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# CLIMATE POLICY IN GLOBAL AND LOCAL ASPECTS

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Abstract

A review article summarising the current state of knowledge and suggesting directions for further research. It is part of a wider review aimed at assessing the effectiveness of climate change policies. The main difficulties considered in the article include the problems of environmental management and strategies for building resilience to climate change induced stress. The issues analysed in the article concern selected problems in the implementation of climate policy at global, regional and local levels. It was found that, under certain conditions, the effects of the measures taken can be counterproductive. The effectiveness and rationality of climate policy was also analysed from an economic perspective.

The aim of the article was achieved on the basis of a review of domestic and foreign literature and documents on the subject, as well as a comparative analysis. The study covered selected issues that, in the author's opinion, should be taken into account when adapting the climate policy formulated at world summits to local conditions. This adaptation should include not only solutions but also targets. In conclusion, the author points out that the evaluation of the effectiveness of climate policy should be carried out at the local level and should include social and economic issues in addition to environmental ones, and should be accompanied by a balance of losses and benefits.

Keywords: climate policy, adaptation plans, carbon dioxide emissions reduction, energy crisis, security and economic balance of climate policy

## 1. INTRODUCTION

Climate change is a global phenomena, but its effects vary in different geographical zones. Differences are also due to local conditions, geomorphology, land use, etc. In responding to climate change, policy seeks agreement between parties representing different interests. This dimension also involves differences due to political, economic or security considerations, among others. Therefore, at the local level, climate policies and especially adaptation plans should be assessed for their effectiveness on each of these issues.

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The extent to which climate policies and adaptation plans formulated at the global and international levels are subject to interpretation and adaptation at the national and local levels may indicate how much they are based on rational considerations and how much they are subject to ideology. There are difficulties here because climate policy is characterised by a high degree of centralisation. On the one hand, standardisation seems to be necessary in order to harmonise indicators for measuring progress and for comparison with the progress of other parties to the climate agreement. On the other hand, standardising targets without taking into account significant differences in local conditions may be counterproductive.

Urban climate is a product of many factors. It is largely dependent on geography, but can be significantly affected by the concentration of human activity. The consequences of climate change are therefore most severe in cities, which are particularly vulnerable to threats because they are centres of economic, administrative, infrastructure, transport and innovation activity, and at the same time because a high proportion of the population lives in urban areas. The intensification of extreme phenomena caused by climate change, combined with the predicted threats, contribute to putting the idea of developing a resilient city in the spotlight. For these reasons, it is important to strive to increase the resilience of urban areas to floods, droughts, winds and hailstorms, and to protect inhabitants from heat, smog and accidents.

Since the beginning of the century, there has been a significant knowledge expansion in the field of climate change. The number of publications dealing with the issues of adaptation to climate change increases exponentially from 1990 to 2020 [54, p. 8]. Johanna Nalau and Brodie Verrall, based on a review of the literature on the subject, show a steady upward trend through the periods 1978-2010 (10.3%), 2011-2015 (35.1%), 2016-2020 (54.6%) [54, p. 4]. Their research used a combination of bibliometric, visualisation and content analysis techniques. This research shows that there are currently more than 1,600 climate change adaptation publications in circulation each year, indexed in Web of Science and Scopus. This averages out to about 4.4 publications per day. This makes it difficult to keep track of all the literature and assess the development of the knowledge base. In addition, Nalau and Verrall found that the USA is the most common country for climate change publications, followed by the UK and Australia, then Germany and China [54, p. 6]. The data collected is available online at https://doi.org/10.1016/j.crm.2021.100290.

A team of 126 researchers across the World analysed around 48,000 articles on climate change [2]. Due to the large number of publications analysed, the research was based on two new approaches, namely machine learning and collaborative networks. From this collection, 1,682 publications on the implementation of adaptation measures were extracted. Based on the analysis, the authors of the review concluded that the research is largely fragmented, localised and incremental, and that the evidence of change and reductions in climate damages achieved is limited [2, p. 996]. In addition, the authors of the review point to major problems with terminology that is not integrated across the literature on impacts of change and that on adaptation. Only about 30% of the studies covered multiple systems, and most of them focused on a single sector. The methodological protocol and databases of data analysed are available online from the authors at https://osf.io/ps6xj.

For the current study, many of the publications were not used due to their fragmented nature, while more attention was given to the authors who analysed climate policy processes in a complementary way. The current study analysed publications on countries from different climate zones, and this was one of the criteria for the review. The results of studies from one climate zone were verified by comparison with studies from another climate zone, taking into account the use of similar methodologies. Statistical analyses based on keyword selection were rejected due to the overrepresentation of publications from the USA and China.

## 2. GLOBAL CLIMATE POLICY

In the current development policies of urbanised areas, we can observe a clear increase in the importance of climate change as a factor shaping the urban agenda. However, despite many global climate conferences, ambitious plans and intensive efforts to reduce carbon dioxide emissions, there are still models that are changing little, traditionally based on coal and excessive consumption of resources and energy, as well as consumerism and the associated waste of environmental resources [12, 13, 33].

Climate change is now a major issue on the global political agenda. Global negotiations at the annual United Nations Climate Change Conferences are supposed to lead to the establishment of a common programme to counteract the effects of change and to strive for climate neutrality [60]. Although the successive climate summits held after the entry into force of the Kyoto Protocol in the period 2005-2019 have been critically assessed as unsuccessful, revealing the enormous difficulties in reaching an agreement, it can be observed that the climate agenda is saturating local development strategies.

Research into responses to climate change and the consideration of adaptation of the urban environment to climate change has been carried out for some time, but has intensified since the Kyoto Protocol in 1997. The gradual development of adaptation plans and measures is described, among others, by Nils Larsson [42] using the example of Canada, which, incidentally, did not ultimately ratify the Protocol, along with the US and several other countries. The difficulties in adopting the document resulted from the inability to establish common rules for implementing the assumptions made. The lengthy political process, protracted negotiations and difficulties of climate management in cities have also been analysed by Brian Webb [71], using Tokyo, New York City, Stuttgart and Manchester as examples. In his research, he pointed to the historical factor as an important factor in explaining the successes and failures of climate policy in the cities analysed. The processes of integrating climate policy with socio-economic development strategies and the need for systemic and innovative solutions at scale are also discussed by Eleanor Tonks and Sean Lockie [68]. On the other hand, Daniel Aldana Cohen [12] takes a much more critical view of the last 20 years of climate action, even calling for a radicalisation of the climate message.

The results of a study carried out by Xin Nie and his team [55] are interesting. They looked at 274 cities in China. The results suggest that it is important to take into account differences in regional development and apply stricter environmental regulations in more developed regions, while avoiding uniform institutional arrangements and more moderate regulations in regions with lower levels of development [55, p. 15]. The research used qualitative comparative analysis to explore the causal and complex configurations between environmental regulation and regional innovation. The authors presented the configuration variables and described the data, which they made available online at https://www.mdpi.com/article/10.3390/su14052876/s1.

Alexandra Lesnikowski et al [43] used systematic content analysis in their study to identify local configurations of adaptation instruments. This approach required an inventory of climate change adaptation policies adopted by local governments between 2010 and 2017. Domain-specific keywords were used to identify relevant documents: "climate change" and "adaptation". The authors grouped policy instruments according to categories of implementation style. The research covered 125 local governments in Canada, France, Germany, the Netherlands and the United Kingdom. The research found that few local governments use a wide range of policy instruments. Most are limited to one implementation style, and those that have more tend to have fewer than five [43, p.15]. The data collected on adaptation policy instruments is presented in tables and is available online at https://eprints.whiterose.ac.uk/169842/1/Lesnikowski%20et%20al%202020.pdf.

Alexandra Lesnikowski et al. found that GHG mitigation strategies emerged from more centralised decision-making processes, while adaptation plans were mostly formulated at the local government level [43, p. 3]. This is supported by studies by Sarah Hughes [32] and Diana Reckien and her team [62], which examine the influence of social, political and economic factors in shaping local adaptation plans.

Diana Reckien and her team surveyed a sample of 200 large and medium-sized cities in 11 European countries. Based on their research, a database was developed containing information on the existence and content of municipal climate change adaptation and mitigation plans. The keyword 'climate change' was used to identify strategic policy and planning documents. This was extended to include documents that referred to climate change in the introduction or as a motivation for the plan. Climate change and sustainable energy plans were included, but other sectoral plans with a different motivation and main objective were excluded. The selection process for climate change policy documents is available online at
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0135597#pone.0135597.s004.

Local adaptation plans focus almost exclusively on cities. This is puzzling because built-up and urbanised areas cover only 1% of the global land. Agricultural and forestry land alone covers more than 75% of the EU's territory. In the EU's climate policy, land use plays a major role in absorbing $CO_2$ from the atmosphere and combating climate change. As part of the centralised Green Deal policy, commitments have been made to increase $CO_2$ sequestration. In 2018, LULUCF regulations were introduced, including how $CO_2$ emissions from land use should be accounted for for the period 2021-2025 [44], but after just five years the regulations were extended to cover all land under cultivation and a commitment was made to achieve -310 Mt $CO_2$ equivalent, or a 15% increase in $CO_2$ removals [45]. As part of these commitments, farmers were required to leave 4% of arable land fallow and to reduce the use of plant protection products by 50%. The Green Deal united farmers in most EU countries in large demonstrations and blockades against the radical restrictions imposed by the European Commission. In the wake of the protests and with EU elections looming, politicians have announced plans to ease restrictions.

The impact of climate change on the disruption of the water cycle is clear. More than 60% of European cities are experiencing water shortages, and this number is expected to increase. The water crisis is worsening - on the one hand, more frequent droughts and fires, but also floods, and on the other hand, the projected significant increase in water demand for agriculture and industry, especially hydrogen and semiconductor technologies. For these reasons, and independently of the Green Deal, the European Economic and Social Committee officially announced in October 2023 a declaration on the establishment of an EU Blue Deal [19]. This is intended to be a comprehensive strategy that complements the Sustainable Development Goals of the UN agenda. The main objective of the EU Blue Deal is to protect and properly manage water resources by increasing water use efficiency, using closed cycles and reducing pollution. As part of the acceleration, the Knowledge and Innovation Communities for Water European Institute of Innovation & Technology supporting contribution to circular and sustainable water management (EIT Water), European Water Centre, Blue Transformation Fund are to be established. There are also plans to appoint a new EU Commissioner to develop cooperation in technology, infrastructure and knowledge, and to create strategic economic partnerships for water with countries outside the EU. EU investment in the Blue Deal is expected to reach €390 billion.

A debate is emerging between proponents of global management of climate change mitigation and adaptation and proponents of decentralisation. The slogan "global change - local adaptation" is evaluated in specific case studies [24]. Many researchers note the unsatisfactory progress of adaptation efforts at the local level. According to Åsa Persson and Adis Dzebo [58], who analysed the global climate agenda using examples from 40 initiatives, the difficulties in implementing climate policy at the local level should be addressed by global and supranational governance.

On the other hand, Morgan Scoville-Simonds and his team [66] and Thomas G. Measham et al [48] point to the need to move adaptation out of the political mainstream and into the realm of practice, with increasing responsibilities for local governments. The argument for this is based, among other things, on the high degree of political polarisation and the resulting divergence of interests, as well as the inefficiency of bureaucratic government administration, which contributes to slowing down progress in implementing adaptation measures [48, p. 904]. This is confirmed by Jeff S. Birchall, Nicole Bonnett and others in an analysis of local climate policy in Surrey (Canada), where they even find that government policies and guidelines can delay the implementation of a local adaptation plan [3, p. 15]. In the case of significant differences in the nature and scope of local adaptation plans implemented in highly diverse climatic, social, political, economic and physiographic conditions, it can be assumed that the research results will confirm one or the other thesis. The use of top-down, uniform indicators to measure progress towards jointly agreed targets is justified, but in specific cases centralisation may have negative local effects.

## 3. EFFECTS OF CLIMATE CHANGE

Climate changes observed worldwide are characterised by an increase in temperature, greater intensity of atmospheric phenomena (heat waves, droughts, rainfall, storms, tornadoes) and higher sea levels. In the case of Poland, the changes observed in recent years are more pronounced in winter and less pronounced in summer, and mainly concern the increase in temperature (by 0.6°C on average) and the increase in precipitation (by up to 16%) [52, p. 10].

Increases in temperature and precipitation in Poland have been studied by, among others, Zbigniew Kundzewicz and his team, who also point to an increase in the number of floods [40, p. 1514]. Droughts, heat waves and heavy precipitation contribute to earlier planting and harvesting dates for some crops, and soil moisture anomalies adversely affect yields [47]. The expected increase in agricultural water use is highlighted by Maciej Sadowski [65, p. 8], but the reported values do not take into account how much of the upward trend in water demand is due to climate change and how much is due to the development and intensification of agriculture. Sadowski and his team do not confirm the increase in precipitation in Poland, but point to a change in its structure. On the other hand, with regard to the increase in temperatures, they note the strongest trend in thirty years - over 4.5°C in terms of minimum temperatures and an increase in the number of days with temperatures over 25°C [65, p. 5]. Global warming over the past few decades is the most well-documented issue about which there is no great doubt. However, there are disputes about the real causes and whether it is a cyclical phenomenon. Studies of climate change can be authoritative over a longer time horizon. Drawing conclusions from the history of change is difficult because the history of systematic measurements is not very long, and the methodology for studying earlier periods is subject to error [35]. In addition, climate is influenced by many factors, some of which are not yet well understood, such as solar magnetic activity, the importance of which has been highlighted by many researchers [1, 26, 29, 31, 35].

However, there is no doubt that higher minimum temperatures, heat waves and droughts are increasingly being observed. Giuseppe Formettaa and Luc Feyen analysed climate-related hazards from 1980 to 2016 and found a steady upward trend in floods, inundations, heat, cold, drought and wind [25, p. 2], despite the noticeable variations observed in some events from year to year. On the basis of their research, they show that, despite the increase in climatic events, the percentage of the population at risk from them is definitely decreasing, and the rate has decreased by a factor of 6.5 compared to the period 1980-1989 [25, pp. 1, 5-6]. There has also been a significant reduction in vulnerability to economic losses, with the rate falling by a factor of 5 [25, p. 1].

In the studies conducted, the relationship between exposure to a weather hazard and impact was analysed in terms of the impact on the population (number of deaths due to a weather hazard) and the economy (amount of monetary losses caused by the hazard). Population vulnerability was defined as the ratio of the number of people killed by a climate disaster to the number of people exposed to the hazard. Similarly, economic losses were defined as the ratio of economic losses at the time of the event to gross domestic product. It was found that the level of GDP may not fully correspond to the wealth of assets exposed to disasters, but in the absence of good measures of wealth, GDP was used as a proxy for wealth, as in other studies. The study analysed seven weather-related hazards for the period 1980-2016: general floods, flash floods, coastal floods, wind hazards, cold weather, heat waves and droughts. The data on fatalities and direct losses due to natural catastrophes was obtained from the Munich RE's NatCatSERVICE database. The data sets and research methodology have been made available online at https://ars.els-cdn.com/content/image/1-s2.0-S0959378019300378-mmc1.docx.

The problem of measuring the effects of change and estimating the costs of climate damage and the savings from mitigation activities is being addressed by many researchers. There are different approaches to econometrically estimate the effects of climate change. The methods used are more or less effective depending on the conditions, and the interpretation of the results is not always justified [39, p. 16]. Delavane Diaz and Frances Moore present the advantages and disadvantages of different parameterisation models depending on the variables they take into account [15, p. 774]. Based on a review of the approaches used, they point to the need for empirical evidence that could improve modelling and increase the effectiveness of climate damage estimation methods [15, p. 780]. According to them, the integration of modelling with empirical evidence should, among other things, take into account the impact of mitigation measures whose effects change over time.

In their review, Delavane Diaz and Frances Moore [15] confine themselves to an analysis of three integrated assessment models (IAMs) representing key elements of the Earth and human systems used by the US government to estimate damages from climate change. These damages are represented in cost-benefit analyses by a damage function, i.e. the relationship between climate variables (including temperature, $CO_2$ concentration and sea-level rise) and economic well-being (GDP). The integrated assessment models (IAMs) analysed by the authors have simplified representations of the economy, climate and impact mechanisms to explore trade-offs in policy design, and are computationally feasible. Delavane Diaz and Frances Moore conclude that unfortunately, due to the complexity of the issues studied, the methodology underlying these simplified quantitative tools does not reflect the current state of scientific knowledge [15, p. 774].

Charles D. Kolstad and Frances C. Moore [39] also reviewed the methods used to measure and assess the impacts of climate change in different dimensions, including on people and economic activity. Based on their research, they assessed the effectiveness of different ways of measuring climate damages and identified issues relevant to estimating the costs of climate change impacts [39, p. 2]. They noted the differences between cross-sectional and panel analyses. According to them, panel methods, by using fixed location and time data, take into account variables omitted by other methods, but are only suitable for estimating short-term impacts and are therefore subject to error in the long term [39, p. 9]. Cross-sectional analyses, on the other hand, are suitable for studying long-term responses in different locations, but their use is not justified in all circumstances [39, p. 16].

One of the indicators studied in the context of global warming is the number of excess heat deaths. In a global comparison, however, it was found that the rate of heat deaths increased by 0.21%, while that of cold deaths decreased by 0.51% [77, p. e421]. Studies of excess deaths due to suboptimal temperatures over the last two decades suggest a decrease of 0.30%, despite the global rise in temperature and the increase in world population. Studies from recent decades show a decreasing trend not only in the number of deaths due to suboptimal temperatures, but also in the number of victims of extreme climate events. The more affluent a society is, the greater its resilience to hazards, due to greater investment in early warning systems and risk management [25, p. 7]. Despite the overall downward trend in the number of victims of climate-related disasters, it is worth noting the disparity between wealthy and nonwealthy countries, which is reflected, among other things, in mortality rates from heat, floods and storms that are up to 15 times higher [4, p. 16].

In summary, many of the risks posed by climate change are presented as probable and estimates are presented as predicted. Forecasts are subject to error, depending on the research methodology used, the factors selected and the models used. Interpretations of the results of studies based on theoretical models cannot replace empirical studies, and only such studies provide a more reliable basis for action. The complexity of the issue and the multitude of factors influencing climate, including the little-known field of cosmoclimatology, make comprehensive analyses difficult. Research is needed to verify previous predictions and to provide actual values and directions of change trends. According to the author, with such a complex issue of climate change impacts and such high costs of mitigation, theoretical models do not provide sufficient assurance of the accuracy of the interpretation of the results and the veracity of the conclusions drawn.

## 4. ADAPTATION PLANS

The response to climate change is increasingly taking the form of action at the regional and local level. This is partly due to the deadlock in international negotiations, especially after the US withdrawal from the Paris Agreement, China's continued indifference to the problem, and the assertiveness of poor developing countries who (rightly) do not want to bear the costs of adaptation. However, much of the decentralisation of adaptation is based on a belief in the effectiveness of local action [6] and the need for a different approach according to the characteristics of a given place [48].

This is also supported by legal regulations of the European Union, starting with the basic document Adapting to climate change: towards a European framework for action [12] in 2009, until the adoption of Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change [18] in 2021. This will be followed by national documents, i.e. the Polish National Strategy for Adaptation to Climate Change (related to the Klimada research project) [52], published in 2013, and the Strategy for Responsible Development until 2020 (with a view to 2030) [51], as well as locally developed urban adaptation plans, prepared on the basis of the Ministry of the Environment's guidelines set out in the Adaptation Manual for Cities [53]. Among the 44 Polish cities participating in this programme, adaptation plans have been developed by, among others, Warsaw (AdaptCity), Radom (RadomKlima), Mińsk Mazowiecki (MPA MM). In Wroclaw, the City of Wroclaw Adaptation Plan to Climate Change until 2030 was adopted in September 2019 [69].

Cities are implementing adaptation strategies not only in the hope of improving their security against climate threats, but also, or perhaps above all, as an opportunity to boost their development and economic recovery, while improving the well-being of their inhabitants. In Europe, adaptation plans are being implemented by cities such as Copenhagen (Copenhagen Climate Adaptation Plan), Rotterdam (Rotterdam Adaptation Strategy), Berlin (Berlin Energy and Climate Protection Programme 2030), Hamburg (Hamburg Climate Action Plan), London (Climate Action Plan), Vienna (Climate Protection Programme).

In the interest of quality of life and ensuring socio-economic stability, in many cities around the world, the climate agenda is driving the prioritisation of discussions in decision-making processes [10]. Increasing the resilience and adaptive capacity of cities reduces the risk of losses caused by extreme climate phenomena. The capacity of the economic and social system, as well as institutions and organisations, to prevent or quickly remedy climate damage is based on knowledge, institutional capabilities, and financial and technological resources [72]. The exchange of knowledge, experience and technology is based on numerous global, regional and national city cooperation networks.

Among the main threats of climate change defined at the local level, warming and associated heat waves, droughts and water scarcity, and floods and waterlogging are the most commonly identified [20, 21]. Both mitigation and adaptation are included in mainstream climate change efforts [7]. Mitigation is the reduction of production and emissions and the absorption [36] of greenhouse gases (GHG), which are considered to be the cause of global warming [67, p. 117]. Adaptation, on the other hand, is the adjustment to actual and projected climate change and its impacts.

The objectives and actions included in urban adaptation plans take into account local conditions. In this dimension, issues such as biodiversity development, increasing biologically active areas, rainwater management (large and small retention programmes), blue-green infrastructure or nature-based solutions should be positively evaluated [9, 37]. In certain circumstances, measures such as protection against coastal and inland flooding become more important [3, 34]. Katarzyna Chrobak and Piotr Kryczka [9] postulate the need to define the principles of correlation between planning and sectoral documents that make up the spatial policy of a city adapting to climate change. They should take into account the territorial dimension and refer to local spatial conditions [9, p. 161].

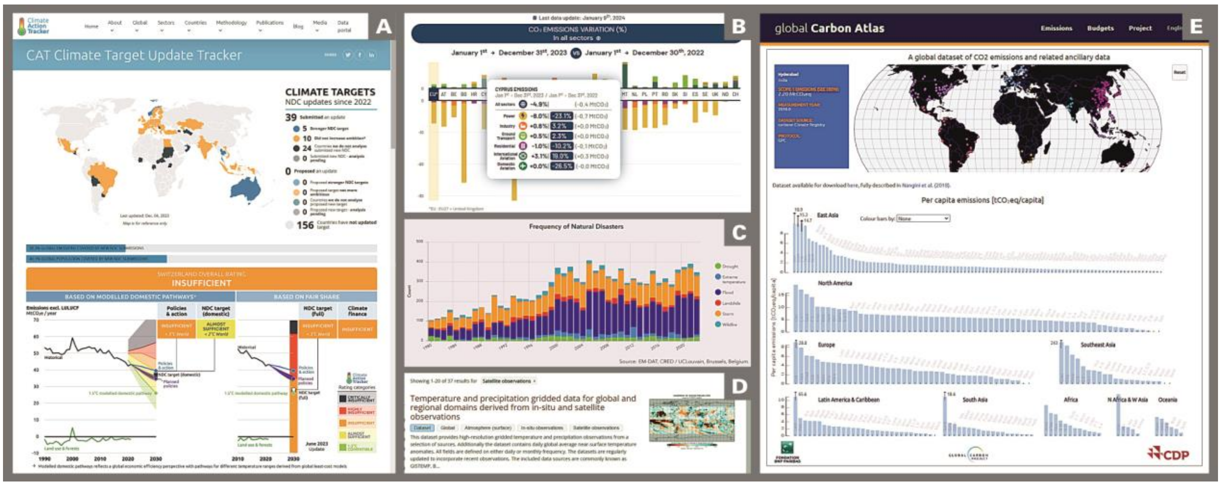


Fig. 1. One of the examples of monitoring and analysis of adaptation actions by research organisations

A) Climate Action Tracker (CAT) tracks progress towards the goal of limiting warming to 1.5°C. https://climateactiontracker.org/, accessed 18.01.2024

B) Carbon Monitor is an international initiative that for the first time provides regularly updated, science-based estimates of daily carbon dioxide emissions. https://carbonmonitor.org/, accessed 18.01.2024

C) The Climate Change Indicators Dashboard is an international statistical initiative to address the growing need for climate-related data in macroeconomic and financial stability analysis. https://climatedata.imf.org/ , accessed 18.01.2024

D) Copernicus is the Earth observation component of the European Union's space programme, which studies our planet and its environment for the benefit of all European citizens. It provides information services based on satellite Earth observation and in-situ data. https://www.copernicus.eu/, accessed 18.01.2024

E) GlobalCarbon Atlas is a platform to explore and visualise the most up-to-date data on carbon fluxes resulting from human activities and natural processes. https://globalcarbonatlas.org/, accessed 18.01.2024

An important issue in developing adaptation potential is the need for joint regional programmes and cooperation at different spatial scales to increase the effectiveness of adaptation strategies [23]. It is worth mentioning the European Climate-ADAPT network (www.climate-adapt.eea.europa.eu), the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC / CCA) or the Copernicus Climate Change Service (C3S). Connecting Delta Cities (C40 Cities) is working well and currently connects 96 cities from around the world and 100 Resilient Cities (100RC), in which about eighty cities are active. There are more than a dozen global networks, including several platforms for sharing knowledge and experience.

Global and international platforms for cooperation between cities are doing well in promoting and mobilising adaptation actions, providing knowledge, arguments and good practices. The monitoring and reporting of adaptation actions, and the recent publication of the results of these analyses, is a great support to climate change-related projects (Fig. 1). Cooperation networks raise awareness and sensitivity to climate issues, but they do not offer specific solutions adapted to a particular region. National cooperation networks provide greater coordination, support and resources needed to carry out tasks that are often beyond the capacity of individual cities [27].

In the scientific field, the idea of a city that responds to climate change is flourishing. Resilience, as a keyword identified in publications, has gradually gained popularity and has come out on top for the period 2016-2020 [55, p. 11]. The concept of urban resilience first appeared in the sense of the ability of the urban ecosystem to maintain basic functions despite disruptions [30], and was then developed by other researchers in economic, epidemiological and social aspects [49]. The contemporary relevance of this development concept is based on the drive to increase resilience in four areas: environmental, social, governance and economic. The resilient city formula is characterised by a set of terms that define the desired characteristics of the city, i.e. reflective, resourceful, robust, redundant, flexible, integrated, inclusive [41]. The concept of a resilient city is based on making the city resilient to 'chronic stresses' or 'sudden shocks', which mainly concerns protection against the effects of extreme climatic phenomena, protection and development of biodiversity and ecosystems, resource and food security, as well as management efficiency and social stability [41, 64].

The concept of resilient development is contrasted with the idea of sustainable development. At the same time, differences are drawn between the reactivity and creativity of development adapted to the dynamics of change and the passivity and conservatism of the principle of development without harming future generations [46]. Many publications and documents on the adaptation of cities to climate change refer to the paradigm of sustainable development.

It is worth noting that the idea of resilient urban development is being disseminated through cooperation platforms of cities interested in sustainable development. This is evidenced, among other things, by a series of congresses organised by ICLEI (Local Governments for Sustainable Development). Through ICLEI, 350 cities from 84 countries have been working together for ten years on development that increases resilience to threats. The optimal approach is to use the thinking and experience of sustainable development gathered over the last three decades and to treat the idea of resilient development as an evolution of that direction.

The concept of resilient city development is gaining momentum around the world, as evidenced by the creation of a number of interdisciplinary research networks (e.g. Resilience Alliance, Resilient City Organisation), cooperation platforms (e.g. 100 Resilient Cities, UN-Habitat Trends in Urban Resilience), strategies (e.g. Global Strategy for the EU, ONZ 17 Sustainable Development Goals), programmes (e.g. UN-Habitat City Resilience Profiling Tool Guide, Making Cities Resilient, OECD Resilient Cities), reports (e.g. ICLEI, United Nations Office for Disaster Risk Reduction).

## 5. ADAPTATION ACTIONS

When analysing the impact of climate change on the design of the urban environment, it seems most appropriate to organise adaptation measures according to the scale of impact. A division that exists in the literature between the urban scale (city and housing estate areas) and the architectural scale (individual plots and buildings) can be applied. Individual projects can cover the whole city (macro scale), housing estates (local scale) or individual objects (micro scale) [74]. Macro-scale actions are most often characterised by a long time horizon for achieving the expected results and high costs, but the effects are also long-lasting and can be impressive in terms of quantity. Actions at the neighbourhood level can achieve a positive effect quite quickly, which is important for gaining the acceptance and involvement of residents. Because of the limited scope, the costs are not relatively high and a noticeable change is an incentive to take further steps.

The quickest impact is achieved by micro-scale solutions, which can help improve climatic conditions in a short time, but with a limited area of impact. Their costs are not high, but in terms of the effect achieved and the area covered, they are the least profitable activities. In most cases, their role is to draw attention to the quality aspect of the living environment, create a positive perception of the place, improve the well-being and satisfaction of the inhabitants and ensure a favourable image of the administrator or the authorities. However, the scale of micro-adaptation measures may carry a risk of excluding the poor from access to clean air, as highlighted by Stephen Graham [28].

Adaptation actions can be divided into education, science and research, legal and policy, technical and organisational, and monitoring. The formulated plans for adaptation to climate change include soft (informational, educational and organisational) activities, which shape social awareness, educate ecologically, promote good practices and those that optimise spatial management, and hard (investment and technical) activities, which include modernisation and construction of infrastructure and building development. The main objective of the basic organisational and technical activities is to achieve effective urban management for impact mitigation and sustainable spatial development, increasing resilience to expected threats.

Table 1. General assumptions of adaptation strategies in the field of city development policy

| Counteracting degradation of the natural environment | Sustainable spatial planning | Sustainable construction |
|---|---|---|
| • reconstruction and protection of ecosystems,<br>• promoting biodiversity,<br>• protection of biologically active surfaces,<br>• maintenance of agricultural and horticultural production. | • sustainable land use,<br>• protection and development of green areas,<br>• soil unsealing and revegetation,<br>• sustainable water management,<br>• maintenance of ventilation corridors,<br>• sustainable mobility. | • development and maintenance of gray-green-blue infrastructure,<br>• energy-saving building development,<br>• use of eco-innovative technologies. |

First, necessary and urgent measures should be taken to adapt to climate change, e.g. monitoring and early warning systems, flood protection infrastructure, spatial planning and development strategies. The next step includes advanced measures to improve the resilience of the environment and built development to climate change. The most costly measures are those at the national level, including the modernisation of farms and diversification of supply, as well as the development and implementation of technologies that reduce the consumption of raw materials and energy resources. An overview of such passive solutions for urban ventilation has been developed by, among others, Ali Cheshmehzangi and Ayotunde Dawodu [8].

Based on the study, they pointed out that passive solutions are particularly beneficial in tropical, hot and humid, and hot and dry climates, where the cooling load is the most important and absorbs a significant proportion of energy consumption. For this reason, their study focuses more on the context of developing countries, where energy consumption is not necessarily a major problem yet, but in the face of rapid economic growth, urbanisation and development, it can pose serious challenges to growth and development.

Soft measures are an important and necessary support for hard measures, therefore adaptation plans should be implemented in a complementary manner, using synergies to increase the effectiveness of the projects implemented. Among adaptation measures, pro-ecological education programmes, stormwater management, development of green and blue infrastructure, and energy-efficient and ecological construction can provide the greatest benefits in the shortest time and at relatively low cost [75]. The importance of raising public awareness of the impact and extent of air pollution is emphasised in research by Shuncheng Yang and Longyu Shi [76]. They draw attention to the need to monitor hazards, control sources of pollutant emissions, and counteract irrational reactions of residents through effective communication and social dialogue.

In their study, the authors covered the Chinese port city of Ningbo on the Yangtze River, specifically six urban districts (Haishu, Yinzhou, Jiangdong, Jiangbei, Zhenhai, Beilun), which differ in air pollution levels, function, population size and population density. The study used a stratified sampling design. Measurements were taken at eight air quality monitoring stations in different counties. In addition to the measurements, questionnaires and interviews were conducted with randomly selected residents living near the air quality monitoring sites, and the results were compared with actual monitoring data. The authors evaluated the differences between the questionnaires and the actual measurement data in terms of "smog severity and its effects" [76, p. 221]. The data collected is available online at https://www.tandfonline.com/doi/pdf/10.1080/10962247.2016.1229235.

In the problem of monitoring the consequences of climate change, there are areas of research for which measurement methods can be defined on the basis of common indicators, making it possible to carry out a comparative analysis and to monitor the progress of projects implemented to improve the quality of life [56, 63]. Research issues include environmental (pollution, degradation and climate change) and urban (urban sprawl, fragmentation, development of green spaces). These areas of interest are common to the concept of healthy and resilient development and to the concept of improving quality of life (Fig. 2).

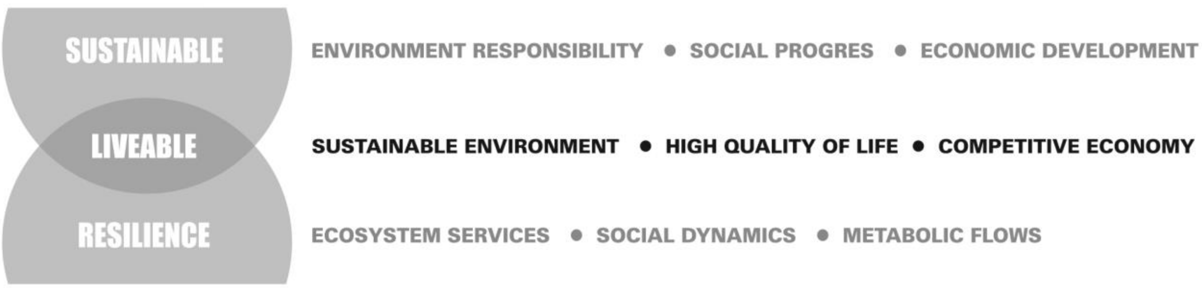


Fig. 2. Differences and common areas of the main concepts of urban development

Monitoring the effects of climate change and disseminating research results have an impact on public discourse and climate policy-making. The observed changes are not very noticeable due to the long time horizon, so their interpretation is not easy. This is pointed out by Zbigniew Kundzewicz, who, together with his team, conducted a comprehensive assessment of tools for monitoring climate change impacts and disseminating measurement results as part of the international CHASE-PL project "Impact of climate change assessment for selected sectors in Poland" [40]. Indicators related to heat waves and precipitation, among others, were studied. Based on the analyses, climate model simulations were carried out for 2021-2050 and 2071-2100 [40, p. 1511].

The research was carried out in collaboration with Norwegian and Polish researchers. The team evaluated the results of the detection of changes in observed climate variables and their impact on the climate in Poland. Projections of climate change were also presented and, based on these, a study of future impacts on sectors was carried out. Summaries of observed changes, conclusions and findings have been compiled in tables available online at https://link.springer.com/article/10.1007/s11600-018-0220-4/tables/1 and https://link.springer.com/article/10.1007/s11600-018-0220-4/tables/2.

Such studies can contribute to a better understanding and interpretation of the effects of climate change and thus support adaptation measures. Many researchers point to the need to develop modern technologies and eco-innovations in climate change adaptation, considering their lack as one of the main barriers [73, 16]. Adaptation measures stimulate the demand for highly skilled human capital, drive the innovative economy and increase the attractiveness and competitiveness of the city. Therefore, there is a growing awareness of the positive impact of adaptation technologies, which bring benefits not only in terms of reducing or avoiding losses caused by negative climate phenomena, but also in terms of improving the quality of life of residents, creating new jobs and stimulating the economy.

## 6. COSTS OF CLIMATE POLICY

The European Green Deal commits the EU to achieving a climate neutral and resource efficient economy by 2050. The EU's adoption of the strategy to achieve neutrality by 2050 (Green Deal) in 2019 coincided with the outbreak of the COVID-19 pandemic (2019). Kristie L. Ebi and her team, analysing the interplay between pandemic and climate change responses, raise concerns about the risk of deviating from ambitious climate targets [17, p. 4]. Climate goals are long-term, and the costs incurred will not be visible in the short term. However, according to Kristie L. Ebi et al, it is possible to leverage post-pandemic investments that also address climate change mitigation and adaptation. In addition, the lessons learned from dealing with the pandemic and its social and economic consequences can be used to improve the effectiveness of climate change mitigation [17, p. 5].

Unfortunately, shortly after the pandemic, a recession-weakened Europe faced another crisis caused by Russia's aggression against Ukraine. As a result of the Russian blockade of the Black Sea and the Sea of Azov, Ukrainian agricultural products flooded the Polish market. Polish farmers are forced to comply with EU regulations and are therefore unable to compete on price with Ukrainian food producers, who are exempt from all regulations. As part of climate policy, EU farmers are being forced to afforest and convert arable land to grassland, re-wet peatlands and reduce the use of fertilisers and pesticides by 50% [44, 45]. The problem is compounded by economic recession and inflation. The long-term impact of a centralised climate policy could be the collapse of European agriculture and a threat to food security. Dependence on agricultural imports is a particular concern, given the potential for supply chain disruptions.

Two years after the strategy to achieve carbon neutrality by 2050 (Green Deal), the European Commission adopted the Fit for 55 (2021) package, which aims to reduce carbon dioxide emissions by 55% by 2030 compared to 1990 levels. Six months later, Russia invaded Ukraine. Despite the COVID-

19 pandemic and the resulting recession, despite the war in Ukraine and the energy crisis, and despite concerns about the ability to meet growing demand, the European Parliament is accelerating the path to so-called climate neutrality by introducing key directives and regulations in 2023 that strengthen the Fit for 55 package.

Among the issues related to the justification for maintaining high limits, it is worth mentioning the research by Aviel Verbruggen and Hanna Brauers on the ineffectiveness of applying uniform $CO_2$ emission prices [70, p. 282]. The results of the study contribute to a negative review of the assumptions of global emission reduction policies based on uniform prices. According to the authors, ignoring social and economic differences increases costs and forces later adjustments and modifications. Taking diversity into account is recommended, among other things, to avoid costly corrective policies and to design more realistic, effective and equitable climate policies.

Despite doubts raised by a number of countries (including Poland), legislation was passed to, among other things, reform the European Union Emissions Trading System (EU ETS), establish the Carbon Boundary Fee (CBAM) and create the Social Climate Fund (SFK). As a result, in addition to industry and electricity, ETS charges have been imposed on industry, construction, heating, transport (including passenger transport and aviation), agriculture and forestry.

For Poland, for example, the tightening of the rules means that the ETS costs associated with electricity generation will be €85.3 billion by 2030, rather than €33.2 billion [61, p. 3]. In ETS terms, the differences between the Fit for 40 adopted in 2019 and the Fit for 55 of 2021 will amount to an additional €189.0 billion. Poland is in a difficult situation due to the recession caused by the COVID-19 pandemic and the threat from Russia, which is waging war in the neighbouring country. The additional burden of climate policy is a serious challenge. Experts are at a loss as to where to find the funds to balance the budget to cover the increased ETS expenditure without raising taxes and without cutting spending on public services (Fig. 3).

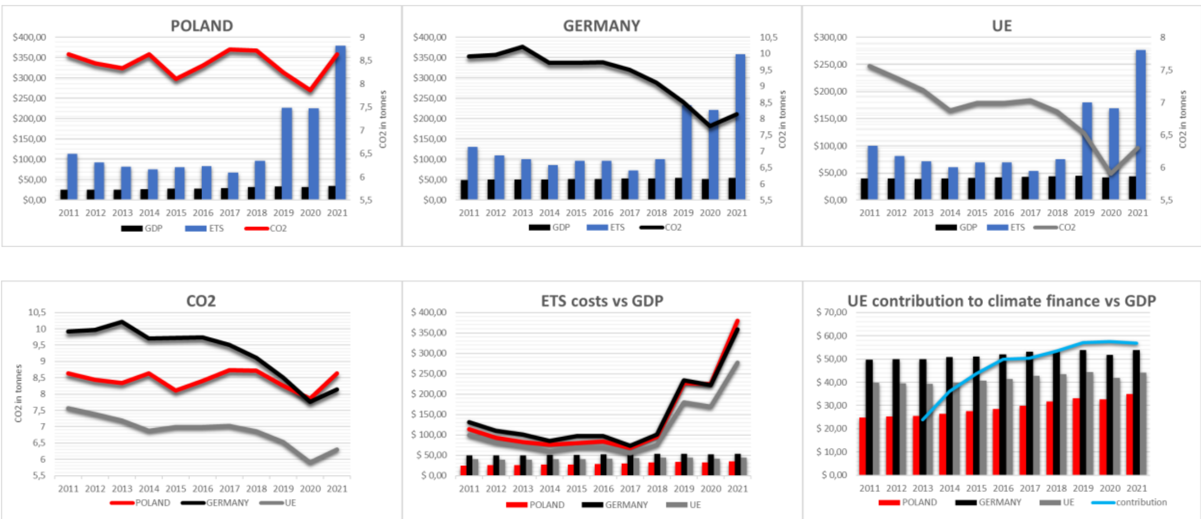


Fig. 3. A study of the differences between Poland and neighbouring Germany compared to the EU. The comparison has been made in terms of the amount of EU Emissions Trading System (ETS) fees in relation to the amount of GDP in relation to $CO_2$ emissions per capita. Source: own compilation based on:
- Per capita $CO_2$ emissions and GDP: https://ourworldindata.org/co2-and-greenhouse-gas-emissions
- EU ETS: https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1
- Europe's contribution to climate finance: https://www.consilium.europa.eu/en/infographics/climate-finance/

The gap between climate change expenditures, estimated benefits and savings is large. Experts at PeKaO Bank calculated the cost of implementing the Fit for 55 package in Poland at around €527.5 billion [61]. Estimated revenues from Fit for 55 climate investments are estimated at €219.5 billion, which, together with the €34 billion EU loan, amounts to €253.5 billion [61, p. 3]. The so-called climate gap will thus amount to €274.0 billion and will have to be covered by the budget. The impact of the Fit for 55 package on macroeconomic variables has been estimated using a modelling analysis and supplemented by identifying the additional burdens that the package will impose on individual sectors of the economy. The overall balance presented does not take into account costs and benefits whose monetisation would require a choice of value system and valuation [61, p. 4]. An example of this is cleaner air and a more stable climate, which are the intended objectives of the package, but their inclusion goes beyond the accounting framework set by the authors. The methodology used to modelling analysis is presented online at https://climatecake.ios.edu.pl/wp-content/uploads/2021/07/CAKE_Mapadrogowa-net-zero-dla-PL.pdf.

According to calculations by experts at the Energy Market Agency, in the structure of electricity production in the period January-November 2023, as much as 59.4% of energy will come from hard coal and lignite and 27% from RES [50, p. 19]. The cost of the ETS will therefore be very high for Poland, as the national energy system is still based on coal, despite heavy spending on the green transition.

In this context, the recommendations (June 2023) of the EU's Scientific Advisory Committee on Climate Change, established under the European Climate Law, recommending a 90-95% reduction in EU emissions by 2040 [22] are received with concern. Meeting such commitments would cost EU countries many times more. There is therefore an ongoing debate in the European forum about the reliability of the analyses and the feasibility of ambitious commitments. Meanwhile, spending on measures resulting from climate policy commitments is already a problem for national budgets, and not only in non-rich countries. In a situation of budgetary discipline in the European Union, which sets the maximum debt ceiling for member states at 60% of gross domestic product (GDP), even countries considered rich, such as Germany, will find it difficult to meet these requirements.

Guillaume Kerlero de Rosbo and his team have calculated that €40 trillion of investment will be needed to achieve the goal of complete decarbonisation of the entire European economy by 2050 [38, p. 26]. As the goal of zero carbon has been defined as minimising emissions and absorbing what cannot be reduced by $CO_2$ sinks (e.g. forests), this research has adopted the same principle to estimate the costs of decarbonisation. The calculations were carried out on a sectoral basis, with simplifications made in the overall syntheses due to the complexity of the issue. The research methodology and the assumptions made are presented in the first three chapters of the report [38, pp. 12-34].

The path to zero carbon will cost every working European €7,400 per year. However, of all the EU countries, Poland is expected to incur the highest expenditure as a percentage of GDP, because it will have to make the biggest transformation effort in the energy, transport, agriculture, construction and industrial conversion to zero-carbon sources. It will cost Poland around €2.4 trillion by 2050 to achieve its Green Deal targets. Annually, this will amount to around €90 billion, or 13.6% of total GDP [38, p. 27]. By comparison, due to the war abroad and the threat from Russia, we are only aiming to spend about 4% of GDP on defence, while about 6.7% of GDP will be spent on health care in 2022.

Globally, $3.8 trillion has been spent on renewable energy investments over a 10-year period. This large amount has been estimated to have contributed to a 1% reduction in the use of fossil fuels for energy production (from 82% to 81%) [59]. However, a recent report by Goldman Sachs [14], led by Michele Dell Vigna, verified this calculation and found that in 2022, compared to 2021, the actual increase in coal-based energy production was 2% globally [14, p. 3]. It should be added that the same analysis found a 2% increase in the share of photovoltaic energy and a 3% increase in the share of wind energy [14, p. 3]. It can be concluded that, despite the development of less energy-intensive technologies, the global growth in renewable energy production is not keeping pace with the faster growth in demand.

The economic impact of climate policy is also assessed by Coilín ÓhAiseadha and his team. They report that $3.66 trillion was spent globally on climate-related investments over a seven-year period (2011-2018) [57, p. 1]. Half of this amount was spent on investments in wind and solar energy. During this period, the share of wind and solar energy in global consumption rose from 0.5% to 3% [57, p. 1]. This means that an average increase in share of around 0.36% was achieved in one year by spending $522.8 billion.

The annual reports of the Climate Policy Initiative (CPI) show a steady increase in climate-related investment spending. The latest report, prepared by a team of experts led by Barbara Buchner, states that the total amount in 2011 was $364 billion and that it will increase fourfold over the next seven years to reach $1.27 trillion in 2022 [5, p. 2]. Half of the total amount will be spent on investments in the energy sector. In the same period, 2021-2022, $63 billion was spent globally on adaptation and as much as $1.15 trillion on mitigation.

According to the authors of the CPI report, all these expenditures are needed to mitigate the expected future losses from temperature increases above 1.5°C. The projected macroeconomic losses are estimated to be at least 18% of global gross domestic product by 2030 and 20% by 2100 [5, p. 11]. According to the CPI, the estimated necessary climate expenditure for the period 2025-2050 is estimated at $266 trillion, but will reduce the losses caused by climate change for the period 2025-2100 by about $1,266 trillion. Unfortunately, despite the climate-related investment spending and the resulting reduction in losses, damages are still expected to exceed $1062 trillion. Based on estimates of global spending, experts suggest that climate investment should reach $5.4-11.7 trillion per year by 2030 and $9.3-12.2 trillion per year over the next two decades [5, p. 10]. It should be noted, however, that various researchers are uncertain about the extent of future temperature rises and the losses that will result.

In summary, the events of recent years have been a stress test for the European Union's climate policy. The short-sightedness of some adaptation plans has been empirically proven. Indicators such as $CO_2$ emissions, coal and gas consumption, and the share of renewables in the energy mix, instead of declining, have increased year on year, despite radically tightened regulations. The EU ETS has also had a greater than expected impact on reducing the profitability of production, and rising energy costs have increased the proportion of the population living in energy poverty. Despite the crisis caused by the COVID-19 pandemic and Russia's aggression against Ukraine, previous carbon dioxide reduction commitments were maintained and even strengthened. New ones, including on electric transport, are being introduced despite criticism from the car industry and the public. As the costs of climate policy commitments are high and their importance for the economic and security situation enormous, it is necessary to consider the overall gains and losses in this context and to assess the rationality of the measures taken.

## 7. CONCLUSIONS

The multiplicity of development ideas should not come as a surprise, since each of them is an attempt to comprehensively cover the complex conditions specific to a given city or a group of cities in a similar situation, or to define their needs and seek answers to them in convergent vectors. Concepts profiled by the specificity of conditions are analysed in comparison with examples of cities with similar characteristics, therefore the interpretation and diagnosis are also adapted to these selected cases. In this situation, it is justified to develop systemic solutions that would form the basis for effective cooperation between cities at regional and national level and would contribute to improving the quality of development planning and optimising management and landscape planning.

It is worth considering devolving more responsibility for climate policy-making to the regional and national levels in order to adapt to local conditions. Diverse conditions require more flexible management at central level and targets should be adapted to local needs. Social and economic issues should also be taken into account when setting climate policy targets. The need to balance climate policy with social and economic aspects should be taken into account. Moving away from centralised and uniform regulations on carbon dioxide reduction can reduce unnecessary costs. Instead, there is a role for local adaptation strategies, including increasing the efficiency of environmental management and developing innovations that improve energy and resource efficiency in all sectors of human activity.

The rapidly growing importance of adaptation plans contributes to the search for knowledge and the development of planning and implementation skills. This should be done in an integrated and comprehensive manner to ensure effective cooperation between all city units and to increase resilience not only in terms of climate change but also in other areas. On the other hand, the development of adaptation plans requires an assessment of the impact of their implementation, based on substantive objectives and well-defined indicators, as well as modern measurement methods.

Predictions based on theoretical climate models are subject to greater or lesser error depending on the methodology used. To improve their effectiveness, they should be integrated with empirical data. It would be useful to continuously analyse and evaluate the rationality and effectiveness of climate policy goals under local conditions. Research should also be developed on factors whose impact on climate has not yet been sufficiently recognised and measured. Knowledge of the types and directions of dependence can help to test the $CO_2$ paradigm, whose abstractness and detachment from local conditions can contribute to public resistance to climate policy. It is the task of scientists to provide a more secure basis for action, especially because of the high costs involved.

It should also be borne in mind that the global impact of climate change could be positive with only slight warming, and even significantly positive in cold temperate countries. The trend in human and economic vulnerability, as measured by global average rates of mortality and economic loss, is clearly favourable. This is partly due to improved methods of forecasting and monitoring events, and more effective ways of protecting against them. Increasingly better methods of predicting and monitoring events and more effective ways of protecting against them also contribute to this. Due to the greater vulnerability of underdeveloped countries, the necessary technologies and support should be provided to increase their resilience to climate stress.

In the Polish context, given the actual balance of the effects of climate change on Poland and the very high costs of the green transition, doubts about the main causes of global warming and the appropriate choice of mitigation measures should be resolved in the scientific and political fields. Climate policy should be assessed holistically in terms of all elements of environmental impact, including but not limited to: actual socio-economic costs, loss of competitiveness vis-à-vis other countries (with different conditions), economic slowdown, impoverishment of society. In addition, the assessment of the rationality of climate change policies should take into account fossil fuel reserves and the associated high dependence of the energy industry on coal.

In light of the current state of knowledge, it can be stated with great caution that the effectiveness and rationality of the national climate policy has not been sufficiently researched, and therefore there are concerns about whether its implementation will have a positive effect for Poland. Given the high social and economic costs, it is necessary to consider whether to submit to the mainstream of global politics or to more actively seek sovereignty in shaping national climate policy.

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