

Natural risks: mitigation and adaptation

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Abstract

Increase of human impact on the environment entailed increase of the numbers of natural disasters and related economic and human losses in last decades. Climate projections suggest further intensification of risks. At the same time, the growth of welfare in many countries, including Poland, increases loss potential. Although Poland is not particularly endangered, as compared to some other countries, such as Japan, natural risks occur. In several cases (for instance, the floods in 1997 and in 2010) losses reached the level of billions. Expected increase of risks calls for strengthening of the preparedness system. Two approaches are possible: mitigation (eliminating the sources of risks) and adaptation (accepting inevitability of losses and trying to reduce the loss). The knowledge on these two approaches is limited. Nevertheless, the traditional approach, relying on structural protection is clearly insufficient.

Key words: natural risks, climate change, adaptation, mitigation, disasters.

1. Introduction – anthropogenic impact

Human impact on the environment has reached an unprecedented scale. Its key elements are: the size of the population and technological and economic progress. Ten thousand years ago five to ten million people populated our planet. It was less than the current population of just one of 26 mega-cities with more than ten million inhabitants each. World's population has dynamically risen during the last two centuries (Table I), reaching 7 billion now.

Even stronger is the dynamics in terms of economic growth, energy production, CO₂ emission, and length of average daily trip (Table I). The term anthropogenic impact reflects human expansion in the natural environment (Kundzewicz, Kowalczak 2008). The human impact disturbs natural circulation of energy, water and air – in the global scale. Man, as never before, influences global processes: composition of atmosphere; river flow; and macro-scale land cover. These are elements, which have impact on the Earth climate, and to a certain extent, on the natural disasters. Humans have power

Table 1. Examples of anthropogenic impacts (source: L Kajfez-Bogataj, personal communication).

	Estimate for the year 1800	Estimate for the year 2000	Growth 1800-2000	Projection for the year 2050
Human population (billion)	1	6	6 ×	9-10
Primary energy production (EJ)	13	420	32 ×	600-1000
Global product (trillion USD)	0.3	30	100 ×	85-110
CO ₂ emission (Gt C)	0.3	6.4	21 ×	5-15
Daily trip (non-walking) (km)	0.04	40	1000 ×	120-160

to transform the Earth in a way comparable to geological processes, such as erosion or volcanic eruption. In order to describe the modern era, Paul Crutzen, Nobel Prize Laureate, coined the term anthropocene.

In the world substantially transformed by humans natural risk are also changing their characteristics. In this paper the challenges posed currently to societies and economies by natural disasters are discussed. Emphasis is put on extreme weather events. Trends in losses and predictions concerning the future risks are presented on the global scale. Further, the Polish case is presented. Main risks and their likely transformations are discussed. Finally, possibilities and difficulties to adapt to and to prevent against risks are examined.

2. Extreme natural events

Increasing human impact on the environment causes serious consequences for both man and nature, particularly it involves increase of risks. Natural risks can be divided into several categories (see, for example, Table II).

The risks indicated in Table II are natural – they have been always present. However, currently, we observe the growth of severity and frequency of some of them. Although the growth of risk-scale is a long-term process in the time-scale of decades, the existing data already show symptoms of change. The number of large natural disasters (causing more than 500 casualties and/or material loss greater than 0,5 billion USD) in last 25 years show growing trend (Munich Re 2009).

Growing number of disasters that have been occurring in last decades lead to increase of losses. Significant growth of adverse social and economic effects caused by weather, have been observed in last decades. Particular catastrophes bring losses reaching many tens of billion USD (Bouwer *et al.* 2007). The record of material damage in a natural disaster is likely to have occurred in the March 2011 earthquake followed by a tsunami in Japan, but an accurate, credible loss estimate is not available yet.

Generally, losses show growing trend. Between 1977 and 1986 average annual losses equalled 8,9 billion USD, while between 1997 and 2006 they rose up to 45,1 billion USD annually (Bouwer *et al.* 2007)¹. Trend analysis, done by Mills (2005), showed that material losses caused by weather events have grown 8 times between 1960s and 1990s (insured losses have grown 17 times), thus quicker than population growth, economic growth, and premium growth. Interestingly, the growth of losses caused by extreme weather events is more dynamic than the growth caused by non-climatic geophysical events such as earthquakes.

Nevertheless, there is high variability of losses in time and space. Data collected by the Belgian Centre for Research on the Epidemiology of Disasters (CRED), for the years 2000-2007, show relatively high level of losses caused by geophysical and hydrological disasters in 2007, compared with 2006 (Scheuren *et al.* 2008). Moreover, there is high geographical variability of threats. Data show that for 2007, higher proportion of losses in Asia are caused by geophysical causes, while in other countries hydrological and climatic ones.

The observed growth of risks has two main reasons. The first is related to the growing number of extreme events, which can be interpreted as higher probability of these events. This tendency can be strengthened in future. Climatic models show that as a result of human impacts several types of extreme weather events are going to occur more frequently in future (Tab. III).

The second reason of growing risks is the significant increase of exposure. It is the result of increasing welfare in modern societies and directions of economic development which accelerate risks. Economic activity and populating dangerous areas (for instance: by spontaneous inhabiting flood-prone areas around megacities in developing countries),

¹ Remarkably, there is scarcity of exact, comparable, and publicly accessible data on natural disasters and losses. Relatively good data are collected by insurance and re-insurance sector, but these data are only partially accessible in public domain.

Table II. Typology of natural risks (source: Scheuren *et al.* 2008, modified).

Biological	Geophysical	Hydro-meteorological risk		
Epidemics	Earthquakes	Heat wave	Flood	Storm
Insect invasion	Volcano eruption	Wild fire	Drought	Hurricane
	Tsunami	Cold wave		

Table III. Extreme weather events and changes of their probability, based on observation from the past and projections for future (source: IPCC 2007).

Phenomenon and direction of change	Likelihood that trend occurred in late 20 th century (typically after 1960).	Likelihood of trend in future, based on projections for 21 st century using SRES scenarios
Warmer and fewer cold nights and days over most land areas	Very likely	Virtually certain
Warmer and more frequent hot nights and days over most land areas	Very likely	Virtually certain
Warm spells and heat waves – increase of frequency over most land areas	Likely	Very likely
Increase of frequency of heavy precipitation events (or – increase of proportion of total precipitation from heavy falls) over most areas	Likely	Very likely
Increase of areas affected by droughts	Likely in many regions since 1970s	Likely

leads to increase of potential losses. The material welfare in flood-prone areas grows. For example, in Japan half of the population and approximately 70% of national assets are concentrated in inundation areas, which constitute only 10% of the country's area. As a result, any natural disaster may cause substantial losses.

3. Extreme natural disasters in Poland

Although the risk of natural disasters in Poland is not particularly high (for instance if compared to Japan), several threats can be observed. Most natural threats are related to atmospheric, hydrological, and geomorphological systems. Among weather and climate related risks are those linked to temperature (very low, very high, glazed frost, hoar frost), precipitation (intense precipitation, snow abundance, snow avalanche, flood, debris flow, land slide, drought, snowless winter, hail), strong wind, lightning, fog, and wild fire.

The flood on the Odra and its tributaries in July 1997, brought many casualties and gross material loss. Similarly – droughts (for instance in 1992, 2006) caused significant losses in agricultural production. Heavy snowing during the winter in 2006 caused collapse of the Katowice Fair building's roof and the death of more than 60 people. Storm winds cause significant losses in infrastructure (damages of roofs, electric line breaks etc.) and in forestry (wind fall of trees).

In Poland, extreme meteorological and hydrological events prevail (Table IV). Nevertheless, there are also seismic threats, among them earth

tremors in mining areas. On September 21st, 2004, a significant seismic effect occurred in the North-East Poland, with epicentre near Kaliningrad (Russian Federation), close to the Polish border.

The global village effect is getting stronger. Poles travel around the world, more than anytime earlier in the history. As a result they are victims of disasters in other countries and continents, for example the tsunami that devastated the South-East Asia on December 26th, 2004 (Kundzewicz 2009).

The most severe losses in Poland, have been caused by floods. However, other risks also cause damage. Losses due to wild fires are presented in Table V. The most catastrophic fires occurred in 1992, in many locations in Poland. The biggest fire was around Kuźnia Raciborska, where approximately ten thousand hectares of forest were burnt, and two firemen died in action.

In several cases losses are intangible and difficult to estimate. Psychological stress caused by a catastrophe and loss of possessions can force one to suicide. Czabański's study notes suicides related to the 1997 flood (Czabański 2005). Disasters cause also negative, and long-lasting, physiological and psychological effects, so called PTSD – *post-traumatic stress disorder*. The 1997 flood on Odra had negative psychological consequences, noted two years after the event (Kaniasty 2003).

Also losses of cultural heritage and natural resources are difficult to estimate. The 1997 Odra flood brought damages to more than 300 cultural heritage objects. Losses were assessed at 23,3 million USD (Informacja Biura... 1998). Large portion of those losses cannot be replaced.

Table IV. Examples of climate and weather related extremes in Poland in last two decades.

Type of extreme event, time and place of occurrence	Loss assessment	Remarks
Flood in July 1997, in the Odra and Wisła Basins	55 fatalities, material losses of 3,6-3,7 billion USD*.	In the years following the flood, there were further floods involving fatalities (for example in 1998, and 2001). Smaller-scale floods cause significant losses year by year, e.g. flood losses in 2005 and 2007 reached 67 million USD (GUS 2006) and 97,5 million USD (GUS 2008), respectively.
Extensive drought in 1992	Significant decrease of agricultural production (decrease of crop production by 20%), numerous wild fires. In many settlements water had to be provided to inhabitants by water carts.	In some parts of Poland the period of extremely low precipitation started in April 1992, and there was no rain for 50 days. Only few millimetres of monthly precipitation total was recorded in June in several meteorological stations in the West and the North Poland. Less severe droughts occurred in 2003, 2006, and 2008.
Heat wave in June and July 2006	Adverse health effects and additional mortality.	Regional Office in Katowice estimated losses caused by the 2006 drought at 29,4 million USD. Dramatic drought causing significant agricultural yield decrease.
Frost in May 2007	Significant losses in fruit growing sector (e.g. peach, walnut).	July 2006-June 2007 was the warmest 12-month period in the history of observations. Warm days in April enhanced vegetation development that was interrupted by the frost wave in May.
Cold winter 2005/2006	More than 200 people froze to death.	Despite global warming, frost is the main natural risk related mortality factor in Poland. Considerable part of victims are homeless people and those abusing alcohol.
“White squall” in Mazury region in August 2007	12 casualties.	Many cases of strong winds (quasi-tornado) were noted in recent years. Whirlwind in August 2008 caused losses at the level of 50 million Polish Zloty in the Opolskie province.
Kyryll windstorm, on January 15-17 th 2007 in Western and Central Europe.	Overall losses were estimated at 9 billion USD. In Poland – 100 million USD (Scheuren <i>et al.</i> 2008).	
January 28 th 2006 in Katowice the roof of the fair building collapsed due to snow mass.	65 people died.	Extremely thick snow cover has not recently been usual in most part of Poland.
Floods devastated large areas in Poland (May-June and August 2010)	Several tens of fatalities, material damage of several billion USD.	Abundant snow cover did not cause snowmelt flood, but saturated the water storage capacity, so that intense and long-lasting rains caused a disaster.

* Poland's Main Statistical Office estimated losses caused by the 1997 flood, in the areas of 24 provinces (Informacja Głównego... 1998). Most of the losses are caused by the flood on the Odra River.

Table V. Losses in forests caused by wildfires (source: GUS 2006).

	Current prices, in millions of USD										
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Value of loss	2.8	6.6	3.5	2.5	3.2	2.6	0.9	1.3	4.8	1.1	1.1

Losses are not only caused by snow excess (avalanches, transportation problems, loss in infrastructure and forestry) but also by snow shortage – for example in the mountain regions living out of winter sports industry.

Climate projections show that in Poland extreme weather events are likely to become more frequent and more extreme in future (Table III). Moreover, economic development does not only enhance life quality and comfort, but, at the same time, it magnifies loss potential. Risks are strengthened by weakness of physical planning and its enforcement in Poland. For instance, new housing developments are sometimes located in floodplains and occurrence of floods unveils such mistakes.

4. Avoiding losses – mitigation and adaptation

There are many factors influencing the level of natural risk. One of these is the climate change. Although climate changes naturally, and many warmer and cooler periods have already occurred, the current change is unique. The atmospheric concentration of greenhouse gases (CO₂, methane, and nitrous dioxide) is very high and increasing. Analysis of content of the air bubbles captured deep in the ice cores, shows that current concentration of CO₂ is higher than any time in the history, which is possible to reach, i.e. 650 thousand years backwards. It is because people emit increasing amounts of greenhouse gases to the atmosphere, and reduce the possibility of CO₂ absorption by plants (carbon sequestration), through the land-use change.

Growing scale of losses caused by natural disasters motivates to searching for counteraction, by mitigation and adaptation. Mitigation can be regarded as treating the causes of the problem, while adaptation is treating the symptoms. The point of departure for mitigation is to note that human activity (especially economic activity involving greenhouse gases), generates higher level of climate-related risks (and consequently – losses), so that reduction of risks is possible through adequate modification of human activity. The best example of mitigation efforts are attempts to curb the anthropogenic warming and associated impacts. It is taken for granted that human activities have impact on climate. However, risks connected to climate change have two components: natural and man-made. Mitigation aims to influence the latter by reducing sources of risks. Practically, however, it meets difficulties. Final effect is dependent on the willingness of all partners (in particular – all high emission countries) to co-operate. It is the weakest-link situation, since the lack of cooperation

of one partner can significantly diminish the results of efforts undertaken by others. The complicated case of the implementation of the Kyoto Protocol shows that the worries are real.

Whatever the results of international agreements in curbing greenhouse gases emissions, adaptation is increasingly important. A realistic view is taken that risks are inevitable, so the task is to reduce the scale of losses. It is possible through reduction of exposure and vulnerability.

The knowledge of efficiency and effectiveness of adaptation and mitigation activities and their relations is still limited. Some mitigation efforts are harmful to adaptation and some adaptation efforts are harmful to mitigation. Biofuels, being a renewable source of energy, i.e. a mitigation measure, can serve as an example of the former effect, because production of biofuels requires water and this is in conflict with adaptation needs in the areas suffering water shortage. Air conditioning can be an example of the latter effect. It helps to adapt to heat waves and hot weather, but since it consumes much energy (typically based on fossil fuels), it is disadvantageous for mitigation, as it leads to intensification of the greenhouse effect. In urban planning, mitigation approach involves higher density of buildings, in order to decrease the need for transportation (as requiring energy), however, adaptation approach suggests rather lower density of buildings, to keep green areas and help in adaptation to heavy precipitation and to heat waves.

The relation between mitigation and adaptation is complicated (Klein *et al.* 2007) and, to a certain extent, dependent on the type of risk. Mitigation is important for risks connected with extreme weather events. An important issue is to establish a proper decision-making body taking into consideration complex space relations, and consequences of decisions in time.

Losses, which can appear because of climate change, are being investigated by many researchers. The so called Stern report (Stern 2007) undertakes an effort to assess losses caused by global warming and associated effects. In conclusions, the report argues that average yearly losses can be significant (at the level of 5% of global product) at the end of twenty first century.

Conclusions

Although natural risks were always present, in the last decades, a significant increase of losses is observed, caused by natural disasters. To some extent, people are responsible for it. Anthropogenic impact brings about higher scale of dangers, while growing welfare increases the potential loss. Moreover, particular risks are combined. For example,

climate change entails losses in agriculture which is caused by insects that appear at the earlier phase of plants development. Similarly, health risks conveyed by ticks grow, because range of this species distribution moves north, and it is dangerous for a longer part of the year. Climate change and alien species invasion increase also risk of allergy. Climate change involves additional biological risks.

Furthermore, an important factor influencing risks (especially flood risk) is an unjustified belief in absolute effectiveness of structural (technological) methods of protection. Even solidly designed (with large safety margin), built, and well maintained constructions (for instance dikes) do not guarantee complete protection, in case if the flood amplitude significantly exceeds the design parameters. Also the short memory syndrome has an impact – with time lapsing after the disaster decisions makers and people gradually forget about the necessity of further investments in strengthening the protection system. Moreover, in case of floods, the systems of transformation of precipitation into river flow have been changed as well. For instance, in Western part of Germany, the urban area coverage (mostly impermeable for rainfall water) doubled during the last 40 years. Increase of scale of impact and growing losses call for the need of revision of traditional approaches to risk protection. In particular, adaptation gets more importance, and it assumes necessity to accept certain level of risk and losses and to focus on risk management. Attempts to “give space back to rivers” and the Dutch attempts of compartmentalisation – establishing areas of relatively lower value dedicated to a controlled inundation in case of high water, in order to protect more valuable areas, can serve as examples. They represent a new, flexible approach to avoid losses, but the success of their implementation depends on education and change of awareness (IMGW 2005).

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