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Wielokryterialna ocena realizacji koncepcji zrównoważonego rozwoju na terytorium polsko-białorusko-ukraińskiego pogranicza za pomocą podejścia MAMIMCA

The MAMIMCA approach: multi-criteria evaluation of the implementation of the sustainable development concept in the Polish-Belarusian-Ukrainian border area

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Agenda

Wprowadzenie / Introduction

Studium przypadku / Case study

Otrzymane rezultaty / Results

Zakończenie – podsumowanie / Conclusions

The research leading to these results received funding from the 'Excellence Initiative – Debuts' under the 'Excellence Initiative - Research University' programme of the Nicolaus Copernicus University in Toruń (Grant number 2586/2020 IDUB).

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Introduction / Wprowadzenie

- The aim of this speech is:
  - to present the author's methodology of sustainable development measurement in a time and space perspective with the use of appropriately selected set of multi-criteria methods,
  - to carry out empirical verification of the proposed approach to the evaluation of implementation of the sustainable development conception in Polish, Belarusian and Ukrainian border regions in the context of social, economic and environmental order.
- Celem wystąpienia jest:
  - zaprezentowanie autorskiej metodyki pomiaru zrównoważonego rozwoju w ujęciu czasowo-przestrzennym z wykorzystaniem odpowiednio dobranego zestawu metod wielokryterialnych,
  - przeprowadzenie empirycznej weryfikacji zaproponowanego podejścia do oceny realizacji koncepcji zrównoważonego rozwoju w przygranicznych regionach Polski, Białorusi i Ukrainy w kontekście ładu społecznego, gospodarczego i środowiskowego.

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Introduction

- The Polish-Belarusian-Ukrainian border region, located at the external border of the European Union, constitutes an interesting research area.
- In May 2004 the eastern and north-eastern border of Poland (including the Polish-Belarusian part of 418 km and the Polish-Ukrainian part of 535 km) became the outer border of the EU, and in December 2007 – the border of the extended Schengen zone.
- This has had a significant influence on the socioeconomic situation of the Polish border areas, as well as on their neighbourhood on the other side of the border.
- This area has become even more sensitive and interesting in view of the current international situation:
    - the migration crisis on the border of Belarus with the EU (2021),
    - the war in Ukraine (2022).

Both these events have dramatically changed the political, social and economic situation in the Polish-Belarusian-Ukrainian border area.

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Introduction

- In this presentation the implementation of the sustainable development concept of six regions in the Polish-Belarusian-Ukrainian border area is examined.
- An original approach called MAMIMCA – Multiple Assessment Multiple Importance Multiple Criteria Analysis (Górecka 2020) – is adopted to order and compare the regions' performance.
- In the evaluation:
  - three different aspects are taken into account (social, economic and environmental),
  - four well-established multi-criteria decision aiding methods are used (PROMETHEE II and EXPROM II with veto thresholds, modified ELECTRE III and TOPSIS),
  - and four different vectors of weights are applied.
- In order to examine the dynamics of the regions' performance, the research covers the years 2014 and 2018.

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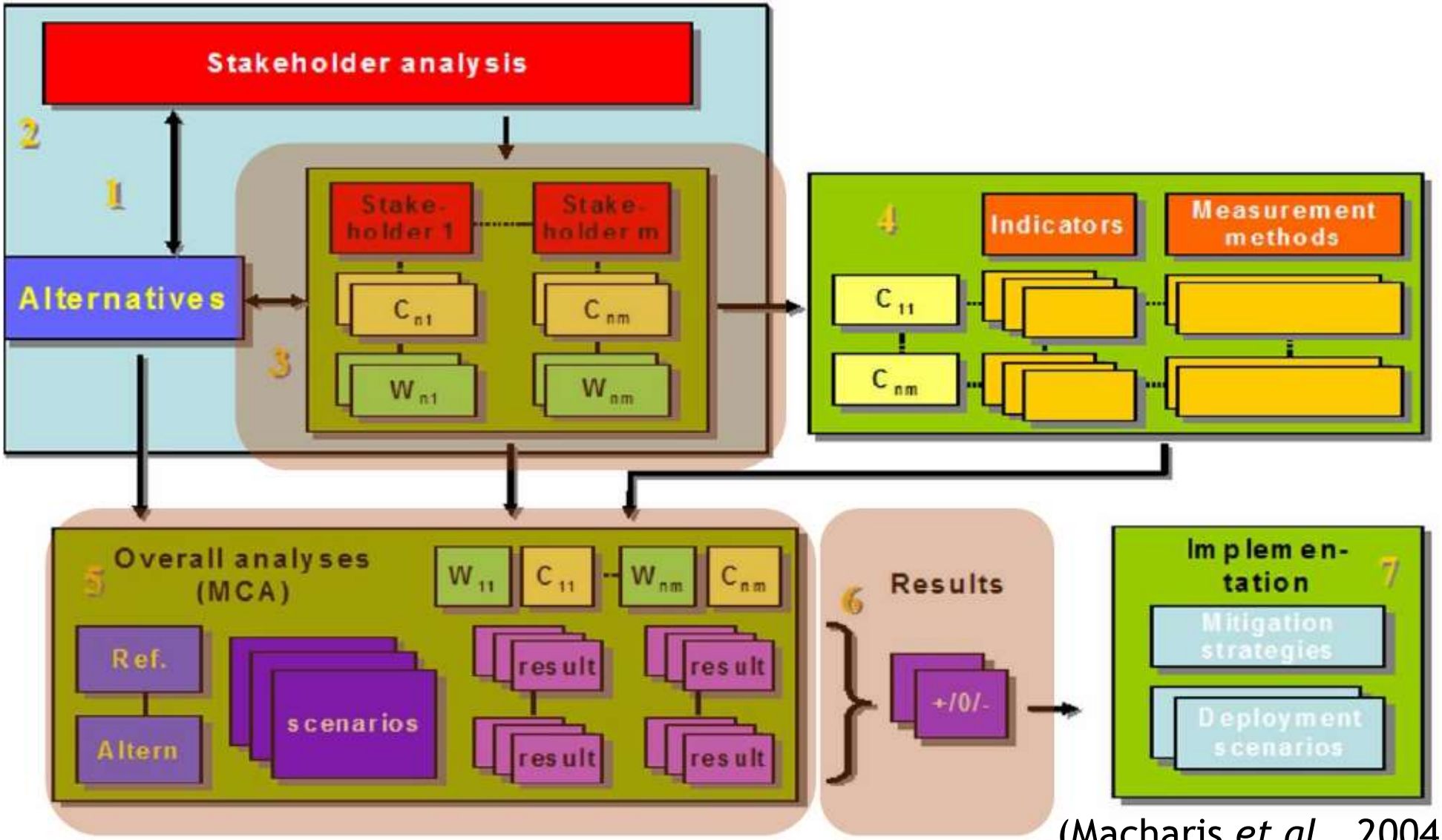
Introduction:
MAMCA – multi-actor multi-criteria analysis



(Macharis *et al.*, 2004)

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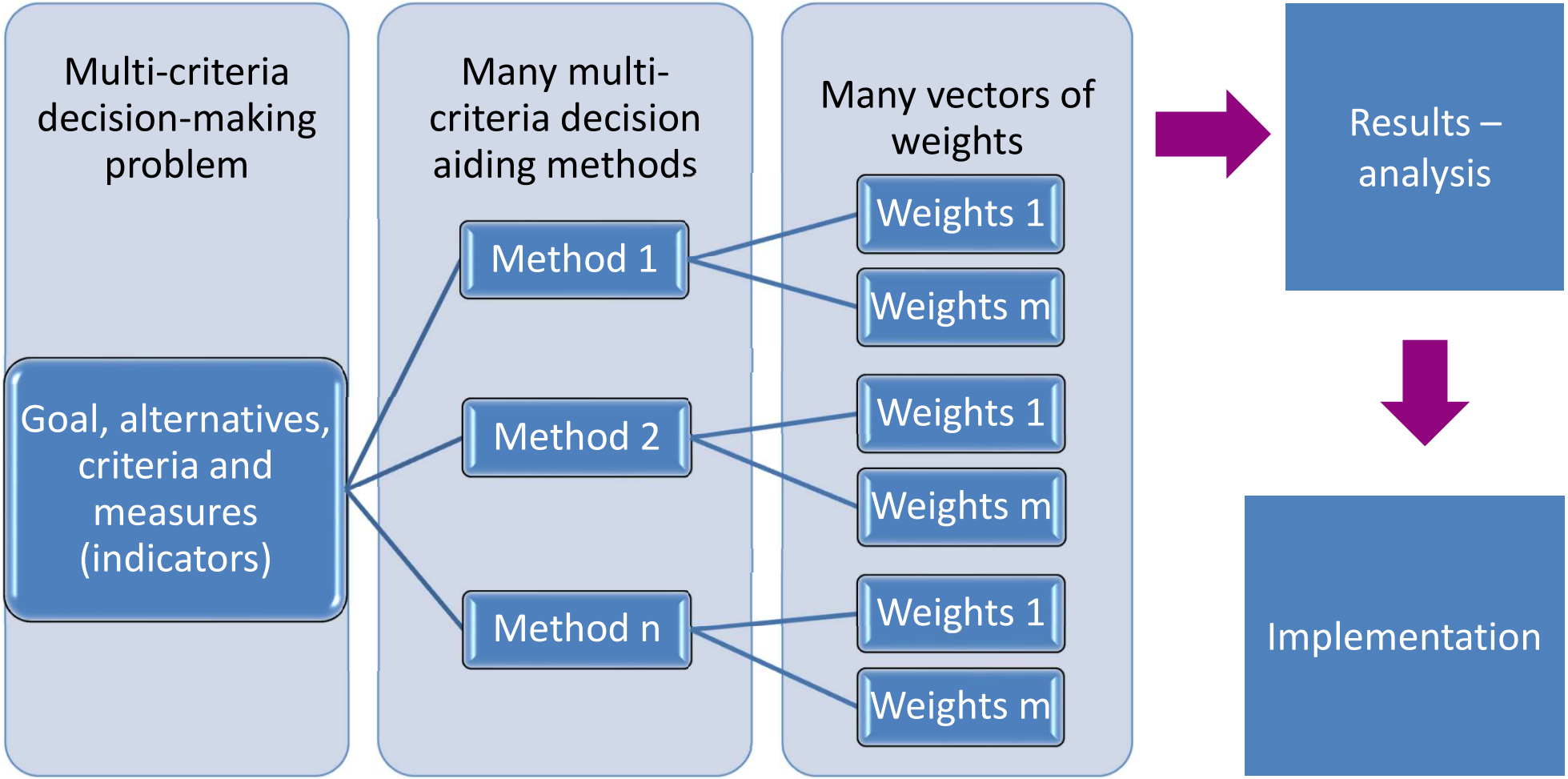
Introduction: MAMIMCA - Multiple Assessment Multiple Importance Multiple Criteria Analysis



(Górecka, 2020)

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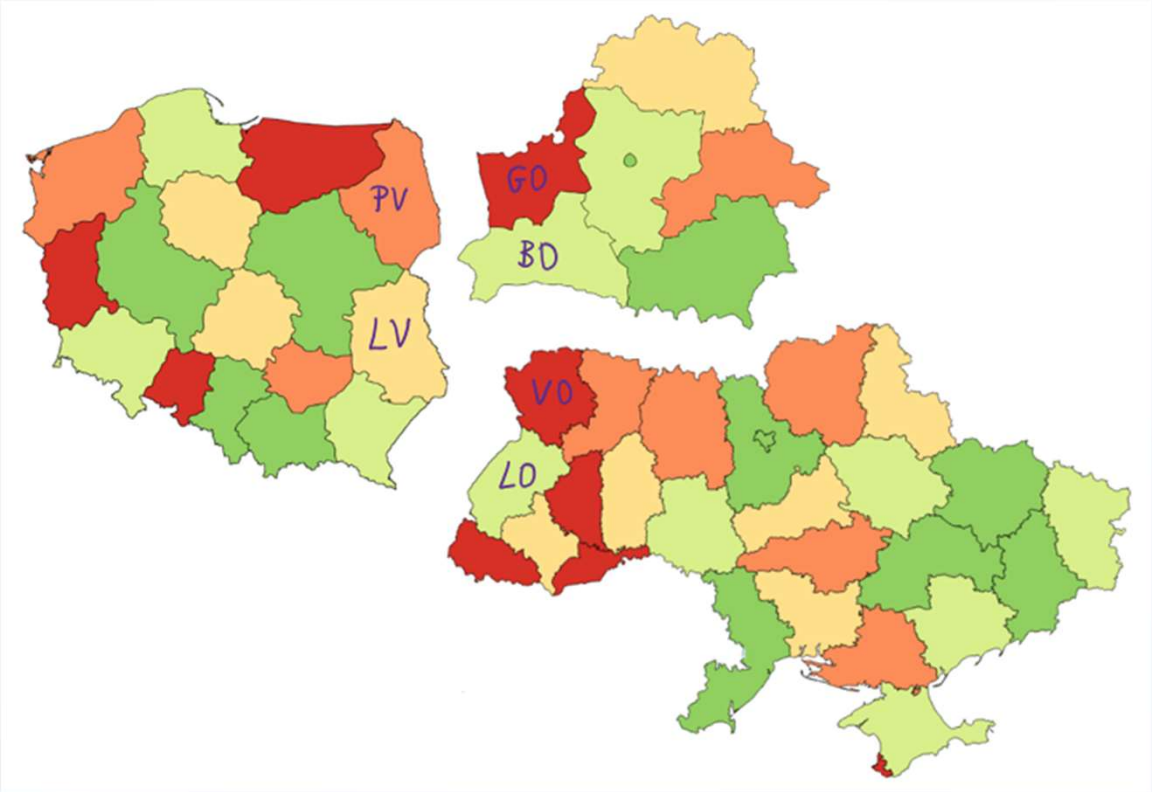
Case study



Statistical data were obtained from: the Polish Central Statistical Office, the State Statistics Service of Ukraine, the Main Statistical Office in Lviv Region, the Main Statistical Office in Volyn Region, and Global Forest Watch.

The complex assessment of the level of sustainable development of six administrative units of the Polish-Belarusian-Ukrainian border zone covered three general criteria represented by thirteen measures.

A considerable barrier in the choice of measures was methodological, terminological and temporal comparability of data: their number and shape were influenced by the availability of equivalent information. Thus, the basis for calculations was the years 2014 and 2018.

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Case study

- **Evaluation of the Polish-Belarusian-Ukrainian border area – goal and general criteria (areas):**

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Case study

Environmental area

- Share of forest land in land area (%)
- Wastes generation (t/km^2)
- Air emissions (t/km^2)

Economic area

- Gross regional product per capita (EUR)
- Registered unemployed (%)
- Research and development expenditure per capita (EUR)
- Avarage monthly wages (EUR)

Social area

- Natural increase/ decrease of population per 1,000 population
- Infant mortality rates (‰)
- Net migration per 1,000 population
- Physicians per 10,000 population
- Number of dwellings per 1,000 population
- Crimes per 1,000 population

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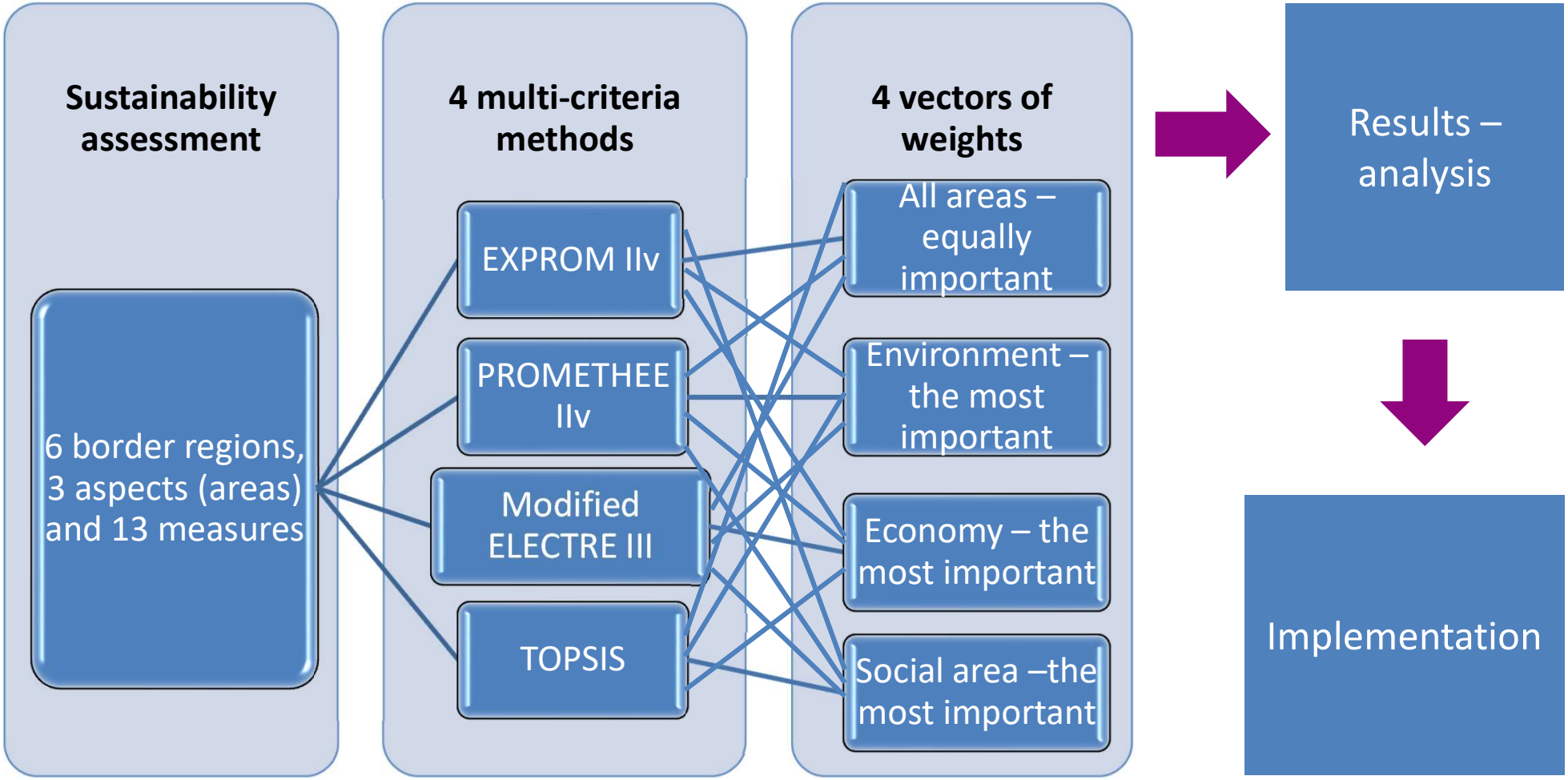
Case study – MAMIMCA



(Górecka, 2020)

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Case study

Model of preferences

f_k	Measure	Min/ max	w_{1k}	w_{2k}	w_{3k}	w_{4k}	q_k	p_k	v_k
f_1	Share of forest land in land area (%)	max	0.111	0.167	0.083	0.083	1.0	5.0	20.0
f_2	Wastes generation (t/km^2)	min	0.111	0.167	0.083	0.083	15.0	30.0	250.0
f_3	Air emissions (t/km^2)	min	0.111	0.167	0.083	0.083	0.5	1.0	5.0
f_4	Gross regional product per capita (EUR)	max	0.083	0.063	0.125	0.063	500.0	1000.0	6000.0
f_5	Registered unemployed (%)	min	0.083	0.063	0.125	0.063	1.0	2.5	10.0
f_6	Research and development expenditure per capita (EUR)	max	0.083	0.063	0.125	0.063	5.0	15.0	75.0
f_7	Average monthly wages (EUR)	max	0.083	0.063	0.125	0.063	60.0	120.0	700.0
f_8	Natural increase/ decrease of population per 1,000 population	max	0.056	0.042	0.042	0.083	0.2	0.5	5.0
f_9	Infant mortality rates (‰)	min	0.056	0.042	0.042	0.083	0.1	0.2	4.0
f_{10}	Net migration per 1,000 population	max	0.056	0.042	0.042	0.083	0.2	0.4	5.0
f_{11}	Physicians per 10,000 population	max	0.056	0.042	0.042	0.083	2.0	5.0	30.0
f_{12}	Number of dwellings per 1,000 population	max	0.056	0.042	0.042	0.083	10.0	20.0	100.0
f_{13}	Crimes per 1,000 population	min	0.056	0.042	0.042	0.083	0.8	3.0	10.0

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Case study

Performance matrix 2014

f_k	Measure/ Region	Lublin voivodeship	Podlaskie voivodeship	Brest oblast	Grodno oblast	Volyn oblast	Lviv oblast
f_1	Share of forest land in land area (%)	23.2	30.7	36.4	34.9	37.8	34.0
f_2	Wastes generation (t/km^2)	280.0	76.4	59.8	90.0	29.0	152.2
f_3	Air emissions (t/km^2)	1.1	0.5	1.6	2.3	0.2	4.6
f_4	Gross regional product per capita (EUR)	7460.26	7735.46	4079.85	4772.94	1477.31	1828.18
f_5	Registered unemployed (%)	12.6	12.9	0.6	0.6	1.8	1.5
f_6	Research and development expenditure per capita (EUR)	76.83	46.82	2.95	2.38	0.62	6.64
f_7	Average monthly wages (EUR)	815.44	800.10	400.45	410.49	173.14	188.41
f_8	Natural increase/ decrease of population per 1,000 population	-1.1	-0.7	0.7	-1.2	0.9	-0.9
f_9	Infant mortality rates (‰)	4.2	4.5	4.4	3.2	6.0	8.5
f_{10}	Net migration per 1,000 population	-2.7	-1.9	-0.5	-0.9	0.7	0.6
f_{11}	Physicians per 10,000 population	24.2	24.7	37.1	48.1	37.4	56.2
f_{12}	Number of dwellings per 1,000 population	352.0	366.1	427.3	453.9	346.3	355.1
f_{13}	Crimes per 1,000 population	17.2	15.5	6.3	6.5	7.4	8,5

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Case study

Performance matrix 2018

f_k	Measure/ Region	Lublin voivodeship	Podlaskie voivodeship	Brest oblast	Grodno oblast	Volyn oblast	Lviv oblast
f_1	Share of forest land in land area (%)	23.4	31.0	36.4	35.7	37.7	34.4
f_2	Wastes generation (t/km^2)	313.2	58.6	74.6	118.4	27.6	98.0
f_3	Air emissions (t/km^2)	0.9	0.4	1.6	2.3	0.3	4.9
f_4	Gross regional product per capita (EUR)	8804.92	9305.21	3476.24	4035.99	1813.58	2183.03
f_5	Registered unemployed (%)	8.0	7.7	0.4	0.4	2.0	1.3
f_6	Research and development expenditure per capita (EUR)	89.35	66.10	3.33	2.79	0.55	5.26
f_7	Average monthly wages (EUR)	952.84	954.01	345.05	346.51	227.86	248.92
f_8	Natural increase/ decrease of population per 1,000 population	-1.7	-1.0	-1.6	-3.7	-2.4	-3.8
f_9	Infant mortality rates (‰)	4.2	4.2	2.0	3.7	7.6	7.0
f_{10}	Net migration per 1,000 population	-2.5	-1.7	-1.4	-0.5	-0.7	0.7
f_{11}	Physicians per 10,000 population	24.7	26.1	41.1	52.9	38.6	52.7
f_{12}	Number of dwellings per 1,000 population	368.9	384.8	446.7	469.4	364.8	366.7
f_{13}	Crimes per 1,000 population	16.2	14.5	5.1	6.0	10.4	10.2

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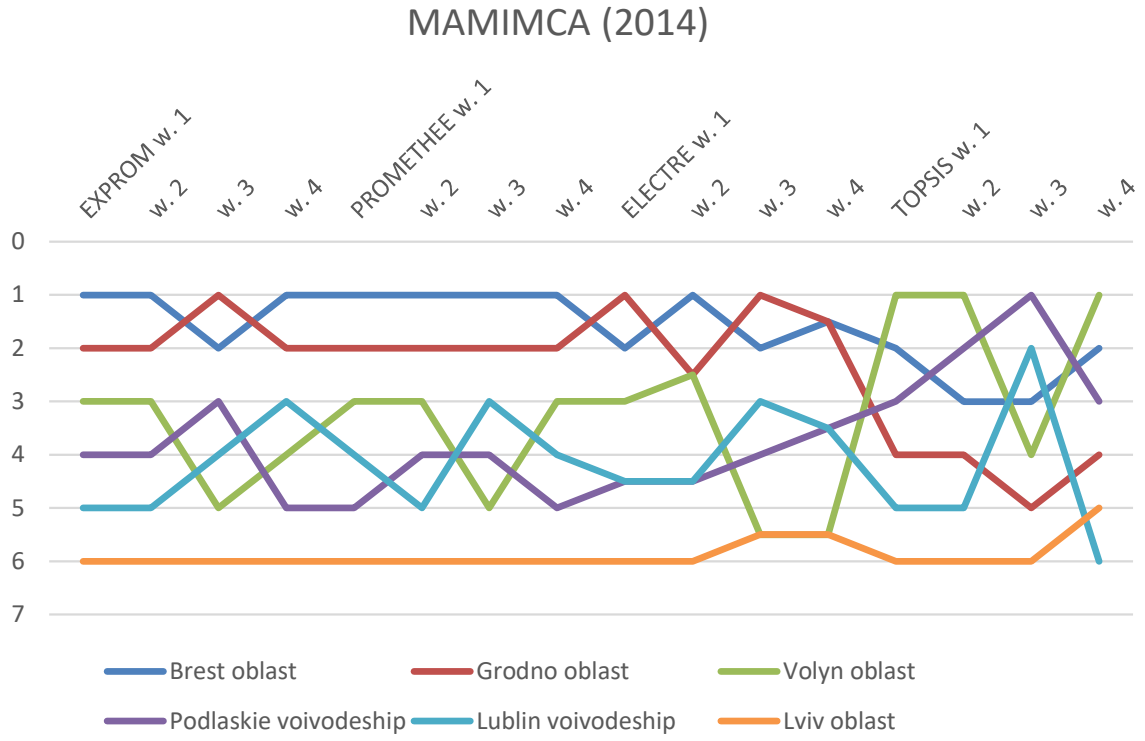
Results

MAMIMCA – results 2014

No.	Region	EXPROM IIv				PROMETHEE IIv				modified ELECTRE III				TOPSIS				Sum	Weighted sum
		w. 1	w. 2	w. 3	w. 4	w. 1	w. 2	w. 3	w. 4	w. 1	w. 2	w. 3	w. 4	w. 1	w. 2	w. 3	w. 4		
1	Brest oblast	1	1	2	1	1	1	1	1	2	1	2	1,5	2	3	3	2	25,5	30,3
2	Grodno oblast	2	2	1	2	2	2	2	2	1	2,5	1	1,5	4	4	5	4	38,0	48,0
3	Volyn oblast	3	3	5	4	3	3	5	3	3	2,5	5,5	5,5	1	1	4	1	52,5	44,3
4	Podlaskie voivodeship	4	4	3	5	5	4	4	5	4,5	4,5	4	3,5	3	2	1	3	59,5	51,7
5	Lublin voivodeship	5	5	4	3	4	5	3	4	4,5	4,5	3	3,5	5	5	2	6	66,5	68,3
6	Lviv oblast	6	6	6	6	6	6	6	6	6	6	5,5	5,5	6	6	6	5	94,0	93,3



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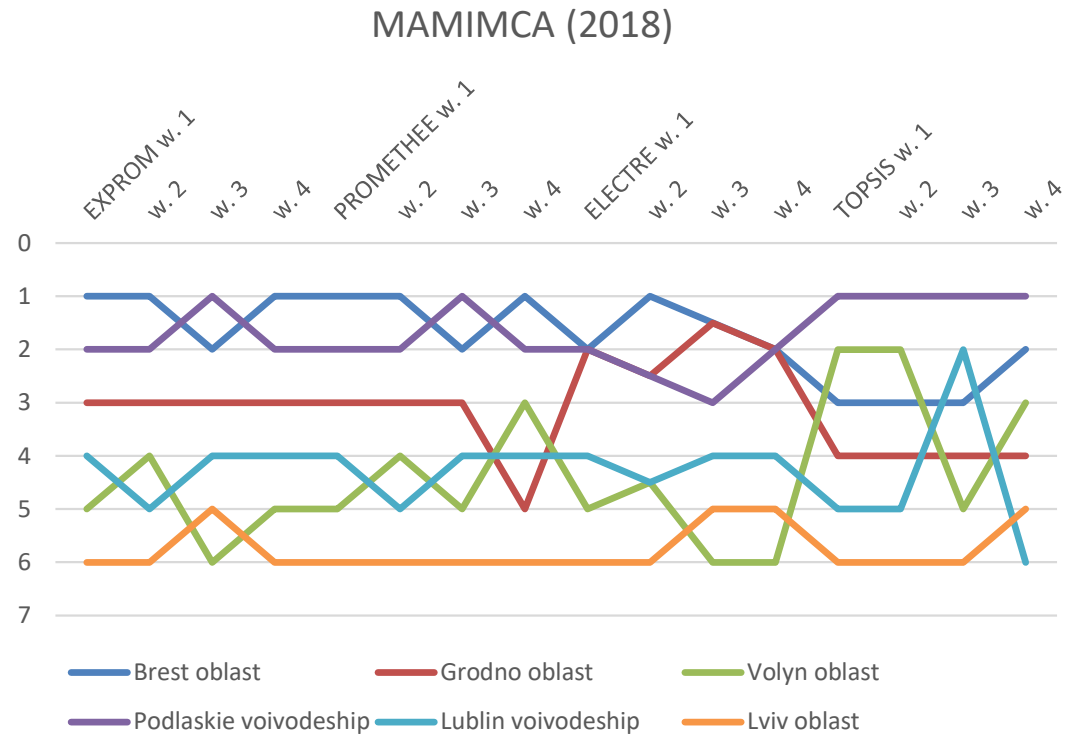
Results

MAMIMCA – results 2018

No.	Region	EXPROM IIv				PROMETHEE IIv				modified ELECTRE III				TOPSIS				Sum	Weighted sum
		w. 1	w. 2	w. 3	w. 4	w. 1	w. 2	w. 3	w. 4	w. 1	w. 2	w. 3	w. 4	w. 1	w. 2	w. 3	w. 4		
1	Brest oblast	1	1	2	1	1	1	2	1	2	1	1,5	2	3	3	3	2	27,5	33,0
2	Grodno oblast	3	3	3	3	3	3	3	5	2	2,5	1,5	2	4	4	4	4	50,0	54,7
3	Volyn oblast	5	4	6	5	5	4	5	3	5	4,5	6	6	2	2	5	3	70,5	63,0
4	Podlaskie voivodeship	2	2	1	2	2	2	1	2	2	2,5	3	2	1	1	1	1	27,5	23,7
5	Lublin voivodeship	4	5	4	4	4	5	4	4	4	4,5	4	4	5	5	2	6	68,5	69,7
6	Lviv oblast	6	6	5	6	6	6	6	6	6	6	5	5	6	6	6	5	92,0	92,0



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Results

MIMCA approach with TOPSIS for 2014 and 2018

No.	Weights I		Weights II		Weights III		Weights IV	
	Region	Distance	Region	Distance	Region	Distance	Region	Distance
1	Podlaskie voivodeship 2018	0.692	Podlaskie voivodeship 2018	0.779	Podlaskie voivodeship 2018	0.681	Volyn oblast 2014	0.664
2	Volyn oblast 2014	0.617	Volyn oblast 2014	0.732	Lublin voivodeship 2018	0.609	Brest oblast 2014	0.647
3	Brest oblast 2014	0.607	Volyn oblast 2018	0.707	Brest oblast 2014	0.521	Podlaskie voivodeship 2018	0.602
4	Podlaskie voivodeship 2014	0.589	Podlaskie voivodeship 2014	0.703	Podlaskie voivodeship 2014	0.519	Grodno oblast 2014	0.568
5	Volyn oblast 2018	0.571	Brest oblast 2014	0.685	Lublin voivodeship 2014	0.514	Brest oblast 2018	0.553
6	Brest oblast 2018	0.564	Brest oblast 2018	0.653	Grodno oblast 2014	0.501	Podlaskie voivodeship 2014	0.538
7	Grodno oblast 2014	0.553	Grodno oblast 2014	0.605	Brest oblast 2018	0.497	Volyn oblast 2018	0.531
8	Lublin voivodeship 2018	0.522	Grodno oblast 2018	0.561	Volyn oblast 2014	0.494	Lviv oblast 2014	0.507
9	Grodno oblast 2018	0.508	Lublin voivodeship 2018	0.486	Grodno oblast 2018	0.476	Grodno oblast 2018	0.491
10	Lublin voivodeship 2014	0.480	Lublin voivodeship 2014	0.478	Volyn oblast 2018	0.472	Lublin voivodeship 2018	0.461
11	Lviv oblast 2014	0.432	Lviv oblast 2018	0.464	Lviv oblast 2018	0.420	Lviv oblast 2018	0.455
12	Lviv oblast 2018	0.431	Lviv oblast 2014	0.349	Lviv oblast 2014	0.414	Lublin voivodeship 2014	0.437

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Conclusions

- Given that the sustainability assessment of the administrative units requires a structured approach, a novel functional framework for such evaluation was presented in this speech. The research used a set of appropriately selected multi-criteria techniques, namely:
    - PROMETHEE II with veto threshold (Górecka, 2013, 2014; Górecka, Pietrzak, 2012),
    - EXPROM II with veto threshold (Górecka, 2014, 2015; Górecka, Szałucka, 2013),
    - modified ELECTRE III (Górecka, 2009),
    - TOPSIS (Hwang, Yoon, 1981; Lai, Liu, Hwang, 1994).
- These were combined with the modified MAMCA methodology (Macharis, 2000, 2004, 2005; Macharis et al., 2012) in the form of the MAMIMCA approach - Multiple Assessment Multiple Importance Multiple Criteria Analysis (Górecka, 2020).

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Conclusions

- The analysis performed has illustrated that the best border region in terms of sustainable development in 2014 was the Brest oblast. In 2018, it was joined by the Podlaskie voivodeship (which was the third worst sustainable region four years earlier).
- In turn, the worst border region from the point of view of sustainable development in both analysed years turned out to be the Lviv oblast which, however, improved a little bit its sustainability in four years.

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Thank you for your attention
Bardzo dziękuję za uwagę