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DISASTER RESILIENCE TOOLS – REDUCING THE LIKELIHOOD OF DAMAGE

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ABSTRACT: The increasing number of natural disasters as a result of climate change has serious consequences in terms of loss of life, damage to health, loss of property and damage to infrastructure. Disasters affect communities in both developing and developed countries. In the former, however, the phenomena occur more frequently, affect a larger group of people, and the losses are often greater and more severe. Resilience issues are increasingly being addressed in the literature. The purpose of this article is to present the concept of resilience in the context of natural disasters and building development capacity. The study presents the authors' definition of resilience to natural disasters. For the purpose of this article, a review of the literature and existing data has been carried out. The presentation of available instruments of resilience to natural disasters security tools shows that despite the unpredictable nature of these events, there are ways to minimise the negative impacts.

KEYWORDS: resilience, natural disasters, tools for building resilience

Introduction

According to the International Law Commission, "disaster" means a calamitous event or series of events resulting in widespread loss of life, great human suffering and distress, mass displacement, or large-scale material or environmental damage, thereby seriously disrupting the functioning of society" (UN, 2016). Mnemonic expression of the term is presented by Chaudhary and Piracha (2021):

Disaster = (Hazard + Vulnerability)/Capacity.

They highlight: "The degree of exposure to a hazard and the level of vulnerability is directly related to the magnitude of a disaster, whereas disaster magnitude is inversely proportional to capacity" (Chaudhary & Piracha, 2021).

The term natural disaster describes a sudden event caused by forces of nature that cause massive destruction, in contrast to technological disaster (Oxford Reference). It should be noted that the Polish Natural Disasters Act distinguishes between two concepts: natural disaster and natural catastrophe. The first is defined as: "a natural disaster or technical failure, the consequences of which endanger the life or health of a large number of people, property on a large scale or the environment on a significant area, and assistance and protection can only be provided effectively by means of exceptional measures, in cooperation between the various bodies and institutions and specialised services and formations under a single command". The second means: "an event related to the action of natural forces, in particular lightning, seismic shocks, strong winds, intense precipitation, prolonged extreme temperatures, landslides, fires, droughts, floods, ice on rivers and seas, lakes and reservoirs, mass outbreaks of pests, plant or animal diseases or contagious human diseases, or the effects of any other element" (Act, 2002). Therefore, with reference to Polish legislation, it can be said that natural disaster is a broader term than natural catastrophe. However, for the purpose of this study, we will use the Anglo-Saxon term natural disasters to refer only to natural disasters without technical failures, which are included in the Polish terminology for the term natural disaster.

According to NASA – Earth Science and Remote Sensing Unit (2023), in 2023, there was flooding in Brazil, India, Ghana, the United Kingdom, South Africa, Korea, Chile, Ecuador, the Democratic Republic of Congo, Somalia, Mozambique, Eswatini, Zambia; earthquakes in Turkey, Syria, Afghanistan; wildfires in Chile, Algeria; cyclones in Madagascar, Ecuador, Peru, India, Brazil; tropical cyclone in Solomon Islands, Myanmar, Bangladesh; tropical storms in Mozambique, Vanuatu, Solomon Islands, hurricane in Mexico, storm in Haiti, eruption in Indonesia (NASA). In 2023, there were around 240 climate-related events, and at least 12,000 people lost their lives (Save the Children, 2023). We remember such tragic events as the 2004 Indian Ocean earthquake and tsunami, Hurricane Katrina in the United States in 2005, the 2010 Port-au-Prince earthquake in Haiti, and the 2023 earthquake in Turkey and Syria.

Natural disasters have serious consequences in social, economic, and environmental dimensions. Appropriate action is therefore needed to build up systems for the early warning of risks, appropriate action during them and restoration after they have ceased. Clearly, countries with a higher incidence of natural disasters should focus more on developing appropriate resilience policies to reduce the likelihood of lasting damage. This article aims to provide the concept of resilience in the context of natural disasters and build development capacity by creating tools that strengthen resilience before, during and after an event to reduce the likelihood of lasting damage. The following research methods were used for the study: a review of the literature on the concept of resilience and the tools used to build it and analysis of the data found.

The concept of resilience in the socio-economic dimension

The issue of resilience relates to many academic fields and areas of socio-economic life. In relation to the former, it is an important concept in psychology. Research developed in the 1970s on how traumatic events impact the functioning and development of individuals and families. Initially, the research looked at people who had experienced violence, separation, homelessness, and the consequences of economic crises or natural disasters, and since then, interest in the consequences of nat-

DOI: 10.34659/eis.2024.91.4.759

ural disasters has grown. Interestingly, according to Boczkowkska (2019): "The phenomenon of resilience lies primarily in a positive approach to thinking about development at the individual, family and societal levels and emphasising the importance of protective factors associated with positive adaptation in the face of threats and traumatic experiences". The issue of resilience has also been addressed in sociology (Piątek, 2018), economics (Mann, 2016; Hallegatte, 2014), ecology (Enel, 2023), and security sciences (Stępka, 2021). The literature also mentions socio-ecological resilience, which "emphasises human responsibility for the profound transformation taking place in the environment, but which in turn can have a negative impact on people and communities" (Enel, 2023). Table 1 gives examples of how the term is used in the disciplines concerned.

Table 1. Definition of resilience in different disciplines

Discipline	Definition	Source
psychology	"(...) a dynamic process that reflects an individual's relatively good adaptation despite the risks or traumas they experience".	Borucka and Ostaszewski (2008)
sociology	"Resilience should be understood as one of the different possible processes by which the poverty ways of life mediate responses to systematic social and economic stresses — such as mass unemployment, severe deteriorations of working conditions or large-scale retrenchment of social transfers and social services — and how, in turn, these ways of life are impacted by these responses".	Estêvão et al. (2017)
economy	Static: "Efficient use of remaining resources at a given point in time to produce as much as possible". Dynamic: "Efficient use of resources over time for investment in repair and reconstruction, including expediting the process & adapting to change".	Rose (n.d.)
ecology	"The ability of a natural system to absorb the effects of change, reorganize itself and adapt to the new context while essentially maintaining its previous structure and functions".	Enel (2023)

Considerations from different disciplines make it possible to identify common features in the sense of the term dynamic, process-oriented, overcoming negativity, adaptive, and remedial in relation to causal stresses as distinguished in the various sciences. Building resilience is about reducing vulnerability to negative phenomena and, when they do occur, coping effectively with them. Actions can be taken by humans or, as in the case of ecology, by nature. Olsson et al. (2015) summed up all the aspects found in the literature: "It is clear that resilience thinking describes important attributes of ecosystems, of materials, and of human beings, that is, the ability to cope with, and recover after, disturbance, shocks, and stress". This paper focuses on the resilience of states, societies, and economies in the context of natural disasters. Resilience can refer to different geographical areas, i.e. regional resilience (Giacometti et al., 2019) or urban resilience (Drobniak, 2012).

The theoretical basis for these considerations is related to the economy and sustainable development. In the economy, the issue of resilience in relation to natural disasters is connected with welfare. According to Hallegatte (2014): "The welfare impact of a disaster does not only depend on the physical characteristics of the event or its direct impacts in terms of lost lives and assets. Welfare impacts also depend on the ability of the economy to cope, recover, and reconstruct and therefore to minimise aggregate consumption losses". However, Chaigneau et al. (2022), pointed out that sometimes measures aimed at ensuring resilience can adversely affect welfare. They give the example of the 2004 tsunami. After the threat ceased, the Indian and Sri Lankan authorities introduced regulations prohibiting the reconstruction of homes and businesses on the coast in order to create buffer zones and build resilience against future tsunamis. However, these restrictions may affect the well-being of displaced people (Chaigneau et al., 2022).

Hallegatte (2014) pointed out macroeconomic and microeconomic resilience. The former includes two components: instantaneous resilience and dynamic resilience. Microeconomic resilience "[depends] on the distribution of losses; on households' vulnerability, such as their pre-disaster income and ability to smooth shocks over time with savings, borrowing, and insurance, and on the social protection system, or the mechanisms for sharing risks across the population" (Hallegatte, 2014). Hallegatte (2014) continued: "The (economic) welfare disaster risk in a country can be reduced by reducing the exposure or vulnerability of people and assets (reducing asset losses),

DOI: 10.34659/eis.2024.91.4.759

increasing macroeconomic resilience (reducing aggregate consumption losses for a given level of asset losses), or increasing microeconomic resilience (reducing welfare losses for a given level of aggregate consumption losses)".

In a natural disaster situation, the macroeconomic dimension also concerns losses related to general infrastructure (including roads, public buildings, and communication systems). In the microeconomic dimension, it refers to private assets (of both enterprises and households). However, taking into account the macroeconomic effects of natural disasters, analyses conducted so far "typically have low- to medium-confidence regarding the extent of the link between disasters and macroeconomic outcomes, possibly due to inherent limitations of economic indicators, such as GDP, lack of data availability and otherwise significant regional impacts being drowned out at the national scale" (Keating et al., 2017). In turn, "disasters have deep and far-reaching impacts on micro-economic levels" because they "undermine long-term competitiveness and sustainability" (Keating et al., 2017). At both macro and micro levels, solutions, resources (human, physical – infrastructure, financial, etc.), and actions are needed to ensure the three phases of repellence: before, during and after a natural disaster. When addressing the issue of natural disasters, it is important to highlight the issues of their impact on socio-economic development and then relate the issue to sustainable development. Resilience in the context of natural disasters (although it could also be related to any other crisis) requires attention to the risk, vulnerability and reconstruction of states, economies and societies. The first is related to the appropriate tools and solutions to anticipate a hazard occurring (e.g. early warning systems). The second is linked to the development of appropriate solutions, mainly infrastructural, to protect society and property against natural disasters (for example, earthquake-resistant bridges) while they last. The third concerns rapid response capacity (crisis management system), the availability and effectiveness of legal and financial instruments for rapid recovery, and the introduction of better safety nets. Each area constitutes an area of pro-development activities, not only through the creation of security solutions but also technical and technological solutions based on knowledge, the improvement of systems for the functioning of public institutions and their coordination, and the construction of modern and safe infrastructure solutions.

Some authors have pointed out the difference between resilience and sustainability. For example, Régibeau and Rockett (2013) highlighted that "resilience refers to the recovery of a system from shocks, whereas sustainability refers to maintaining current opportunities into the long run future". In the first case, the aim is to be able to rebuild efficiently and effectively. The second is to exploit the potential created in the long term. The literature review also revealed authors who identified "five conceptualisations of the interrelationship between sustainable development and resilience":

- resilience is an extension of neoliberal sustainable development,
- resilience is a response to the failure of neoliberal sustainable development,
- resilience integrates climate security and sustainable development,
- resilience is a prerequisite for sustainable development,
- resilience is qualitatively different to sustainable development.

They also stated that: "resilience discourse constitutes neither an updating of the language of sustainable development nor a new discourse of environmental and development policy governance. Rather, it is an ambiguous concept that interacts with sustainable development in multivarious ways, with distinct political, conceptual and practical consequences" (Ferguson & Wollersheim, 2022). The literature also distinguishes the following links between the two terms (Pisano, 2012):

- the need for persistence,
- systems thinking.

Here, it is worth noting the interconnection of the three issues discussed: resilience, well-being and sustainability (Figure 1). As Chaignea et al. (2022) argue well-being dimensions (material, relational and subjective) can be sources of resilience. For example, by providing adequate infrastructure against flooding, one can protect fixed assets (e.g. public buildings, production and service facilities, etc.) against flood waves. As a result, after the danger of flooding ceases, there will be no need to reconstruct it, i.e. incur expenditures for this purpose and allocate funds for other purposes, including development. Thus, there will be no need to spend time and financial resources on the reconstruction of fixed assets that would have suffered in the absence of such infrastructure.

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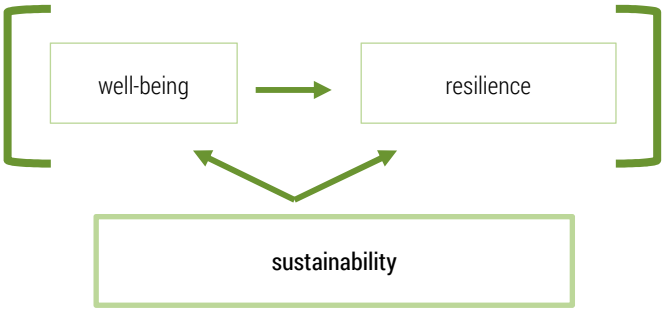

Figure 1. Well-being, resilience and sustainability

The question then arises as to whether or not well-being is conditioned by resilience. If resilience is being built as a result of a threat that has occurred, then the consequences of the actions taken should be taken into account, so that some social groups are not excluded from the welfare effort, as in the example cited (Chaigneau et al., 2022) of the exclusion of coastal areas. It should be pointed out that well-being is conditioned by resilience, but resilience can also be conditioned by wellbeing. Developed countries devote more resources (because they have them) to research and development, are more concerned with resilience and can afford to shape resilience.

Both well-being and resilience should be built on the basis of sustainability, which means that they should be built on the basis of the sustainability of the three orders: economy, society and environment. Based on the above considerations, the authors propose the following definition of resilience to natural disasters: the capacity to develop and implement solutions (legal, financial, material – infrastructure, technical; organisational, monitoring, institutional, etc.) – based on sustainable development – to protect against disasters, with the flexibility to modify these solutions in the event of disasters, while building development capacity and creating well-being through these activities. Building disaster resilience should be based on the cooperation of government, local government, local communities, scientific and research institutions and educational establishments, as well as businesses and non-governmental organisations.

Natural disasters and their impact on the economy and society

Nowadays, more than ever, the risks associated with climate change are being highlighted, and it is therefore vital to consider the issue of climate resilience: "the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to the climate" (US Economic Development Administration, n.d.) The need to protect against natural disasters and their effects should be seen as a source of climate resilience. The list of negative consequences that natural disasters have on the economy and society is long. Social consequences include the loss of life or health, changes in quality of life and well-being, disruption of social life, interruptions in education, impaired access to health care, homelessness, and loss of all or some personal property. Economic consequences include damage to infrastructure, the need to allocate funds for reconstruction and providing assistance to those in need, loss of part of GDP (e.g., freezing economic activity for the duration of the emergency and the reconstruction of damaged infrastructure, initial inhibition of investment), as well as changes in water resources and ecosystems. To illustrate the problem, the following data were analysed: the number of deaths from disasters around the world and in Europe (Figure 2), the total number of people affected by disasters (Figure 3), the number of people left homeless from disasters around the world and in Europe (Figure 4), and annual economic damage from disasters as a share of GDP in the world (Figure 5). An attempt was made to determine trends for the selected variables. However, it was immediately noted that the variables change by leaps and bounds, leading to the conclusion that it is impossible to forecast natural disaster data. It should be stressed that while natural disasters are difficult to predict, it is possible to measure their impact on GDP once they have occurred and to predict the time it will take for the economy to return to its pre-disaster state.

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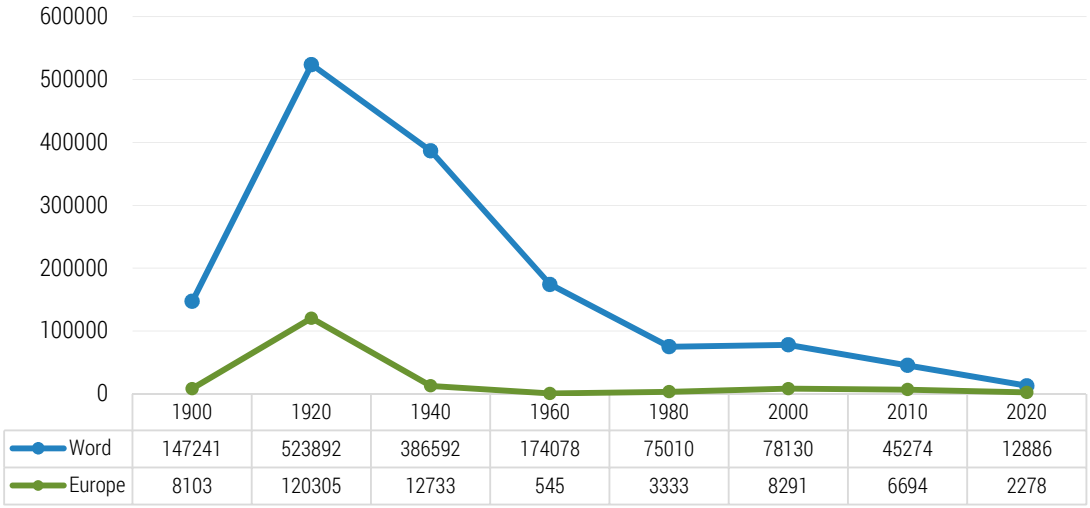
Asia achieves the highest values for all variables. A decreasing trend is evident in the number of deaths resulting from sudden events, both in the world and in Europe. However, were it not for 1920, one could speak of a constant trend; if there are any deviations over the period, it only indicates a meaningful increase in this variable.

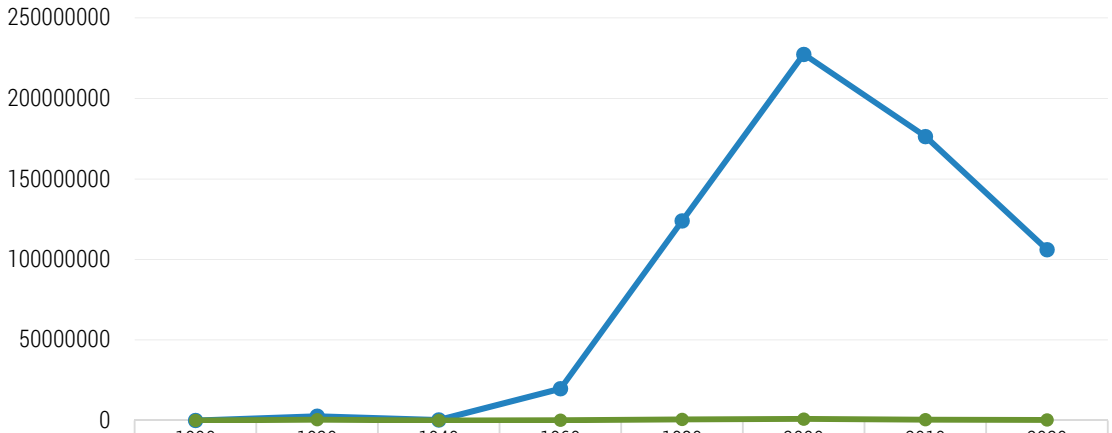


	1900	1920	1940	1960	1980	2000	2010	2020
Word	147241	523892	386592	174078	75010	78130	45274	12886
Europe	8103	120305	12733	545	3333	8291	6694	2278

Figure 2. Decadal average: Number of deaths from disasters around the world and in Europe

Source: authors' own study based on Our World in Data (n.d.).

As Figure 3 shows, the year 2000 stands out as having the highest number of people affected. Since 1900, there has been a marked increase in this figure, both worldwide and in Europe.



	1900	1920	1940	1960	1980	2000	2010	2020
World	59279	2657446	346079	19735648	123963470	227413950	176391760	106145020
Europe	29883	500600	6063	223820	666325	932501	516000	328065

Figure 3. Decadal average: Number of total people affected by disasters

Source: authors' own study based on Our World in Data (n.d.).

The year 2000 saw the highest number of people losing their homes due to disasters (Figure 4). The values of this variable have remained consistently high since 1900, with the exception of 1920 for Europe.

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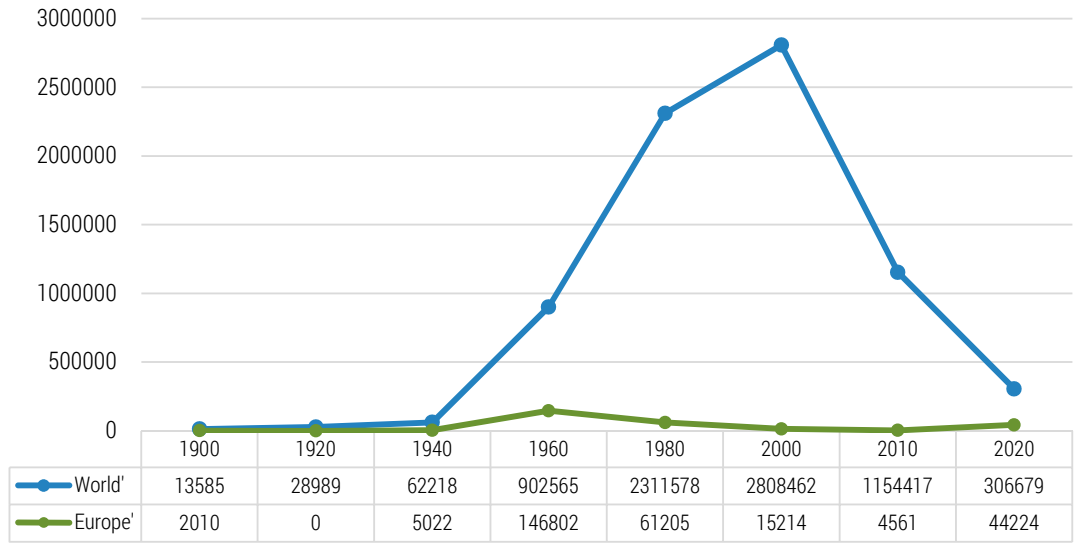
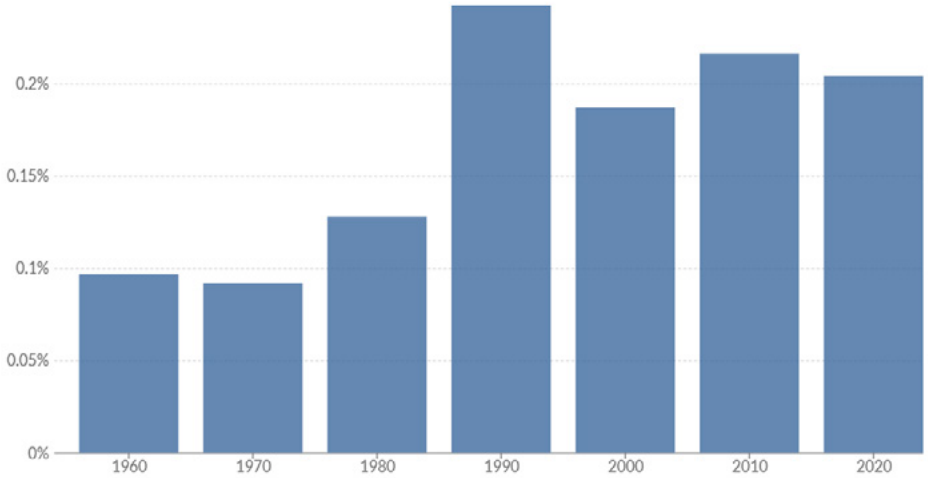


	1900	1920	1940	1960	1980	2000	2010	2020
World'	13585	28989	62218	902565	2311578	2808462	1154417	306679
Europe'	2010	0	5022	146802	61205	15214	4561	44224

Figure 4. Decadal average: Number of people left homeless from disasters around the world and in Europe

Source: authors' own study based on Our World in Data (n.d.).

The largest loss of GDP in the world was due to a disaster that occurred in 1990. Since 1960, there has been an increase in this variable, although, as with the other variables, there are step changes here, demonstrating that the effects of sudden events cannot be predicted. The largest global GDP loss was due to a disaster that occurred in 1990. There has been an increase in this variable since 1960, although, as with other variables, there are step changes, showing that sudden effects characterised by high dynamics and large-scale events cannot be predicted.



Note: Decadal figures are measured as the annual average over the subsequent ten-year period. This means that the figures for '1900' represent the average from 1900 to 1909; '1910' is the average from 1910 to 1919, etc.

Figure 5. Decadal average: Annual economic damages from disasters as a share of GDP in the world

Source: authors' own study based on Our World in Data (n.d.).

Figures 6 to 11 show the annual economic damage from disasters as a share of the GDP decadal average for 1960, 1980, 1990, 2000, 2010 and 2020 in each world region. The United States, Mexico, Peru, Chile, China, Argentina, Algeria, Madagascar and Australia are the regions of the world where the high values of the analysed variable in each decade can be indicated. In Europe, it is Portugal, Spain and France.

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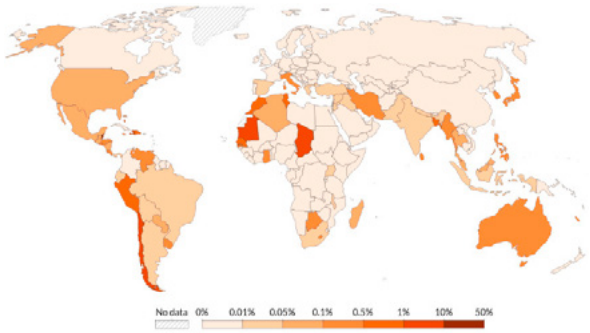

Figure 6. Decadal average: Annual economic damage from disasters as a share of GDP, 1960

Source: authors' own study based on Our World in Data (n.d.).

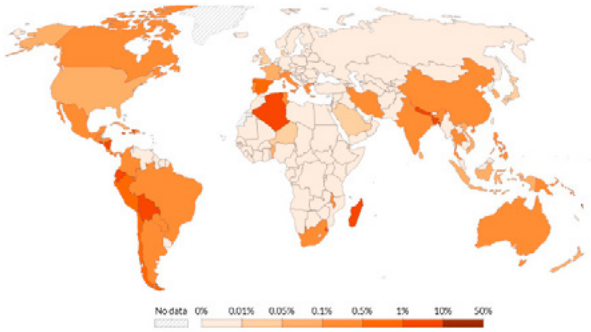

Figure 7. Decadal average: Annual economic damage from disasters as a share of GDP, 1980

Source: authors' own study based on Our World in Data (n.d.).

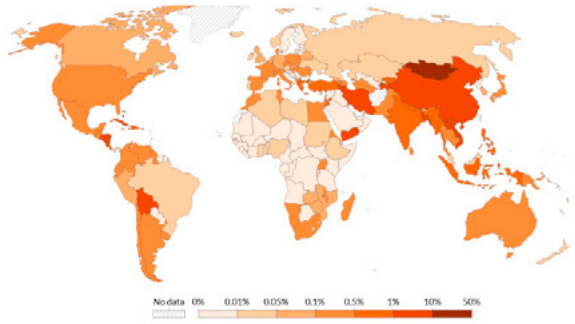

Figure 8. Decadal average: Annual economic damage from disasters as a share of GDP, 1990

Source: authors' own study based on Our World in Data (n.d.).

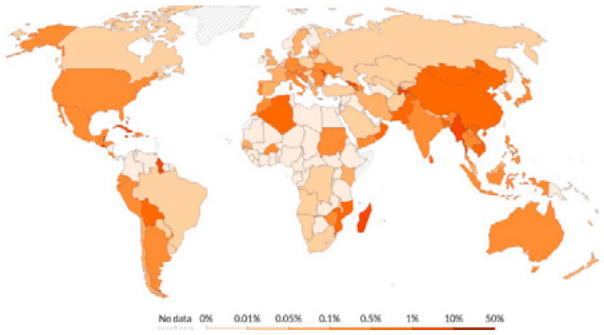

Figure 9. Decadal average: Annual economic damage from disasters as a share of GDP, 2000

Source: authors' own study based on Our World in Data (n.d.).

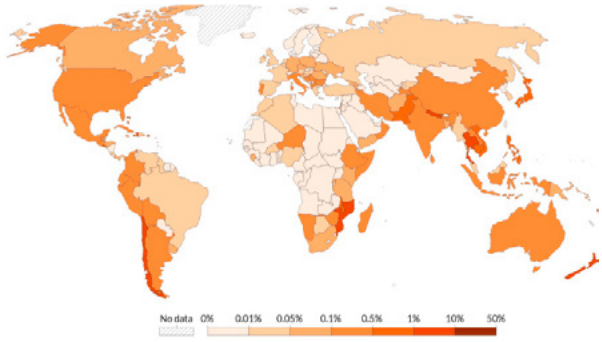

Figure 10. Decadal average: Annual economic damage from disasters as a share of GDP, 2010

Source: authors' own study based on Our World in Data (n.d.).

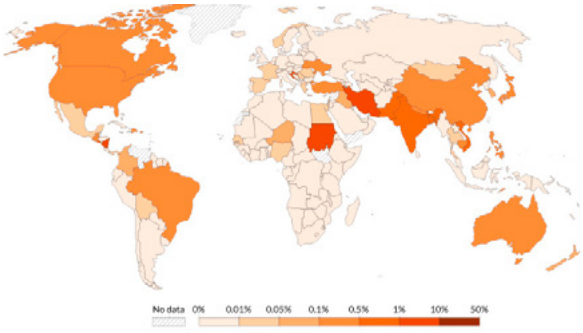

Figure 11. Decadal average: Annual economic damage from disasters as a share of GDP, 2020

Source: authors' own study based on Our World in Data (n.d.).

Data analysis indicates that the continent most threatened by natural disasters while also suffering the most loss of life and casualties is Asia, followed by the Americas, Africa, Europe, and then Australia and Oceania. The distribution of extreme weather events is reflected in the actual register of natural disaster events recorded on a daily basis.

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Shaping resilience to natural disaster

Activities related to disaster resilience building should be comprehensive and systemic. Constructing resilience requires action to be taken, first and foremost, by states and, through them, by other actors in the free market economy, as well as by NGOs and local communities. In terms of economic resilience, governments should "apply the following policy 'tryptic':

- preventing the build-up of potential vulnerabilities,
- preparing to absorb shocks when they occur, and
- the ability to engineer a swift rebound from those shocks" (OECD, 2009).

Keating et al. (2017) stated: "resources available for coping and reconstruction, combined with individual actions taken in pre- and post-disaster periods, determine how well an individual, household, firm or community respond to, cope with, and adapt to risks over-time" (sic). Activities are implemented at global, regional, national and local levels by international organisations, regional integration groups, governments, local authorities, non-profit organisations, entities, and households. Each has different types of instruments and tools. The broadest seem to be in the case of governments, including legal, financial, organisational administrative, and management instruments. When there are natural disasters, cooperation between states and international institutions is important. Examples include the Hyogo Framework for Action (Hyogo Framework), "a guideline to reduce vulnerabilities to natural hazards" (UN, 2007), adopted by the United Nations Member States, and then the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework), which has seven goals (UN, 2015):

- Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020–2030 compared to 2005–2015,
- Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015,
- Substantially reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030,
- Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030,
- Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020,
- Substantially enhance international cooperation with developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030,
- Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030" (sic) (UNDRR, n.d.).

Notable activities include the United Nations Development Programme (UNDP) and the program "Strengthening Climate Information and Early Warning Systems for Climate Resilient Development and Adaptation to Climate Change" for Africa, Asia and the Pacific (UN, 2020). In March 2022, the UN Secretary-General launched "the Early Warnings for All initiative, which called for every person on Earth to be protected by early warning systems by 2027" (UNDRR, n.d.). The framework of the Executive action plan for 2023–2027 is based on four pillars: Risk Knowledge and Management, Observations and Forecasting, Dissemination and Communication, and Preparedness to Respond (WMO, 2022).

At the state level, resilience to the threat of natural catastrophes could be building early warning systems, for example, in Japan (Kodera et al., 2021), or appropriate disaster risk assessment systems. Risk education activities are also being developed. It is also important to develop the appropriate infrastructure, e.g. appropriate building structures (for example, in Japan, in the event of an earthquake), bridges (for example, the Golden Gate Bridge in San Francisco), or high flood protection (for example, the Thames Barrier in London), among others. Infrastructural solutions require knowledge, the involvement of specialists, and the use of high technology. On the one hand, these solutions ensure safety. On the other hand, they represent a potential for development due to the knowledge and skills applied, as well as the improvement of management processes, coordination, and information exchange.

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One instrument to protect against the negative impact of sudden natural events is insurance. Due to the increased risk of disasters, the insurance sector is exposed to a higher risk of increased claims. For these reasons, a solution that is now being promoted among developed countries and those at high risk is a comprehensive system of cooperation between the state, citizens and insurers to mitigate the effects of natural disasters. Such systems ensure the protection of property through insurance, the diversification of risks with specially created funds, and the reduction of catastrophic losses through an emphasis on preventive measures. There is also a guarantee of compensation payments to property owners (real estate and property) for damage covered by the insurance contract. They are based on a well-developed catastrophe risk management process and have programs for simulating the course of a catastrophe and analysing its risk and appropriate field models (e.g. DTMs – digital terrain models, hydrodynamic model of rivers, and GIS spatial information system). Although they focus mainly on housing, they also apply to important public facilities and social infrastructure (e.g. schools, hospitals, bridges, and roads). Such solutions are already in place in France, the USA, Japan, New Zealand, Turkey (supported by the World Bank), Belgium, Spain, the Netherlands, Norway, Switzerland, the United Kingdom, Italy, Denmark, Portugal, Austria, the Czech Republic and Australia. Implementation and preparatory work is underway in many countries (including Poland). Such insurance programmes, supported by the government of a given country or based solely on the country's property insurance system, have proven their worth in highly developed countries for years as national or regional programmes that provide protection for life and property in the event of natural catastrophes[1].

Another financial instrument is catastrophe bonds, also known as "Act of God" bonds. These bonds are securities whose listing or repayment itself is linked to the occurrence of natural disasters. Due to the possibility of a catastrophic event occurring, these bonds carry a higher interest rate than government bonds. When a catastrophic event occurs, these bonds become worthless. When losses after a catastrophe exceed the level specified in the terms of the issue, the issuer is relieved of all financial obligations. If, on the other hand, there is no disaster by the bond's maturity date, the bond-issuing company redeems the bonds from investors and pays the coupon for the final period (Boryczka et al., 1998).

These bonds most often have coupons attached, characterised by attractive interest rates, averaging from around 1.5% to around 5% above a risk-free interest rate such as LIBOR. These coupons are paid in part or not at all if, over a certain period, the issuer's catastrophe losses or insurance sector losses calculated according to the value of an established catastrophe index exceed the agreed level. Other conditions set out in individual contracts also provide for the loss of part or even all of the nominal value, as well as the extension of the issuer's redemption date. Typically, however, investors are guaranteed a certain minimum payout on each coupon. As a general rule, the greater the risk of losing the invested capital (i.e., the greater the chance of a catastrophe causing losses in excess of the agreed level), the greater the coupons offered (Sopocko, 2009).

Catastrophe bonds appeared on the regulated OTC markets in 1995. Initial difficulties, mainly related to a lack of confidence in the new product, were overcome in late 1996. It then became apparent that catastrophe bonds, as instruments to protect the issuer against loss, were an alternative to redeeming policies that covered natural risks. These bonds are mainly issued by insurance companies and government agencies responsible for settling disaster-related claims, e.g. the CEA (California Earthquake Authority) in the United States. Today, bonds are also traded on stock exchanges, e.g. the Bermuda Stock Exchange. In addition, investment funds are being set up to invest their funds only in catastrophe bonds. The first such fund is the Swiss Leu Prima Cat Bond Fund, managed by Bank Leu (Sopocko, 2009).

An analysis of functioning catastrophe protection systems and programs around the world makes it possible to distinguish between two models, applied according to the degree of state support and efficiency of the insurance system in a given country. In model I, the system is based on the welfare function of the state. The government and public institutions are involved in the prevention, insurance protection and compensation processes that result from catastrophic events. In model II, a country's system is based on the insurance market and is therefore provided by insurance companies that offer insurance products. In practice, the two models often intermingle, but one of the models always

[1] Compare with: *Kataklizmy. Opinie. Prawo, Ubezpieczenia, Reasekuracja.* (2004). Warszawa: „Hubertus": Agencja Unia-Press. (in Polish).

DOI: 10.34659/eis.2024.91.4.759

dominates. Model I can be found in France, Switzerland, Norway, the Netherlands, Spain and the USA, among others, while model II is found in Germany, Austria, Denmark, the UK, and Portugal (Michalak, 2016).

The lack of data on the effectiveness of the different models makes it impossible to reliably answer the question of which model is more beneficial.

In summary, natural disaster resilience tools can be grouped into categories (see Table 2). However, it is important that they are implemented and systematically improved.

Table 2. Typologies of instruments for resilience to natural disasters

Criterion	Types	Examples of instruments
1. duration of action	a) preventing the build-up of potential vulnerabilities	early warning systems
	b) preparing to absorb shocks when they occur	resilient infrastructure, e.g. seismic-resistant buildings
	c) the ability to engineer a swift rebound from those shocks	Insurance
2. The entity implementing the activities	a) government	crisis management system
	b) international organization	early warning systems
	c) local governments	emergency procedures for residents
	d) enterprise	alert systems
	e) NGO	educational material and training
	f) research institutions	advanced technologies for building materials and structures
	g) local communities	local support centres for people affected by natural disaster
3. Scope of the instruments	a) law	regulations for building in areas listed as hazardous
	b) financial	financial support for people affected by natural disaster
	c) administrative	designation of emergency coordinators
	d) organizational	provision of material resources e.g. clothing, food, water, etc. in case of emergency

They should also be tailored to local conditions and hazards and be flexible enough to be easily adapted to different circumstances. Last but not least, they should contribute to sustainable development.

Conclusions

Many academic disciplines are considering the issue of resilience. For this paper, attention was given to building resilience in economics and the link to the concept of sustainable development based on literature sources. The term itself is interdisciplinary, while building resilience in the context of shaping a development framework is multidisciplinary. Therefore, the study presented the authors' definition of the term.

The data presented in the article highlighted the consequences of natural disasters. The presentation of the available instruments of resilience to natural disasters shows that, despite the unpredictability of these events, there are ways to minimise the negative effects. These tools make it possible to build the resilience of governments, societies, and businesses in the context of natural disasters. The next step of the study will be to analyse the extent to which economic operators use the available tools.

DOI: 10.34659/eis.2024.91.4.759

The unpredictable nature and magnitude of potential losses caused by extreme events make total resilience unattainable. Despite this, all possible steps should still be taken to increase resilience.

The contribution of the authors

Conceptualization, D.M. and P.S.; literature review, D.M. and P.S.; methodology, D.M. and P.S.; formal analysis D.M. and P.S.; writing, D.M. and P.S.; conclusions and discussion, D.M. and P.S.

The authors have read and agreed to the published version of the manuscript.

Acknowledgements

This research has been supported by Polish Association of Environmental and Resource Economists (81%), University of Lodz (9 %), University of the National Education Commission, Krakow (9%).

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DOI: 10.34659/eis.2024.91.4.759

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INSTRUMENTY ZAPEWNIAJĄCE ODPORNOŚĆ NA KLĘSKI ŻYWIOŁOWE

STRESZCZENIE: Klęski żywiołowe, powiązane ze zmianami klimatu, przyczyniają się do utraty życia, uszczerbku na zdrowiu, utraty mienia i uszkodzenia infrastruktury. Klęski żywiołowe dotykają społeczności zarówno w krajach rozwijających się, jak i rozwiniętych. W tych pierwszych zjawiska te występują jednak częściej, dotykają większą grupę ludzi, a straty są często większe i bardziej dotkliwe. W literaturze coraz częściej jest poruszane zagadnienie odporności. Celem niniejszego artykułu jest przybliżenie pojęcia odporności w kontekście klęsk żywiołowych i budowania potencjału rozwojowego. W opracowaniu przedstawiono autorską definicję odporności na wypadek klęsk żywiołowych. Na potrzeby niniejszego artykułu dokonano przeglądu literatury i istniejących danych. Prezentacja dostępnych narzędzi bezpieczeństwa pokazuje, że pomimo nieprzewidywalnego charakteru klęsk żywiołowych, istnieją sposoby na zminimalizowanie ich negatywnych skutków.

SŁOWA KLUCZOWE: klęski żywiołowe, odporność, narzędzia budowania odporności

DOI: 10.34659/eis.2024.91.4.759