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EXTENT AND NATURE OF CLIMATE CHANGE AND ITS IMPACT ON PUBLIC SECURITY RISKS

Abstract

Climate change is currently one of the most important challenges faced by mankind. The purpose of this article is to give a coherent account of the scope and nature of these changes and their impact on universal security threats. The research process consisted largely of a review of the literature on the subject and an analysis of specialized, available documents and reports prepared by international environmental organizations. Climate change includes increases in temperature, changes in precipitation, sea level rise, extreme weather events and many other impacts that have enormous consequences for people, ecosystems and economies. Barriers are described that could prove to be an obstacle to implementing more sustainable development that could directly contribute to increased preventive and adaptive capacity, reduced emissions and vulnerability. The importance of adaptive capacity, which is a complex function of wealth, technology, information, skills, infrastructure, institutions and equity, was emphasized.

Streszczenie

Zmiany klimatyczne stanowią obecnie jedno z najważniejszych wyzwań, przed którymi stoi ludzkość. Celem artykułu jest spójne przedstawienie zakresu i charakteru tych zmian oraz ich wpływ na zagrożenia bezpieczeństwa powszechnego. Proces badawczy polegał w dużej mierze na przeglądzie literatury przedmiotu oraz analizie specjalistycznych, dostępnych dokumentów oraz raportów przygotowanych przez międzynarodowe organizacje działające na rzecz ochrony środowiska. Zmiany klimatyczne obejmują wzrost temperatury, zmiany opadów, podnoszenie poziomu morza, ekstremalne zjawiska pogodowe i wiele innych skutków, które mają ogromne konsekwencje dla ludzi, ekosystemów i gospodarek. Opisano bariery, które mogą okazać się przeszkodą we wdrażaniu bardziej zrównoważonego rozwoju, który mógłby bezpośrednio przyczynić się do zwiększenia zdolności zapobiegawczych i adaptacyjnych, zmniejszyć emisje i podatność na zagrożenia. Podkreślono znaczenie zdolności adaptacyjnych, które są złożoną funkcją bogactwa, technologii, informacji, umiejętności, infrastruktury, instytucji i sprawiedliwości.

Keywords: *Common security threats, Climate change, extremes, adaptive capacity, threats*

Słowa kluczowe: *Zagrożenia bezpieczeństwa powszechnego, Zmiany klimatyczne, ekstrema, zdolności adaptacyjne, zagrożenia*

The ministerial *Strategic Adaptation Plan for Climate Vulnerable Sectors and Areas up to 2020 with an Outlook to 2030* (Ministerstwo Środowiska, 2013) describes some trends in these developments, but makes no reference whatsoever to the evolution of the universal security system. Similar standards are also in place worldwide. A report by the US government agency NOAA (National Oceanic and Atmospheric Administration – US government agency for weather forecasting, storm warnings, warnings of other extreme weather events), in a similar vein, portrays climate change as overlooking the issue of universal security. Climate change is currently one of the most pressing challenges faced by humanity. Addressing this issue effectively requires a comprehensive and coordinated global response. One of the leading strategies in this regard is the European Green Deal, established by the European Union. The European Green Deal aims to combat climate change and promote sustainable development by transitioning to a climate-neutral economy by 2050. This strategy encompasses a wide range of initiatives, including reducing greenhouse gas emissions, investing in green technologies, and enhancing the resilience of ecosystems and communities. The European Green Deal serves as a crucial framework for EU member states, including Poland, to implement effective measures for mitigating and adapting to climate change. This article aims to provide a coherent account of the scope and nature of these changes and their impact on universal security threats.The development of new technologies, the growing role of information and the rivalry between the various security actors in expanding their knowledge base mean that the system can be improved, but are measures being taken to do so that are adequate to the scale of the threat?

At present, in the context of climate change, intensive research and understanding of complex environmental phenomena is required. Experts from the European Environment Agency (EEA) predict that southern and south-eastern Europe will be particularly vulnerable to the effects of these changes. Noticeable increases in maximum temperatures and decreases in precipitation are already being observed, which can pose challenges to the economy, agriculture and ecosystems (Kotir, 2011, pp. 587-605). The phenomenon of hydrological drought, manifested by falling river levels, is not only causing difficulties in accessing water, but also an increased risk of forest fires and loss of biodiversity. In response to these challenges, Europe is intensively

developing and implementing a variety of climate and adaptation services to minimise the adverse impacts of climate change and improve the resilience of communities and the environment. Valuable and insightful knowledge on assessing the vulnerability and risk of these phenomena and their impact on society and ecosystems is essential to effectively manage climate challenges. Therefore, science should focus on in-depth research in these areas to develop appropriate strategies and approaches to adapt to a changing climate.

This issue is also extremely important from a societal perspective for several key reasons, first and foremost for reasons of public safety and health. Climate change affects people's health through an increase in extreme weather events such as heat, floods, severe winds and hurricanes (Patz at al., 2009). They pose a threat to the life and health of the population, especially the more vulnerable people, such as children and the elderly. Attention must be paid to the availability and quality of food and water. Droughts and extreme rainfall reduce access to water resources and agricultural crops, which in turn can lead to malnutrition and hunger. Climate change also affects various economic sectors such as agriculture, tourism, fisheries, energy or infrastructure. Extreme weather events can cause great material damage, and adapting to climate change requires investing in new technologies and infrastructure. It is also increasing social inequalities and reinforcing disparities between the rich and the poor poor (Solomon M., 2016, Shyam 2017). And finally, these changes lead to population migrations, both internal and international, which can exacerbate social and political conflicts. Prolonged droughts or flooding can force people to leave their homes and seek better living conditions elsewhere. For several years now, there has been a relatively high level of interest from the Pomeranian Region in these issues. Recent extreme weather phenomena in the province have intensified the interest of local authorities and inhabitants in the causes of these phenomena. Therefore, it seems justified to reflect already today on the issue of civil protection in the event of phenomena bearing the hallmarks of natural disasters as a result of climate change. Moreover, the high social costs of the consequences of extreme weather phenomena additionally affect the level of security in the province, both in its objective and subjective dimensions, which translates directly into the sense of security of its inhabitants. It therefore seems necessary to set the right directions for the evolution

of the universal security system under conditions of natural disasters caused by climate change not only on a national scale, but also in individual regions.

The scientific and social conditions associated with the above problem also translate into its practical dimension. There is, in fact, a fully justified need to set the right directions for the evolution of the public security system in climate change conditions in order to find effective methods and tools to protect the population, infrastructure and the environment from the effects of phenomena that we are unable to prevent, but are able to minimise.

The purpose of this article is to provide a coherent account of the scope and nature of these changes and their impact on universal security threats. In this context, the research hypothesis is formulated as follows: *Effective implementation of the European Green Deal will significantly enhance the adaptive capacity of regions, thereby reducing the vulnerability of public security systems to the impacts of climate change.*

This article aims to test this hypothesis by reviewing relevant literature, analyzing specialized documents and reports from international environmental organizations, and assessing the potential barriers and strategies for effective climate change adaptation and mitigation.

Societal security threats posed by climate change

Universal security threats posed by climate change are pervading practically all spheres of the society. The implications of these changes include health, economic, environmental, social and political aspects. The impact is experienced at both the individual and community level, introducing complex challenges that require a holistic approach and large-scale collaboration. Comprehensive strategies are needed that address these multiple risks and seek to build more resilient communities and systems that are ready for a changing climate. Such approaches will minimise negative impacts and allow better adaptation to new climate realities.

What is visible to the naked eye is global warming, which is associated with a 1°C increase in the Earth's temperature (Besler & Besler, 2000, pp. 48-52). This is only the beginning of climate change, and already the entire ecosystem

is clearly feeling the increase in intensity. Now, with an increase in average temperature of 0.8°C, numerous unprecedented phenomena can be observed, such as record heat waves, shifting climate zones, melting glaciers, stronger hurricanes, disintegration of Arctic and Antarctic ice, rising ocean levels, thawing of permafrost, storms and storms, desertification, droughts, fires and floods. The average temperature of the Earth is expected to rise by 3-4°C by the end of this century – a marked increase (Besler & Besler, 2000 pp. 48-52). In addition, the average land rise will change to limits between 4 and 7°C and this will not mean the end of the rise at all (Kassenberg, Szymalski, Świerkula, 2019, pp.14–16).

When analysing the threats to public safety caused by climate change, it is of great importance to define a catalogue of the main threats. As can be seen, the threats have a substantial impact on many areas of life. Different hazards have a different intensity of ailment (Ziobro, 2020). The denominator that unites all hazards is that they pose serious threats to human life and health. In more general terms, rising temperatures can lead to increased cases of . heat-related illnesses, heatstroke, respiratory diseases and allergies. Additionally, climate change affects the distribution of insect-borne disease vectors such as malaria and dengue. Global warming is reducing agricultural yields, leading to food shortages and rising prices. This may further cause the phenomenon of climate refugees and the consequent need for adaptation may force changes in lifestyles, energy use or consumption, which will consequently affect people's daily habits and society as a whole. Hurricanes, floods or droughts, among others, imply disruptions to energy, water or communication supplies. Exacerbating social and international conflicts over access to resources, migration, inequalities and competition for scarce natural resources is becoming a feature of the modern world, and communities with lower incomes and poorer access to resources are often more vulnerable to the effects of global warming , exacerbating social inequalities.

In analysing climate change affecting all forms of human activity, the authors, referring to the IPCC report 4, synthesised a set of risks by region. The results of the analysis are presented in Table 1.

Table 1. *Examples of some anticipated regional impacts*

Region	Anticipated changes
Africa	- Between 75 and 250 million people are expected to be exposed to water stress (lack of or limited access) by 2020 due to climate change. - By 2020, yields of non-irrigated crops could decrease by up to 50% in some countries. Agricultural production and access to food in many African countries will be severely reduced. This will lead to diminished food security and consequent widespread malnutrition. - By the end of the 21st century, rising sea levels will become a threat to densely populated coastal areas. Adaptation costs could amount to at least 5 to 10% of GDP. - By 2080, according to projections of numerous climate scenarios, the area of arid and semi-arid lands in Africa will increase between 5 and 8 per cent (TS).
Asia	- By 2050, there will be a reduction in the size of available freshwater resources in central, southern and south-east Asia, particularly in the major river basins. - There will be an increased risk of sea flooding on the coasts of southern, eastern and south-eastern Asia, particularly in the area of populous large deltas, and in areas of some deltas also following river flooding. - Climate change is expected to amplify the pressures resulting from rapid urbanisation, industrialisation and economic development on natural resources and the environment. - In eastern, southern and south-eastern Asia, as a result of more frequent floods and droughts, morbidity and mortality from food poisoning are expected to increase.
Australia and New Zealand	- Biodiversity in some particularly rich ecosystems, such as the Great Barrier Reef and Queensland's humid tropical forests, is expected to decline significantly by 2020. - By 2030, water security problems in eastern Australia and parts of New Zealand (part of eastern, Northland region) will have become intensified. - By 2030, agricultural and forestry production will have declined in extensive areas of southern and eastern Australia and eastern New Zealand due to increasing droughts and fires. Nevertheless, the remaining areas of New Zealand can initially expect certain benefits. - By 2050, progressive coastal development and population growth could exacerbate the risks posed by rising sea levels, increased frequency and strength of storms and coastal flooding.
Europe	- Climate change is expected to increase Europe's regional diversity in terms of natural and capital resources. In addition, negative impacts will include a greater risk of flash floods, more frequent coastal flooding and intensified coastal erosion (due to more frequent storms and sea level rise). - In mountain areas, glacier disappearance, reduced snow cover and declining winter tourism are to be expected, as well as widespread species extinction (in some areas up to 60% by 2080 according to high-carbon scenarios). - For the area of southern Europe, a region sensitive to climate variability, climate change (high air temperature, droughts) is anticipated to worsen living conditions, as well as to reduce water availability, the hydropower potential of rivers, summer tourism and agricultural productivity. - Predicted heat waves and fires caused by climate change will increase health risks.

Latin America	- By mid-century, the increase in air temperature and the associated decrease in soil moisture could lead to the gradual replacement of tropical forest by savannah in the eastern Amazon. There will be a proliferation of 'dryland' vegetation. - Predicted species extinctions will contribute to a significant decline in biodiversity in many areas of tropical Latin America. - Yields of some important crops, as well as livestock production, will become decreased, adversely affecting food security. In the temperate zone, soybean yields are expected to increase. Overall, the number of people at risk of hunger will increase (TS; mean certainty). - Changes in the distribution of precipitation and the disappearance of glaciers will result in a significant decrease in drinking water supplies and water resources used for agriculture and energy production.
North America	- Warming in the western mountains is expected to result in the disappearance of snowpack, more winter floods and reduced summer runoff, reducing access to existing water resources. - In the early decades of the century, moderate climate change is expected to increase total yields of rainfed crops by 5 to 20%, but with considerable variability among regions. Crucial challenges are predicted for crops that are either close to the upper range limit or those that depend on high water use. - Cities currently experiencing heat waves are expected to face an increase in their number, intensity and duration as the century progresses, with the potential for adverse health effects. - Coastal communities and habitats will be increasingly vulnerable to the impacts of climate change interacting together with development and pollution.
Polar regions	- The main predicted biophysical effects relate to reductions in the thickness and extent of glaciers, ice sheets and sea ice, and changes in natural ecosystems, with detrimental effects on a wide range of organisms, including migratory birds, mammals and higher trophic chain predators. - For communities in the Arctic, impacts, especially those resulting from changes in snow and ice conditions, will be of an ambiguous nature. - Harmful impacts will include the local infrastructure and traditional indigenous lifestyles. - In both polar regions, specific ecosystems and natural habitats will be vulnerable due to lowered climate barriers to invasion by alien species.
Minor islands	- Sea level rise is presumed to exacerbate flooding, storm surges, erosion and other hazards, thereby threatening the infrastructure, settlements and equipment that provide livelihoods for island communities. - Deteriorating coastal conditions, such as beach erosion and coral fading, are expected to affect local resources. - By mid-century, climate change is likely to reduce water resources on many smaller islands, for example in the Caribbean and Pacific, to the point where they become insufficient to meet demand during periods of low rainfall. - With higher temperatures, it is expected that there will be an increase in the invasion of non-native (non-indigenous) species, especially on islands in the mid to high latitudes.

Source: citation (Pachauri, 2007, Pub. by IOŚ, 2009. p. 10-11)

It is important to assess these threats to the universal security system in terms of the impact on its sectors. Such a summary has been prepared by the authors in Table 2.

Table 2. *Examples of possible impacts of climate change caused by changes in the occurrence of extreme weather events and climatic events, based on projections for mid – 21st century*

Phenomenon and trend direction	Probability of future trends based on projections for the 21st century from SRES scenarios (SRES, 2000)	Examples of main projected impacts on sectors			
		Agriculture, forestry and ecosystems	Water resources	Human health	Industry, settlement and population
On most land areas, warmer and less frequent cool days and nights, warmer and more frequent hot days and nights	*Practically certain* [b]	Increased yields in cooler environments; reduced yields in warmer environments; more frequent insect infestations	Impact on water resources dependent on snow melt; impact on water supply water supply	Reduction in human mortality due to reduced exposure to cold	Reduced energy demand for heating; increased demand for cooling; reduced air quality in cities; reduced disruption to transport due to snow, ice; impact on winter tourism
Heat waves. Increase in frequency over most land areas	*Very likely*	Reduced yields in warmer regions due to heat stress, increased danger of fires	Increased demand for water, water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially in the elderly, chronically ill, very young and single people	A reduction in the quality of life for people in warm areas without adequate housing; the elderly, the very young and the poor will be affected

Heavy rainfall. Increase in frequency in most areas	*Very likely*	Damage to crops; soil erosion, inability to cultivate due to saturation of soils with water	Negative impact on groundwater and surface water quality and surface water; contamination of water resources; water shortages may temporarily decrease	Increased risk of death, injury and infection, respiratory diseases and skin	Disruption of settlement, trade, transport and society due to flooding; impact on urban and rural infrastructure; loss of property
Regions affected by more frequent droughts	*Likely*	Land degradation, lower yields, crop damage; increased livestock mortality; increased fire danger	More widespread water stress	Increased risk of water and food of water and food supply, increased risk of malnutrition, increased risk of water – and food-borne diseases and food	Interruptions in water supply for settlements, industry and population, lower potential hydropower production; possibility of population migration
Increased activity of intense tropical cyclones	*Likely*	Damage to crops; uprooting of trees uprooting, destruction of coral reefs	Power cuts resulting in disruption of in the supply of water	Increased risk of death, injury, water – and food-borne diseases; post-traumatic stress disorder and stress	Disruption caused by flooding and strong winds; reduction of private insurance in the affected area, possibility of population migration, loss of property
Increased number of high sea level incidents (excluding tsunamis) [c]	*Likely* [d]	Salinisation of irrigation systems, estuaries and freshwater systems	Reduction in freshwater availability due to saltwater intrusion	Increased risk of death and injury during floods	Costs of coastal protection vs. relocation, ability to move populations and infrastructure; see tropical cyclones above

Comments:

a. No change or development in adaptive capacity is taken into account. The estimated probability in the second column refers to the phenomena listed in the first column (table 3.2);
b. Warming up the most extreme days and nights of each year;
c. Extreme high sea level depends on mean sea level and regional weather systems. It is defined as the highest of 1% of the hourly values of the observed sea level at the station for a given reference period;
d. In all scenarios, the projected global mean sea level in 2100 is higher than in the reference period. The effects of changes in regional weather systems on extreme sea level have not been estimated.

Source: Own study based on (Pachauri, 2007, Pub. by IOŚ, 2009. p. 10-11)

Analyzing the impacts of climate change, it is important to note that rising temperatures are causing glaciers to melt, which in turn leads to rising sea levels. Depressional areas, such as islands and low-lying coastal regions, are particularly vulnerable to flooding, which in the future may intensify human migration. These migrations, known as climate migrations, pose a significant challenge to the international community, as they require coordinated efforts in resource management, infrastructure, and migration policies. Climate change also causes widespread ecological impacts. Rising temperatures threaten biodiversity, leading to the endangerment of plant and animal species and the degradation of their natural habitats. Some cold-adapted species, which are particularly sensitive to climate changes, may become extinct. Additionally, the destruction of plankton in seas and oceans, which plays a crucial role in the Earth's oxygen balance, has serious consequences for global ecosystems. Plankton, like forests, is essential for maintaining the planet's oxygen equilibrium. These ecological impacts also have a direct effect on public security, especially in terms of ensuring ecological security. Ecological security involves providing the population with environmental resources of adequate quantity and quality, such as water, air, soil, and food. The degradation of natural environments and the loss of biodiversity can lead to shortages of these resources, which in turn increases the risk of social and political conflicts, as well as health challenges. Therefore, the impacts of climate change are multifaceted, encompassing both direct consequences, such as the flooding of depressional areas and human migration, and indirect consequences, including threats to ecological security. Effectively addressing these

threats requires global cooperation, investments in environmentally friendly technologies, and the implementation of sustainable development policies that protect both ecosystems and human communities.

Summarising the discussion so far, we can conclude that climate change is having a significant impact on the level of public safety. In particular, there is an increase in the number and frequency of extreme weather events and rainfall and flash floods, more intense risk, as well as an escalation in droughts and possible coastal flooding. In addition, an increase in the frequency and intensity of hot weather is forecast. It can be assumed with a high degree of probability that these phenomena will contribute to an increase in the number of natural disasters, with an increase in the risk to human health and life and the environment.

Climate change adaptation in security policy

The issue of climate change is one of the key aspects in discussions concerning the modern world, whether politically, socially or economically. This is also why many theories, controversies and misunderstandings have grown up around it, which in many ways detract from its importance. However, a number of disturbing climate phenomena indicate that the issues at stake cannot be ignored. In particular, it is difficult to argue with facts that are already taking place and indicate that current climate change may pose a threat to socio-economic development and a direct threat to security (Barnett, Adger, 2007, pp. 639-655). These include:

- a sharp rise in global temperatures observed since the early 1990s,
- an increasing concentration of greenhouse gases in the atmosphere, which since the mid-1800s has increased by several to several tens of percent depending on the gas,
- an increase in the frequency of adverse climatic events in some regions of the world, such as droughts, floods, downpours and others,
- progressive desertification processes in the temperate zone,
- rising water levels in the world's oceans,
- significant changes occurring in the extent of Arctic ice and the Greenland ice sheet and ecosystems.

In security policy, one method of accommodating climate change is to become adapted to it. Many adaptation models and related concepts are available in the literature. In this paper, the authors focus on adaptation measures with an eye on the trend in which direction the changes are heading and whether they are being implemented at all. In the past, references to adaptation to weather conditions and climatic phenomena can be seen all over the world. The need for their implementation and the validity of this should not be debated. The current climate situation is such that, despite local and regional actions, additional adaptation efforts will be needed to reduce the adverse consequences of estimated climate change and its variability, regardless of the scale of the preventive actions taken, over the next two to three decades. In addition, it should be made clear that vulnerability to climate change can be exacerbated by other factors. Citing the findings of experts from the Intergovernmental Panel on Climate Change *they are the result of current dangerous climatic phenomena, poverty, unequal access to resources, food insecurity, trends in economic globalisation, conflicts and the extent of epidemics (*Special Report Climate 2020, p. 58). Since the start of the 21st century, the beginnings of adaptation measures may be observed. But these initiatives have been implemented to a limited extent only. The opportunity for minimising the impacts of climate change is precisely in the adaptation process. It is these actions that can reduce the vulnerability of sectors to negative impacts. Examples of proposed or implemented adaptation programmes are presented in Table 3.

Table 3. *Selected examples of planned adaptation measures*

Sector	Adaptation option/ strategy	Structure of the relevant policy	Main barriers and opportunities related to implementation (straight font = barriers, diagonal font = opportunities)
Water	Dissemination of rainwater recovery; water storage and conservation techniques, water reuse; desalination; water use efficiency and irrigation	National water policies and integrated water resources management; water risk management	Financial, human resources and physical barriers; integrated water resources management; linkages with other sectors
Agriculture	Adjusting sowing dates and diversifying crops; relocating crops; improving land management, e.g. erosion control and protecting soils by planting trees	R&D policies; institutional reform; land leases and agrarian reform; training; capacity building; crop insurance; financial incentives e.g. subsidies and tax credits	Technological and financial barriers; access to new crop varieties; market; longer growing season in higher latitudes; income from 'new' products
Infrastructure/ neighbourhoods (including coastal zone)	Resettlement; breakwaters and storm barriers; dune restoration; land acquisition and creation of wetlands/ wetlands as buffers to sea level rise and flooding; protection of existing natural barriers	Integrated climate change standards and regulations; land use policies; building codes; insurance	Financial and technological barriers; availability of space needed for resettlement; integration of policy with governance; links with sustainable development goals
Human health	Action plans related to health impacts of heat; medical emergency services; improved surveillance and control of climate-sensitive diseases; clean water and improved hygiene	Public health policies addressing climate risk; strengthening health services; regional and international cooperation	Limitations in human tolerance (vulnerable groups); limitations in knowledge; financial capacity; improved health services; improved quality of life
Energy	Strengthening overhead transmission and distribution infrastructure; underground wiring of plants; energy efficiency; use of renewable energy sources; reducing dependence on a single energy source	National energy policies, regulations, fiscal and financial incentives to encourage the use of alternative energy sources; mainstreaming climate change into design standards	access to viable alternatives; financial and technological barriers; adoption of new technologies; stimulation of new technologies; use of local resources

Source: Own study based on (Pachauri, 2007, Pub. by IOŚ, 2009. p. 15)

As can be seen, the scale of the ongoing and planned programmes is quite substantial. Unfortunately, the incorporation of such measures into the policy

entails numerous barriers that may hinder the implementation of ambitious measures. The adoption of measures intended to reduce greenhouse gas emissions may get resistance on the part of political interests, social groups or economic sectors that fear loss of influence, profits or jobs. Moreover, some economic sectors, particularly those based on fossil fuels, may resist changes that could threaten their economic interests. The implementation of adaptation and mitigation measures may require significant financial resources, which poses a challenge in terms of public budgets and funding availability. The existing lack of coherence between different policy sectors can hinder the development and implementation of coordinated actions. A very important barrier such as public unawareness, lack of environmental education, may inhibit acceptance and support for the programmes introduced, and indeed a section of the public may resist lifestyle changes. Also of importance is that costs are incurred in the short term, while benefits and savings only emerge in the long term. These and other negative actions limit both the implementation and effectiveness of adaptation measures. Adaptive capacity is closely linked to the culture of a society and the economic condition and capacity of a region. When the aforementioned capacities are analysed, phenomena such as natural and man-made capital resources, social linkages and property systems, human resources and institutions, governance systems, national income, health and technology are all present alongside them *(*Special Report Climate 2020, p. 15). The above shows that countries with low levels of economic and cultural development are far more vulnerable to the effects of climate change. However, the risks are so great and cover so many sectors that highly developed societies with significant adaptive capacities also remain vulnerable to climate change and extreme events (Smit, Pilifosova, 2003, p.9).

Implementing adaptation programmes is the only feasible way of becoming adapted to climate change. At this point in time, unfortunately, no specific technology can provide the full preventive potential in any sector. In order to be able to implement these programmes, the entire economic prevention potential must be unlocked. Its structure is generally larger than the market potential. However, unlocking the full prevention potential is not straightforward. It requires a whole series of policy actions and any barriers to its release will be removed. This overview (Table 4) was prepared by the UN Intergovernmental Panel on Climate Change.

Table 4. *Selected examples of key sectoral technologies, policies and actions and barriers and opportunities for prevention*

Sector	Key mitigation technologies and practices available commercially (key mitigation technologies and practices planned for commercialisation before 2030 shown in diagonal font)	Policies, actions and instruments recognised as environmentally effective
Energy supply	improved supply and distribution efficiency; fuel switching from coal to gas; nuclear energy; heat and power production from renewable sources (hydro, solar, wind, geothermal and bioenergy); combined heat and power production; early use of carbon capture and storage (CCS) technologies, e.g. storage of CO_2 removed from natural gas; CCS for gas, biomass and coal-fired generators; advanced renewable energies, including tidal and wave energy, concentrating solar power and photovoltaics	reduction of fossil fuel subsidies; carbon taxes or levies on fossil fuels; permanent subsidy scheme for renewable energy technologies; renewable energy obligation; producer subsidies taxes on vehicle purchase, registration, use and motor fuels; tolls and parking fees influencing mobility needs through land use regulation and infrastructure planning; investing in attractive forms of public transport and non-motorised forms of transport
Construction	efficient artificial and day lighting; more efficient electrical, heating and air-conditioning equipment; improved kitchens, improved insulation; passive and active solar projects for heating and air-conditioning; alternative cooling fluids, recovery and reuse of fluorinated gases; integrated design of commercial buildings involving technologies such as smart meters providing feedback; integrating photovoltaic cells into buildings	product standards and labelling coding and certification of buildings demand management programmes stimulating the leadership of the public sector, including the supply incentives for energy service companies
Industry	more efficient electrical equipment; heat and energy recovery; material reuse and substitution; non-CO_2 emissions control; broad suite of process technologies; advanced energy efficiency	emission factor legislation; development of standards; subsidies; tax credits; tradable emission allowances; voluntary agreements.
Agriculture	improved cropland and pasture management to increase soil carbon storage; restoration of exploited peatlands and degraded soils; improved rice and animal husbandry and manure management techniques to reduce CH_4 emissions; improved nitrogen fertilization techniques to reduce NO_2 emissions; replacement of fossil fuels with energy crops; improved energy efficiency; improved crop yields	financial incentives and regulations to improve land management; maintenance of soil carbon; efficient use of fertilizers and irrigation
Forestry / forests	afforestation; reforestation; forest management; reducing deforestation; wood product management; use of forest products in the form of bioenergy to replace fossil fuels; improvement of tree species to increase biomass productivity and carbon fixation; improvement of remote sensing techniques to analyse carbon potential from vegetation cover/soils and land use mapping	financial incentives (national and international) to increase forest area, reduce deforestation, and maintain and manage forests; land use regulations and compliance with them
Waste	CH_4 recovery from landfill; waste incineration with energy recovery; organic waste composting; controlled wastewater treatment; reuse and waste minimisation; use of bio-covers and bio-filters for optimal CH_4 oxidation	financial incentives to improve waste and wastewater management renewable energy incentives or obligations waste management provisions

Main barriers	Main possibilities
resistance from interest groups can hinder the implementation	appropriate to create markets for low-carbon technologies
efficiency may decrease with rising incomes	particularly appropriate for countries that are currently setting up their transport systems
necessary periodic review of standards implementation can be difficult the need to develop legislation from which companies would benefit	attractive for new buildings government procurement can expand demand for energy-efficient products success factor: access to third-party funding
importance of national policy stability given international competitiveness predictable allocation mechanisms and stable prices an important signal for investment success factors include: clear objectives, baseline scenario, involvement of third parties in the design, review and formal monitoring provisions, close cooperation between government and industry	may be appropriate to stimulate the assimilation of technology
	it can encourage synergies with sustainable development and the reduction of vulnerability to climate change and thus overcome barriers blocking the implementation of action
barriers include lack of investment capital and land ownership issues	may be helpful in overcoming poverty
availability at local level of low-cost fuels most effectively applied at national level with a strategy to enable enforcement	potential stimulation of the flow of technology

Source: Pachauri, 2007, Pub. by IOŚ, 2009. p. 1

Barriers as described above may prove to be an obstacle to the implementation of more sustainable development that could boost preventive and adaptive capacities, reduce emissions and vulnerability. On the other hand, it is very likely that climate change may slow down the pace of achieving sustainable development. It is projected that in the second half of the century, climate change may hinder the achievement of the Millennium Development Goals. Therefore, adaptation is an essential component of both short – and long-term action. Existing obstacles, constraints and costs of action may cause temporary problems but may fail to reduce or stop adaptation processes and programmes. In the longer term, failure to undertake mitigation measures could arguably cause natural, managed and social systems to exceed their adaptive capacity. The time period over which this could occur will vary between sectors and different regions. There are interesting determinants of adaptive capacity in the literature which include economic wealth, technology, information and skills, infrastructure, institutions and equity.

Economic resources, whether expressed as economic assets, capital resources, financial resources, wealth or poverty, the economic condition of nations and societies is clearly a determinant of adaptive capacity (Burton at all, 1998, pp. 5.1–5.20; Kates, 2000, pp. 5–17). In turn, the absence of technology can severely limit the ability to implement adaptive options by reducing the range of possible responses (Scheraga, Grambsch, 1998, pp. 85–95). Adaptive capacity is likely to vary according to the prevalence of and access to technology at different levels from local to national and across all sectors (Burton, 1996, pp. 55–67) . Building adaptive capacity requires a strong, unifying vision, scientific understanding of the problems, openness to the challenges, pragmatism in developing solutions, community engagement and commitment at the highest political level (Holmes, 1996, pp. 461–472). This is only possible if it is ensured that systems are in place to disseminate information on climate change and adaptation at national and regional levels and that forums exist for discussion and innovation on adaptation strategies at different levels. It is also the adaptive capacity of the system consisting of the availability of resources for decision-makers, as well as vulnerable sub-sectors of the population and will vary according to the social infrastructure (Toman, Bierbaum, 1996, pp. 5–15). Defining the role of institutions as a means of holding society

together, imparting meaning and purpose, and enabling adaptation, countries with well-developed social institutions are thought to have greater adaptive capacity than those with less effective institutional arrangements (Smith, Lenhart, 1996, pp. 193–201). And the final determinant relates to equitably distributed access to resources. Adaptive capacity will be enhanced if the social institutions and arrangements governing the allocation of power and access to resources within a community, nation or the world ensure that this access is highly equitable (Adger, 1999, pp/ 96–119).

Summary and conclusions

Climate change is currently high on the agenda for research and action to minimise its impacts. In view of the above, a number of important conclusions emerge:

1. Whatever their cause, they are now becoming a reality and require a great deal of analytical and research work to be undertaken to define their course and, above all, their effects.
2. They have global repercussions, mainly due to an increase in the surface temperature of our planet and an increase in the concentration of greenhouse gases in the atmosphere. If we recognise this fact, then we must be aware that action taken to reduce the effects and consequences of climate change and to adapt to the above changes requires coordinated action by the entire international community.
3. Europe and Poland are not spared either. Some planned climate change adaptation measures are already emerging; however, more intense and comprehensive adaptation measures are needed to reduce the vulnerability of systems to these changes.
4. They also have far-reaching consequences for public safety, so action should already be taken now to adapt public safety systems to the risks generated by climate change.
5. It is likely that failure to prevent climate change may, in the long term, cause the adaptive capacity of natural, economic and social systems to be exceeded.

6. A broad range of mitigation methods are already available or planned for implementation before 2030 in all sectors.
7. Mitigation measures can delay, reduce or avoid a number of negative impacts. Efforts intended to reduce emissions and investments made to do so over the next twenty or thirty years will have a decisive impact on the potential to achieve a lower level of stabilisation of greenhouse gas concentrations in the atmosphere.
8. The barriers, limits and costs of adaptation are not fully recognized, partly because effective measurements of adaptation are highly dependent on specific geographic and climatic risk factors, as well as institutional, political and financial constraints.
9. Adaptive capacity varies considerably by region, country and socio-economic group. The ability to adapt and cope with the impacts of climate change is a function of wealth, technology, information, skills, infrastructure, institutions and equity.
10. Increasing adaptive capacity is necessary to reduce vulnerability, particularly in the most vulnerable regions. These actions are broadly equivalent to those that promote sustainable development and equity.

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