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Climate Change in Hungarian Rural Society: Assessment of Adaptive Capacity

Judit PAPPNÉ VANCSÓ[a*] – Mónika HOSCHEK[b] – Ferenc JANKÓ[a]

[a] Institute of International and Regional Economics, Faculty of Economics, University of West Hungary, Sopron, Hungary
[b] Institute of Economics and Methodology, Faculty of Economics, University of West Hungary, Sopron, Hungary

Abstract – Beside sustainable development, vulnerability might be the most frequently used expression in environmental studies. Vulnerability depends on the intensity of the impacts on a natural or social system as well as on its adaptive capacity. Appropriate adaptation warrants successful survival of the system even under high impact, when its vulnerability is significantly reduced; therefore, measuring adaptive capacity should have an established place in the methodology of impact – adaptation – vulnerability research. The main problem is to find relevant data that are required to establish indicators. In our study, the focus was laid on measuring adaptive capacity within vulnerability research, and on identifying possibilities for accurate calculation of adaptation. An attempt was made to determine the adaptive capacity to droughts in the micro-regions of Zala County. It could be established that the adaptive capacity of the population in the rural areas of Zala County to the expected increase in drought frequency is very low, which can be primarily explained by the lack of knowledge about adaptive agriculture.

adaptive capacity / vulnerability / adaptation / drought / climate change

Kivonat – A vidéki társadalom klímaváltozással szembeni alkalmazkodóképessége. A sérülékenység a fenntartható fejlődés mellett talán a legnépszerűbb fogalom a környezeti kutatásokban. A sérülékenység mértékét az adott ökológiai vagy társadalmi rendszert érő hatások erőssége és az alkalmazkodóképesség mértéke határozza meg. A megfelelő adaptáció még erős hatások mellett is lehetővé teszi egy rendszer sikeres fennmaradását, jelentősen mérsékelve a sérülékenységet, így a hatás – alkalmazkodás – sérülékenység összefüggésben értelmezett vizsgálatok módszertanában kiemelt jelentőséget kellene kapnia az alkalmazkodóképesség körültekintő becslésének. A mérések során felmerülő legfőbb probléma az indikátorok előállításához szükséges releváns adatok felkutatása. Tanulmányunkban a sérülékenység vizsgálatokon belül első sorban az alkalmazkodóképesség becslésének kérdéseit igyekeztünk körüljárni, feltérképezni azokat a lehetőségeket, amelyek az alkalmazkodás pontosabb számítását teszik lehetővé, majd kísérletet tettünk aszállyal szembeni alkalmazkodóképesség meghatározására Zala megye kistérségeiben. A leglényegesebb következtetéseket összegezve kijelenthető, hogy Zala megyében az aszályosság várható növekedése mellett a rurális tereken élők alkalmazkodási kapacitása jelentéktelen, ami elsősorban az alkalmazkodó mezőgazdálkodással kapcsolatos ismeretek hiányával magyarázható.

alkalmazkodási kapacitás / sérülékenység / alkalmazkodás / aszály / klímaváltozás

[*] Corresponding author: vancsojudit@gmail.com; H-9400 SOPRON, Erzsébet u. 9. Hungary

1 INTRODUCTION

Measurement and estimation of societal adaptive capacity mostly belongs to the methodology of vulnerability research. Impacts, which enhance social vulnerability to outside stress, should be mapped and social preparedness for those negative effects must be assessed. Previous research showed that accurate measurement of adaptive capacity causes the greatest problem among the factors of vulnerability; quantitative methods are combined with qualitative techniques (e.g. Wilhelmi – Wilhite 2002, Adger – Wincent 2005; Brooks et al. 2005; Gupta et al. 2010). These questions earn great importance in the Hungarian literature as well (Pálvölgyi et al. 2010, Pálvölgyi – Czira 2011, Pappné Vancsó et al. 2014a, 2014b; Farkas 2015), so we put the focus of the study here on showing a methodological case study from a rural region in Hungary (Zala County). Nevertheless, it is important to introduce the context in which adaptive capacity is interpreted; thus, we also present how vulnerability has come into the focus of climate change research, and review the definition and methodological issues around vulnerability studies.

Vulnerability as a term has been known for a long time. It was first used in the medical and biological sciences; however, it has become an interdisciplinary concept, which has a crucial role in climate change and adaptive capacity research both from the side of natural and social sciences (see e.g. Vincent 2004, Smit – Wandel 2006; Kittel et al. 2011). Assessment of vulnerability and adaptive capacity research can be interpreted as responses given to the challenges of climate change, which started from the examination of local areas and reached the comparative analysis of national capacities. Local and regional-level analyses, however, have still remained very important as climate change affects certain areas in different ways and, therefore, the adaptive opportunities and capacities of local populations may also be different. Fortunately, research on regional level vulnerability not only appears in foreign professional literature, but similar studies have also been carried out in Hungary mainly in connection with the impacts of climate change on ecological and built environment (droughts, forest fires and urban heat waves, see Pálvölgyi et al. 2010, Pálvölgyi et al. 2011), and its complex impacts from the perspective of the environment (Farkas 2015).

Within the group of indices used for vulnerability calculation, indices for adaptive capacity are typically made of data, which are able to approach a particular problem indirectly, since information for large-scale examinations may be obtained almost exclusively from statistical databases. However, this does not present a problem in the case of indices used for impact-mapping because the indices of given possible outcomes of climate change (drought, heat wave frequency, excess water inundation) are already available (e.g. drought index) or they can be easily established (e.g. changes in the frequency of days with excess water inundation). However, given the lack of data which directly measure adaptive capacity, the results may become broad-brush.

Our research focuses on the elimination of this problem, and also on how to measure adaptive capacity accurately. Following the above mentioned domestic studies, we measured drought and flash flood vulnerability in micro-regions of Zala County, taking the concept of adaptive capacity into further consideration (Pappné Vancsó et al. 2014 a, 2014b). The local population will face two major problems concerning the proposed impacts of forecasted climate change delineated in mainstream national documents (Láng et al. 2007, NCCS 2008; NCCS 2013) and publications (e.g. Pongrácz et al. 2009; Sábitz et al. 2013), underlined as well as by the results of a questionnaire survey carried out in 2013, which examined the impacts of climate change on agricultural society. These are the increase in drought frequency as a result of decreasing amount of uneven precipitation and the gradually warming climate (1), and the more frequent flash floods, which can also be attributed to the uneven distribution of rainfall (2). This paper does not provide a comprehensive picture of vulnerability, but it aims to highlight the problems of measuring adaptive capacity by the example of adaptive capacity to droughts.

2 THEORETICAL BACKGROUND

The term “vulnerability” was first placed into the focus of climate change research by Peter Timmerman (1981) under the influence of the major objectives of the World Meteorological Organisation (WMO) at that time. The WMO set it as a key research objective to determine those characteristics which made societies at different levels of development vulnerable or adaptive to fluctuations or changes in the climate. Timmermann’s definition – “vulnerability is the degree to which a system acts adversely to the occurrence of a hazardous event” (ibid. p. 21.) – has been transformed in several ways, which suggests that similarly to sustainable development and sustainability, vulnerability is a term that is subject to constant change and is difficult to define.

According to the working group of IPCC engaged in vulnerability research, from the perspective of climate change, a vulnerable system is sensitive even to slight changes in climate, and its adaptive capacity is seriously limited. In contrast, a flexible system or society is insensitive to fluctuations or changes in the climate, and is capable of adaptation (McCarthy et al. 2001).

Similar to vulnerability, adaptation and adaptive capacity are diverse terms, which can be approached from several perspectives. Attempts have been made to formulate a general definition for adaptive capacity as well, according to Brooks, N. (2003) for instance, it is interpreted as “adjustments in a system’s behaviour and characteristics that enhance its ability to cope with external stress”. Actually, the term can be interpreted from several perspectives, for example, from that of biology (e.g. Bock 1980), or forestry (Mátyás – Kramer 2016). Environmental adaptive capacity, which is closely related to our topic, may also be interpreted from the perspective of ecosystem and society. Adaptation depends on the natural systems, genetic and biological diversity, and the diversity of species. However, in social systems the existence of institutions and networks which preserve knowledge and experience support flexible problem-solving and restore the balance of power among different social groups (Berkes et al. 2002).

Naturally, different interpretations have been formulated to define adaptive capacity to climate change. Smit, B. et al. (2000) describes adaptation as adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts. In another perspective, adaptations are interpreted as the adjustments in individual groups and institutional behaviour in order to reduce society’s vulnerability to climate change (Pielke 1998). According to the IPCC, adaptive capacity is defined as the ability of a natural or social system to adapt to climate change, to moderate potential damages, to take advantage of the opportunities, or to cope with the consequences (McCarthy et al. 2001). The common feature of the different definitions is that they imagine adaptive society as a system which is capable of self-organisation and self-regulation, and is able to cope with the potential negative consequences of climate change.

3 MATERIALS AND METHODS

During our work, we took the methodology and certain findings of earlier Hungarian vulnerability research as a basis, which started from the correlations between impacts, adaptive capacity and vulnerability proposed by the IPCC. As a first step in applying the model, we identified those climatic problems (e.g. drought) which may make the affected systems, in our case agricultural society, vulnerable. Secondly, we identified those impacts which stemmed from the exposure (e.g. exposure to drought) and sensitivity (e.g. soil sensitivity to drought) of the system, by taking the appropriate indicators into consideration. As a third step, we calculated adaptive capacity, and evaluated vulnerability based on the relationship between the impacts and adaptive capacity (Pappné Vancsó et al. 2014 a, 2014b).

For the purposes of calculation, we took the parameters presented in *Table 1* into consideration, where we also included some other indicator groups used for vulnerability research as a comparison. In our study, the main objective was to make adaptive capacity calculations more accurate; therefore we would not delineate the comprehensive process of vulnerability calculations.

As can be seen in *Table 1*, vulnerability research focusing on the same problem may be very different in terms of perspective. Similarly, the different methods for calculating adaptive capacity are also varied. When establishing the indicators for measuring adaptive capacity of the rural population in Zala County, we started from the findings of a questionnaire survey and interviews which were conducted within the framework of a project acknowledged below. The aim of the questionnaire survey was to measure the respondents' perception of climate change, their knowledge of adaptation, and their established strategies and practices.

Table 1. Indicators used for calculating drought sensitivity

Indicators used for measuring social vulnerability to drought (*Pappné et al. 2014a.*)		
Impact		Adaptation
Exposure	Sensitivity	
PaDI	- certain physical and water management features of the soils: field water capacity, wilting point, available water resource, infiltration rate, hydraulic conductivity, bedding of soil profile, features determining soil's special water management, water retention ability	- level of knowledge relating to adaptive agriculture (e.g. technology and varietal conversion) - availability of water for irrigation - proportion of direct and indirect agricultural support per farming unit - HDI - Indicator calculated based on the figures above
Indicators used for measuring social vulnerability to drought (*Pálvölgyi et al. 2010; 2011*)		
Impact		Adaptation
Exposure	Sensitivity	
Pálfai Drought Index (PDI)	- certain physical and water management features of the soils: field water capacity, wilting point, available water resource, infiltration rate and hydraulic conductivity, bedding of soil profile, features determining soil's special water management, water retention ability	- gross value added of agriculture per farmer - agricultural subsidies per hectare

Table 1 cont. Indicators used for calculating drought sensitivity

Indicators used for measuring environmental, economic and social vulnerability (*Farkas et al. 2015)*		
Impact		Adaptation
Exposure	Sensitivity	
Changes in the number of hot days (1980-2010) Changes in the average temperature (1980-2010) Changes in the amount of rainfall (1980-2010) Size of plot Amount of water supplied	- proportion of people employed in agriculture - proportion of income from small-scale agricultural production - proportion of people employed in industry - number of people suffering from respiratory or circulatory diseases per 1,000 people - number of patients taking GP consultation per 1,000 people - ratio of people over 65 to total population	- amount of income per one tax payer - ratio of people with university degree within the population aged 25 or over - number of scientific or engineering-technological enterprises per 1,000 people
Indicators used for measuring vulnerability to droughts (Drought Vulnerability Index) (*Wilhelmi – Wilhite 2002*)		
Impact		Adaptation
Exposure	Sensitivity	
agro-meteorological data: long-term precipitation Crop Moisture Index (CMI)	- water retention ability of the soils	- availability of irrigation

Their knowledge about adaptive agriculture and about the need for changes in the existing agricultural practices formed the basis of the indicator, including the changes in crop structure, planting periods and planted varieties, the use of plastic tunnels against frosts, covering, hail protection nets against hail damage, more efficient spraying, collecting rainfall, planting cover crops instead of ploughing that leads to soil dehydration and constructing draining systems. Increasing the proportion of forests and establishing water reservoirs for the purposes of irrigation. These factors were indicated in proportion to all the respondents (*Table 2*), interpreting it as 100% when each respondent was aware of and used the particular solution. When calculating the indicator for adaptive capacity, this component was taken into account as a factor weighting 60%.

A significant proportion of the respondents mentioned irrigation as an adaptive solution; therefore, we also took irrigation into account in the micro-regions subject of the research (proportion of surface water to the size of lands not irrigated) as a factor weighting 20%. However, seeing that irrigation may become an issue, and water sources suitable for irrigation may be scarcer in the future (NDS, 2014), this indicator should be taken into account with due care in our case. Prevention would be the appropriate solution in the adaptation process, increasing the water retention capacity of the soil, reducing evaporation by using modern agro-technological equipment and growing plant species with abilities to adapt to uneven precipitation.

Therefore, irrigation offers a less efficient solution for adaptation to droughts compared to the other possibilities mentioned above; however in Zala County, such opportunities are far from being exploited: based on the data provided by WTWD (2014) only 0.2% of the total arable land belongs to that category. Therefore, it can be presumed that there would be remaining reserves even in the case of increasing droughts. Seeing that irrigation is basically connected to surface waters, we considered the ratio of available surface waters (water courses, channels and standing waters) to the size of arable lands not irrigated in the particular micro-region when calculating the indicator. We used the CORINE land cover data included in the NISRDP (TEIR) database. For instance, the 2.1 value of region Nagykanizsa means the proportion of the extent of surface waters to the total area used as not irrigated arable land in the micro-region. Naturally, the indicator is not perfect as the geographical extent of surface waters may not determine their actual water content; however, it illustrates well the availability of and limited access to surface waters. Irrigation, therefore, may be a necessary solution in certain cases, which cannot be ignored when calculating adaptive capacity, thus it was taken into account as a factor weighting 20%.

For adaptive capacity calculations, another 5-5% was assigned for three indicators relating to farmers' ability in applying for tenders. Aptitude and resilience may also be very important factors of adaptation, which were expressed in the successful applications of farmers living in the micro-regions for agricultural support. It can be reasonably assumed that micro-regions which are able to apply for tenders efficiently are more capable than their less successful counterparts. Regions where the proportion of support other than direct area-based payment is higher are presumed to be more capable since obtaining indirect subsidies and the application process pose great challenges due to the difficulties of application. It is also a significant indication, whether there are differences in the amount of funds received per farmer because a wealthier farmer may also be more successful in forced adaptation. In the case of the three indicators, we always regarded the best performing regions as 100%, and compared the performance of the other regions to that percentage. The data required to establish the three indicators were obtained from the public-interest database of the Agricultural and Rural Development Agency (ARDA 2014).

Adaptation also depends on human factors including knowledge and preparedness; therefore, when formulating our index, we also took the Human Development Index (HDI) into consideration. HDI is an aggregate index, with the components of life expectancy at birth, years of schooling, and gross national income per capita. Considering the fact that the latter component cannot be constructed on the regional level, we substituted it by income per capita. In our calculations, HDI was evaluated between 0 and 100, and similar to agricultural support, the micro-region with the best HDI index was regarded as 100%. Similar to the last three indicators, this one was also taken into account as a factor weighting 5% for the calculation of adaptive capacity. The data relating to life expectancy at birth and the years of schooling were provided by the Hungarian Central Statistical Office (HCSO 2011) broken down by micro-region. The data relating to income per capita broken down by settlement were retrieved from the NISRDP database.

4 RESULTS AND DISCUSSION

Based on the results of the questionnaire survey, it can be generally established that nearly 90 percent of the respondents perceived the signs of climate change. It was reflected by the occurrence of dry summers, uneven precipitation and the changes in the normal pattern of the seasons. It was generally stated that such changes had negative impacts on agriculture. Only 30 percent of the respondents claimed that they would be able to adapt to the consequences of climate change in some way. They saw that the success of adaptation laid in environmentally-conscious lifestyle (approximately 20%), irrigation (nearly 60%), and the changes in existing agricultural practices i.e. adaptive agriculture (17%). As highlighted above, the latter would offer a more efficient solution than irrigation in the battle against drought; relatedly, that is why we weighted the "level of knowledge relating to adaptive agriculture (technology and varietal conversion)" as the most important indicator representing the adaptive capacity of the society. Seeing that in this respect we observed no significant differences among the micro-regions, the results were also similar in every case. Obviously, the efficiency of comparative analyses carried out on micro-regional level within a single county may be challenged even at that point, especially in the case of Zala County, where there are no significant differences in terms of natural conditions or land-use. It is more likely to obtain mathematically interpretable results from research addressing the whole country.

Table 2 shows that the access to surface waters is severely limited. The regions of Lake Balaton and Kis-Balaton would be exceptions, but we did not take their whole water surface into consideration because their access and availability is low relative to the proportion of their water surface, and Balaton is not surrounded by arable lands but areas for holiday purposes, and Kis-Balaton is a nature protection area. In the future, in the case of increased needs for irrigation, the availability of surface waters may be improved by constructing irrigation channels, water reservoirs among the hills and down-hole wells; however, such infrastructural investments and water use would incur additional expenses for agriculture.

Table 2. Calculation of adaptive capacity in the micro-regions of County Zala

	Micro-region								
	Hévíz	Keszthely	Lenti	Letenye	Nagykanizsa	Pacsa	Zalaegerszeg	Zalakaros	Zalaszentgrót
Level of adaptive agriculture (variety and technology conversion %)	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Ratio of surface waters to size of arable lands not irrigated (%)	1.2	5.0	0.2	0.9	2.1	5.0	0.5	5.0	0.3
Proportion of tender amounts won per farmer in relation to the best-performing micro-region (%)	23.0	58.0	72.0	38.0	50.0	100.0	49.0	41.0	56.0
Ratio of tender-winning farmers from all the farmers in relation to the best-performing micro-regions (%)	58.0	77.0	100.0	42.0	51.0	60.0	70.0	59.0	67.0
Ratio of indirect support from all the support won in relation to the best-performing micro-regions (%)	68.0	74.0	100.0	58.0	84.0	67.0	77.0	69.0	64.0
HDI in relation to the best-performing micro-regions (%)	93.66	94.10	79.53	45.58	91.64	47.24	100.0	35.62	57.74
Adaptive capacity (%)	**12.0**	**16.0**	**18.0**	**9.0**	**14.0**	**15.0**	**15.0**	**11.0**	**12.0**

Source: data calculated based on data by WTWD 2014, NISRDP 2014, ARDA 2014, HCSO 2011 and own questionnaire survey data.

In the case of indices related to tender applications, it is very difficult to assess the success or failure of certain micro-regions. The number of tender applications per farmer is very low: the county average is 23 percent, which means that only 23 percent of all registered farmers receive some agricultural support. This, however, can be explained by the high rate of small-scale farmers rather than by their failure (there are nearly 20,000 registered farmers in Zala County). The distribution around the average is insignificant: the micro-region of Nagykanizsa has the lowest (18%) and Lenti has the highest (35%) figures.

The tender amounts won per farmer (HUF 540,000 in county average) represent more significant differences between the micro-regions even if not on a large scale. Accordingly, the micro-region of Pacsa was in the most advantageous (HUF 1,000,000) while that of Hévíz in the least successful (HUF 230,000) position.

The ratio of direct area payments to indirect agricultural support was 48-52 percent on the county level in favour of indirect supports. The distribution of the amounts won is similar between the two tender types. It was typical of the majority of the micro-regions that the proportion of direct area payments exceeded that of indirect support with the exception of the micro-regions of Zalaegerszeg (50.7%), Nagykanizsa (56%) and Lenti (66%) where the ratio of direct area payments exceeded 50 percent; therefore, in this regard these three micro-regions are considered to have the highest performance.

Although there are differences among the three micro-regions, such differences are insignificant, and they do not modify the extent of adaptation, but only modulate it. Due to land fragmentation and the significant number of land owner farmers who possibly do not apply for tenders at all, it is very difficult to assess their success in tender applications.

The HDI values of the micro-regions in Zala County are between 24 (Zalakaros) and 64 (Keszthely), the average value of the nine micro-regions is 48, which significantly falls behind the ideal maximum values. Based on the index it cannot, therefore, be established that people in the county have good or exceptional socio-economic conditions. The general conditions of the society may also influence its adaptive capacity. It is arguable whether qualification or income position have an impact on adaptive capacity; however, poor health or low life expectancy at birth may contribute to it.

As it can be seen in the table above, based on the parameters examined there are no significant differences among the micro-regions in terms of adaptive capacity. The main reason is that local knowledge, which is required for adaptation about technology and varietal conversion, is typically not significant in the county as a whole. Having regard to the other indicators, no significant differences can be observed either between the micro-regions, which would essentially affect the findings. The micro-regions are prepared for the increasing needs for irrigation since agricultural irrigation has no traditions in the area. Based on the HDI, which indicates the level of schooling, income position and health condition, the social conditions of people living in the agricultural area of Zala County is about average, but far from being ideal.

Micro-regional level research focusing on one county if compared to the best performing research area, are not sufficient due to the limited comparability. Although databases are linked mostly to administrative boundaries, it would be more useful to connect climate change adaptation research to boundaries of geographical or agricultural regions, because perception of drought and its problems seems more relevant in case of cultural landscapes than on the micro-regional level.

In comparison with previous research (Wilhelmi – Wilhite 2002, Pálvölgyi et al. 2010, 2011, Farkas et al. 2015), we attempted to review the issue of adaptation, and in this regard we found it essential and important to ask for the opinion of the concerned people. Another difference was that in consultation with the relevant water authority, we obtained detailed information about the current utilisation of irrigation, and we also gained access to an individual database for the establishment of the micro-regional level HDI index. Previous research attempted to measure adaptive capacity based on indirect data, focused mainly on economic indicators, and referred to factors such as schooling or financial position (Wilhelmi – Wilhite 2002, Brooks et al. 2005; Smit, B. – Wandel, J. 2006; Pálvölgyi et al. 2010, 2011, Farkas et al. 2015). Even though these characteristics are naturally important for adaptation, neither of them can specifically suggest whether the local population is or would actually be able to adapt to climate change. Comprehensive and reproducible studies require data that are also available to everyone over time; such studies, however, cannot be used to directly measure adaptive capacity. The rural population's knowledge about droughts and climate change in general, and about adaptation seen as responses to such challenges can only be measured accurately if we directly ask the opinion of the people concerned by means of detailed field work. Conducting field questionnaire surveys and interviews is time-consuming and their results may not be reproduced easily year by year; their main advantage, however, is that their findings are more specific compared to other studies which use available data exclusively; also, significant information will not get lost.

5 CONCLUSION

The study of societies' vulnerability to climate change has been brought into the focus of scientific research in the last few years. Similar to the diverse impacts of climate change, vulnerability studies are also diverse. However, the common feature of all such studies is that they examine the extent of vulnerability in relation to impacts and adaptive capacity in every case. Adaptive capacity has an essential role in dealing with the impacts. Nevertheless, the common ground of studies to date is for the means used for measuring adaptive capacities. They mostly used indirect indices which could be established on the basis of data retrieved from electronic databases with easy access, relating to the economic and social relations of the particular society, and presuming that societies with good conditions can adapt better to the challenges posed by climate change. In our research, we examined how the method of measuring adaptive capacity could be made more precise, and how to introduce new indicators in addition to the existing ones which are based on the opinion, experiences, and established adaptation practices of the society concerned. We found that if we want to learn about a society's knowledge about actual adaptation, direct questioning of the people concerned and detailed field work are essential. Indirect data relating to a society's health conditions, economic situation and qualification may be necessary components of the adaptation indicator; however, the most important index of the indicator must relate to adaptation practices. The drawbacks of questionnaire surveys and field work is that they are very difficult to reproduce with the lapse of time. Nonetheless, their main advantage is that they contribute more specific results to the adaptation index than indirect data, which, therefore, significantly increases the usability of the findings of vulnerability research and their occasional application in adaptation policies.

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