Dorota MICHALAK

EFFECTIVE WATER MANAGEMENT AS AN IMPORTANT ELEMENT OF ADAPTATION TO CLIMATE CHANGE IN POLISH CITIES

Dorota **Michalak**, PhD – *University of Lodz*

Correspondence address:
Rewolucji 1905 Street 41/43, Łódź, 93-214, Poland
e-mail: dorota.michalak@uni.lodz.pl

ABSTRCT: As indicated by the Strategic Plan of Adaptation to Climate Change in Poland (SPA 2020), sectors sensitive to the impact of climate change are "water management" and "spatial economy and urbanized areas". Cities are directly threatened by three phenomena: the intensification of the urban heat island, heavy downpours causing flooding, and drought, which is conducive to water deficit in cities. The aims of this study are: (1) a comparative analysis of the impact of climate change on water management – in Poland and other EU countries, (2) an analysis of the public water supply level in Poland and EU countries, (3) an assessment of the involvement of Polish cities in adapting to the climate to other EU countries – a comparative analysis of the Eurostat index "Population covered by the Covenant of Mayors for Climate & Energy", and (4) an evaluation of how the adaptive policy has been implemented in the field of water management in Polish cities – a survey carried out among the cities in the project "Let's feel the climate!".

KEY WORDS: climate change, water management, city policy, adaptation

Introduction

As indicated by the Strategic Plan of Adaptation to Climate Change in Poland (SPA, 2020), one of the sectors sensitive to the impact of climate change is "water management" (Ministry of the Environment, 2013). Threats, including various forms of flooding, occur practically all over Poland, and are related not only to climate change but also to anthropogenic factors.

Inappropriate spatial management, in particular, allowing investment in threatened areas, including flood zones of rivers, a too low natural retention capacity, and artificial reservoirs, limit effective actions when there is an excess or lack of surface waters.

There is a risk that, in the future, these phenomena will occur with increased frequency. The scenarios indicate an increased likelihood of flash floods caused by strong rainfall, and this may cause flooding of areas where spatial management is not properly implemented. Snow cover affects the formation of water resources to a large extent. Forecasts predict that the length of time the snow lies will gradually decrease, and in the middle of the 21st century, it may be, on average, 28 days shorter than today. The reduction in the maximum value of water in the snow can have both a positive and negative impact. A positive effect of the decrease in the water content in the snow cover is the lower probability of thaw floods. On the other hand, it can contribute to the deterioration of both the soil structure and the condition of ecosystems. In addition, climate change can lead to another serious problem – water shortages.

The next sector indicated in the SPA is "Spatial economy and urbanized areas". The SPA indicates that climate change will lead to a reduction in the available space of particular types of conducted or planned activity, due to the increased risk of flooding, the increased risk of landslides, the intensification of water and wind erosion processes, water deficit, and the elevation as well as lowering of the groundwater level. Climate change affects a whole range of spatial development problems, which, in extreme cases, may generate social conflicts and limit development opportunities. Cities are directly threatened by three phenomena: intensification of the urban heat island, strong downpours, which cause flooding, and drought, which is conducive to water deficit in cities. Extreme precipitation events like floods pose a threat to urban infrastructure through flooding and landslides, and the destruction of communication routes, buildings and property.

Research methods

The aforementioned consequences of climate change for the water management of Polish cities indicate the need to conduct adaptation activities. The aims of this study are:

1. A comparative analysis (benchmarking method) of the impact of climate change on water management – in Poland and other EU countries.
2. An analysis of the public water supply level in Poland against the background of other EU countries – a comparative analysis of existing sources.
3. Am assessment of the involvement of Polish cities in adapting to climate change compared to other EU countries – a comparative analysis of the Eurostat indicator "Population covered by the Covenant of Mayors for Climate and Energy".
4. An assessment of the implementation of the adaptation policy in the field of water management in Polish cities – a survey in 44 cities that are partners in the project "Let's feel the climate!".

Climate change and water management – Poland and EU countries

Climate change can significantly affect the water economy of a given country, through its impact on the amount of rainfall or the intensification of extreme phenomena. To compare this impact in Poland and other EU countries, in table 1, data have been collected and split into Eastern and Western Europe, regarding:

- line 1 – the forecasted changes in rainfall in the period from 2071-2100 (compared to the period from 1961 to 1990),
- line 2 – total cost of weather events per capita in 1980-2015 (including three types of events: meteorological – e.g., storms; climatological – e.g., extreme temperatures, droughts; and hydrological – e.g., floods, floods, storms, freezing lakes),
- line 3 – the forecasted annual number of people affected by the flood by 2080.

The collected data are presented in four separate climate change scenarios set out in the PESTA II report (PESTA, 2009, pp. 38-41):

a) Reference Simulation – a simulation presenting the main features of the entire set of 12 A1B simulations, not including the conduct of significant mitigation actions (includes simulations: A1B KNMI-RACMO2-ECHAM5, A1B ECHAM5-UKMO).
b) Reference Variant 1 – warmer and drier compared to the average values of the direction of climate change (includes simulations: A1B METO-HC-HadRM3Q0-HadCM3Q0, A1B ECHAM5-DMI).

c) Reference Variant 2 – colder and more humid compared to the average values of the climate change direction (includes simulations: A1B DMI-HIRHAM5-ECHAM5, A1B EGMAM2006 – FUB).
d) Simulation 2°C – a simulation based on the E1 scenario, used to illustrate the future effects of climate change in the case of global mitigation actions (including simulations: MPI-REMO-E4, E1 ECHAM5.4-MPI).

Table 1. Climate change and water management in Poland and EU countries split into East and West

Eastern Europe												
Comparative variable	PL	CY	CZ	EE	LV	LT	MT	SK	SI	HU	BG	RO
1a) Change [%]	**2.8**	-19	0	18	18	18	-19	0	0	0	-19	0
1b) Change [%]	3.7	-14	-7	16	16	16	-14	-7	-7	-7	-14	-7
1c) Change [%]	2.0	-14	5	21	21	21	-14	5	5	5	-14	5
1d) Change [%]	2.1	-14	-3	11	11	11	-14	-3	-3	-3	-14	-3
2 [euro per capita]	376	514	940	71	149	270	156	308	738	556	288	486
3a)	345	258	82	20	20	20	258	82	82	82	258	82
3b)	450	456	144	40	40	40	456	144	144	144	456	144
3c)	347	313	85	20	20	20	313	85	85	85	313	85
3d)	459	474	158	56	56	56	474	158	158	158	474	158

Western Europe									
Comparative variable	PL	AT	BE	DK	FI	FR	LU	GR	ES
1a) Change [%]	**2.8**	0	8	18	18	0	0	-19	-19
1b) Change [%]	3.7	-7	1	16	16	-7	-7	-14	-14
1c) Change [%]	2.0	5	15	21	21	5	5	-14	-14
1d) Change [%]	2.1	-3	3	11	11	-3	-3	-14	-14
2 [euro per capita]	376	1535	364	1815	352	948	1519	677	812
3a)	345	82	345	20	20	82	82	258	258
3b)	450	144	450	40	40	144	144	456	456
3c)	347	85	347	20	20	85	85	313	313
3d)	459	58	459	56	56	58	58	474	474

Comparative variable	PL	NL	IE	DE	PT	SE	GB	IT
1a)Change[%]	**2.8**	8	8	8	-19	18	8	-19
1b) Change [%]	3.7	1	2	1	-14	16	2	-14
1c) Change [%]	2.0	15	12	15	-14	21	12	-14
1d) Change [%]	2.1	3	7	3	-14	11	7	-14
2 [euro per capita]	376	412	1009	1159	579	466	976	1129
3a)	345	345	70	345	258	20	70	258
3b)	450	450	136	450	456	40	136	456
3)	347	347	86	347	313	20	86	313
3d)	459	459	207	459	474	56	207	474

In Table 1, the following country codes were used (according to ISO 3166-1), Austria – AT, Belgium – BE, Bulgaria – BG, Cyprus – CY, the Czech Republic – CZ, Denmark – DK, Estonia – EE, Finland – FI, France – FR, Greece – GR, Spain – ES, Ireland – IE, Lithuania – LT, Luxembourg – LU, Latvia – LV, Malta – MT, Netherlands – NL, Germany – DE, Poland – PL, Portugal – PT, Romania – RO, Slovakia – SK, Slovenia – SI, Sweden – SE, Hungary – HU, Great Britain – GB, Italy – IT.

Source: author's own work based on: PESTA, 2009, pp. 32-35; Norwegian Meteorological Institute, 2013, p. 83; Ciscar, 2011, p. 2681; EC, 2009, p. 24.

The analysis of row 1, the intensity of precipitation for EU countries, indicates a change in their size in the range from a drop by 2% to an increase of 6% (depending on the scenario). It will be possible to observe their shift from the south to the north; in the adopted East-West division of Europe, the highest precipitation increases will occur in Estonia, Latvia, Lithuania, Poland, while the highest falls will be in Cyprus, Malta and Bulgaria. In Western Europe, the highest increases in precipitation will occur in Denmark, Finland and Sweden, with the highest falls in Spain, Portugal and Greece. In Poland, Germany, the Netherlands and Belgium, rainfall will rise from 1% to 15%.

The consequence of climate change is extreme weather phenomena, which can significantly affect the hydrological situation of a country. In Eastern European countries, the highest level of caused by weather events in the period from 1980 to 2015 (row 2) occurred in the Czech Republic and Slovenia, the lowest in Estonia. Poland, with a loss level of 376 euro per person, took 6th place.

Analyzing the lines from 3a to 3d in table 1, it can be noticed that the countries of Eastern Europe, where the largest population will suffer as a result of floods until 2080, include Poland, Bulgaria, as well as Malta and Cyprus.

In Western Europe, the largest total losses caused by weather events per capita in 1980-2015 were recorded respectively in Denmark, Austria and Luxembourg (losses over 1500 euros per capita); the lowest value occurred in Finland, Belgium and Poland (a loss of 350-380). The forecasted number of people affected by flood indicates the highest values for countries of Western Europe such as: Poland, Germany, Belgium, the Netherlands, Greece, Spain, Italy and Portugal.

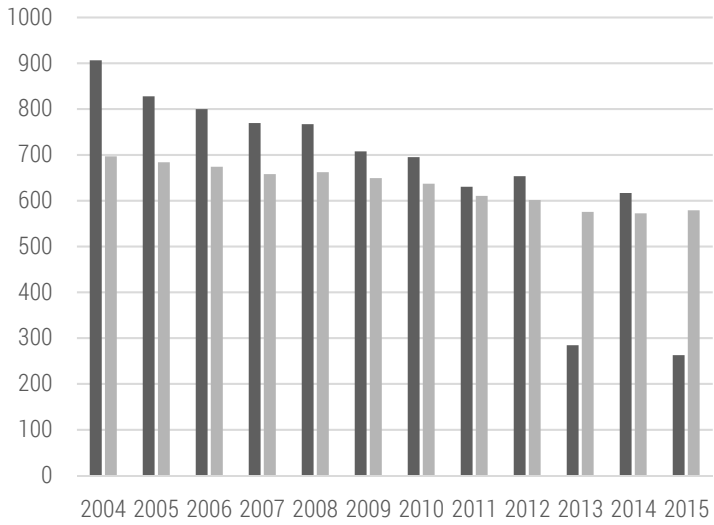
The water management of Polish cities against the background of EU countries

As indicated in figure 1, in the period from 2004 to 2015, public water supply in Poland was lower than the EU average. The share of the Polish public water supply ranged from 3.4% (2007) to 4.9% (2014) of total consumption (table 2).

Table 1. Polish percentage in total EU share of public water supply consumption

2004	3.5%
2005	3.5%
2006	3.8%
2007	3.4%
2008	3.9%
2009	4.2%
2010	3.8%
2011	4.2%
2012	3.5%
2013	1.2%
2014	4.9%
2015	1.6%

Figure 1. Polish index of public water supply against the EU average



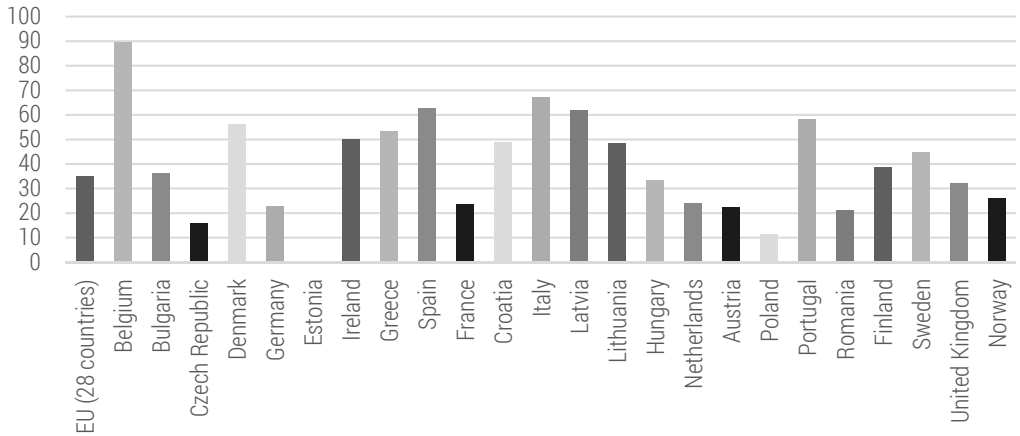
Source: author's own work based on Eurostat.

Despite the inclusion of 2013 and 2015, the analysis omits these two years due to the lack of data from Spain, whose share in other years was a significant contribution to the reported total value; the lack of this data significantly reduced the total consumption, which would contribute to erro-

neous conclusions. When calculating the average value, only those countries that reported this indicator above 0 were included – from 19 to 26 countries (e.g., Malta, throughout the entire period under examination, indicated a value of 0 for most sectors, which is not logically justified) (http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=ten00006&language=en).

One of the EU projects dedicated to the issue of climate change in cities is the "Covenant of Mayors", under which mayors signed a declaration committing themselves to reducing CO_2 emissions in a given city by at least 20% by 2020. This should contribute to the implementation of the Climate Package through the realization of the Sustainable Energy Action Plan. In particular, emission reductions should be achieved by saving energy, promoting renewable energy, and educating citizens about sustainable energy use. The agreement is, therefore, part of the actions intended to prevent the worsening of climate change. Together with the newly approved agreement, it covers over 1,600 cities from 32 countries, inhabited by around 120 million people. In Poland, the agreement covers 40 cities. All initiatives concern preventive actions (http://www.eumayors.eu/plans-and-actions/good-practices.html).

Figure 2. Percentage of total population covered by the Covenant of Mayors for Climate and Energy signatories



Source: author's own work based on Eurostat.

As shown by figure 2, in 2015, the highest percentage of the total population covered by the Covenant of Mayors for Climate and Energy signatories was in Belgium, at 89.4%. The following countries with the high levels of this indicator are Italy (67%), Latvia (61.9%), Portugal (58.3%), Denmark (56.1%) and Greece (53.5%). Throughout the Union, this agreement covered

35.1% of the population in 2015. Poland has one of the lowest levels of the percentage of the population covered by the agreement. At 11.5%, it is higher than only Estonia (0.1%) and countries with 0%, i.e., Cyprus, Luxembourg, Malta, Slovenia and Slovakia. Countries like Iceland and Switzerland have not released data in this area (http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=sdg_13_60&plugin=1).

Adaptive policy in the field of water management in Polish cities

In order to assess the implementation of the adaptive policy in the field of water management in Polish cities, a survey was carried out in 44 cities that are partners in the project "Let's feel the climate!" This project is the result of the need to prepare a Municipal Plan of Adaptation to climate change (MPA) in connection with the EU policy in this area, in particular, the Strategy for adaptation to climate change of the European Union of April 16, 2013. The starting point for the development of urban adaptation plans is the Strategic Adaptation Plan for sectors and areas sensitive to climate change by 2020, with a view to 2030 (SPA 2020), adopted by the Government in October 2013. The foundation for the preparation of the MPA is the assessment of the vulnerability of a given city to threats resulting from climate change.

The questionnaire was sent five times to the coordinators responsible for creating the MPA in individual cities. For high-quality research and the largest possible research sample, the study was supported by the main project coordinator and regional coordinators. Out of 44 cities, the questionnaire was completed by 32 cities (73%).

The majority of respondents, 78%, indicated that their city uses mechanisms of support for economic entities in implementing measures to prevent climate change (inhibiting their behaviour), but only in 8 cities (25%) are there activities aimed at the effective use of resources in the region (using methods to measure the use of water and ways to reduce its consumption). 75% of respondents declared that their city uses mechanisms to support business entities in adapting to climate change, most of which indicated that they are contingency plans in the event of a flood (19 responses, 59% of respondents), contingency plans for water shortages (15,47%) and the development of green urban infrastructure to protect the city against floods and flooding (11,34.5%).

Among the most important adaptive needs mentioned above, the answer "increasing the region's water safety" was indicated in 21 cities surveyed (65.7%) and it was the third most frequently indicated answer, along with

"urban transport development". Only in 2 cities is there a need to identify methods for measuring the safe use of water and ways to reduce its consumption (together with "increasing the food security of the region" it was the least frequently indicated answer).

Among the most frequently used solutions in the field of water management was the answer "elimination of leaks in transmission and distribution networks" (14 cities) and "education in the scope of saving water resources" (14). Solutions such as monitoring systems were less frequently indicated: measurement of available water and hazard systems, i.e., extreme weather phenomena (8), collection systems, use and drainage of rainwater to prevent flooding (8), use of a sustainable rainwater management system, which consists of infiltration hollows, rainforests, permeable surfaces and green walls and roofs (6), the use of barrels to collect rainwater (5), the construction of "green roofs" to reduce the effect of the urban heat island, energy saving and reducing outflow rainwater (4), remote sensing systems: early flood warning (4), incentives for independent regulation of groundwater (3), and remote sensing systems: monitoring of safe water extraction (2). None of the respondents indicated the following solutions: construction of seawater desalination plants using renewable energy sources and supplying it to the city, modification of protective systems such as a firewall to better adapt to extreme weather events and minimize environmental damage, dissemination of information indicating that use of water from a given company is below or above safe levels for water management, and the use of remote sensing systems, notification via SMS of farmers with excessive water consumption and stress on arable waters.

Conclusions

Forecasts indicate that Poland is the country most exposed to the occurrence of floods, despite having one of the lowest levels of previous losses caused by extreme phenomena. The consumption of the Polish public water supply is lower than the EU average, and the level of involvement of Polish cities in adaptation issues, assessed on the basis of the share of the population covered by the Covenant of Mayors, can be described as low.

The conducted survey indicates that Polish cities are in the early stages of introducing adaptation activities. They are concentrating on preventive measures, and there is a low degree of implementing adaptation activities. The main problem is financing, the lack of commitment of the relevant entities, and a lack of attempts to engage society. In the field of water management, there is a low degree of utilization of mechanisms for the effective use of water resources; the main adaptation actions are fighting against the

effects of floods; the most important adaptive need is to increase the region's water security; and the most commonly declared adaptation solutions are eliminating leaks in the transmission and distribution networks, and education, in terms of saving water resources.

This survey and the analysis of the existing data allow us to note that there is still a low level of quality data available at the EU level. We can also observe that, in Poland, there is a focus on adaptation activities, in particular, on the need for reporting, and a cyclical presentation of work, which is connected with obtaining financing. Adapting to climate change makes sense with the full involvement and close cooperation of all stakeholders, at the local, national and international levels. The Polish MPA may be created and made public; however, due to the fact that basic mistakes at the project planning stage have already been made, their implementation is questionable. There can be only a hope that they will be a good diagnostic basis for subsequent projects.

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