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A Comparative Analysis of Initiatives and Adaptation Measures To Climate Change Undertaken in Poland and Eastern EU Countries

Abstract

Climate change is one of the greatest contemporary threats to our planet's environmental, social and economic condition. It is accompanied by massive changes in life support systems on Earth, where its far-reaching effects will be felt in the upcoming decades. The development of a national adaptation policy (strategy and/or plan) serves as an instrument that provides the necessary framework for adaptation by coordinating the consideration of climate change across relevant sectors, geographical scales, and levels of decision making. The purpose of this paper is to compare the degree of influence of climate change on the economy of the Eastern European Union and compare national strategies for adaptation to climate change in selected countries of Western Europe and Poland. The study shows that countries bearing the brunt of the negative impacts of climate change are Cyprus, Malta, Bulgaria and Poland. These countries recorded the highest climate change index, the greatest losses in terms of estimated GDP, household welfare, land losses, and lower incomes in the agricultural and tourism sectors. With appropriate adaptation measures, countries such as Lithuania, Latvia and Estonia can take advantage of the future changes in weather conditions. A shift in the productivity of the agricultural sector and tourism from south to north can be noted.

Keywords: *climate change, forecasts and costs of climate change, adaptation to climate change*

JEL: *O2*

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1. Introduction

Significant changes in climate, and its impacts, are already visible in contemporary Europe. Increasing temperatures, rising sea levels, melting of glaciers and ice sheets, as well as more intense and frequent extreme weather events are among the challenges already created by and driven by climate change. The Intergovernmental Panel on Climate Change (IPCC) has confirmed that there is an increase of key risks for Europe, with climate change projected to have adverse impacts in nearly all sectors and across all sub-regions, albeit with large differences in types of impact (Mimura et al. 2014, pp. 869–898).

In 2013, the European Commission adopted the communication 'An EU Strategy on adaptation to climate change', which includes several elements to support Member States in their adaptation processes: providing guidance and funding; promoting knowledge generation and information sharing; and enhancing the resilience of key vulnerable sectors through mainstreaming. In addition, the EU has also agreed that at least 20% of its budget for the 2014–2020 period should be spent on climate change-related actions, including mitigation and adaptation (EC 2013, p. 3).

National adaptation strategies (NASs) and plans provide a general and mostly nonbinding policy framework for guiding the adaptation activities of governmental authorities and non-state actors. As for other policy domains, policymaking at the national level has a key role in creating an 'enabling environment' for planning and implementing concrete actions. It is at this level that medium- to long-term adaptation objectives need to be formulated and gain political support, and where coordination mechanisms are to be established in order to secure the engagement of key actors. Overall, the development of a national adaptation policy (strategy and/or plan) serves as an instrument that provides the necessary framework for adaptation through coordinating the consideration of climate change across relevant sectors, geographical scales, and levels of decision making (Hildénet al. 2014, pp. 3–4).

The purpose of this paper is to compare the degree of influence of climate change on the economy of the Eastern European Union and compare national strategies for adaptation to climate change in selected countries of Western Europe and in Poland.

2. Research benchmarking

In order to compare the degree of influence of climate change on the economy of individual countries and, against the background of various countries of the Western European Union, present a strategy for adaptation to climate change in Poland, a benchmarking study was conducted (Croatia was left out of the study due to a lack of sufficient data).

Table 1. The results of benchmarking

Comparison	Poland	Cyprus	The Czech Republic	Estonia	Latvia	Lithuania	Malta	Slovakia	Slovenia	Hungary	Bulgaria	Romania
1a)	Increase of 2.3 °C	Increase of 2.9 °C	Increase of 2.4 °C	Increase of 2.9 °C	Increase of 2.9 °C	Increase of 2.9 °C	Increase of 2.9 °C	Increase of 2.4 °C	Increase of 2.4 °C	Increase of 2.4 °C	Increase of 2.9 °C	Increase of 2.4 °C
1b)	Increase of 3.7 °C	Increase of 4.1 °C	Increase of 3.9 °C	Increase of 4.1 °C	Increase of 4.1 °C	Increase of 4.1 °C	Increase of 4.1 °C	Increase of 3.9 °C	Increase of 3.9 °C	Increase of 3.9 °C	Increase of 4.1 °C	Increase of 3.9 °C
1c)	Increase of 4 °C	Increase of 3.6 °C	Increase of 4.4 °C	Increase of 3.6 °C	Increase of 3.6 °C	Increase of 3.6 °C	Increase of 3.6 °C	Increase of 4.4 °C	Increase of 4.4 °C	Increase of 4.4 °C	Increase of 3.6 °C	Increase of 4.4 °C
1d)	Increase of 5.5 °C	Increase of 4.7 °C	Increase of 6 °C	Increase of 4.7 °C	Increase of 4.7 °C	Increase of 4.7 °C	Increase of 4.7 °C	Increase of 6 °C	Increase of 6 °C	Increase of 6 °C	Increase of 4.7 °C	Increase of 6 °C
2)	Increase of 3.3–3.7 °C	Increase of 4.5–4.9 °C	Increase of 3.3–3.7 °C	Increase of 3.3 °C	Increase of 3.3–3.5 °C	Increase of 3.3–3.5 °C	Increase of 4.1 °C	Increase of 3.3–3.7 °C	Increase of 3.7–4.1 °C	Increase of 3.9–4.1 °C	Increase of 4.1 –4.3 °C	Increase of 3.7–4.1 °C
3)	Increase of 3.4–3.8 °C	An increase of 2.6–3 °C	An increase of 3.4–3.8 °C	Increase of 4.6 °C	Increase of 4.2 °C	Increase of 4.2 °C	Increase of 1–1.4 °C	Increase of 3.4–3.8 °C	Increase of 1.8–2.6 °C	Increase of 3–3.4 °C	Increase of 1.8 –2.9 °C	Increase of 3 °C
4a)	Increase of 3%	Decrease of 7%	Increase of 2%	Increase of 10%	Increase of 10%	Increase of 10%	Decrease of 7%	Increase of 2%	Increase of 2%	Increase of 2%	Decrease of 7%	Increase of 2%
4b)	Increase of 1%	Decrease of 15%	Decrease of 2%	Increase of 10%	Increase of 10%	Increase of 10%	Decrease of 15%	Decrease of 2%	Decrease of 2%	Decrease of 2%	Decrease of 15%	Decrease of 2%
4c)	Increase of 6%	Decrease of 13%	Decrease of 4%	Increase of 19%	Increase of 19%	Increase of 19%	Decrease of 13%	Decrease of 4%	Decrease of 4%	Decrease of 4%	Decrease of 13%	Decrease of 4%
4d)	Decrease of 1 %	Decrease of 28%	Decrease of 16%	Increase of 24%	Increase of 24%	Increase of 24%	Decrease of 28%	Decrease of 16%	Decrease of 16%	Decrease of 16%	Decrease of 28%	Decrease of 16%
5a)	12	0	6	1	1	1	no data	16	3	8	4	23
5b)	6	4	6	2	3	4	no data	0	5	5	6	13
5c)	5	2	2	1	3	3	no data	1	3	5	0	4
6a)	Increase of 15 thousandmln €	Increase of 8 thousandmln €	Increase of 1 thousandmln€	Decrease of 6 thousandmln €	Decrease of 6 thousandmln €	Decrease of 6 thousandmln €	Increase of 8 thousandmln €	Decrease of 1 thousandmln €	Decrease of 1 thousandmln €	Decrease of 1 thousandmln €	Increase of 8 thousandmln €	Decrease of 1 thousandmln €

Comparison	Poland	Cyprus	The Czech Republic	Estonia	Latvia	Lithuania	Malta	Slovakia	Slovenia	Hungary	Bulgaria	Romania
6b)	Increase of 19 thousandmln €	Increase of 19 thousandmln €	No changes	Decrease of 6 thousandmln €	Decrease of 6 thousandmln €	Decrease of 6 thousandmln €	Increase of 19 thousandmln €	No changes	No changes	No changes	Increase of 19 thousandmln €.	No changes
6c)	Increase of 12 thousandmln €	Increase of 9.5 thousandmln €	Increase of 2 thousandmln€	Decrease of 5 thousandmln €	Decrease of 5 thousandmln €	Decrease of 5 thousandmln €	Increase of 9.5 thousandmln €	Increase of 2 thousandmln €	Increase of 2 thousandmln €	Increase of 2 thousandmln €	Increase of 9.5 thousandmln €	Increase of 2 thousandmln €
6d)	Increase of 22 thousandmln €	Increase of 41thousandmln €	Increase of 9 thousandmln€	Decrease of 9 thousandmln €	Decrease of 9 thousandmln €	Decrease of 9 thousandmln €	Increase of 41thousandmln €	Increase of 9 thousandmln €	Increase of 9 thousandmln €	Increase of 9 thousandmln €	Increase of 41thousandmln €	Increase of 9 thousandmln €
7a)	Decrease of 0.3%	Increase of 0.27%	Increase of 0.14%	Increase of 0.55 %	Increase of 0.55 %	Increase of 0.55 %	Decrease of 0.27%	Decrease of 0.14%	Decrease of 0.14%	Decrease of 0.14%	Decrease of 0.27%	Decrease of 0.14%
7b)	Decrease of 0.42%	Decrease of 0.62%	Decrease of 0.28%	Increase of 0.48%	Increase of 0.48%	Increase of 0.48%	Decrease of 0.62%	Decrease of 0.28%	Decrease of 0.28%	Decrease of 0.28%	Decrease of 0.62%	Decrease of 0.28%
7c)	Decrease of 0.34%	Decrease of 0.41%	Decrease of 0.33%	Increase of 0.56%	Increase of 0.56%	Increase of 0.56%	Decrease of 0.41%	Decrease of 0.33%	Decrease of 0.33%	Decrease of 0.33%	Decrease of 0.41%	Decrease of 0.33%
7d)	Decrease of 0.68%	Decrease of 1.36%	Decrease of 0.48%	Increase of 0.75%	Increase of 0.75%	Increase of 0.75%	Decrease of 1.36%	Decrease of 0.48%	Decrease of 0.48%	Decrease of 0.48%	Decrease of 1.36%	Decrease of 0.48%
8a)	Decrease of 1%	No influence	Increase of 5%	Increase of 37%	Increase of 37%	Increase of 37%	No influence	Increase of 5%	Increase of 5%	Increase of 5%	No influence	Decrease of 0.48%
8b	Decrease of 3%	Decrease of 12%	Increase of 5%	Increase of 39%	Increase of 39%	Increase of 39%	Decrease of 12%	Increase of 5%	Increase of 5%	Increase of 5%	Decrease of12%	Increase of 5%
8c)	Increase of 2%	Decrease of 4%	Increase of 3%	Increase of 36%	Increase of 36%	Increase of 36%	Decrease of 4%	Increase of 3%	Increase of 3%	Increase of 3%	Decrease of 4%	Increase of 3%
8d)	Decrease of 8%	Decrease of 27%	Decrease of 3%	Increase of 52%	Increase of 52%	Increase of 52%	Decrease of 27%	Decrease of 3%	Decrease of 3%	Decrease of 3%	Increase of 27%	Increase of 3%
9a)	Increase of 2%	Decrease 1%	Increase of 2%	Increase of 4%	Increase of 4%	Increase of 4%	Increase of 2%	Increase of 2%	Increase of 2%	Increase of 2%	Decrease 1%	Increase of 2%
9b)	Increase of %	Decrease 1%	Increase of 3%	Increase of 6%	Increase of 6%	Increase of 6%	Increase of 3%	Increase of 3%	Increase of 3%	Increase of 3%	Decrease 1%	Increase of 3%

Comparison	Poland	Cyprus	The Czech Republic	Estonia	Latvia	Lithuania	Malta	Slovakia	Slovenia	Hungary	Bulgaria	Romania
9c)	Increase of 13%	Decrease 2%	Increase of 14%	Increase of 20%	Increase of 20%	Increase of 20%	Increase of 14%	Increase of 14%	Increase of 14%	Increase of 4%	Decrease 2%	Increase of 14%
9d)	Increase of 16%	Decrease 4%	Increase of 17%	Increase of 25%	Increase of 25%	Increase of 25%	Increase of 17%	Increase of 17%	Increase of 17%	Increase of 17%	Decrease 4%	Increase of 17%
10a)	345	258	82	20	20	20	20	82	82	82	258	82
10b)	450	456	144	40	40	40	40	144	144	144	456	144
10c)	347	313	85	20	20	20	20	85	85	85	313	85
10d)	459	474	158	56	56	56	56	158	158	158	474	158
11)	Decrease 0.917/899.67/ Decrease 0.0049	Decrease 0.783/111.61/ Decrease 0.051	Decrease 0.32/111.61/ Increase 0.0027	Decrease 0.237/47.78/ Decrease 0.0004	Decrease 0.237/47.78/ Decrease 0.0004	Decrease 0.237/47.78/ Decrease 0.0004	Decrease 0.783/111.61 Decreaseo 0.051	Decrease 0.32/111.61/ Increase 0.0027	Decrease 0.32/111.61/ Increase 0.0027	Decrease 0.32/111.61/ Increase 0.0027	Decrease 0.783/111.61/ Decrease 0.051	Decrease 0.32/111.61/ Increase 0.0027
12)	Decrease 0.0381/ Increase 0.011	Decrease 0.015/ Increase 0.010	Decrease 0.007/ Increase 0.007	Decrease 0.046/ Increase 0.040	Decrease 0.046/ Increase 0.040	Decrease 0.046/ Increase 0.040	Decrease 0.015/ Increase 0.010	Decrease 0.007/ Increase 0.007	Decrease 0.007/ Increase 0.007	Decrease 0.007/ Increase 0.007	Decrease 0.015/ Increase 0.010	Decrease 0.007/ Increase 0.007
13a)	12/–14	11/–28	17/–20	8/–8	8/–8	8/–8	11/–28	17/–20	17/–20	17/–20	11/–28	17/–20
13b)	24/–25	18/–52	31/–37	15/–13	15/–13	15/–13	18/–52	31/–37	31/–37	31/–37	18/–52	31/–37
13c)	19/–26	18/–49	31/–39	9/–11	9/–11	9/–11	18/–49	31/–39	31/–39	31/–39	18/–49	31/–39
13d)	33/–37	28/–64	52/–53	14/–16	14/–16	14/–16	28/–64	52/–53	52/–53	52/–53	28/–64	52/–53
14	0.21–0.37	0.37–0.52	0.3–0.37	0.26–0.3	0.26–0.3	0.21–0.26	=>0.52	0.21–0.37	0.21–0.26	0.37–0.52	0.37–0.52	0.26–0.52
15	Medium willingness	High willingness	Low willingness	Medium willingness	Medium willingness	Medium willingness	High willingness	Medium willingness	Low willingness	Medium willingness	High willingness	Medium willingness

Comparison	Poland	Cyprus	The Czech Republic	Estonia	Latvia	Lithuania	Malta	Slovakia	Slovenia	Hungary	Bulgaria	Romania
16	Decision	Formulation	Formulation	Formulation	Formulation	Monitoring and evaluation	Implementation	Formulation	Formulation	Decision	Formulation	Decision
17)	Agriculture, water resources, coastal zones and forestry	Water resources, soils, coasts, biodiversity,agriculture, forests, fisheries & aquaculture, public health, energy, tourism and infrastructure	Water management, agriculture, forest biodiversity, ecosystem services, urbanized landscape, health, crisis situations, protection of the population,-tourism, transport, industry and energy sector .	Integration as response to key EU policies – Common Agriculture Policy, Cohesion Policy and the Common Fisheries Policy	Various sectoral polices such as forestry, environmental policies, Rural Development Program	Various sectoral polices such as agriculture, forestry	Various sectoral polices-Tourism, Water Management Plan, Storm Water Plan, national environmental policy.	Mainstreaming of proposed adaptation measures into the relevant operational programs for the period 2014–2020	Guidelines on how to include adaptation in spatial planning, various sectoral policies include adaptation – agriculture, forestry	Various sectoral policies such as the National Water Strategy, Biodiversity Preservation Strategy	Agriculture and Forest policies	Industry, agriculture, fisheries; tourism; public health; infrastructure; transport; water resource, flood protection; forestry; energy, biodiversity, insurance, education

Sources: Author's own compilation based on Pesta 2009, pp. 32–35; Norwegian Meteorological Institute 2013, p. 83; Ciscar et al.2011 p. 2681; EC 2009, p. 24; EEA Report 2014, pp. 24–27.

Benchmarking is a management method that can be defined as a creative comparison with the 'best'. This method involves learning from leaders in the field of best practices. It is not about copying ready-made solutions, but imitating proven successful ways to handle challenges. The idea behind benchmarking is a search for ideas outside the main area of business and setting standards for organizations through creative imitation.

In the comparative analysis presented below, benchmarking was carried out using the following steps:

1. Projecting changes in the climate during the period from 2071 to 2100; Tracking changes in temperature in the summer months (June–August) in the years 2000–2100 (obviously based on projections for future years);
2. Tracking changes in temperature during the winter months (December- February) in the years 2000–2100 (with the same reservations as above);
3. Projecting changes in rainfall during the period from 2071–2100;
4. Calculating the number of loss events – Hydrological events / meteorological events / climatological events;
5. Projecting the annual impact of climate change in the 2080s in terms of GDP loss;
6. Projecting the annual effects on household welfare in all impact categories for the 2080s;
7. Projecting changes in agricultural crops caused by climate change by the year 2080;
8. Projecting how tourism might change;
9. Projecting the expected annual number of people affected by flood in 2080;
10. Projecting land losses – region total (%) Value (Million $) and change in GDP (%) for the year 2085 (in the event of no adaptation);
11. Projecting land losses – region total (%) Value (Million $) and change in GDP (%) for the year 2085 (in the event of adaptation actions);
12. Human health: projecting heat/cold-related deaths for the year 2080 (death rate per 100,000 population per year);
13. Creating a climate change vulnerability index;
14. Encouraging a willingness to develop policies and to undertake adaptation actions at the national level;
15. Marking stages in the adaptation policy process;
16. Mainstreaming adaptation into sectoral policies and programs.

The data collection process began with a benchmarking analysis of secondary sources, which include, among others, Polish and foreign publications, reports, materials, and websites. Most of the collected data are presented in four climate change scenarios prepared by PESETA for the period 2071–2100 (Christensenet al. 2007, pp. 1–6) (Table 1.)[1]:

[1] In the table, the comparative figures have been numbered from 1 to 19, and the markings a–d relate to PESETA' climate change scenarios.

a) B2-Global model HadAM3H/HadCM3, regional model-HIRHAM, CO_2 concentration 561 ppm, temperature increase 2.5 °C.
b) A2-Global model HadAM3H/HadCM3, regional model-HIRHAM, CO_2 concentration 709 ppm, temperature increase 3.9 °C.
c) B2-Global model ECHAM4/OPYC3, regional model-RCAO, CO_2 concentration 561 ppm, temperature increase 4.1 °C
d) A2-Global model ECHAM4/OPYC3, regional model-RCAO, CO_2concetration 709 ppm, temperature increase 5,4 °C.

3. Conclusions from the benchmarking study

In the scenarios assuming an increase in temperature of 2.5 and 3.9 °C the lowest temperature rise is expected in Poland, and the highest in Cyprus, Estonia, Lithuania, Latvia, Malta and Bulgaria. In the other two scenarios, the lowest temperature rise is expected in Cyprus, Estonia, Estonia, Lithuania, Latvia, Malta and Bulgaria, and the highest in the Czech Republic, Slovakia, Slovenia and Romania. In terms of the division of the months into summer and winter, in the period June-August temperatures will record the highest increases in Cyprus, the lowest in Estonia, while in the period December-February the highest increase will be in Estonia, and the lowest in Malta. In Poland, the predicted temperature changes in the summer will rise from 3.3 to 3.7 °C, in the winter 3.4 to 3.8° C. The same increase is expected in the Czech Republic and Slovakia (among the countries analyzed in the summer months in three countries the growth of temperatures will be smaller, in the other six greater, and Poland occupies the sixth position in the winter months).

Analyzing the various scenarios it can be seen that the temperature increase by an average of 2.5° C in most countries will increase rainfall, while a decline is expected in Bulgaria, Cyprus and Malta (where rainall may decrease by up to 28%). In Poland, the decline in rainfall may be 1% if the scenario of a temperature rise of 5.4° C would come true.

The most frequently occurring hydrological events from 1980 to 2010 (such as floods, flash floods, storm surges, glacial lakes) were in Romania (23), Slovakia (16) and Poland (12), while the most frequently occurring meteorological events (such as storms) were in Romania (13), Poland, the Czech Republic, and Bulgaria (6), and the most frequently occurring climatological events (extreme temperatures, drought) were in Poland and Hungary (5), and Romania (4). In total, the most extreme weather events in the studied region occurred in Romania (40) and Poland (23). Table 2 shows the greatest weather anomalies which occurred between 2009 and 2015 (the Table includes the events which happened in countries

which are taken into account in the benchmarking research). In the analyzed region, flooding is the most serious extreme weather phenomenon, which has caused the greatest losses.

Table 2. The large loss events in Europe, 2009–2015

Date	Event	Affected area	Overall losses in US$ (in million)
June–August 2015	Heat wave	Poland, Austria, Belgium, France, Germany, Italy	1,250
April–August 2015	Drought	Bosnia and Herzegowina, Croatia, Czech Republic, Hungary, Moldova, Poland, Romania, Serbia	1,800
30.3–1.4.2015	Winter Storm Niklas	Austria, Czech Republic, Belgium, Germany, Netherlands, Poland, Switzerland, United Kingdom	1,400 and 11 fatalities
13–30.5.2014	Floods	Serbia, Croatia, Bosnia and Herzegowina, Romania	3,600
30.5–19.6.2013	Floods	Austria, Czech Republic, Germany, Hungary, Poland, Switzerland	15,200
2–12.6.2010	Floods	Germany, Hungary, Romania, Slovakia, Czech Republic, Poland, Austria	3,800 and 7 fatalities
8–13.1.2010	Winter damage, snowstorms	Germany, United Kingdom, France, Switzerland, Poland, Spain, Netherlands	1,730
23–24.7.2009	Severe storm, hailstorms	Austria. Germany. Czech Republic. Poland. Switzerland	1,800 and 11 fatalities

Source: Munich Re NatCatSERVICE database, https://www.munichre.com, access 31.10.2016.

Analyzing the rows from 10a to 10d of Table 1 it may be noted that the countries where most people will be most affected by flood are Poland, Bulgaria and Cyprus. Columns from 6a to 6d present the annual impact of climate-change scenarios in the 2080s in terms of GDP loss (in million €). The scenarios are identi-

fied by the average EU temperature increase, although temperature is not the only determinant of economic impacts. Impacts are determined by the combination of SRES socioeconomic scenarios and data, the associated emissions scenarios, and the use of alternative climate models, leading to different spatial patterns of the climate variables. These factors explain why, for example, the economic costs are higher in the EU overall and in most regions under the 3.9 °C scenario than under the 4.1 °C scenario.

The highest increase in annual GDP loss until 2080 is expected in Poland (from 12 to 22 billion €), Cyprus, Malta and Bulgaria (from 8 to 41 billion €). In Estonia, Lithuania and Latvia, the annual GDP is predicted to increase as a result of climate changes from 1 to 9 billion € (assuming ceteris paribus). In these countries, a favorable climate impact can also be seen in the growth in agriculture, where the estimated changes in agricultural crops caused by climate change will amount to an increase by 2080 from 36% to 52%, and GDP in agriculture will increase from 0.08% to 0.9% (Pesta 2009 pp. 43–45). In other countries, the increase of up to 2.5 °C will not produce much adverse change (a decline in agricultural products will take place only in Poland (–1%) and Romania (–0.48%). However, in other scenarios a clear shift of the revenue from the agricultural sector to the north can be seen. In countries like Cyprus, Bulgaria and Malta, agricultural crops will decline from 4% to 27%. Polish agriculture can be advantaged only by a change in temperature of 4.1 ° C, with a growth in crops to 2%; in other cases it is estimated to fall from 1% to 8%.

The above results can be translated into gains or declines in terms of annual household welfare. In Estonia, Latvia and Lithuania increases in the welfare of households will be, depending on the scenario, from 0.55% to 0.75%. In other countries, annual household welfare will drop from 0.14% to 1.36% (0.14–0.48% in the Czech Republic Slovakia, Slovenia, and Romania; 0.3–0.68% in Poland, and 0.27–1.36% in Cyprus, Malta and Bulgaria).

One of the dangerous consequences of climate change is rising sea levels and loss of coastal land, which entails a loss in GDP due to the loss of land used for production purposes.

An important role in the significant declines in GDP is played by, in addition to the direct impact of the loss of productive land, indirect costs associated with the loss of land, such as sectoral and market substitution effects, and international trade (Bosello et al. 2007, pp. 549–571).

The values in row 11 of Table 1 present the land losses as a percentage of the total surface in the region, its economic valuation, and the economic valuation in terms of percentage changes in GDP. The country with the highest total losses, without adaptation measures, in values of the region and change of GDP is Poland, followed by Cyprus, Malta and Bulgaria, while the introduction of adaptation measures in all countries can lead to increases in GDP. In Poland, this increase is the largest, as the introduction of adaptation measures leads to an increase

in GDP of about 0.0159 (compared to the negative percentage change in GDP in the absence of adaptation measures). Lithuania, Latvia and Estonia, despite losses in the region, will record GDP growth, which will expand with the introduction of adaptation measures.

A positive dimension of climate change can be observed in the "death rate from cold." In all countries the number of people dying from cold will decline. The biggest declines will be recorded by Cyprus, Malta and Belarus under all scenarios. The smallest declines will be recorded in Estonia, Latvia and Lithuania, followed by Poland.

Unfortunately analysis of the "death rate from heat" is not so positive. In all countries the number of people dying because of heat will grow. The worst situation is expected in Cyprus, Malta and Romania, where the number of deaths could rise from 17 to 52 per 100,000 inhabitants per year (in Poland from 12 to 33 per 100,000 inhabitants per year).

The impacts of climate change on European regions are presented in the form of a synthetic index. This climate change index combines information on vulnerability to drought, populations affected by river flooding and exposed to coastal erosion, and the exposure to climate change of the agriculture, fisheries and tourism sectors. The index shows an asymmetric core periphery pattern for the EU. Regions under the highest pressure are generally located in the south and east of Europe. This is due mostly to changes in precipitation and an increase in temperatures, which will have an impact on vulnerable economic sectors, with river floods also contributing to the overall effect in Hungary and Romania (EC 2009, p. 24). Among the countries which were analyzed, the highest values for this index were for Malta, followed by Cyprus, Bulgaria and Romania. The value of the index was presented in ranges because it varies within an individual country; for instance the southern part of Poland has the same value as the index for the northern part of Bulgaria, Romania and northwest Czech Republic.

4. Adaptation strategies of eastern EU members

A study by the European Environment Agency' (EEA) has shown how EU members defined their "willingness to develop policies and to take adaptation actions at the national level." A "low willingness" was declared by the Czech Republic and Slovenia, a "medium willingness" by Poland, Estonia, Lithuania, Latvia, Hungary and Romania, and a "high willingness" by Cyprus, Bulgaria and Malta.

The "stage in the adaptation" presented shows how far advanced are various stages of implementation plans for adaptation to climate change. The adaptation plans of seven countries surveyed (from Eastern Europe) are in the initial phase of "for-

mulation" (although the first phase in the study was "agenda-setting"). Poland, along with Hungary and Romania, is at the stage of "decision". Malta and Latvia declared the most advanced phase in their implementation of planned adaptation measures.

Poland adopted its national adaptation strategy (NAS 2020) on 29 October 2013. This document is focused on adaptation, not mitigation. In addition, adaptation issues are mentioned in other documents developed in Poland: in integrated strategies; in the Medium-Term Development Strategy to 2020; and in the Long-Term Development Strategy to 2030. Since not all adaptation issues were included in these documents, the Ministry of Environment launched the KLIMADA project, and its result was the NAS 2020, which covers the issues that were not mentioned in the above-mentioned strategies.

The NAS 2020 indicates the objectives and directions of adaptation actions in the most vulnerable sectors and areas in the period up to 2020: water management, agriculture, forestry, biodiversity and protected areas, health, energy, the building industry, transport, mountain areas, the coastal zone, spatial development and developed urban areas. The vulnerability of these areas and sectors was identified on the basis of climate change scenarios developed for NAS 2020. At the regional and local levels, the communes and municipal centres for crisis management are in the frontlines of defence against the negative impacts of climate change. They oversee emergency services, respond to floods, and coordinate environmental protection actions. Supporting bodies include: Meteorology, Hydrology and Water Management (monitoring);the State Fire Service; Regional Hydrology and Water Management; Regional Water Management Boards, and other parties. Policy instruments for implementing adaptation are to a very large extent still under development. As stated above, Poland has declared that urban areas, agriculture, water and coastal areas are priority areas for implementing adaptation programmes. Regarding water, a portfolio of adaptation measures has been identified and implementation has begun at all levels of governance.

Crisis management encompasses activities by public administration authorities as an element of a national security management system, which consists of preventing crisis situations, planning activities for their control, emergency responses, remediation of their effects, and the restoration of affected resources and critical infrastructure. All of these elements are impacted by climate change.

The Ministry of Environment is in charge of the project for coordination of the development of Urban Adaptation Plans for cities with more than 100,000 inhabitants in Poland, financed via the Infrastructure and Environment Program 2014–2020, within the NAS 2020 implementation process. Plans developed by the project will cover over 30% of the Polish population, who live in the covered cities. The project will be completed by 2018 and the main goals are determination of the vulnerability of the largest cities to climate change (risk identification, risk assessment); planning for adaptation actions at the local level; and raising awareness of the need for adaptation to climate change at the local level.

In Poland, adaptation to climate change is mainly of a nationwide scope, however some adaptation activities are carried out at the sectoral level, in particular for agriculture, water resources, coastal zones, and forestry The implementation of the National Adaptation Strategy includes mainstreaming adaptation into sectoral policies, primarily those related to agriculture and forestry, biodiversity, ecosystems and water resources, coastal zones, infrastructure, and subsequently the preparation of a program for implementation (Ministry of the Environment 2013, pp. 36–48).

The National Adaptation Plan of **Cyprus** is a framework of actions for the effective preparation and implementation in the country of actions in response to the observed and expected changes in climate. The Adaptation Plan foresees approximately 250 measures, actions, and practices as being necessary for effective climate change adaptation in each of eleven policy areas: water resources, soils, coasts, biodiversity, agriculture, forests, fisheries & aquaculture, public health, energy, tourism and infrastructure. For each of the abovementioned policy areas, Sectoral Adaptation Plans have been prepared, including a set of adaptation measures that were prioritized.

The latest project in Cyprus was CYPADAPT (2011–2014), the main aim of which was to strengthen and increase Cyprus's adaptive capacity to climate change impacts through the development of a National Adaptation Strategy. The following specific objectives for the accomplishment of the CYPADAPT aims have been adopted: outline knowledge about current climate variations; describe future changes projected for the 21st century; characterize the adaptive capacity to cope with the present-day climate; provide estimates of potential impacts under future climate change events; assess the relative vulnerability of different systems, sectors or communities to climate change; and propose appropriate measures for adapting to climate change (Internet source A).

The Czech Republic Adaptation Strategy focuses mainly on prevention and includes observed climate change impacts and recommendations of appropriate adaptation measures, including their mutual linkages as well as linkages to mitigation measures. Adaptation measures are proposed in the following areas: The water regime in landscape and water management, agriculture, forest management, biodiversity and ecosystem services, urbanized landscape, health and hygiene, crisis situations, protection of the population and environment, tourism and recreation, transport, industry and the energy sector (Internet source B).

In **Estonia**, the actions taken so far have mainly been about climate change mitigation (the reduction of greenhouse gas emissions) and emergency responses, but there is as yet no separate strategy of adaptation to the impacts of climate change. The main project "Elaboration of Estonia's Draft National Climate Change Adaptation on Strategy and Action Plan (2009–2014)" included the following: analysis of available information and planning of further activities; description of past climate change trends and the projection of future scenarios; sectoral evaluation

of climate change impacts; development of sectoral measures of adaptation to climate change; assessment and prioritization of their projected costs; preparation of the strategic environmental assessment 'Elaboration of Estonia's Draft National Climate Change Adaptation Strategy and Action Plan'; and informing the public through an information portal and outreach events. (Internet source C).

In **Lithuania**, the purpose of the adaptation strategy is modernization of the most important economic sectors (energy, industry, transport, agriculture); installation of eco-innovative technologies; decreasing the vulnerability of the main economic sectors which are vulnerable to an increase in oil prices and other energy security problems involving the use of fossil fuels and rational and sustainable use of resources (using new low carbon technologies, higher use of RES, reduction of energy consumption, construction of new intelligent, low-or zero-energy buildings, modernization of electricity grids), reducing air pollution to decrease of the negative health effects, creating sustainable agriculture and forestry, and preserving biodiversity (Internet source D).

The main program of **Latvia** is "Climate Change impacts on water environment in Latvia – KALME (2006–2009)". Its objectives are encompassed in its adaptation policy – a) analyzing the existing policy of adaptation to climate change in Latvia's water dimension; b) implementation – transforming the new knowledge produced by the Program into proposals for planning for national development; c) adaptation of environmental policy and other policies to climate change; and d) dialogue – promoting the practical implementation of Program outputs and facilitating dialogue between research on climate change impacts on water and governmental institutions, local governments, and businesses, depending on the research outcomes. Actual projects include: "Value of Latvian ecosystem and its dynamics in the influence of climate – EVIDEnT (2014–2017)"; and "Increasing territorial development planning capacities of planning regions and local governments of Latvia and elaboration of development planning documents (2013–2016)" (Internet source E).

The National Climate Change Adaptation Strategy of **Malta** aims to build upon the National Strategy for Policy and Abatement Measures Relating to the Reduction of Greenhouse Gas Emissions of 2009, in terms of governance and policy infrastructure. The National Climate Change Adaptation Strategy seeks to identify recommendations in various sectors which are vulnerable to climate change, such as water, agriculture, infrastructure, building, human health and tourism. It also addresses the financial impacts as well as sustainability issues. Malta has adopted the Climate Action Act, 2015 (CAP 543) to streamline Malta's commitments on climate change on both main fronts of climate action, namely mitigation and adaption, in a legally binding way. This Act aims to instil ownership across the board to fine-tune effective climate actions and governance. Specifically, in terms of adaptation the Climate Action Act, 2015 (CAP 543) dictates a process of conducting periodic reviews and updates of the National Adaptation Strategy. It also

foresees the inclusion of information on climate change's actual and projected impacts (Internet source F).

The National Adaptation Plan of **Slovakia** assumes following measures in particular fields/sectors (Ministry of Environment of the Slovak Republic 2004, pp. 6–8):

- Protecting the geological environment and soil of potentially vulnerable areas against landslides (adjust water regimes and ensure vegetation cover); increasing the inundation and retention capacity of the area; changing the water regime of non-irrigated soils; and infiltration belts.
- Hydrology and water management- decelerating water runoff from the river basin; implementation of measures for the effective use of water resources to ensure sustainability and to minimize the pollution of water resources by discharges of untreated or insufficiently treated municipal waste water.
- Biodiversity – strengthening of the natural regeneration of forests and their sustainable use; diversification of landscape and landscape structures; increasing the landscape connectivity (building of a green infrastructure, supporting the creation of corridors and stepping stones, elimination of the barrier effect of roads and railways, elimination of barriers in water streams); and systematic, long-term mapping, monitoring of population events and of invasive alien species.
- The urban environment – defining an urban structure of cities in order to allow better air circulation; supporting and ensuring the re-use of rainwater and wastewater; and ensuring and supporting the adaptation of transport and energy technology, materials, and infrastructure to climate change.
- Health – extending the network of monitoring stations to monitor the concentration of biological allergenic particles and creating and continuously maintaining public reporting and alerting the public to extreme weather events.
- Agriculture – protection of the biotopes and their integrated production and ecological stability; use of irrigation, with emphasis on irrigation efficiency and conservation of water; ensuring the traditional breeding of Slovak species.
- Forestry – measures supporting biodiversity, ecological stability and community service of the forest and improvement of forest management with respect to their adaptation to climate change.
- Transport – optimizing the design of roads with respect to climate change and maintaining a high frequency weather monitoring system and the issuance of timely alerts in endangered areas.
- Energy – increasing the safety of power plants.
- Tourism – transferring skiing activity to higher altitude centres and reorienting threatened winter resorts toward other activities.
- Disaster risk management – monitoring threats and risks, protecting critical infrastructure, and implementing a civil protection and crisis management system.

In **Slovenia**, since September 2014 the Ministry of Environment and Spatial Planning has been in charge of policy-making in the area of adaptation. The Law Amending the Environmental Protection Law regulates mainly matters related to climate change mitigation, while there is no specific legal basis for actions on adaptation. The main cross-sectoral strategic document that included adaptation measures was the Draft Strategy for the Transition of Slovenia to a Low-Carbon Society by 2060, produced in 2011 and scheduled for a second public consultation in March 2012 by the now dissolved Government Office for Climate Change. The Draft Strategy contains strategic guidelines for both mitigation and adaptation, which have since been followed through. In order to attain the long term goals of maintaining the vulnerability to the adverse effects of climate change at the present level, in view of the expected increase in exposure, the adaptation guidelines proposed in the Draft Strategy were aimed at increasing the resilience and adaptive capacity of society, economy, and nature in the following ways: through increasing the understanding of climate change, knowledge of its predictions, and knowledge concerning methods of adaptation; integrating adaptation objectives and measures into sectoral policies, programs and projects through sustainable spatial planning; strengthening the resilience of local communities by providing resources for adaptation measures; and finally raising awareness through training and education (Internet source G).

The **Hungarian** plan for adaptation to climate change focuses mainly on preventive measures and assumes (András 2011, pp. 31–32) the following:

- the use of fossil energy resources must be reduced;
- in the medium-term energy consumption must be maintained at the current level, and subsequently it must be significantly reduced;
- an energy conservation movement must be launched;
- fiscal policy must be re-designed with a view towards climate protection;
- the share of renewable energy must be increased to 186.5 PJ by 2020;
- requirements for cogeneration's suitability for use must become more stringent;
- rather than offering citizens in need financial compensation for rising energy prices, the affected segment of the public should be helped to save energy more efficiently;
- the lowest acceptable fuel efficiency standard applicable to the use of biomass for energy purposes must be increased;
- the support scheme for the production of electric power through renewable energy must be designed in a way that it allows for supplanting the greatest quantity of fossil fuels possible;
- the current share of public transportation must be maintained;
- combined transport needs to be developed and its share in total transport needs to be increased;
- urban and suburban public transportation must be developed;
- a road toll system must be established;

- waste management practices must be improved;
- large-scale recycling of products with high energy needs is necessary;
- waste consisting of foodstuffs must be directed towards use as biogas.

In **Bulgaria**, the adaptation plan (Ministry of Environment and Water Republic of Bulgaria 2012, pp. 69–79) is based on:

- The Environmental Protection Act (EPA) regulates the basic conditions and principles of the management of public relations with respect to environmental protection. The EPA establishes a scheme for trading greenhouse gas emissions;
- The Energy Act (EA) establishes the public actions associated with the activities of production, import and export, transmission, transit, and distribution of electricity, heat and natural gas, transmission of oil and oil products by pipelines, trade in electricity, heat and natural gas, and the powers of state bodies to define energy policy and to regulate and to exercise control. It designates the bodies responsible for carrying out the energy policy as well as the instruments underlying the energy policy.
- The Renewable Energy Act (REA) regulates the public actions associated with the production and consumption of electricity, thermal energy, and cooling energy from renewable sources, gas from renewable sources, and biofuels and energy from renewable sources in transport. The main purpose of this Act is to promote and support the production and consumption of energy and fuels from renewable sources.
- The Energy Efficiency Act (EEA) regulates the public actions relevant to the state policy for improving the energy efficiency of final energy consumption and the provision of energy services.
- The Clean Ambient Air Act regulates the limitation of emissions into the air from stationary sources and the quality requirements for liquid fuels – activities directly related to greenhouse gas emissions.
- The Forestry Act manages plans and programs, determines the admissible level of use of forest resources and offers guidelines to achieve the goals of forest management for a period of 10 years.
- The Special Planning Act (SPA) regulates the procedures for preparation, approval and amendment of general and detailed spatial development plans of settlements.
- The Agricultural Land Protection Act (ALPA) allows land use changes of agricultural land only in certain specific cases. The owners and the users of agricultural land are entitled to tax and credit preferences when implementing the mandatory limitation on agricultural land use as well as when implementing projects to restore and improve the fertility of agricultural land.
- The Agricultural Producers Support Act (APSA) regulates state support to farmers with regard to the implementation of the measures included in the National Plan for Agricultural and Rural Development.

- The Waste Management Act (WMA) lays down the requirements for the establishment of regional waste management systems.
- The Energy Strategy of the Republic of Bulgaria until 2020 covers four main areas: tackling adverse climate change; reducing the energy intensity of the economy and increasing energy efficiency; reducing the external dependency of the European Union on imported energy resources; and promoting economic growth and employment.

In July 2013 the **Romanian** Government adopted Romania's National Climate Change Strategy (2013–2020), the main aim of which was to provide an action framework and guidelines that will enable each sector to develop an individual action plan in line with the national strategic principles. The adaptation component addresses 13 sectors: industry; agriculture and fisheries; tourism; public health; construction and infrastructure; transport; water resources and flood protection; forestry; energy; biodiversity; insurance; recreational activities; and education. Complementary strategies to the NAS are the National Strategy on Drought Effects Mitigation, the Action Plan for Addressing Nitrate Pollution from Agricultural Sources, the National Plan for Irrigation Rehabilitation and Reform, the National strategy for the prevention of emergency situations, the National Strategy for Flood Risk Management in the medium- and long-term, River Basin Management Plans, the Master Plan for Coastal Protection and Restoration, the National Strategy for investments in the irrigation sector, and National strategic guidelines for the sustainable development of disadvantaged mountain areas (Internet source H).

5. Conclusions

In analyzing changes in weather conditions one can observe the following general features of the Eastern EU countries (EEA 2012, 20):

- Northern Europe (Lithuania, Latvia and Estonia): temperature rises much larger than the global average, decrease in snow, lake and river ice cover, increase in river flow, northward movement of species, increase in crop yields, decrease in energy demand for heating, increase in hydropower potential, risk of increasing damage from winter storms, and an increase in summer tourism.
- Central and Eastern Europe (Poland, Slovakia, Slovenia, Hungary, Bulgaria and Romania): increase in warm temperature extremes, decrease in summer precipitation, increase in water temperature, increasing risk of forest fires, decrease in the economic value of forests.
- Mediterranean region (Cyprus, Malta, Croatia): temperature rise much larger than the European average, decrease in annual precipitation, decrease in annual river flow, increasing risk of biodiversity loss, increasing risk of desertifi-

cation, decreasing demand for agriculture, decrease in crop yields, increasing risk of forest fires, increase in deaths from heat waves, decrease in summer tourism and a potential increase in other seasons.

All of the countries which were researched perceive the problem of progressive climate change, but the plans and adaptation strategies are in various stages of implementation. Countries such as the Czech Republic, Hungary, Bulgaria, Lithuania and Estonia limited their adaptation to mitigation and reducing carbon dioxide emissions (a low-carbon economy, reduced energy consumption, the use of alternative energy sources). The strategy of adaptation measures in countries such as Cyprus, Latvia, Malta, Slovakia, Slovenia, Romania and Poland assumes the necessity of preventive action and adaptation in key sectors of the economy. The strategies of these countries indicate the importance of carrying out adaptation measures not only at the central level but also at local levels, including in sensitive sectors such as agriculture, protection of forests, fishing and coastal water management. In addition, the strategies of Latvia, Poland, Slovenia and Romania stress the importance of education and dialogue between all economic entities. Implementation of the National Climate Change Adaptation Strategy is possible through inter-ministerial cooperation. In this regard, implementation of climate-specific actions on adaptation is undertaken by the relevant Ministries or departments, depending on the different sectors in which action is being taken.

The countries that will bear the brunt of the negative impacts of climate change are Cyprus, Malta, Bulgaria and Poland. These countries have recorded the highest climate change index, the greatest losses in estimated GDP, household welfare and land losses, and lower incomes in the agricultural sector and tourism. Among the countries in the worst situation, only the Bulgarian plan focuses on mitigation issues alongside adjustment.

With appropriate adaptation measures, dry countries as Lithuania, Latvia and Estonia can take advantage of the coming changes in weather conditions. One can notice a shift in the productivity of the agricultural sector and tourism from south to north.

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Streszczenie

ANALIZA PORÓWNAWCZA INICJATYW DZIAŁAŃ ADAPTACYJNYCH DO ZMIAN KLIMATU PODEJMOWANYCH W POLSCE I W PAŃSTWACH WSCHODNICH UE

Zmiany klimatu to jedno z największych współczesnych zagrożeń dla naszej planety w wymiarze środowiskowym, społecznym i gospodarczym. Towarzyszy im zmiana w systemach podtrzymujących życie na Ziemi, a ich skutki będą odczuwalne w nadchodzących dziesięcioleciach. Rozwój krajowej polityki adaptacji (strategii i/lub planu) jest instrumentem, który dostarcza niezbędnych wskazówek do prowadzenia działań adaptacyjnych w zależności od sektora, regionu czy poziomu decyzji. Celem niniejszego artykułu jest porównanie stopnia wpływu zmian klimatu na gospodarkę krajów Wschodnich Unii Europejskiej i porównanie krajowych strategii adaptacji do zmian klimatu w wybranych państwach Europy Wschodniej i w Polsce. Z przeprowadzonego badania wynika, że regionami, które najdotkliwiej odczują negatywne oddziaływanie zmian klimatu są Cypr, Malta, Bułgaria i Polska, to te kraje odnotowały najwyższy „climatechange index", największe straty w szacowanym PKB, straty w dobrobycie gospodarstw domowych, straty ziemi, mniejszych dochodach w branży rolnej i turystycznej. Przy odpowiednich działań adaptacyjnych, kraje takie jak Liwa, Łotwa i Estonia mogą skorzystać z nadchodzących zmian panujących warunków atmosferycznych. Można zaobserwować przesunięcie się produktywności branży rolnej i turystycznej z południa na północ.

***Słowa kluczowe**: zmiany klimatu, prognozy i koszty zmian klimatu, działania adaptacyjne do zmian klimatu.*