural component of the process from that caused by humans. This fact is considered e.g. in the definition of White (1973): "An interaction of people and nature governed by the co-existent state of adjustment of the human use system and the state of nature in the natural events system".

In general, an extensive natural disaster need not always represent a process of the highest intensity; what matters is the extent of deviation from the "normal state", to which individual components of the environment have been adapted on a long-term basis. David (1993) describes this phenomenon as follows: "In fact we can define an extreme event as any manifestation in a geophysical system (litosphere, hydrosphere, biosphere or atmosphere) which differs substantially or significantly from the mean."

Natural hazards, no matter whether floods or e.g. volcanic activity or earthquake, have an entirely different impact when occurring in highly populated compared to less populated areas. There is always a relationship between the natural process on one side and its impact on vulnerability of the human society on the other. Goudie (1983) states that in the course of the past 125 years, the "impact of environment upon mankind" changed gradually into the "humanity's impact on environment". In such a case when lives are endangered directly or when values created by the human society are affected in any manner, we speak of natural risks. Extent of the risk is thus given not only by the intensity degree of the natural process concerned but also by the population density or infrastructure built. This is a quality, variable not only in space but also in time, from the viewpoint of the human society development. For example floods have formed in numerous river basins a part of the landscape development from the paleogeographic point of view, without unfavourable impacts or even with beneficial effects (see e.g. the Nile river in past millennia). We need to approach evaluation of floods adopting this point of view.

In determining natural risks, two approaches are applied (Bolt et al., 1975). The first case concerns the so-called relative risk. Intensity degrees of the natural process are compared only with each other (e.g. low, medium, high) and the probability of occurrence of the given phenomenon is not included. The second case of the natural risks evaluation applies the probabilistic risk in the sense of the phenomenon occurrence probability in the given time interval. However, determining of the probabilistic risk is very complicated due to insufficient accurate information which would lead to the time classification.

3. Increase of the Natural Disasters Occurrence

The question whether the natural disasters occurrence has been rising since the past decades or not forms the subject of many discussions. In fact, there is no worldwide database which would gather the data needed according to uniform methodology. Moreover, data coming from the third world do not exhibit comparable accuracy and in respect to the lower degree of technical development, they cannot exhibit accuracy in the nearest future, either. For example, the estimated number of people killed in the greatest natural disaster of the western hemisphere, when an earthquake in Peru in 1970 with subsequent phenomena such as rockfalls and landslides, reaches 50.000 to 80.000

persons (cp. e.g. Plafker et al., 1971; Browning, 1973; Bolt et al., 1975). Accurate numbers are not known. The lack of data for correct statistical analysis and the data non-homogeneity are mentioned e.g. also by Patera (2000).

Furthermore, this problem is affected by the increase of informedness related with the gradually globalized world. If we admit the increasing trend of the natural disasters occurrence, then the question arises whether this is not only an apparent phenomenon. Nevertheless, certain comparisons have been performed, both from the viewpoint of life losses and material damage as well as occurrence of phenomena according to individual types of processes (see below).

A relatively known and easily explainable fact is that the problem of economically developed countries is represented especially by material damage, higher losses in human lives are a significant feature of the third world countries on the contrary. David (1993) reveals the share of the third world countries in the total number of persons killed to be 95%. The same author mentions a paradoxical phenomenon, when e.g. a relatively small natural disaster may cause great material damage (when occurring in a developed country), on the contrary, a great disaster is very "cheap" from the viewpoint of its economic price (in a third world country). However, in spite of the high degree of technical development, repeated significant losses in human lives occur in countries such as e.g. the US, Japan or in some Mediterranean countries. Distribution of individual types of natural disasters on the Earth, including floods, is apparent from Tab. 1; Fig. 1 provides comparison for a more recent period (only for droughts, floods and wind storms).

Tab. 1 Loss of life by disaster type and by region during 1947–1980 (afer Shah, 1983)

	No. of events	**Asia**	**Oceania**	**Africa**	**Europe**	**South America**	**Caribbean + Central America**	**North America**
Earthquake	180	354,521	18	18,232	7,750	38,837	30,613	77
Tsunami	7	4,459						60
Volcanic eruption	18	2,805	4,000		2,000	440	151	34
Flood	333	170,664	77	3,891	11,199	4,396	2,575	1,633
Wind storms	402	504,890	290	1,417	435	205	16,877	5,027
Avalanche	12	335,000			340	4,350		

It follows from Fig. 2 stemming from data of 1960–1990 that the material damage increased in the course of the period observed. Increase of the number of victims is still unprovable (Fig. 3). While the periods with maximum total damage do not correspond with enormous numbers of victims (cp. Figs. 2 and 3). This is related with the course of consequences of natural disasters in developed and third world countries (see above).

Increase of the amount of risk of natural disasters can be explained in several ways. On the one hand, it concerns continuous settling in endangered zones due to the settlement density increase (e.g. Bolt et al., 1975). In the case of volcanic erruptions, it

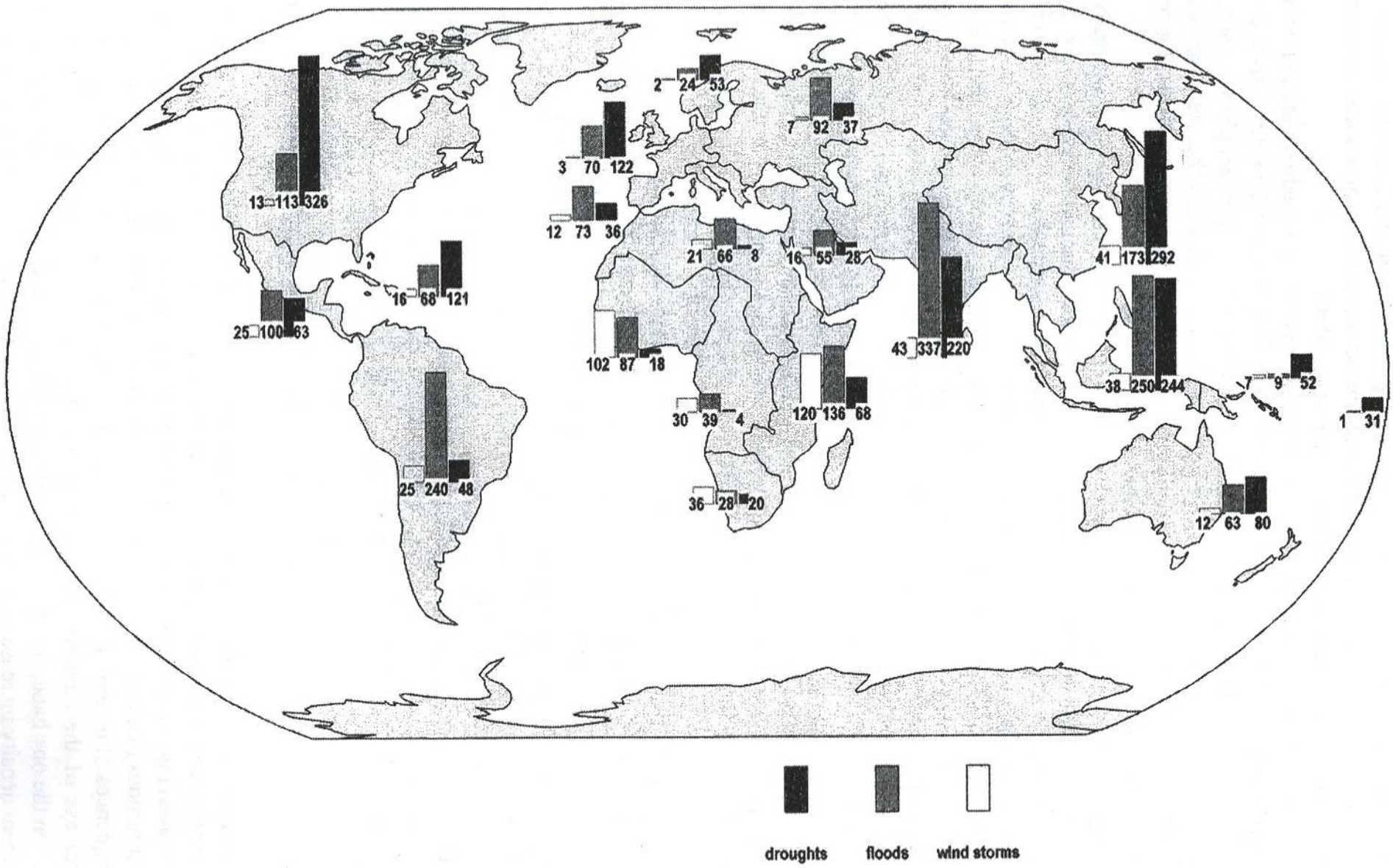

Fig. 1 The occurence of droughts, floods and wind storms: a geographical overview for 1973–2002 (ISDR, 2003)

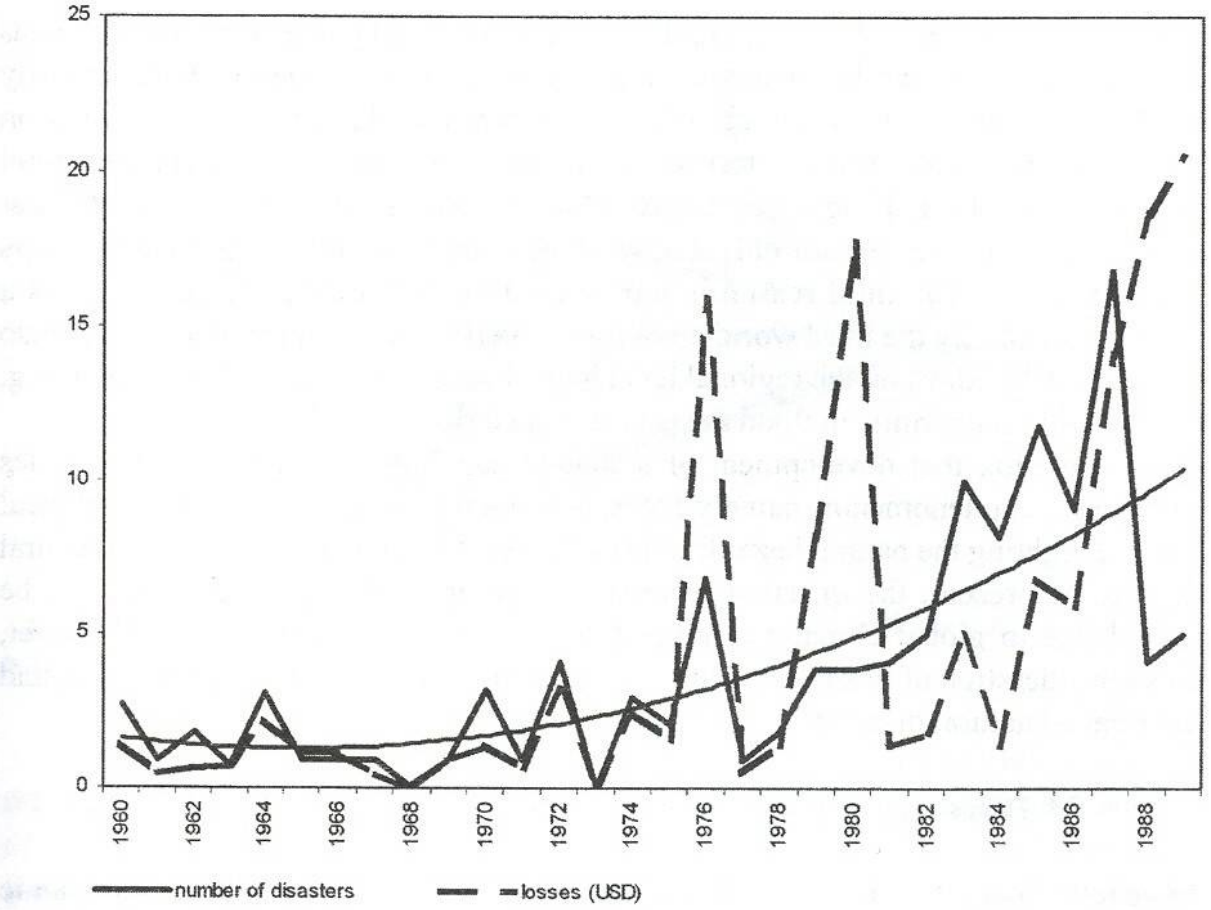

Fig. 2 Number of disasters and amount of losses 1960–90 (after David, 1993; Berz 1988 and 1992)

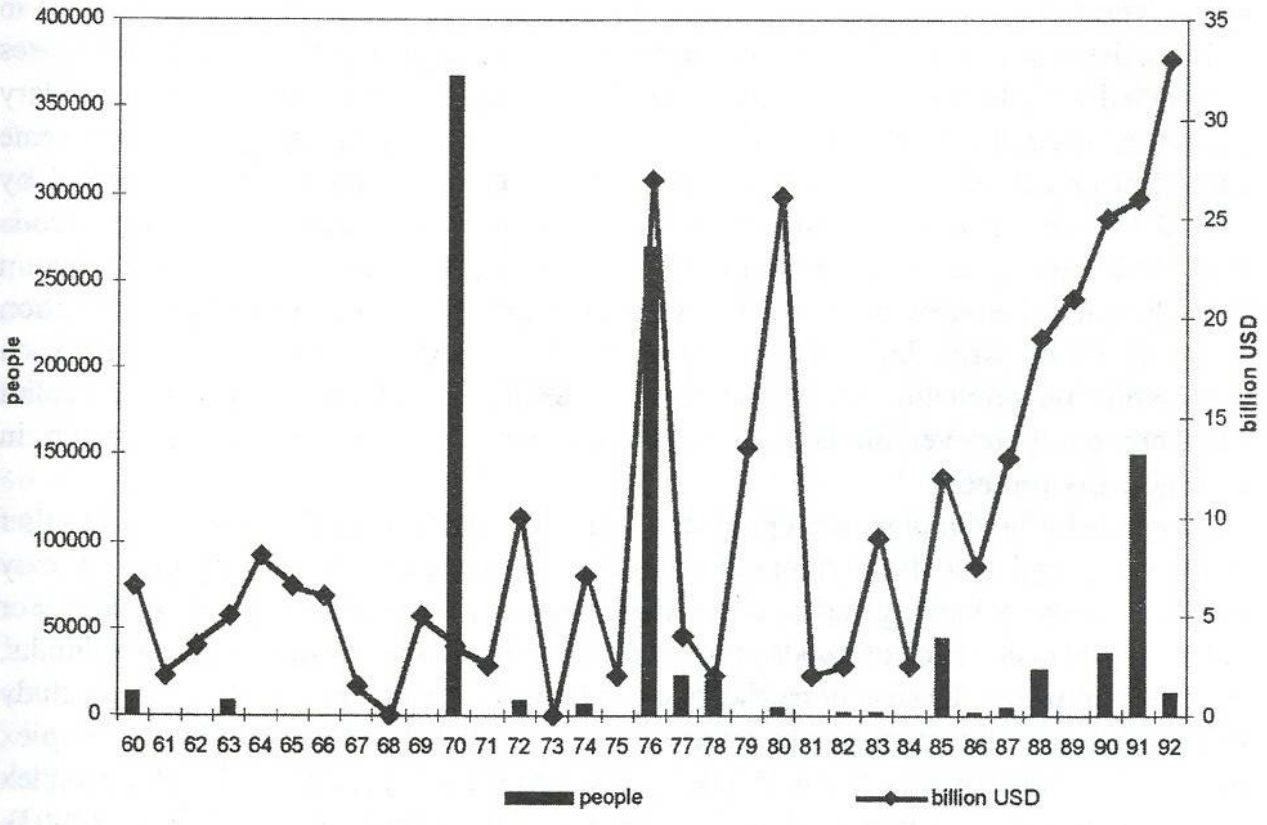

Fig. 3 Annual total of deaths and missing persons and annual total of economic losses from 1960–1992 (after Berz, 1992)

means settling at feet of volcanoes; or settling on valley flood plains in the case of areas endangered by floods. While reasons are of economic nature (increase of profit), mostly in developed countries, or existential – often in the third world countries. Another reason is represented by inappropriate interventions in the environment. From the viewpoint of floods, it is most often large-area deforestation or insensitive modifications of water courses bringing a local benefit only, but worsening outflow conditions in lower parts of the river basin. The third reason is represented by lack of knowledge – this is a problem of especially the third world countries, nevertheless local problems occur also in unqualified decisions on the regional level in developed countries. This concerns e.g. issuing of building permits in flood areas or in landslide areas.

It is a paradox that development of technical capabilities in developed societies brings a negative phenomenon, namely excessive reliance on capabilities of the technical progress in fighting the natural hazards, and deflection from any respect towards natural processes. At present, the question whether the number of natural disasters can be increased due to global climatic changes has been discussed extensively. However, serious consideration of this issue requires longer observation series (climatic ones and the number of natural disasters).

4. Floods in the Physical-Geographic Sphere

In general, natural hazards represent a case of sudden and fast response of dynamic systems to changes of external as well as internal conditions. Natural, dynamic systems are always a set of an entire series of mutually interconnected factors affecting each other. The scientific base of physical geography represents an efficient instrument in solving these processes, showing a disastrous course frequently, thus also the processes connected with floods. This concerns not only the floods themselves but also secondary processes accompanying the floods (e.g. slope movements occurring due to extreme rainfalls) or caused by the floods directly (e.g. slope movements again, caused by lateral erosion of water courses or increased level of underground water). Kalvoda (1996) characterized unstable landforms as those which "show a lack of equilibrium with the natural environment and are trying to obtain equilibrium through modification or by means of particularly dynamic processes". And the flood may be precisely such a dynamic phenomenon which accelerates establishing of equilibrium in the relief development. However, on the other hand it also can cause a state of disequilibrium in a certain environment.

The need of a complex concept of the natural disasters study follows from the relief polygenesis and also from frequent mutual interconnecting, when one process may function as the activating factor of another type of a destructive natural process. For example, the occurrence of floods may be also conditioned by, besides extreme rainfalls, the dam rupture in the case of earthquakes or significant slope movements. In the study of disposition of the given area to natural hazards, we thus need to stem from a complex of conditions and processes which may interact with each other (Fig. 4). The complex physical-geographic concept of flood research is presented e.g. by Kolejka (2003). The author also mentions geoecological aspects of this natural process. The interaction between floods and slope movements has been studied e.g. by Kirchner – Krejčí (2002).

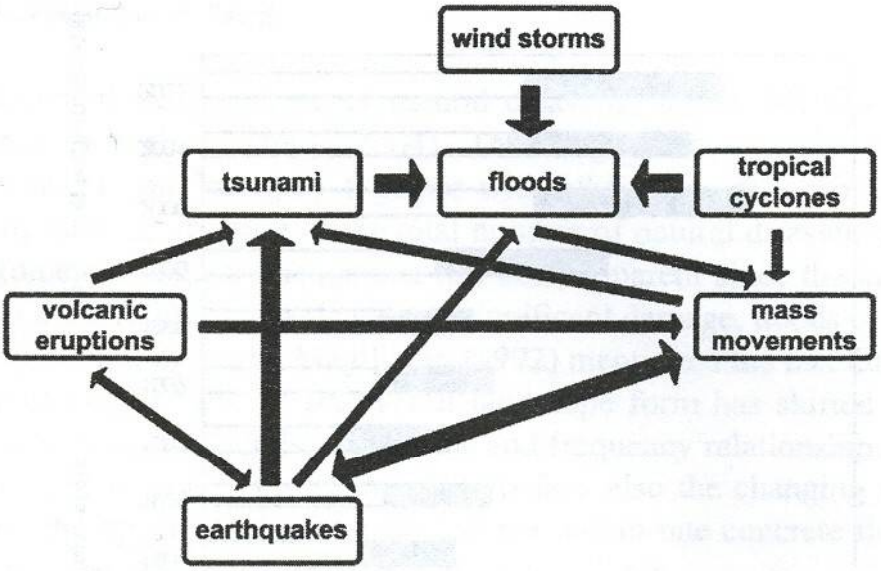

Fig. 4 Links between natural hazards (after Kukal, 1982). Arrows are indicating the causality of natural processes

Within the framework of the entire scale of varied natural disasters types, we can remark those occurring very rapidly, and those on the other hand, the start and course of which is relatively slow. Those with the most rapid course include earthquakes (seconds), tornados (minutes); the slow ones include e.g. the surface subsidence or various forms of earth degradation (years to centuries). On the imaginary scale of the course speed, floods can be classified approximately in the middle (hours to days). The so-called flash floods are manifested within hours. This is a very important characteristic from which the time needed to warn the population is derived.

As an example, we can mention the flash flood on the Olešenský Brook in June, 2004, when rainfalls in Ledeč nad Sázavou were not strong, nevertheless especially the upper part of the Olešenský Brook was hit by the storm activity and the flood wave carried along several passenger cars and flooded houses on the quay.

Social-economic factors adjoined gradually the originally primary natural component. For example, the extent of the flood destructive effect is given by the natural component (rainfalls intensity, level of infiltration, relief inclination, extent of the river basin etc.), but also by the settlement degree in the flood area. Human activities may and may not represent an activating effect of such rapid changes, or possibly they may co-act, accelerate these processes. The problem in the study of causes and significance of natural hazards lies in determining the level and intensity of the human activities influence. The result is thus the need of complex study of phenomena, while preserving a certain specifity between e.g. endogenous- and exogenous-conditioned phenomena. For example, tectonic-conditioned earthquakes and volcanic activity have their source of energy as well as activating impulse outside of reach of the human society influence. The situation is more complicated in the case of floods and their research represents a demonstration of interaction of partial geographic disciplines. One-sided and limited angle of view may often lead to wrong interpretations, and in the final result, it may form the basis of the irreconcilable approach of the "engineering" and "conservationist" concept of the flood causes determining.

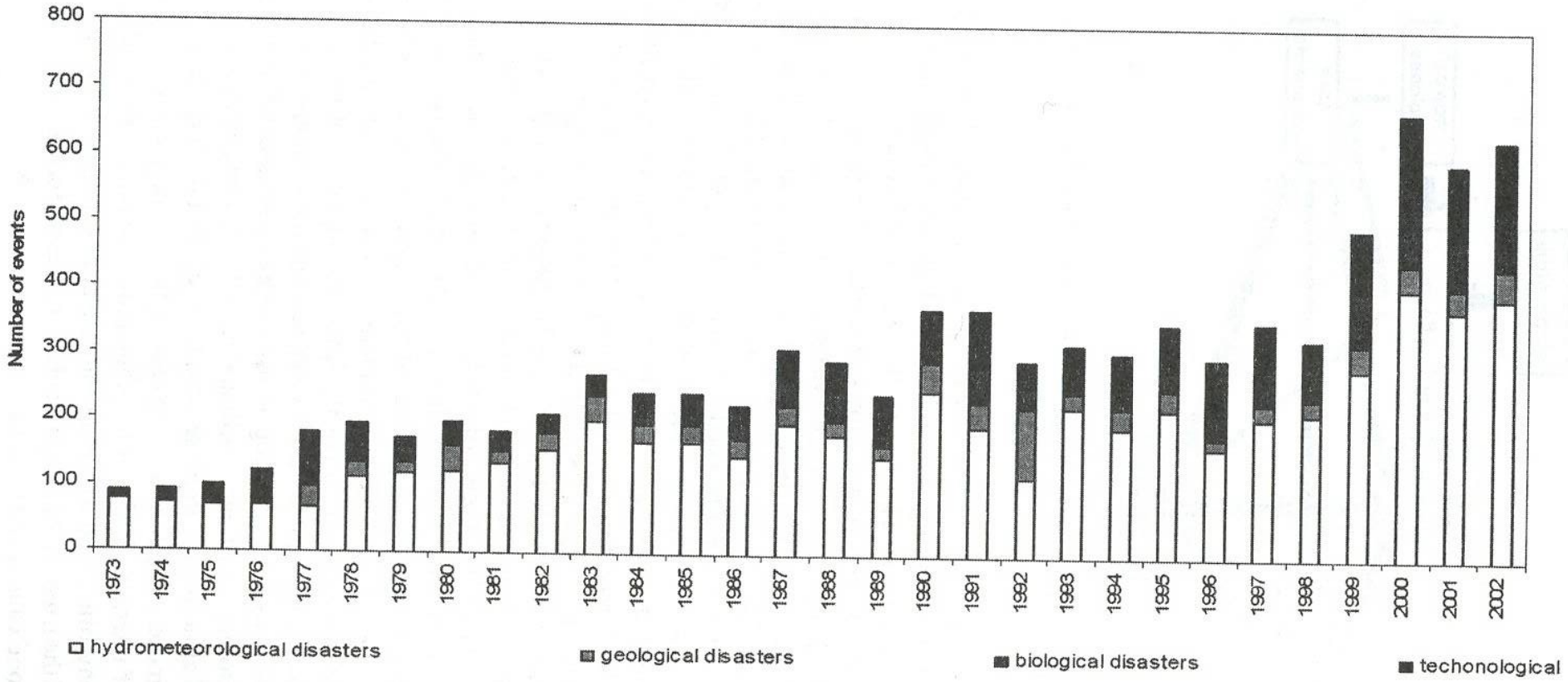

Fig. 5 Occurrence of disasters by disaster type: an overview of last 30 years (ISDR, 2003)

5. Evaluation of Floods

In comparison of various types of natural disasters, floods fall among the most significant ones (see also Hladný, 2004). Their significance is shown in Fig. 5, however, included in one category together with other hydrometeorological phenomena. In any case, an increase of the total number of natural disasters as well as of the very hydrometeorological phenomena has been apparent since the last five years (1998–2002). Patera (2000) states that as for significant damage, floods occupy the top position among natural disasters. Magilligan (1992) mentioned the fact that: "Analysis of the effects of extreme events on overall landscape form has shifted geomorphic attention away from a focus on the magnitude and frequency relationship of discharge to a focus on flood power". This approach considers also the changing width of the valley between the upper and lower water course within one concrete flood, and the changing intensity of destruction manifestations linked to it.

Comparison of the impact of floods on individual population categories according to income is interesting, as well – hydrometeorological phenomena are compared only (Fig. 6). In the case of floods, the graph shows a similar distribution of impacts as in wind storms, only the differences between the richest and poorest population section are not as drastic. On the one hand, this is a consequence of the fact that developed countries or richer population sections dispose of means for better protection and they can thus alleviate these negative influences; on the other hand, it follows from the graph that not even these population sections are free of impact of the floods influence. They thus cannot eliminate the hazard.

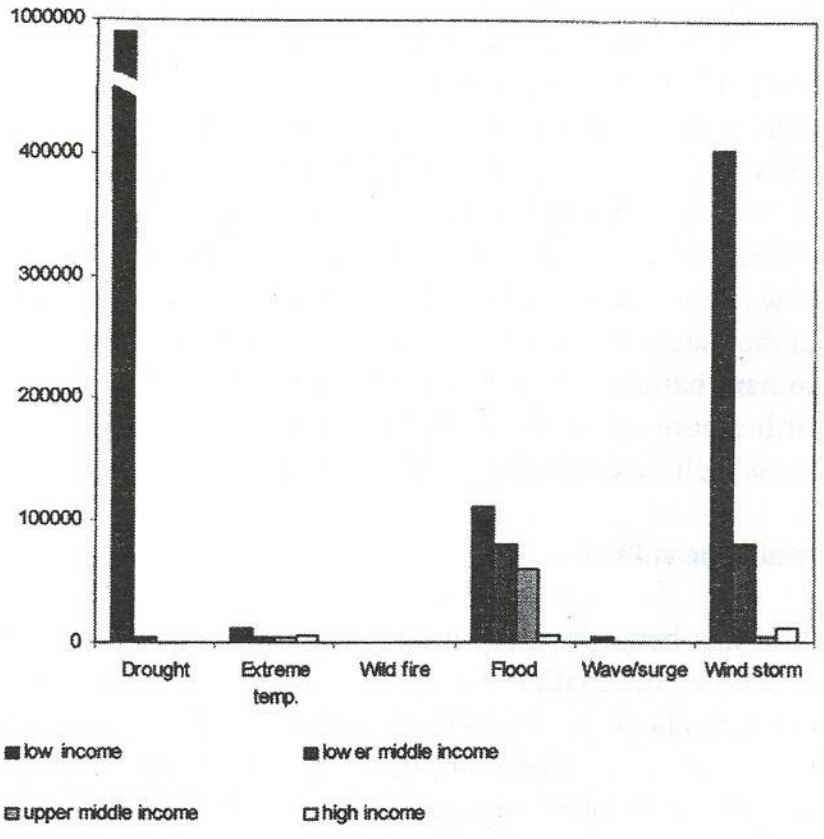

Fig. 6 Number of people killed by income classes (ISDR, 2003)

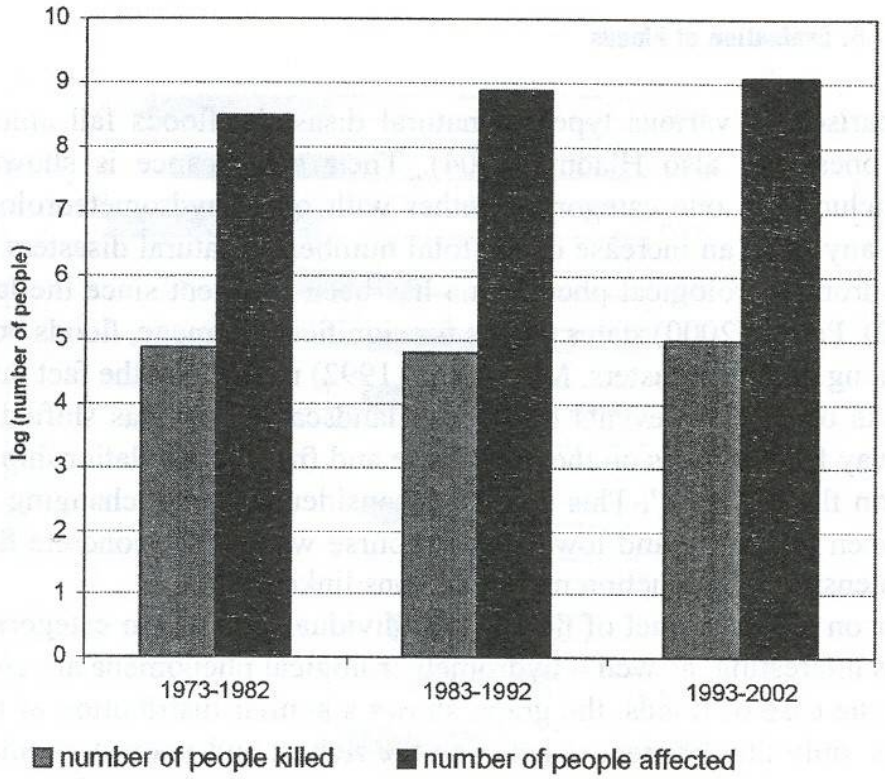

Fig. 7 Flood impacts (ISDR, 2003)

Comparison of three consecutive ten-year periods shows that the number of flood victims has not been rising markedly, nevertheless the number of affected persons has been increasing (Fig. 7), which can be explained by improving protection of the population, informedness etc. In any case, again this provides evidence of an increasingly serious nature of the problem.

From the regional distribution point of view, floods represent the greatest problem (in absolute numbers) in regions marked on the world map (in Fig. 1), such as Central Asia, Southeastern Asia and South America as the third. While such natural disasters are included in which either more than 10 inhabitants die or more than 100 people suffer damage and/or the state of emergency is declared or international aid is asked for. From the viewpoint of their share in the total number of hydrometeorological disasters, floods represent a dominant natural phenomenon (besides the regions mentioned) in Central America and furthermore e.g. in South and also Eastern Europe (Fig. 1), including the Czech Republic, as well (according to ISDR, 2003).

6. Reduction of Risks

Great attention has been devoted in recent years to natural hazards, both on the national level as well as internationally. This is proven e.g. by the Decade for Natural Disaster Reduction, declared by the United Nations for the 90s of the past century. It was accepted by 93 countries in the world. Its aim consisted especially in developed countries helping less developed regions. It incorporated a broad scale of activities from organization of theoretic research of natural processes, terrain research and stock-taking, to building of warning networks and global monitoring. Thanks to their

specific features, partial types of natural hazards were moreover accompanied also by different activities. In the case of floods, these were e.g. zoning of rainfalls and the outflow conditions research.

In spite of all the research and increasing technical capabilities, in fighting natural disasters we are mostly left to reduction of risks and impacts. Some, such as e.g. volcanic activity, are relatively predictable, although not yet with sufficient accuracy nor with satisfactory estimate of the explosions intensity. On the contrary, earthquakes are difficult to predict. Floods, too, are not predictable in a longer time advance. In dependence on rainfalls occurred or rainfalls coming, floods to arrive can be modelled, which is a question of days and hours.

Zoning is important in this respect, while one of possible approaches lies in determining the risk in the given area as "a function of the cumulative severity of damage from earthquakes, floods and so on, irrespective of the frequency of occurrence of these events" (Bolt et al., 1975). In this case, the time as one of factors influencing the given process is not incorporated. The other possible methodological approach consists in considering the frequency of occurrence of natural hazards. This allows for comparing rarely occurring phenomena of disastrous impact with much more frequently repeating cases with lower intensity. In such cases, the probability of occurrence in the given locality / region is usually related to 100 years.

The issue of occurrence regularity of these phenomena is problematic. In some types of natural hazards (e.g. earthquakes), the theory is applied that the tension/energy accumulated must be released – thus more frequently in shorter periods or once in a longer time period with greater intensity. However, this would be true only in uniform growth of the tension accumulation. For example, in the case of the litospheric plates movement, it would have to be uniform. Another problematic issue is whether a sufficiently long time series is available in order to eliminate random manifestations. In this case, e.g. geomorphological research may be of assistance, enabling us to identify older events from records in the relief than where the human memory reaches or records in chronicles. The current predictive models of volcanic activity of Popocatepetl are derived from sedimentologically as well as archaeologically well documented series of the volcano erruptions in the past 22.000 years (Sheridan et al., 2001). Nevertheless, not even this is sufficient for the case of Popocatepetl and potential endangering of the Mexico City agglomeration, for an erruption with the highest intensity occurred only once in 22.000 years, which is not applicable statistically. In the case of floods, we cannot use e.g. the theory of accumulation and repeated releasing of energy. It is thus apparent that limits of usage apply even to zoning considering the time factor.

The question to what extent the population is aware of occurrence of natural hazards in the given region is connected with reduction of the risks, as well. In connection with earthquakes in the Mediterranean area, the so-called local seismic cultures are mentioned, reflecting the extent of general awareness of the dangerous nature of the natural phenomenon. In this case, it does not really matter whether we speak of earthquakes or floods, but the frequency of the phenomenon mentioned is important. Floods as well as earthquakes fall among those which, like the majority of natural hazards, repeat in irregular intervals. The principle of forming general awareness of natural disasters lies in the fact that these events must appear in the given locality with

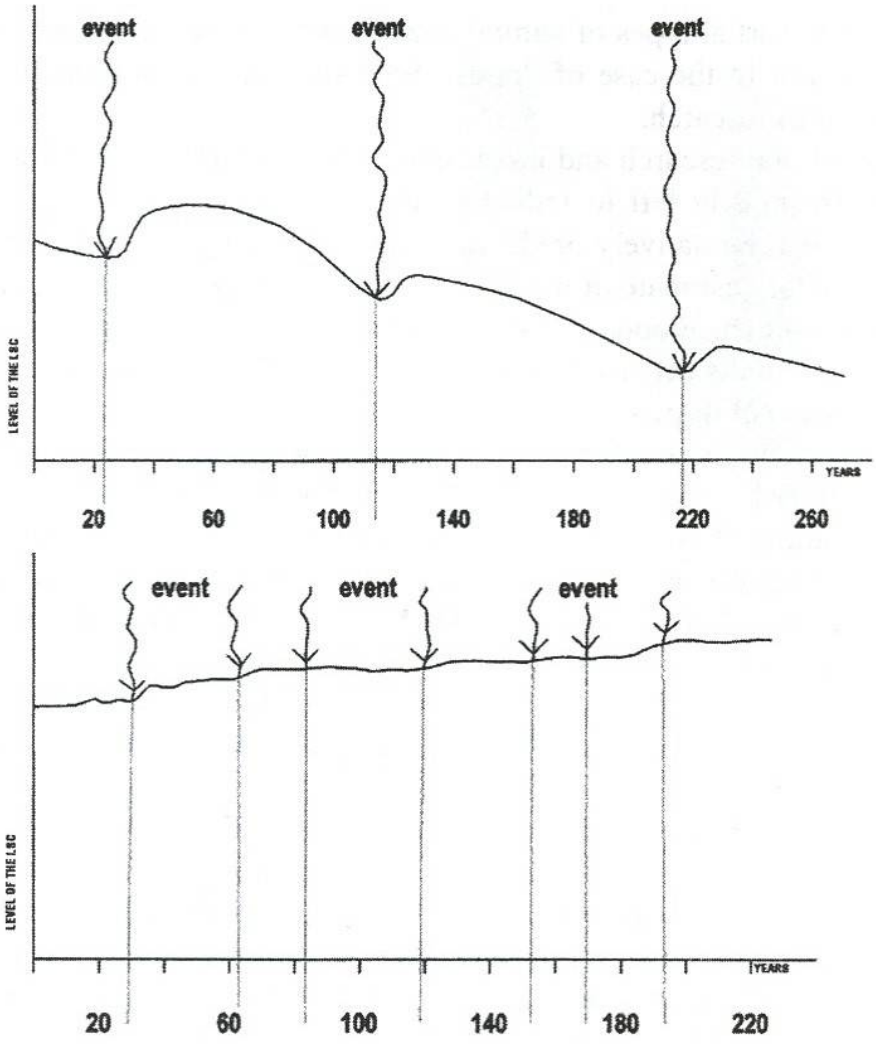

Fig. 8 Local seismic cultures (Newsletter IDNDR, No. 12, 1993)

sufficient frequency (up to 30–40 years). So that people do not forget and are able to pass practical information important for survival from one generation to another – e.g. what localities should not be settled (e.g. in the floods or slope movements hazards) or how to build houses resistant against tremors. When a natural disaster occurs with a lower frequency, e.g. after 100 years (Fig. 8 upper part), awareness of the inhabitants of this event slips away. Moreover, the intensity of the natural phenomenon must be sufficient in order to be perceived as a hazard by the inhabitants (Fig. 8 lower part). The need of historic awareness of the dangerous nature of floods is mentioned also e.g. by Vaishar et al. (2000). They understand it as the essential prerequisite of prevention.

In connection with development of modern information technologies it seems that this principle will start to lose its significance, nevertheless for most people living on the Earth it is still a matter of topical importance. Moreover, we can just recall how insufficiently the potential floods hazard was perceived in the Czech Republic before 1997.

In conclusion, a relatively known thought can be mentioned, published recently by e.g. Prager et al. (2000) in the introduction of their book: "We will never control the furious Earth, but through our scientific understanding of its nature, we may be able to prevent tragic and costly losses".

7. Conclusion

With respect to the fact that natural hazards are usually hard to quantify a relative risk is evaluated. Not only the intensity of the hazardous process is important but also the extent of deviation from a "normal state", it means from the long-term adapted condition. The increase of natural hazards as a consequence of global warming is discussed worldwide but in fact a database which would statistically confirm this fact does not exist and moreover up to now was not adobted a uniform methodology how to gather the appropriate data. To answer the question whether the frequency of natural disaster is increasing is embarrassed by the increase of information. What is unambigouesly demonstrable is the growth of material damages in the well developed countries and rise of losses in human lives in third world countries. All of these above mentioned facts are valid for floods as well. Some statements are for floods specific – e.g. a negative impact on population of all income classes (opposite to droughts). The number of flood victims is rising but not markedly. What is escalated is the number of affected persons. For floods stands the same like for the other types of hazardous processes – the general awareness of natural hazards is descending slowly but steadily with the time in the case that no new events comes ower.

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POVODNĚ V KONTEXTU PŘÍRODNÍCH OHROŽENÍ A RIZIK

Résumé

Hlavním cílem této přehledové studie je představit povodně jako součást přírodních ohrožení a rizik. Vzhledem k tomu, že přírodní systémy jsou vždy souborem celé řady vzájemně propojených a ovlivňujících se faktorů, je vědní základna fyzické geografie účinným nástrojem při řešení těchto často katastroficky probíhajících procesů, tedy i těch spojených s povodněmi. Jednotlivé typy přírodních katastrof mají sice svá specifika plynoucí z podstaty přírodních procesů, nicméně mají i řadu společných znaků, zejména ve vtahu k lidské společnosti. Povodně zaujímají mezi přírodními katastrofami významné místo, a to jak z pohledu četnosti těchto jevů tak i jejich následků. Problémem jsou jak ve vyspělých zemích, kde způsobují zejména materiální škody, tak i v rozvojových státech, kde je vyšší procento ztrát na lidských životech.

Přírodní ohrožení mají zcela jinou váhu pokud vznikla a existují v osídlených oblastech než v oblastech málo využívaných. V takovém případě, kdy jsou přímo ohroženy životy či jsou nějak dotčeny hodnoty vytvořené lidskou společností, mluvíme o přírodních rizicích. Otázka zda v posledních desetiletích dochází či nedochází k nárůstu výskytu přírodních katastrof je předmětem mnoha diskuzí. Ve skutečnosti neexistuje žádná celosvětová databáze, která by shromažďovala dle jednotné metodiky potřebné údaje. Prokazatelný je již ovšem nárůst škod a zvýšení rizikovosti těchto procesů. Z hlediska ochrany před povodněmi je důležité povědomí mezi obyvatelstvem o nebezpečnosti tohoto jevu.

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