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Potential Applicability of Vulnerability Assessments in the Western Balkan Countries

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Abstract.
The Western Balkan (WB) region is one of the relatively vulnerable parts of the continent to climate change: it faces several challenges today and will face potential problems (e.g., increasing risks of flash floods, sea-level rise, droughts, heatwaves, forest fires, etc.) over the coming decades, too. Proper adaptation to these challenges must play a decisive role in sectoral and local decision-making of these counties. Risk and vulnerability assessments, based partly on geographic information systems with map contents, can be one of the potential tools to find proper responses to climate change impacts in European countries. The main problem statement of the article emphasizes the low weight of these analytical decision-support tools in WB countries' climate and development policies. It examines what types of vulnerability assessments are helpful in WB countries and whether their results show significant territorial differences in given states. To answer these questions, through two case studies, we used a combination of the IPCC- and impact chain-based CIVAS model and complex indicator development methods from the international literature and the Hungarian NAGIS system. Our analyses are principally territorial assessments: they focus on comparing regional/local territories/destinations and identifying relative territorial differences. Through these, we intend to contribute to the recognition of the usefulness of complex vulnerability approaches in WB countries for evaluating climate change risks and identifying future policy responses. The results in the two case studies show that definite territorial inequalities exist in exposure indicators in both analyzed WB countries. Similarly, significant spatial differences in the sensitivity and adaptability factors are also expected. The suggested vulnerability approach proposed here can help countries develop appropriate climate adaptation responses.

Keywords: climate change, climate adaptation, strategic planning, sectoral vulnerability, tourism, heat waves

jel CLASSIFICATION codes

Q54; Q58; R58

1. Introduction

1.1. Relevance of the problem

The challenges caused by climate change (CC) impacts are key geo-economic issues in Europe. CC is perhaps one of the most important phenomena that have recently dominated the discourse of sustainable development [25]. Beyond the changes in climatic factors, weather extremities' growing intensity and frequency can also be experienced. All of these have serious environmental, social and economic consequences, causing the growing vulnerability of the exposed sectors/communities. Additionally (or rather: principally), CC occurs in the geographical space. Its several spatial impacts deepen further existing regional and settlement network-related differences and economic/social inequalities.

Moreover, adaptation has become the centre of attention worldwide due to the processes mentioned above. This recently gained significance can be observed also within the international climate policy. Local causes and impacts of CC have attracted attention since the mid-to-late 1990s. The 2001 Marrakech Accords was the first Conference of Parties to the UNFCCC that recognized adaptation as an essential climate policy element (The Accord created even new funding mechanisms to help developing nations to adapt to climate impacts). From 2005 onwards, developed countries began writing and adopting comprehensive national adaptation strategies as long-term plans to reduce climate impacts [32]. International and national programmes to develop local climate action plans and support decision-making appeared, though this "first generation" of local plans dealt rather with mitigation than adaptation [2, 12, 32]. Adaptation only emerged at the beginning of the 2010s as an essential and complementary response to CC and significantly increased its weight in developed countries [2, 24]. Finally, the Paris Agreement in 2015 nominated adaptation as an equal policy pillar with mitigation [31, 9].

Nevertheless, there is a significant difference between the two climate policy pillars. While Greenhouse Gas (GHG) emission causes problems worldwide, and its management requires global cooperation and negotiations, adaptation has to find local answers for particular local climate impacts. Local communities implement these responses through local planning and actions.

Consequently, local, regional, and even national CC adaptation planning need proper methods to identify local climate impacts on affected stakeholders/elements, avoid maladaptation, and find suitable solutions. In practice, vulnerability assessments are one of the main tools for these functions. Regarding the recent literatures' implications, the effects of CC, the vulnerability to them, and the examination of adaptability are increasingly becoming the focus of attention. In the last one and a half decade, many studies have dealt with the complex issue of vulnerability related to CC [15], its modelling e.g. [21], or its particular sectoral aspects [10]. The examinations are territorial: they trace relative territorial differences. The Intergovernmental Panel on Climate Change (IPCC) defined vulnerability as "*the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes*" [15]. Vulnerability can vary depending on a system's characteristics (exposure, sensitivity, and adaptive capacity). A newer assessment framework introduced in the IPCC 5th Assessment Report focuses on risks, as opposed to the previous IPCC methodology, which put vulnerabilities at the centre [16, 17; 18]. However, due to methodological inconsistencies and difficulties of the newer methodologies, in practical evaluations and planning the vulnerability assessment framework introduced in the IPCC 4th Assessment Report is still frequently applied(E.g. in the COPERNICUS and the NAGiS.) [26].

The Western Balkan (WB) region is one of the relatively vulnerable parts of Europe. However, its countries are not among the most significant GHG emitters of the continent, so in their case, rather adaptation to and preparation for CC impacts and consequences are more important issues than emission reduction. In the Balkans, highly vulnerable sectors (e.g., agriculture, energy infrastructure, maritime economies, tourism) and territories (e.g., mountainous areas, landlocked plains and coastal zones) emerge. WB countries' national strategies and geopolitical positions cannot be managed appropriately without consciously considering the issue of CC, especially climate adaptation, in their strategic planning and development policy activities. These climate impacts, socio-economic consequences, and sectoral vulnerabilities may occur primarily locally (in municipalities and smaller areas). Consequently, municipal leaders and micro-regional/regional decision-makers of the WB countries (and even national policymakers who coordinate the works of the formers) have a fundamental interest in properly planned adaptation steps. For this, they require better, more profound, up-to-date knowledge of the issues. Optimally, this information can be provided by climate risk and vulnerability analyses. Their mapped results about known and expected impacts of and vulnerability to CC are often provided by decision support (DS) systems based on GIS. However, the use of these methods and tools in the WB countries seems to be significantly lower than in the Western and Northern European regions.

The aim and objectives of this study reflect on this recognized problem: it provides local and national level actors with an example of useable methodology to make them capable of assessing their respective vulnerability to CC in a relatively quantitative way. According to our hypothesis, despite the actuality and weight of CC-related challenges in the WB countries, and the growing emergence of vulnerable territories and sectors in the region, only few national-level vulnerability assessments and related decision-supporting tools appear in the region. Our research questions are as follows: what type of vulnerability and risk assessments deal with the WB countries and according to them, which are the most common vulnerable sectors and thematic fields in the region? Finally: could the impact chain-based CIVAS model serve as a proper tool for the WB countries, showing an adequate spatial picture of climate vulnerability? The three RQs are answered by subchapters 3.1, 3.2, and 3.3.

2. Background and methodology

2.1. Background of the research

As part of the Implementation Framework of the Kyoto Protocol (of the United Nations Framework Convention on Climate Change) a programme implementing bilateral cooperation between developed and developing countries that ratified the Paris Agreement, started. In Hungary, the Ministry of Technology and Industry participated in this initiative to implement bilateral climate-proofing actions in the WB countries. In the framework of this support, a series of research started in 2018 in Hungary, aiming at overviewing the situation of adaptation policy-related decision-making activities in the WB countries and offering suitable solutions for the region's countries based on European and Hungarian practices. Parallel with this project and party building on its results we also analysed the countries' vulnerability assessment activities. This article introduces the first results of these analyses.

2.2. Logic of the study and contribution to knowledge

The structure of the article follows the logic of our research. In the first phase, we made a brief survey of climate exposure, sensitivity and adaptive capacity-related data availability and existing vulnerability analyses in the WB countries to determine whether a proper basis in these states for complex vulnerability assessments exist or not. Secondly, international best practices of web-based climate change-oriented decision support systems were also overviewed, focusing on Europe and North America, the two leading geographical regions in the field of adaptation-oriented GIS activities. As a result, we identified the most suitable vulnerability assessment methods out of these DS systems that can be used properly in the WB countries' circumstances. In the third phase, we also conducted draft vulnerability analyses for chosen sectors/vulnerability topics in given WB countries to test the applicability of vulnerability assessment methodologies in practice. Finally, in the "Conclusions" part, we summarize our findings, the limitations of the analyses, and the potential further directions of the research. The intended contribution to knowledge is the recommended assessment methodology for the WB countries' different sectoral vulnerability topics and the practical testing of these methods.

2.3. The applied methodology in the case studies

The study reveals how vulnerability assessments are generally helpful for a more profound understanding of local/regional/national level territorial differences in different thematic cases. For this, the article introduces two case studies, using the deductive approach mentioned by Yin to prove the practical usage of the impact chain-based vulnerability assessment concept in different cases [33]. The first pilot study focuses on the vulnerability of Albania's tourism sector; the second on heat wave related vulnerability of Montenegro.

Regarding their methodology, these assessments show several common points. As for the **climatological background**, we turned to the Hungarian National Adaptation Geo-Information System (NAGIS) (For the reasons please see subchapter 3.2.). For implementing climate vulnerability assessments, especially for the exposure analysis parts, adequate data about the current and future climate situation is needed, so beyond the present situation analysis, the case studies tried to model also conditions of future periods. The analyses concentrate on three-time windows: beyond the present time, for the 2021-2050, and the 2071-2100 periods. Regarding climatic data, two types of them were used: on the one hand, the climatological measurements (grid data) for the past/present climate from the DanubeClim database; on the other hand, climate model data from the CORDEX database for the future climate (The spatial resolution of climate data was 0.1° in DanubeClim and 0.11° in CORDEX.). The data were identified according to the combination of 2 climatological models and two climate change scenarios (The models were the EC-EARTH and the CNRM-CM5; meanwhile, the scenarios were chosen out of the four new-generation Representative Concentration Pathways of the IPCC's 5th Assessment Report (AR5): RCP4.5 and RCP8.5. In the future, these can be completed by new pathways of the 6th Assessment Report (AR6).). The parallel use of more models and scenarios (and their combinations) guarantees the elimination of uncertainties deriving from naturally contradicting model results and helps to elaborate more realistic projections through comparisons of similar results.

The primary objective of examining climate vulnerability is to explore how a region is at risk of CC. Hence vulnerability analyses have a territorial focus: they compare regions and define relative territorial differences. Local impacts of CC influence social, economic, and environmental systems. Therefore, the territorial impacts of CC should also be examined in the context of sensitivity and adaptability of the analysed systems [28].

Similarly to the internationally known DPSIR (Drivers, pressures, state, impact and response model of interventions.) model, the Climate Impact and Vulnerability Assessment Scheme – CIVAS – model was designed to provide a unified methodological framework for quantifiable climate impact assessments. (CIVAS was developed by the CLAVIER project (Climate Change and Variability: Impact in Central and Eastern Europe). It was supported by the European Commission's 6th Framework Programme (GOCE Contract Number: 037013). Its method examined the effects of climate change on the natural and constructed environment. The CIVAS model was based on an approach published in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change of 2007. Accordingly, the vulnerability is caused by the expected effects and the lack of adaptive capacity, and the magnitude of the expected impact is determined by exposure and sensitivity [15]. This method is also used in the Hungarian NAGiS (nagis.hu).) [19]. The essence of the model is to define several critical factors for CC phenomena and their effects:

1. Exposure (through climate models) shows how climate changes at the local/regional level. In contrast to sensitivity (characteristic of the affected sides), exposure only depends on the specific geographic area. It is calculated from measured (present) and modelled (future) climate data.

2. Sensitivity presents the weather-dependent behaviour of the affected stakeholders and analyses how they react to impacts. Sensitivity is considered independent of CC and mainly characterized by the affected system. Information from the literature can help to determine it.

3. The potential impact as both characteristic of a geographic location and the affected system is a linear mathematical combination of standardized/neutralized sensitivity and exposure indicators.

4. Adaptability represents the strength and character of the socio-economic responses of the local community/economy.

5. Vulnerability is a complex indicator that combines expected impact indicators with standardized adaptability data.

The application of the CIVAS model has two main phases: 1) definition of the main effects, indicators, and calculation procedures; 2) carrying out calculations, evaluations, and analyses. In case of evaluations in WB countries, the use of these methods is highly recommended.

3. Results: WEAK presence of vulnerability assessments and DS activities in the WB countries; but useable methodology emerges from the NAGiS

3.1. Surveying data and DS activities in the WB countries

To overview the climate adaptation-related data availability, vulnerability and risk assessment activities and decision support situation in the WB countries, we turned to different types of sources: national climate adaptation reports/assessments and situation analyses available about WB countries (the list of them can be found at the end of the Bibliography). According to the findings, the impacts of CC affect every country in the Western Balkans. As Table 1 shows, flash floods, floods, vulnerability to geological hazards, and heat waves affect each WB countries, while other challenges emerge in specific geographic areas of the peninsula.

The region's forests are affected by heatwaves, forest fires and decrease in biodiversity, especially in the countries where forest coverage is significant (e.g., Montenegro, Albania, and Bosnia and Herzegovina). The coastal areas are vulnerable to CC due to sea-level rise, heatwaves, and coastal erosion – Croatia, Albania, and Montenegro are significantly affected. The mountainous and hilly parts suffer from flash floods, meanwhile in the landlocked, plain territories inland water inundations can cause serious problems (Table 1).

Due to the harmful **impacts of CC**, several sectors are generally vulnerable in the region. Montenegro, Croatia, and Albania suffer from current and expected climate

Table 1: Climate impacts in the Western Balkans by countries (gray coloured cells indicate existing climate impacts according to the overviewed studies; while white cells indicate the lack of information about related climate impacts) Source: edited and collected by the authors.

	forest fires	geological hazards	sea-level rise, coastal degradation	flash floods	floods	inland water inundation	heat-waves, droughts	drinking water reserves' sensitivity
ALB								
BYH								
CRO								
KOS								
MON								
MAC								
SRB								

impacts on the tourism sector, the leading economic sector in these countries, so its damages could seriously affect national economies. Other sectors that are especially exposed: agriculture due to droughts and floods (in landlocked countries such as Kosovo, North Macedonia, and Serbia, with vast amounts of arable lands); nature protection due to high biodiversity losses; water management due to the extremities: sometimes droughts, sometimes floods/flash floods cause problems. The energy infrastructure is also highly exposed to weather extremities (Table 2).

Particular geographical areas (e.g., mountain ranges, river valleys, coastal areas, or cities) are also exceptionally vulnerable. These cases show the geographic diversity of the Western Balkans. Tables 1 and 2 show that the region is vulnerable to CC impacts both in general and in sectoral terms, so **national climate policies must elaborate adaptation strategies and actions** to handle these challenges. The research revealed that several WB countries actually prepared climate strategies at the national level according to the EU accession requirements (Table 3).

All countries but Bosnia and Herzegovina have climate strategies for the 2020-2030 decade. These strategies focus more on mitigation than adaptation. All of the investigated countries elaborated their National Adaptation Strategies (NAS), while the number of explicit adaptation programmes (NAP) is significantly smaller. As for **vulnerability assessment-related data**, meteorological, climatological, and hydrogeological data are primarily available from meteorological or hydrogeological services' sites, but mainly for a restricted period and limited territories. Obtaining data in printed/electronic form for more territories and extended time frames requires further negotiations with national authorities. Much weaker availability can be observed in connection with other vulnerability assessment-related data, particularly sensitivity and adaptability-oriented territorial socio-economic and environmental or infrastructural ones from different sectors at lower territorial levels.

Table 2: Most vulnerable sectors to CC in the Western Balkans (gray coloured cells show sectors which are affected by the adverse impacts of CC impacts according to the overviewed studies, while white cells indicate the lack of information about climate impacts on a given sector) Source: edited and collected by the authors.

	Forestry	Maritime policy	Tourism	Agriculture	Nature protection	Water provision	Energy production	Water management	Settlement development
ALB									
BYH									
CRO									
KOS									
MON									
MAC									
SRB									

The results show that though almost all countries (especially Albania, Croatia, Montenegro, North Macedonia, and Serbia) have conducted **vulnerability assessments** during the recent decade; these are, however, initiated /required mostly by international organizations (European Commission, UNFCCC, and UNEP). Consequently, the elaboration of these documents is funded and coordinated frequently by these international organizations. Only a few domestically initiated assessments were conducted, which indicates that **although the problem of CC has been recognized in the WB countries, it is still a low-priority area.**

Our survey also found several websites in each country serving as **decision support systems**. However, they are primarily specific sector- or dissemination-oriented sites (e.g., GeoHrvatska and Croatian Water in Croatia or the thematic websites of the RGZ Ministry in Serbia). Only the meteorological service's website provides GIS-based climatological data visualization in Kosovo. All in all, there are no really comprehensive national horizontal, adaptation-oriented web-based decision-support systems with map visualization and measurable datasets in the WB countries that deal with thematic adaptation fields, let alone with more than one topic (Table 3).

3.2. Overviewing international DS system practices

In the second phase of the research, to establish a proper basis for the later recommendations, an overview of international (good) practices was conducted to choose the most suitable vulnerability assessment methodologies for the WB countries. This phase introduced examples of the international web-based analytical DS practices and analysed existing solutions. According to the results, several main types of decision-supporting websites could be identified. 1) Some websites collect existing knowledge (articles, books, project descriptions) from the field of climate adaptation without any concrete analyses or assessments. 2) Other websites frequently provide users with forums and knowledge-sharing solutions on online platforms. 3) Another type collects the links of and information about other GIS-based systems: securing the availability of different tools instead of providing a specific application; 4) the fourth type especially offers analysable and measurable, vulnerability-oriented database and data visualization by maps. Out of these types, the latter is the most appropriate source for our later analyses.

Most of the analysed websites/applications were from Europe and North America due to the two region's benchmark nature in CC related GIS activities. Some websites concentrate on specific sectors (e.g., the American CERAT) or territories (e.g., the Californian CalAdapt). Other types serve as holistic/comprehensive solutions (e.g., NAGiS in Hungary or HORA Hazards in Austria). The examples from EU member states mainly help information exchange, knowledge sharing, and interactive communication between partners. Meanwhile, overseas (primarily North American) solutions more frequently serve as a specific decision support system that builds on a database and map-based GIS solutions.

All in all, several examples were collected. Finally, after some narrowing, the ten most promising tools (The Urban Adaptation Support Tool, the Climate-ADAPT Map Viewer and Urban Vulnerability Map Book application, the UKCIP Adaptation Wizard, the CLIMSAVE Impact Assessment Model and the Hungarian National Adaptation Geo-Information System from Europe; and the CalAdapt, the Climate Wizard, the EPA website and the CREAT Climate Scenarios Projection Map; the Climate.gov and the Data Snapshots applications from the USA.) were chosen and examined in more detail, according to different aspects (1) objective and operation principle of the tools, through which motivations, goals, and audience were analysed; 2) professional climate policy content (the covered sectors, vulnerability topics) of the websites; 3) spatial level of the examined adaptation fields (spatial resolution of the professional content, the availability or the lack of the subjects' spatial features on the websites); 4) users' environment (web-based IT environment: clarity, structure and design elements); 5) presence of decision support tools on the website (database, text contents, graphs, map availability, the possibility for the users to generate own information); 6) territorial level of decision support, and 7) available best practices that can be used in WB countries.). Regarding the results, numerous good examples can be utilized in the WB countries if they would like to

Table 3: The overview of the adaptation and climate policy's state of the art in the countries of the Western Balkans. Collected and edited by the authors.

	Data availability	Availability of vulnerability assessments	Climate Change Strategy	National Adaptation Strategy	National Adaptation Programme	Adaptation DS systems
Albania	Limited data availability	Yes, in the Third National Communication of the Republic of Albania under the United Nations Framework Convention on Climate Change (2016) (UNFCCC)	National Climate Change Strategy (2019)	Strategjia e Ndryshimeve Klimatike dhe Planet e Veprimit, 2019 Tirane	National Adaptation Planning (NAP) to Climate Change in Albania Framework for the Country Process (2017)	No (only meteorological service website)
Bosnia and Herzegovina	Limited data availability	Yes, in the Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change (2016) (UNFCCC)	Not available	Climate Change Adaptation and Low-Emission Development Strategy for Bosnia and Herzegovina, 2013	No (under process)	No (only meteorological service website)
Croatia	Meteorological data: in tabular form, but not for the proper length of time and only for a small area; hydrological data available on some topics	Yes: Results of the Climate Modelling on the High Performance Computing Velebit System; Second, Third and Fourth National Communication of the Republic of Croatia under the United Nations Framework Convention on Climate Change (2006) (UNFCCC)	Low Carbon Development of the Republic of Croatia until 2030 and with an outlook at 2050	Strategy for adaptation to climate change of the Republic of Croatia	No (under process) it will build on Climate Change Adaptation and Low Emission Development Strategy (2013)	No (only meteorological service website)
Kosovo	Limited data availability	Not available	Climate Change Strategy 2019-2028	Strategija Per Ndryshimet Klimatike 2019-2028 Plani I Veprimit Per Nryshime Klimatike 2019-2021	Action Plan for the Climate Change Strategy (2016)	Yes; GeoHrvatska, Croatian Water
Montenegro	Hydrological and meteorological data is available, MonStat also will able provides data for a DS system	Yes; 17 assessments, including; Montenegro's Third National Communication on Climate Change (2020) (UNFCCC); CAMP–SB, CAMP Montenegro: Defining the Coastal Setback (2013); Podgorica Vulnerability Assessment (2015); Coastal Area Management Programme Montenegro (2006–2015); ICZM, National strategy for integrated coastal zone management (2015), etc.	National Climate Change Strategy (NCCS) to 2030 (2015)	Izrada Nacionale Strategije O Klimatskim Promjenama Do 2030. Godine	No (under process)	No (only meteorological service website)

start to conduct vulnerability assessments and to establish vulnerability-oriented and

Table 3: The overview of the adaptation and climate policy's state of the art in the countries of the Western Balkans. Collected and edited by the authors.

North Macedonia	Limited data availability	Yes, in the Third National Communication on CC (2014) (UNFCCC)	National Climate Change Strategy (NCCS) to 2030 (2015)	Long-term Strategy on Climate Action and Action Plan, 2021	Not available	No (only meteorological service website)
Serbia	Meteorological yearbooks, for extended periods and extended meteorological stations	Yes, in the Second National Communication of the Republic of Serbia under the United Nations Framework Convention on Climate Change (2017 (UNFCCC)	Low Carbon Development Strategy with action plan (Long-term Strategy) (2019)	Climate Strategy & Action Plan Republic of Serbia	Serbia's First National Adaptation Plan (2015)	Yes; Two sectoral decision support systems of the RGZ.

climate adaptation-related decision support systems. Nevertheless, out of the analysed websites, the NAGiS seems to be the most helpful example for the WB countries. It offers multifunctional data systems, data visualization, and information for users about different vulnerability topics. As opposed to the other websites, NAGiS does not concentrate on a given, single vulnerability topic or sector but focuses on a series of them (NAGiS covers topics from flash floods through water reserves, heat waves, storm damages to tourism's complex vulnerability, rainwater management, or geological hazards.).

Regarding its functioning and internal logic, out of the overviewed examples, NAGiS is the simplest. It has the most overviewable dataset, the most understandable structure and the most implementable methodological and climatological background due to its relatively clear impact chain analyses. It also covers those vulnerability topics that are the most frequent also in the Balkan Peninsula. Consequently, our pilot vulnerability studies in the WB region were building on the logical and methodological foundations of the NAGiS system.

3.3. Pilot vulnerability assessments

The article presents implemented vulnerability assessments as examples of a chosen impact chain-based vulnerability analysis method. We chose two topics (tourism's climate vulnerability and heat waves) that are major challenges in two pilot countries (Montenegro; Albania), and pilot analyses were conducted for these. The two chosen thematic areas are among the most affected by CC in the WB region. The pilots provide comparable results between the two countries, and their complex assessment methodology has been already tested in NAGiS. Based on the examples of the two pilot analyses, in the WB countries' in the future further vulnerability assessments can be conducted.

3.3.1. Tourism's complex climate vulnerability in Albania

For the climate vulnerability assessment of the Albanian tourism sector, we suggested a combination of the CIVAS model (already introduced in the article) and complex indicator development methods. Tourism-centered climate vulnerability assessments reveal how CC impacts threaten a given destination. The analysis is principally a territorial assessment: it focuses on comparing regional/local destinations and identifies relative territorial differences. Since the effects of climate change appear in the local social, economic, and environmental dimensions, it is recommended to examine the territorial effects at the micro regional or municipal level [28].

Applying the model, **the starting point is the identification of local impacts and consequences** based on related literature, local interviews, and statistic data. After examining the potential and existing impacts, the analysis goes on with **identifying the objects affected by CC.** In case of tourism we can focus on tourism products, so we enlist and classify tourism types. Sensitivity and adaptability indicators can be defined later for these categories.

The basis of our examination can be Albania's actual and recent tourism development strategies. According to the documents prepared during the last one and a half decades, three main pillars stand out as main products [7, 22, 30, 20, 1]. Even a particular strategic goal deals with product development in the actual Albanian national tourism development strategy, declaring three main pillars – *coastal, natural,* and *thematic tourism* types (Coastal tourism speaks for itself. The „natural" group comprises eco- and active tourism-oriented types, while the group „thematic" comprises mainly the cultural heritage, business, and health tourism branches.). Additionally, considering the Albanian partners' responses during the project, they also identified three main groups of tourism products in Albania: *Coastal Tourism Product* - coastal beach tourism, navies; *Natural Tourism Product* - mountain tourism, ecotourism, coastal active tourism; and *Thematic Tourism* - including several specific forms such as agritourism, event and business tourism, cultural, gastronomic and health tourism. As we can see, this classification is almost the same (or very similar) as those that emerged in the above-introduced strategies, with the three main pillars: **coastal, eco & active and cultural heritage tourism**.

The first step of using the CIVAS model is the **identification of exposure indicators**. During the analysis, exposure aspects were examined through complex indices in an integrated way. In this phase, we suggest using the complex tourism indices formerly applied in the NAGiS (for detailed description of the methodology see [29, 14]. Out of the three NAGiS indices (An advantage of the CIT (Climate Indicator of Tourism) is that it makes tourism type-specific vulnerability analyses possible. The mTCI (modified Tourism Climate Index) can be considered a more sophisticated version of the TCI (Tourism Climate Index) method, but its calculation is nearly as complicated as that of the CIT. It requires among other things the calculation of Physical Equivalent Temperature (PET). During the analysis there were no available PET data for Albania.), due to data availability constraints (e.g. special data needed by mTCI and CIT could not be received from Albania), we recommend applying the TCI with its simpler methodology. For creating the index we used data obtainable from Albania. The necessary datasets were: the day comfort index (T_{max} and RH_{min}); the daily comfort index ($T_{average}$ and $RH_{average}$); the daily precipitation (mm); the daily duration of sunshine (hour); and the daily average wind speed (m/s) (T average means the daily average temperature; RHaverage the daily average relative humidity and Tmax the daily maximum temperature.).

Narrative and cartographic outputs of our analysis are thematic maps in county (or in other words prefecture, the NUTS3 level of Albania) resolution at the national level. The analyses concentrated on three time windows: beyond present time situation analysis both for the 2021-2050 and the 2071-2100 periods. Grid (and based on these, county-level) climate exposure data were identified according to the combination of 2 meteorological models (EC-EARTH, CNRM-CM5) and two climate change scenarios chosen out of the four new-generation Representative Concentration Pathways of the 5th Assessment Report (AR5) of IPCC: the moderately optimistic RCP4.5 and the pessimistic RCP8.5. For the mentioned time windows, thematic maps and analytical tables were prepared about climate exposure.

Identification of exposure indicators occurred in the form of TCI's regional territorial averages. Raw climate data and projections were defined for grid points on the territory of Albania. The grid data's averages were projected to territorial units (counties/prefectures). Territorial averages were calculated after grid data having weighted by territory – for this, we needed the polygon file representing grid points, so we had to assign a territory for each grid point (These territories were created as Thiessen polygons, which are polygons around point-like FC (feature class) elements. Any point in the polygon area is closer to the FC point in the polygon than any other FC point.).

We know which polygon part (as a cross-section of the counties and polygons) belongs to which county, how big their area is, and what the exact value of the grid is. We calculate an average weighted by territory for the counties out of these values. The TCI values were identified for counties in a monthly break. Out of these, different periodical averages were calculated for the three different tourism types for the three time windows (In the case of the sea- and lakeside beach tourism, the calculation was based on data of the main season (June-August); eco-and active tourism calculated with the average of the March-November period, and the city-break tourism's calculation was based on the whole 12-month average.).

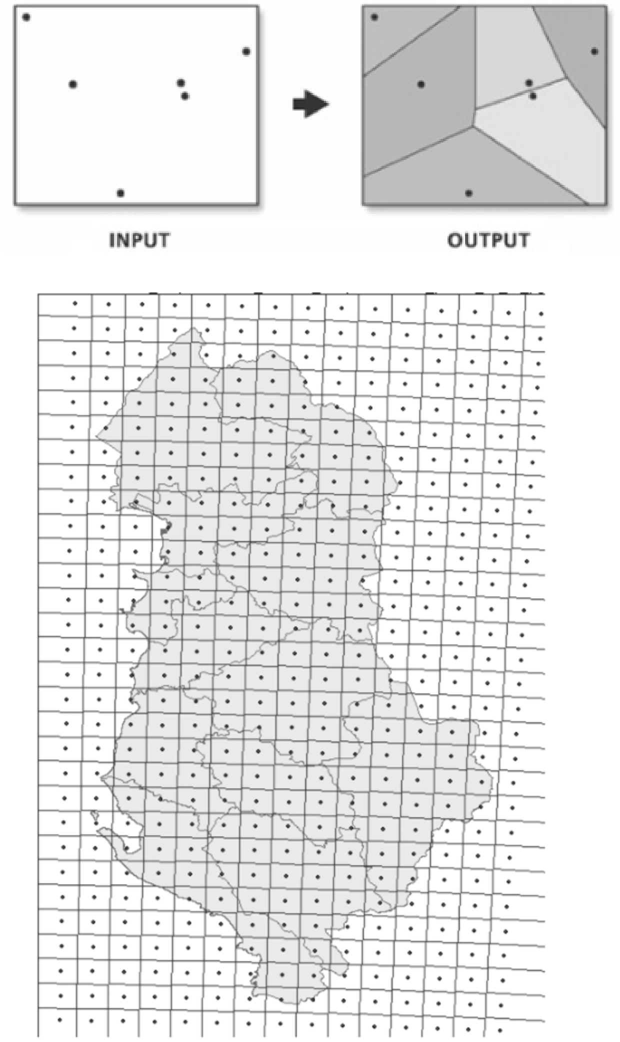

Figure 1: Creation of territorial averages of climate raw data for Albania using grind points and Thiessen polygons. Source: HMGS, 2020.

Unlike typical CIVAS assessments' exposure parts, the applied TCI indices are not negative ones: the higher their values are, the more favourable comfort is indicated for consumers of the given tourism product. The values are dispersed between 0 and 100; values above 80 represent basically favourable; values between 60 and 80 optimal/average/moderate, and values below 60 unfavourable conditions.

Due to data availability, our vulnerability assessment had to halt after the exposure phase. Regarding the further steps we suggest our methodology also for the future completion of the Albanian tourism sector's vulnerability assessment. During this, two presumptions of CIVAS methodology have to be applied: 1) sensitivity is independent of the geographical location; 2) sensitivity does not change during time due to CC, so the analysis calculates with constant sensitivity in a given geographical area. Consequently, sensitivity depends only on the affected side (in our case, the supply spectrum of the destination). During the examination, we presume that due to the territorially differentiated sensitivity, climate change has different impacts on different territories. The different tourism activities (=products) react to climatic changes with different sensitivity simultaneously.

Consequently a particular group of sensitivity indicators can be identified for each of the three tourism types. To create **complex sensitivity indicators** from these groups of indices, we can use one of the examples available in the European literature, an analogy for the Tourism Penetration Index. The index was elaborated by an ESPON (2006) study [8], and its first application in Hungary [27] was based on that.

The mathematical combination of exposure and sensitivity indicators can be used **to specify expected impacts**. The first step is to make the calculated exposure and sensitivity indicators dimensionless through standardization or normalization (values of the standardized or normalized indicators must between 0–100 or 0–1). These dimensionless values can be added together linearly. The results of their combinations will be the expected impact indicators.

Indicators can also describe the **adaptive capacity** for each tourism product, similar to sensitivity calculations. The complex adaptability indicator comprises socio-economic indices (e.g. revenues, income, and education) of a region and characteristics of the regional tourism sector, trying to demonstrate the strength and character of adaptation responses of the local society and economy.

Finally, **vulnerability** can be defined as the combination of impact and adaptability indicators. Besides the already dimensionless impact indicators, the adaptability indicators have also to be made dimensionless, by the standardization or normalization method mentioned above. As an additional step, dimensionless indicators of adaptability should be multiplied by -1 to adjust the low and high values of the indicators to the low and high values of exposure and sensitivity (The higher the sensitivity indicator the less suitable, the situation is; meanwhile the higher, the adaptive capacity data the more suitable is, the situation.). These dimensionless values can be added together linearly. The results of their combinations are the expected vulnerability indicators.

According to the analysed climate model – climate scenario combinations, Albania's tourism sector is and will be exposed to CC. By the end of the century, some destinations' and products' situation might improve while others deteriorate. Currently, the

Figure 2: TCI values of Albania's counties for beach tourism for 1971-2000 period (the first row) and for 2071-2100 (the second and third rows). Calculations are based on the CNRM-CM5 climate model (left) and EC-EARTH climate model (right), RCP4.5 scenario (second row), and RCP8.5 scenario (third row). Source: HMGS, 2020.

temperature and precipitation conditions provide favourable circumstances principally for beach tourism; meanwhile, active and city-break tourism has rather optimal (but, of course, appropriate) conditions. Progressing in time, though (in the case of active and city-break tourism), some catching-up processes can be observed, with improving climate conditions in the country's landlocked and mountainous regions and commencing position changes between the favourable-unfavourable categories in the case of the beach tourism. These tendencies are caused by the expected warming-up and desertification processes during the next century (centuries). However, it is not worth drawing too profound conclusions from the exposure study alone, as we will see in the Conclusions.

3.3.2. Impact of heatwaves in Montenegro

The correlation between temperature and health effects in Western European cities was demonstrated in the international literature, particularly in terms of mortality [11, 6, 5]. In contrast, minimal research results are available for South-Eastern Europe. No figures have been published about the additional deaths attributable to heat/heatwaves in Montenegro. **We aimed to formulate methodological recommendations for assessing the impacts of heat waves in the country and determining the data requirements for the investigations.**

The NAGiS system contains average summer temperature and the number of heatwave days as the leading climatic exposure indicators of heat wave vulnerability. Excess mortality caused by heat waves is also contained in the NAGiS heat wave layer group. The purpose of creating the maps and data tables was to present the excess mortality for the present and expected future periods and to make the data usable for analyses aiming at the estimation of CC effects. The analyses were made from a database interpolated to a regular NAGiS grid network based on meteorological measurements, using the data series of the ALADIN-Climate climate model representing a moderately optimistic scenario. To characterize the present period, based on the daily average temperature data observed between 2005 and 2014 and the daily mortality data of the population, analyses were carried out at the micro regional and county level to determine the excess deaths attributable to heat.

Exposure indicators similar to those in Hungary may also be created for Montenegro, taking into account the general characteristics of the country's climate. Heat waves occur most probably during the summer season, due to the combination of increased warming and periods without precipitation. Below we examine the expected change in the temperature in the summer season for the territory of Montenegro, based on climate data from the CORDEX database.

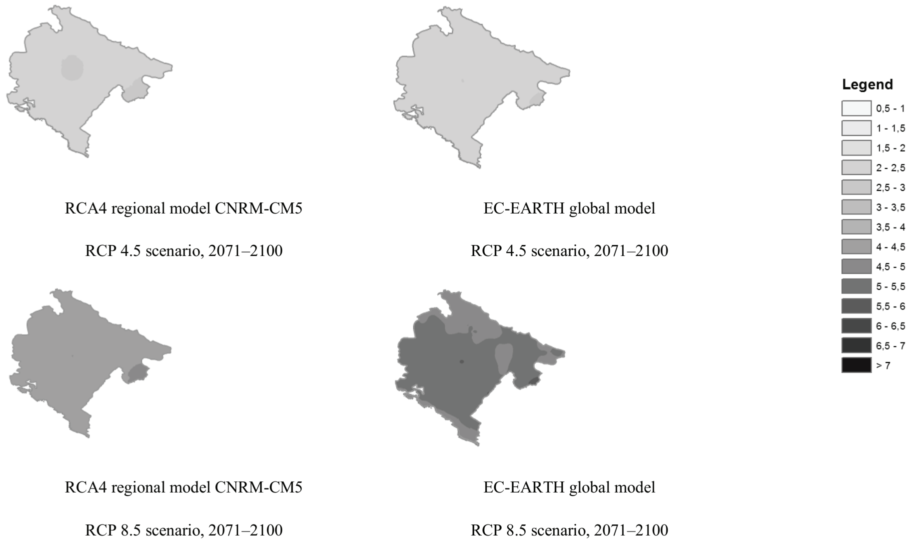

Figure 3: The expected change in summer temperature (°C) for the period 2021–2050 in Montenegro, based on RCA4 regional model simulations CNRM-CM5 (left) and EC–EARTH (right) global model data based on RCP 4.5 (top) and RCP Based on the 8.5 (bottom) scenarios Source: own construction, based on HMGS (2018).

Based on model simulations, the expected summer temperature rise is almost homogeneous in all of Montenegro. According to the simulations based on the RCP 4.5 scenario, the increase is around 1.5 °C by the middle of the century and around 2.5 °C by the end of the century. Simulations based on RCP 8.5 show a more significant increase in temperature (Figure ??). At the end of the century it can reach up to 6 °C in some areas, which strongly increases the risk of heat waves (Figure 3) [13].

Based on the introduced data, the future **exposure** parameter must be the change in the number of heatwave days. The heatwave days are when the daily mean temperature exceeds the threshold and the mortality rate rises faster (Figure 5). The **sensitivity** can be described as changes in daily mortality data, and the **impact** of heatwaves is the excess mortality on heatwave days. The excess mortality can be calculated as the difference between the daily mortality on days with a higher mean temperature than the threshold value and the daily mean expected mortality. The degree of adaptive capacity must also be defined to determine the vulnerability. To this, it is necessary to examine society's health measures and health conditions. During the study's preparation, it was impossible to explore the aspects of sensitivity and adaptability in Montenegro particularly, so it is necessary to develop the research on this topic further.

The association between temperature and mortality shows a characteristic J or U shape; in the „warmer" part of the curve, the correlation is linear above a threshold value. The slope of the line represents the impact of heat on a given population. This can be described by the „Relative Risk" estimate presented as the percent increase

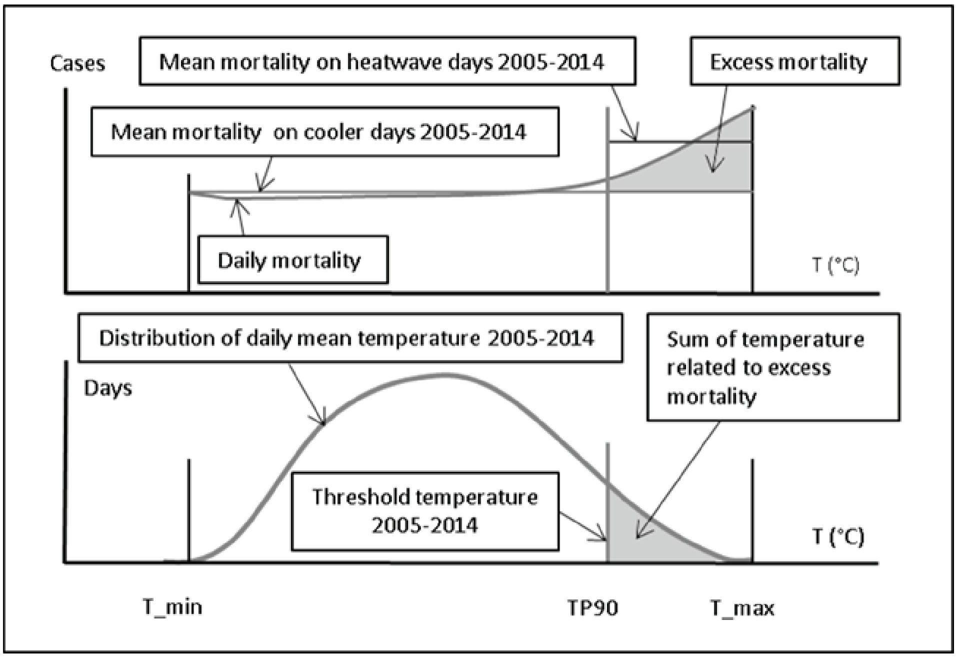

Figure 4: The expected change in summer temperature (°C) for the period 2071–2100 in Montenegro, based on RCA4 regional model simulations CNRM-CM5 (left) and EC-EARTH (right) global model data based on RCP 4.5 (top) and RCP 8.5 (bottom) scenarios Source: own construction, based on HMGS (2018).

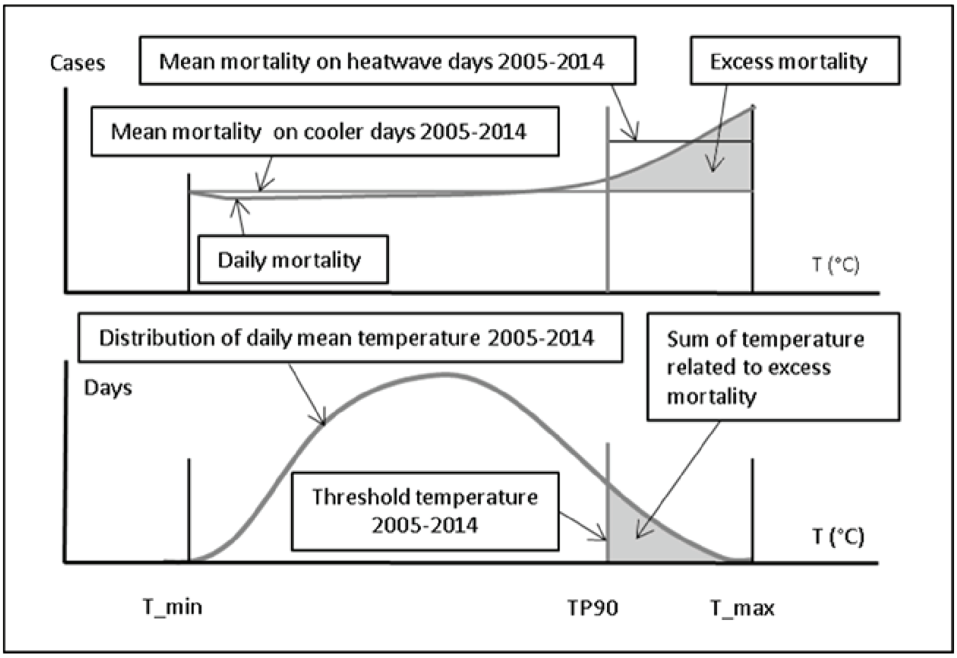

Figure 5: Scheme of the methodological process of calculating heat-related excess mortality Source: Bobvos et al, 2015.

of mortality by 1°C increase in the daily mean temperature. The excess mortality can define the impact of heat; this is calculated as the difference between the daily mortality on days with a higher mean temperature than the threshold value and the daily mean expected mortality (Figure 5). The expected mortality can be defined as the daily mean mortality of the days with a lower mean temperature than the threshold value [23, 3].

The measured meteorological data and the data of the regional climate models are suitable input parameters for estimating of the relationship between temperature and mortality. The measured daily temperature and daily mortality data are necessary to assess the threshold temperature and the heat-related excess mortality in the present period. This present period is proposed to be defined as the past 5-10 years. Using this relationship, future excess mortality can be determined based on future changes in heatwave days. This can be determined from climate model results.

Analysis at the regional level is proposed to perform statistical calculations due to the more significant number of daily death cases. Based on the climatic conditions of Montenegro, **three different climatic regions** can be defined: Seaside municipalities, Central continental municipalities (Middle Region), and Northern mountainous municipalities (Northern Region).

The proposal aims to calculate the values for the observed present time based on annual average characteristics for the present climate period (1991-2020) and then to determine the projections for the future (2021-2050, 2071-2100). In our detailed analysis, we also provided suggestions for the data to be collected for conducting the research and for the study's methodology [13].

4. CONCLUSION

As for main conclusions, increasing number of challenges (changing temperature and precipitation patterns, increasing weather extremities and their consequences) affect Europe and within it the WB countries. Several common vulnerability topics (heat waves, coastal erosion, forest fires, water reserves' sensitivity, increasing vulnerability of tourism, etc.) can be observed in all or the majority of these countries, requiring similar responses from the different states.

Parallel with this situation, climate adaptation has inevitably come to the fore in the recent decade in climate policy, and, as opposed to mitigation, it needs territorially different answers to territorially different local problems. Consequently, local/micro regional/regional decision making (and national one, because it coordinates the lower levels' work) needs professional support, objective information, analysable data and evidence base about climatic challenges and potential responses. Territorially sensitive vulnerability analyses could provide this information for decision makers. However, there are only few examples of climate vulnerability assessments, monitoring and evaluation activities in the region, and currently no holistic, horizontal web-based national climate adaptation DS systems exist in the WB countries; only a few sectoral ones work in Serbia and Croatia.

Overviewing international examples of vulnerability assessment concepts and GIS-based climate adaptation-oriented decision support systems, the Hungarian NAGiS and its CIVAS-based vulnerability analysis logic seems to be the most simple solution to understand, implement and overview for the WB region out of the analysed practices.

Also, pilot vulnerability assessments were conducted. We can see: though mostly only exposure data were available during the research in the WB countries, however, significant territorial differences emerged based on these. The socio-economic and environmental condition data; the sensitivity and adaptability indicators based on these, and the vulnerability as their combination are also expected to show particular spatial patterns with significant differences. The already existing NUTS-3 level territorial differences are expected to be even deeper at the municipal level. Consequently, analyses, assessments, and decision support systems exploring these territorial inequalities and patterns would be especially useful for national and local adaptation policies and decision-making. In light of this, these tools' absence or low presence in the examined countries is particularly thought-provoking. Progress is definitely needed in this field so that climate policy, with help of these tools, can monitor the changes in climate impacts, consequences and the situation of the affected parties, laying the foundation for the development of appropriate response measures.

5. Recommendations:

1. Comprehensive vulnerability analyses and risk assessments must be conducted in the WB countries at the national and regional level, serving as situation analyses for future adaptation policies, strategies, programmes;

2. For these analyses, a single vulnerability assessment and climatological logic is recommended to be developed and used to make results comparable;

3. This single analytical logic is suggested to be built on NAGiS' experience because its vulnerability assessment methodology is relatively easy to implement, overview and understand;

4. To create a proper framework for these analytical works, holistic climate adaptation DS systems with mapping application is suggested to be established at the national

level in each country, covering all special vulnerability topics of the given state to visualize the results of vulnerability assessments;

5. Beyond climatological data, indices from several other fields are needed to complete vulnerability assessments beyond exposure analyses;

6. Meanwhile, data availability, especially in the field of environmental, socio-economic data and especially at micro regional, local and regional level has to be improved;

7. Based on the results of the case studies, the establishment of future climate adaptation-oriented national planning, monitoring, reporting and evaluation (MRE) systems is worth thinking about, utilizing the planned vulnerability assessment and climatological logic.

As for the **limitations of the research**, it is not worth drawing too profound conclusions from the exposure study alone. On the one hand, the tourism sector's actual situation and climate vulnerability are influenced seriously by the tourism product-specific sensitivities and different social-economic adaptive capacities of different destinations – these latter aspects cannot be considered by the exposure analysis. In the case of heat waves, sensitivity and adaptability factors also seriously influence the complex vulnerability of territories. On the other hand, the current, 12-prefecture-based analysis of Albania's tourism vulnerability and the national-level analysis of Montenegro's heatwave exposure hide the more nuanced differences. Climate data and grid numbers available for Albania and Montenegro compared with the number of municipalities show a similar scale. The "one settlement ≈, one grid" relation would make the creation of territorial averages more difficult, so we applied only a county-level analysis in Albania and an even rougher one in Montenegro. On top of that, data availability is also in question at settlement level. Considering that it caused problems even at the Albanian prefecture level to obtain data for the sensitivity and adaptation analyses, these latter parts of the assessment had to be cancelled in both countries. Further deficiency is the lack of detailed analysis of winter sport tourism, which is also a key product in Albania. In the future, calculating such an index could be one of the methodology's further improvement directions. Overall, the current exposure assessment and the recommended additional methodological steps can serve as a proper basis and logical framework for future complex vulnerability analyses in Albania and Montenegro.

It is worth contemplating the possible **further directions of research**. It is strongly recommended to extend the analyses for as many WB countries, regions and sectors as possible along with the common vulnerability topics of the macro region (sensitivity to forest fires, coastal vulnerability, sensitivity of water reserves) and beyond the NUTS 3 level (possible for municipal level). It is also worth applying solutions beyond the CIVAS model: the methodology is suggested to be further refined or other methodologies to be brought into the analysis. It is not an easy task: adaptation is difficult to be quantified, so the further development of indicator sets is a complex problem. All in all, the current analyses are just the beginning: their future expansion could further deepen the explanatory power and usefulness of the methodology. All in all, realizing the existing and potential CC impacts on the region and the lack of or undeveloped/unconscious nature of possible preparatory adaptive or preventive measures, it is evident that there is an unambiguous necessity for the deepening and dissemination of related knowledge base in WB countries. To support these, the results of this research can serve as initial steps.

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