Andreász Kosztopulosz – Éva Kuruczleki (eds.) (2020): The Challenges of Analyzing Social and Economic Processes in the 21st Century. University of Szeged Faculty of Economics and Business Administration, Szeged, https://doi.org/10.14232/casep21c.12

Climate change among the least developed – a Case study of Sarkad LAU 1 region

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Climate Change is a global phenomenon that has geographically varying impacts. To fulfill Hungary's climate obligations and implement effective adaptation practices, we need to understand the working mechanism of climate change in smaller territorial units. Regional differentiating is of paramount importance in regional strategy making.

As part of an on-going research that aims to identify the local impacts of climate change and the local answers against it, this paper is analyzing the local properties and opportunities of the case study of Sarkad LAU 1 region. Sarkad region is one of the most underdeveloped yet one of the richest areas in natural resources like biodiversity, landscape, and cultural heritage. This duality highlights the need to act against the negative outcomes of climate change. The local main climate effects of climate change are indicated by using the cartograms of the National Adaptation and Geoinformation System database. It is crucial to identify the local vulnerability in order to take effective measurements promoting adaptivity and mitigation.

As a result of the research, the unique properties of the LAU 1 region the ways of adaptation in connection with climate change are indicated.

Keywords: Adaptation, Climate change, Climate vulnerability, LAU1 regions, Sarkad region

1. Introduction

IPCC Special Report on the impacts of global warming of 1.5°C is the most recent and comprehensive scientific knowledge on climate change which highlights the following aspects:

- Rising of global mean surface temperature due to human activities has reached approximately 1 °C above preindustrial levels and likely to reach 1.5 °C between 2030 and 2052;
- Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, and the magnitude and rate of warming variates the risks at different geographic locations, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options;
- Depending on the geographical location global warming of 1.5 °C increase mean temperature in most land and ocean regions, the number of heatwave days, duration and severity of heavy precipitation events and the probability of drought and precipitation deficits;
- Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming

of 1.5°C. The increase in global warming is projected to affect human health, with primarily negative consequences (IPCC 2018).

Scientific evidence highlights the need for effective mitigation and adaptation measures worldwide. The phenomenon of global climate change is now getting in the center of attention which is urging global decisionmakers, researchers, non-governmental organizations to act (Hajnal 2006). The most important stages of the fight against climate change at the international level were the Kyoto Protocol and the Paris Agreement. By ratifying the documents, Hungary along with other 191 parties have committed itself to reduce greenhouse gas emissions, thus decarbonizing its socio-economic structure. In order to meet our obligations, the Hungarian Parliament adopted a law (LX. 2007), which orders the creation of the National Climate Change Strategy (NCCS). Since the adoption of the first NCCS the climate change-related strategic framework of Hungary has been developed by the following elements:

- Second NCCS – adopted in 2018;
- Long-term Strategy of Hungary – adopted in 2020;
- Second Hungarian Energy Strategy – adopted in 2020;
- National Energy and Climate Plan – adopted in 2020;
- National Climate Change Action Plan – adopted in 2020;
- All the Hungarian counties (NUTS 3) established and adopted climate strategies in 2018 based on their unique properties, opportunities and obstacles;
- 113 Hungarian settlements (mainly cities) applied successfully for creating their own climate change strategies in 2019, at this point their establishment is in progress.

The development of the strategic framework shows the importance of the subject and the need for national plans and actions to be distributed within smaller territorial units.

The scientific research of this paper also emphasizing the role of the rurality, with highlighting the statistics and local opinions in one of the least developed and most climate-vulnerable region in Hungary.

The logical structure of this paper contains three elements:

1. Describes the working mechanism of climate change;
2. Indicates the territorial climatic effects which select the most climate-vulnerable areas in Hungary;
3. Present the results of the field research in the Sarkad LAU 1 region.

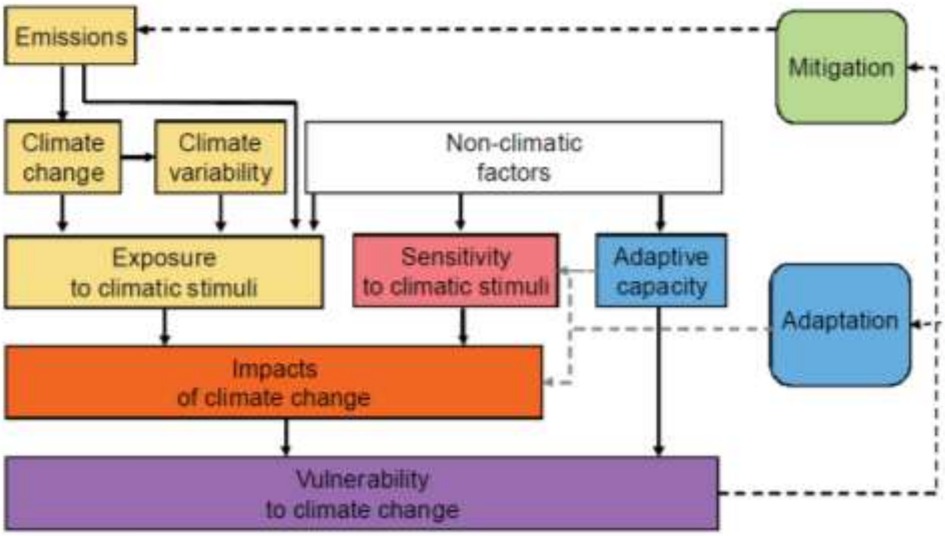
The analysis zooms from the national level to a small region, from national climate effects to its local economic, social and environmental manifestation.

2. The working mechanism of climate change

Understanding the connection between the elements of climate vulnerability is the key to effective mitigation and adaptation measures. Among the various climate vulnerability models created for different purposes (focusing on the natural or human environment) this paper uses the results of an ESPON Climate project which aimed to establish a vulnerability assessment as a basis for identifying regional typologies of climate change exposure, sensitivity, impact and vulnerability (Greiving et al. 2011).

According to the ESPON Climate project climate vulnerability can be interpreted by the following element:

Figure 1 ESPON Climate Change research framework



Source: Greiving et al. 2011, p. 3

The main definitions used by the model are:

Exposure: the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected. Unlike sensitivity (which characterizes the effector), the exposure is characteristic only of a geographical location.

Sensitivity: weather-dependent behavior (e.g. drought, flood risk) of the affected party (e.g. agriculture, human health). It is the attribute of the affected system, which is independent of climate change.

Vulnerability: complex indicator, combines expected effects with adaptive ability, considering that the expected impact may be more severe in a region with less adaptability (Greiving et al. 2011).

The model should be considered in the following logical sequence:

1. The anthropogenic greenhouse gas emissions contribute to the rise in global average temperature, thereby contribute to climate change;

   Changing global climate parameters affect local climate parameters (temperature, precipitation, wind), weather extremities such as heat waves (three consecutive days above the daily average temperature of 26.6ºC[1]), causing storms and floods. The appearance of these characteristics in the local geographic space is called the exposure of the given area;
2. The *effects* of the changing climatic parameters, the more frequent weather extremities, are basically due to two factors, *exposure* and *sensitivity*. In other words, the nature and volume of the climate effect affecting the affected party (such as a crop plant, a human organism or an industry) depend to a large extent on its relationship with the natural environment - in the case of a closer, more indirect relationship the effects on the effector are more frequent, stronger and thus it became more sensitive;
3. The result of climate impacts - which can be *positive* (e.g. widening the growing season) and *negative* (eg increasing number of drought days) – depends to a large extent on the so-called *non-climatic factors*. These factors together form the adaptive ability of the affected party to adapt to the negative climate impacts;
4. In summary, the affected party and the (changing) weather together make a system with stronger or weaker relations. The vulnerability of this system, the damage caused by climate impacts are determined by the potential climate impact and the adaptability to it;
5. The affected party and the weather system also strive to reach balance (equilibrium), which can be achieved by changing the agricultural structure of areas that are unsustainable due to climate impacts (e.g. the use of heat-tolerant, genetically modified plants) or even depopulation (Greiving et al. 2011).

3. Climate vulnerability in Hungary and in the Sarkad LAU1 region

Assessing the climate vulnerability of a given area accessible and reliable data is needed. Exposure, adaptation, and vulnerability related data in Hungary are collected within the NAGiS (National Adaptation Geo-information System, established in 2014, and it is operated by the Hungarian Geological and Geophysical Institute) database (Sütő, 2016). The cartograms generated by the data point to the nature of the climate effects that can be projected in Hungary and to the potential volume of damage they cause regionally. The following cartograms highlight the regionality of climate vulnerability, particularly in the Sarkad LAU1 region.

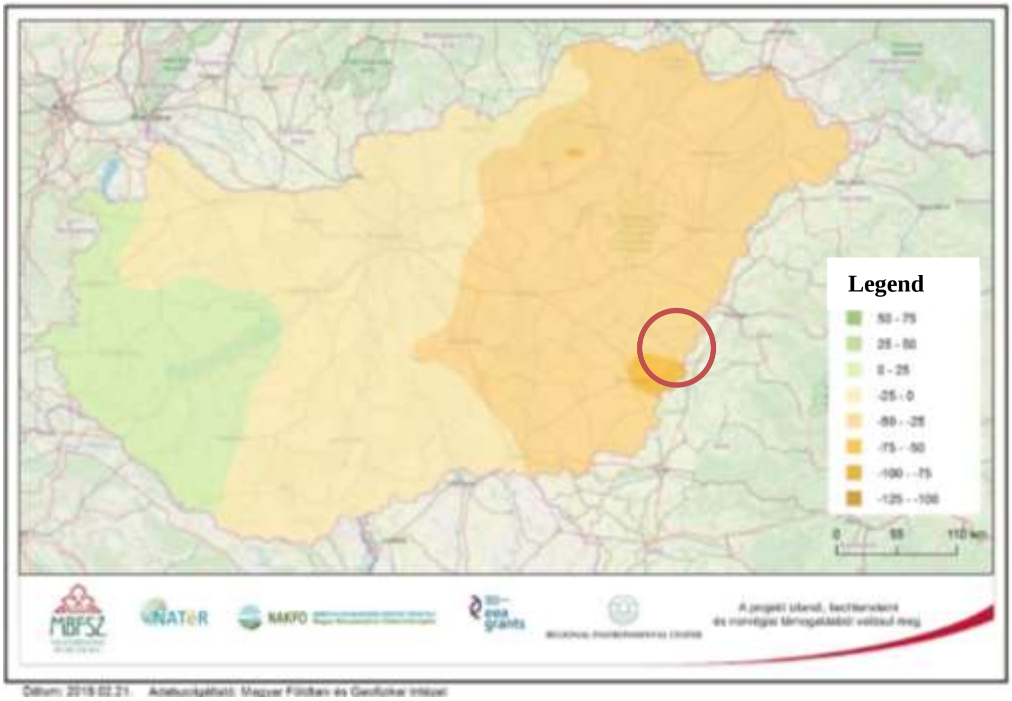
[1] Defined by the National Directorate General for Disaster Management, Ministry of the Interior, there is currently no uniform, globally accepted terminology. Source: www.katasztrofavedelem.hu, 2020

Within the given framework of this study, it is only possible to present the most important cartograms related to the main parameters of the ESPON model, which show the regionality and inequalities of the mechanism of climate change.

3.1. Exposure

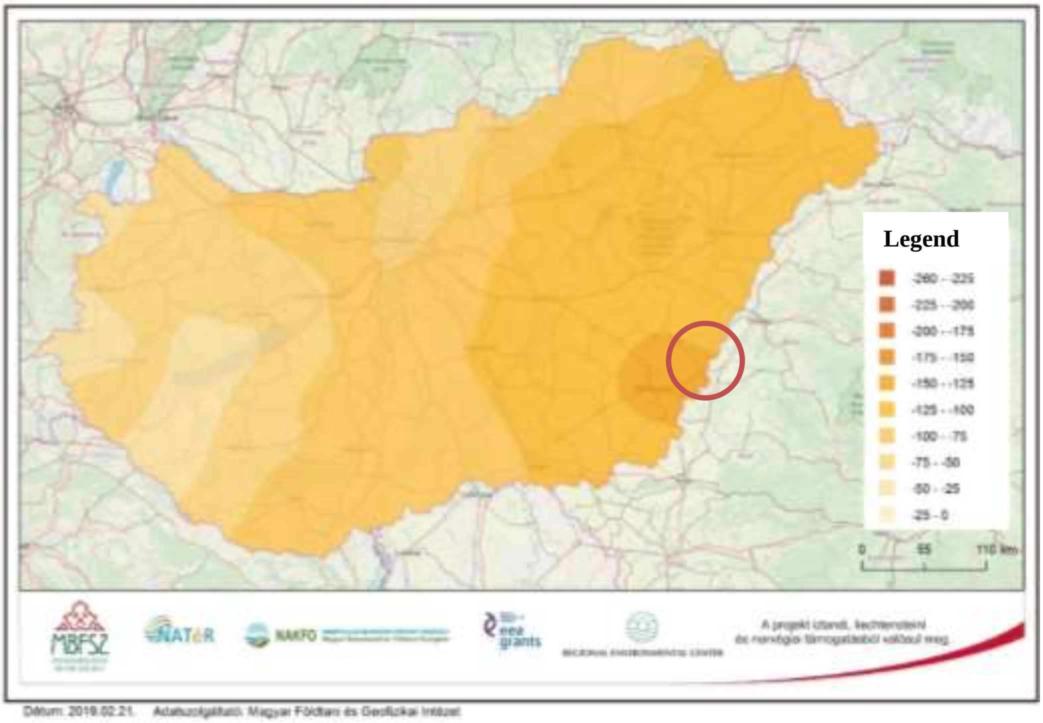
The quantity of precipitation can be both disadvantageous when the monthly amount is fell in a short period causing floods and inland waters or the time between two rainfalls extends and droughts occur. The following cartograms (*Figures 2 and 3*) highlights the changes in regional precipitation and climatic water balance. Drying of eastern Hungary can be observed which may have a severe impact on the natural ecosystem, agriculture and drinking water supplies.

Figure 2 Exposure – Expected changes in regional precipitation in the period 2021–2050, ALADIN-climate model (mm)



Note: the red circle highlights the territory of the Sarkad LAU1 region.
Source: National Adaptation Geo-information System, 2019

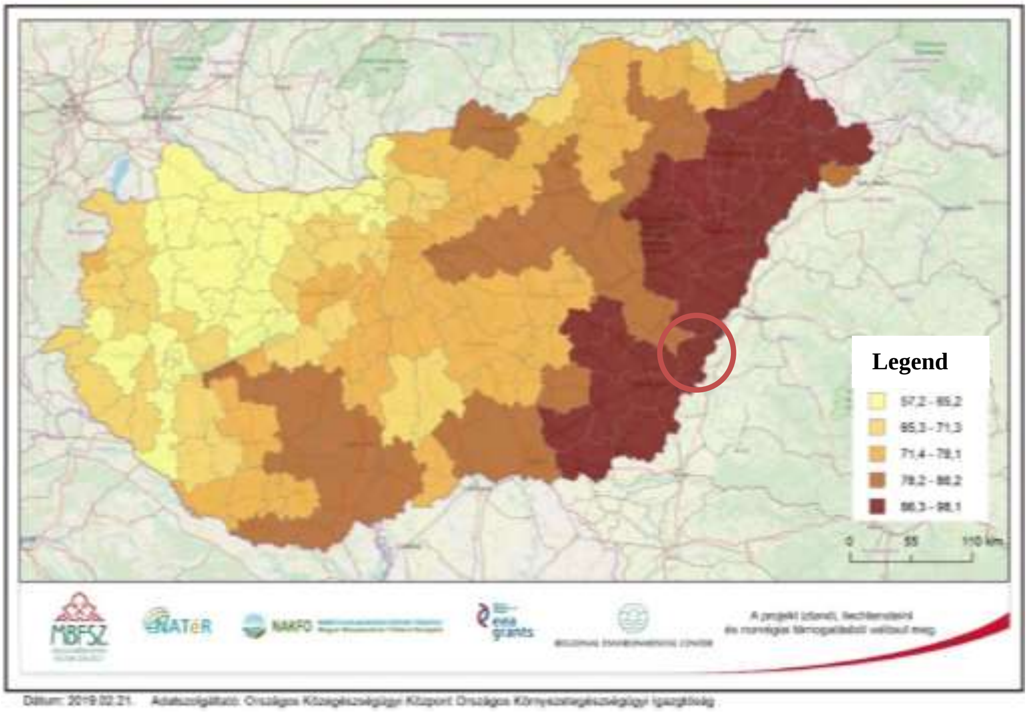
Figure 3 Exposure – Expected changes in climatic water balance in the period 2021–2050, ALADIN-climate model (mm)



Note: the red circle highlights the territory of Sarkad LAU1 region
Source: National Adaptation Geo-information System, 2019

Besides precipitation, heat stress is the other key effect that affects negatively the regional liveability. Figure 4 shows the regional distribution of heat waves which is higher in number in the eastern part of Hungary. Long-lasting high-temperature days mean a great challenge to the human organism – increasing mortality – as well as the infrastructural elements as the road network and buildings – increasing their maintenance costs.

Figure 4 Exposure – Frequency of heatwave days in the period 2021–2050, ALADIN-climate model



Note: the red circle highlights the territory of Sarkad LAU1 region
Source: National Adaptation Geo-information System, 2019

Exposure related data showed regional disparity where areas located to the east are exposed more to the decreasing yearly precipitation and the higher number of heatwave days.

3.2. Sensitivity

To understand vulnerability first, we had to identify the most exposed areas to the changing climate parameters. The next step is to take a closer look at the affected parties of the mentioned areas. The most thorough picture of sensitivity can be achieved by examining the three main areas – the natural environment, society and economy.

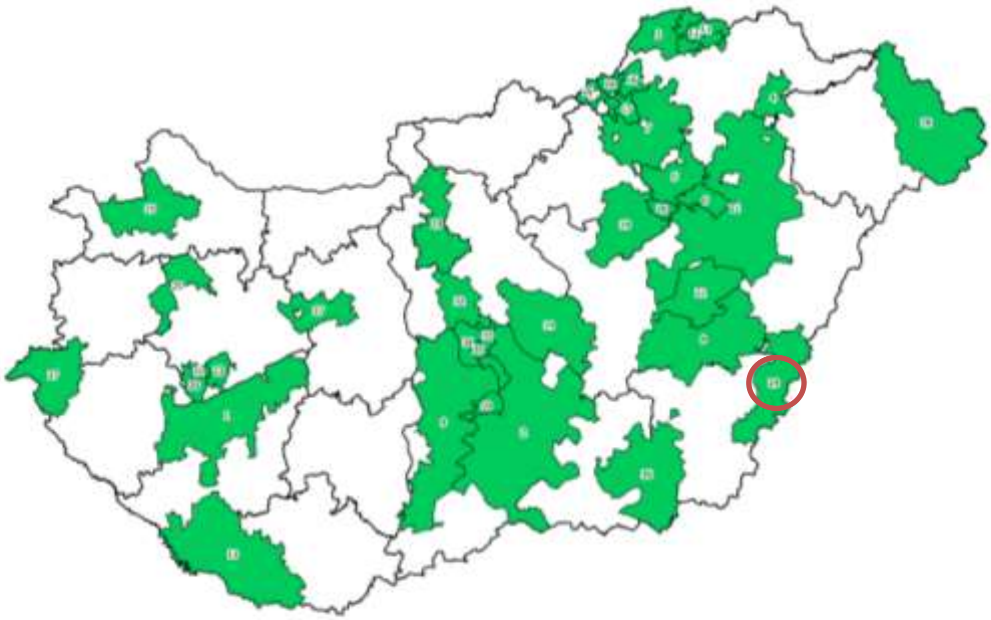
3.2.1. Natural sensitivity

The most climate-sensitive natural areas are identified by the 2/2002. (I. 23.) Government Decree which basically distinguishes three categories:

- 1. important sensitive natural areas;
- 2. highly important sensitive natural areas;
- 3. planned sensitive natural areas.

According to the Government Decree, sensitive natural areas are "those which, through subsidized, voluntary restrictions, ensure the protection of habitats, the conservation of biodiversity, landscape, and cultural and historical values." This paper uses the category of the *highly important sensitive natural environment* for identifying areas whose natural environment the climate-sensitive (see Figure 5). These areas where "internationally outstanding natural, landscape and cultural-historical values exist, whose survival in the medium term (5–10 years) is doubtful without the promoting of environmentally friendly farming" (§ 3, 2/2002. (I. 23.) Government Decree).

Figure 5 The geographical location of the highly important sensitive natural environment areas



Note: the red circle highlights the territory of Sarkad LAU1 region
Source of data: 2/2002. (I. 23.) Government Decree, own editing

3.2.2. Socio-economic sensitivity

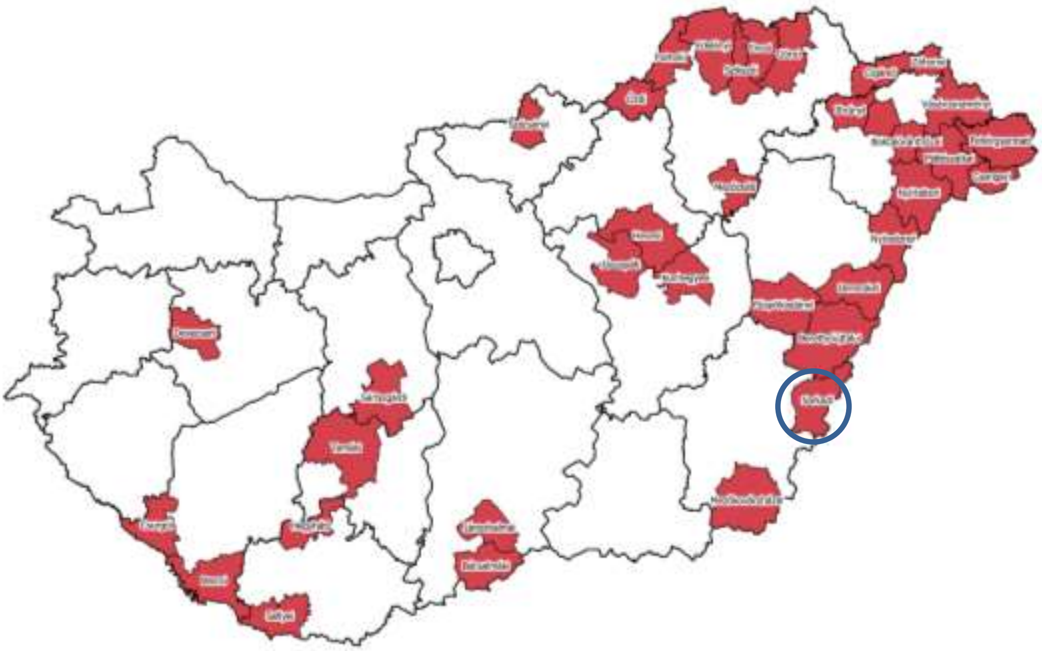
In order to compare the socio-economic development of the individual LAU1 regions of Hungary, (XI. 26.) Government Decree was created, which uses a complex statistical indicator. The indicator includes 24 indicators of socio-demographic, housing and living conditions, local economy and labor market, infrastructure and environment. Based on this, 3 categories can be defined:

- beneficiary regions: regions whose complex score is lower than the average of the complex score of all regions;

- regions to be developed: regions with the lowest complexity within the beneficiary regions, where 15% of the country's cumulated population lives;
- regions to be developed with a complex program: regions with the lowest complex indicator within the beneficiary districts, where 10% of the cumulated population of the country lives (Government Decree 290/2014 (XI. 26.), § 1, 2)

The methodology of the research uses the category of “regions to be developed with a complex program”, which settlements are among the least developed in Hungary. Figure 6 shows the location of these settlements which are facing serious socio-economic problems that have an extremely negative impact on their adaptability.

Figure 6 The geographical location of the “regions to be developed with a complex program” areas

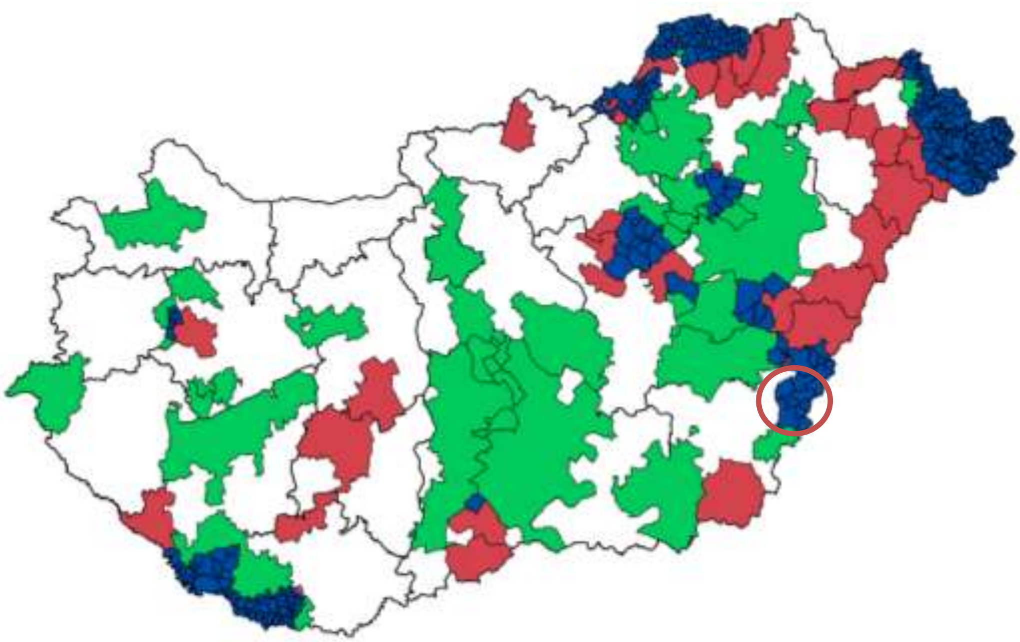


Note: the blue circle highlights the territory of Sarkad LAU1 region
Source of data: 290/2014. (XI. 26.) Government Decree, own editing

3.2.3. Overall sensitivity

In order to visualize the altogether the sensitivity of natural environment, society, and economy the intersections, figures 5 and 6 should be analyzed focusing on their intersections. Regional distribution of overall sensitivity is the following:

Figure 7 The geographical location of the most climate-sensitive areas



- Highly important sensitive natural environment areas;
- "Regions to be developed with a complex program" areas
- Intersections of natural and socio-economic sensitive areas

Note: the red circle highlights the territory of Sarkad LAU1 region
Source: own editing, 2019

It can be seen that the most sensitive settlements in the border peripheral areas are Somogy, Borsod-Abaúj-Zemplén, Szabolcs-Szatmár-Bereg and Békés counties, while in the inner peripheries Veszprém, Heves, Jász-Nagykun-Szolnok, Bács-Kiskun and Hajdú-Bihar counties. These municipalities are likely to be most sensitive to the local effects of global climate change.

3.3. Vulnerability in Hungary

Figure 7 highlighted that most of the sensitive areas can be located in the eastern part of Hungary which are more exposed to climate change as well. These two elements make them the most climate-vulnerable which means that the most severe impacts – like droughts, heavy precipitation, longer and higher temperature heatwaves – meet the least adaptive socio-economic areas which have the most precious natural resources. Unless effective governmental interventions or programs for increasing the adaptive capacity, these – like Sarkad region – vulnerable settlements will face the greatest climate damages which further hinder their future development.

4. The manifestation of vulnerability – the case study of Sarkad region

4.1. Methodology

Vulnerability analysis highlighted the areas which are the most exposed to climate change, have the poorest socioeconomic conditions and have the most precious natural resources – Sarkad region is among these areas.

Understanding the true nature of climate vulnerability not only requires analyzing data or cartograms but primary research methods are also needed. Questioning local leaders, farmers, residents and other stakeholders greatly supplements and orients the research's findings and the final conclusion.

In this case, the primary research was focused on Sarkad region. The main goal of this paper was to pave the way for extensive, multi-stakeholder research that covers all of the settlements within the region. To fulfill this role a field trip was held within Sarkad – the center of Sarkad region – and one of its settlement, Kötegyán.

Four people were asked during a semi-structured interview, selected by the following criteria:

- **An agricultural advisor**: he has connections with most of the farmers within the region, moreover he is a beekeeper, hunter and has extensive knowledge about local agricultural vulnerability, and the local farmers' answers for the challenge;
- **Mayor of Kötegyán**: she was born in Kötegyán and she and her family are cultivating one of the largest agricultural lands;
- **Notary of Kötegyán**: he was born in Kötegyán as well and he is the notary of Kötegyán for 15 years which gives him a broad perspective in the changes in the settlement;
- **The local organic producer**: he lives in Kötegyán since 1953 where he was the first to use organic producing methods. Besides the agricultural production, he also maintains one of the few accommodations in the settlement. Questioning him lead the conversation in various fields, connected with Kötegyán, which highlighted his vast knowledge about the history of the settlement, changes in the composition and habits of the residents, or in the surrounding natural environment.

The semi-structured interview was suitable to keep the conversation on track and gain important side-information at the same time. Every stakeholder answered both general and stakeholder-specific questions, which concerned the following topics:

- their past and present in the region: demographic questions, profession, general opinion about their hometown;
- changes in Sarkad region – demographic, economic or environmental;
- the source climate change – for example, it is human-made or a natural process – how does it affect their life;
- specific questions about their contribution to climate change, ongoing or planned mitigation, adaptation measures as a resident or as a stakeholder.

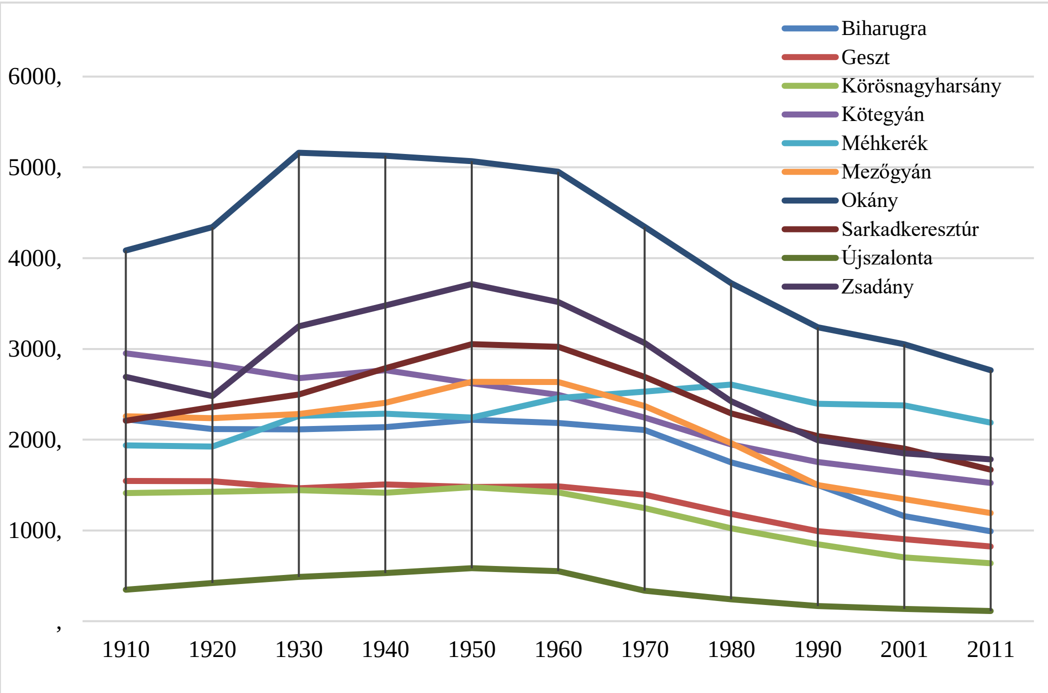
4.2. Findings

The answers of the interviewees confirmed the less favorable socio-economic conditions which were indicated by the indicators of the 290/2014. (XI. 26.) Government Decree.

The main messages of the interviews are the followings:

1. **The greatest problem is the low number of employment opportunities**. Kötegyán has suffered one of the greatest decreases, in 1950 there were 450 workplaces today it is only 50, which is connected to 4–5 agricultural producers. Sarkad region as a peripheral location has limited opportunity to attract investments, businesses, without employment opportunities settlements, are depopulating (see figure 8) at an increasing rate.

Figure 8 Changes in population in Sarkad region, 1910–2011



Data source: Hungarian Central Statistical Office, own editing, 2019

2. Besides the decreasing number of inhabitants and companies, the interviewees agreed that **climate change is the most serious threat to the region**. Significant dependence on agricultural production – which is one of the most exposed to climate change –, infrastructural problems (e.g. healthcare, road network, water, and electricity supply), caused by the decreasing population makes climate vulnerability palpable.

3. **The original agricultural production is less effective** – cultivating hard soils, tilling –, it is crucial for competitiveness to apply more suitable methods which more resistant to the changing climate parameters. On the other hand, both the agricultural advisor and the organic farmer agreed that conditions for beekeeping are dramatic worsening which makes almost impossible to maintain the activity.

4. **Serious infrastructural developments are needed in various fields**. In agriculture, it is getting common – due to the changes in the distribution of precipitation – that both drainage and irrigation systems are needed. The number of draught days, as well as days with heavy precipitation, is increasing which causes severe damages on the arable crops yields. The other areas of infrastructural development are road networks and public institutions (e.g. hospitals, general practitioners, schools, retirement homes), which have to face extreme weather conditions as heavy rainfalls and heatwaves. For defending human lives and property these infrastructural elements have to be revised and reconstructed with having in mind the new extremities in weather parameters.

The interviews confirmed the negative picture of vulnerability in Sarkad region and gave an inspection to the local situation. Aside from direct local effects and those consequences, interviewees were asked about the cause-effect relation of climate change which highlighted the serious lack of information and knowledge on the theme. The only idea of clime adaptation action was changing the agricultural methods in the region but apart from that, no effective solution was mentioned. Moreover, littering was named as one of the main causes of climate change, which is a piece of important misleading information.

5. Conclusion

The field research not only verified the statistics on climate vulnerability but supplemented the negative picture. Lacking financial resources and verified information both decrease the adaptive capacity of the Sarkad region which increases the severity of the future climate damages. These negative impacts may lead to the deterioration of unique swampy and reedy areas of Kis-Sárrét and increasing the migration outward to the region.

6. Summary

Climate vulnerability is composed of two elements, first is climate exposure which consists of the local effects of global climate change. The two main factors of exposure were highlighted in the analysis, distribution of precipitation and the changes in numbers of heatwave days.

The second is sensitivity which was approached from three directions: sensitivity of the natural environment, society, and economy. According to the cartograms of NAGiS and the ones which were created by the author of this paper the most climate-vulnerable areas in Hungary can be found at the borders of the country

– outer peripheries – and at a few inner peripheries, mainly in Heves, Jász-Nagykun-Szolnok, Borsod-Abaúj-Zemplén, Hajdú-Bihar counties.

These areas will have to face to most severe climate effects against which they have the least opportunities to adapt – given their grave economic and social situation.

Acknowledgments

„Supported by the ÚNKP-19-3-I New National Excellence Program of the Ministry for Innovation and Technology."

Nemzeti Kutatási, Fejlesztési és Innovációs Hivatal

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Appendix

Number	Name of the area
1	Drylands at the southern reservoir of Balaton
2	Sand dunes region reservoirs of Tisza
3	Main territory of Aggtelek National Park, Galyaság
4	Bodrogköz, Kopaszhegy
5	Borsodi-Mezőség
6	Borsodi-Mezőség, Buffer zone of Hortobágy National Park
7	The buffer zone of Bükk National Park
8	Surroundings of Dévaványa
9	Plain of Dunavölgy
10	Plain of Dunavölgy, Sand dunes region reservoirs of Tisza
11	North-Cserehát
12	North-Cserehát, the Main territory of Aggtelek National Park, Galyaság
13	Wooded pastures in Baranya county
14	Gerje-perje plain
15	Hanság
16	Hills of Heves-borsod
17	Hills of Heves-borsod, Buffer zone of Bükk National Park
18	Hills of Heves-borsod, Surroundings of Ózd
19	Heves plain
20	Heves plain, Borsodi-Mezőség, Buffer zone of Hortobágy National Park
21	The buffer zone of Hortobágy National Park
22	The buffer zone of Hortobágy National Park, Surroundings of Dévaványa
23	Káli basin
24	Kis-Sárrét
25	Marcal basin
26	Surroundings of Ózd
27	Őrség-Vendvidék
28	Szatmár-Bereg region
29	Szentendre island
30	Tapolca basin
31	Tapolca basin, Káli basin
32	Turjánvidék
33	Turjánvidék, Sand dunes region reservoirs of Tisza
34	Turjánvidék, Plain of Dunavölgy
35	Turjánvidék, Plain of Dunavölgy, Sand dunes region reservoirs of Tisza
36	Vásárhelyi-Csanádi plains
37	Velence-lake and Sárvíz valley