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Land protection versus planned land consumption: an example of the Hradec Králové Region

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Abstract: One of the most significant environmental problems in Europe is the land use change as a result of urbanization. The estimate of future agricultural land takes in the Czech Republic previously published in this journal is alarming; however, this is based on arbitrarily determined assumptions. Our contribution brings a more realistic assessment of the extent of expected land takes (example of the Hradec Králové Region). For this purpose, the data from the municipalities' Planning Analytical Materials (PAM) on buildable areas (and redevelopment areas) and data on the existing expansion of built-up areas are used. Particular attention is paid to the best quality soils included in the 1st and 2nd protection class of agricultural land resources (ALR), because some municipalities located in fertile agricultural areas argue about the necessity to build up good-quality land. The Pearson correlation coefficient has been used for the evaluation to what extent the share of the soils included in the 1st and 2nd protection classes of ALR out of the total area of the municipality is really related to the share of best quality soils in planned buildable areas. The spatial statistics method – geographically weighted regression (GWR) has been used to find spatial deviations from the global relationship model. There is a clear differentiation between the municipalities as to whether they are able to rather protect the best soil or whether they are planning future construction predominantly on it. E.g. in municipalities with about 30–50% of the land included in the 1st and 2nd ALR protection classes, buildable and redevelopment areas are designed from 0 to 100% for these highest classes of ALR protection. However, the total strength of the association (Pearson's r) between these indicators is large, $r = 0.80$ (or $r = 0.95$ when "the point-index value of agricultural land" was used instead of ALR protection classes). The results of GWR show that higher deviations from the model value, both positive and negative ones, are not spatially clustered but located next to each other. Greater deviations occur more frequently in the more fertile western part of the region, where there is a higher pressure on good-quality land, which is either intended for development or protected on the basis of local factors (including spatial planning of individual municipalities). Estimation of future developments has revealed a substantial over-dimensionality of planned buildable areas – they will potentially be built up in more than 100 years.

Keywords: buildable areas; land take; land use change; reduction of farmland; spatial planning; urbanization

Ineffective soil protection is a pan-European problem. This concerns mainly the rate of change, the frequency and the extent, which increased substantially in the second half of the 20th century (Antrop 2000). In the past, cities were established in areas with the highest quality agricultural land, so that they could be supplied with food in close surroundings. The expansion of cities then leads to a loss of the best soils (Kozák *et al.* 2010). Farmers often have to move to less fertile areas located at higher altitudes

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(*cf.* Grădinaru *et al.* 2015), which is also the case in the Czech Republic. Other authors, however, point out that urban sprawl is the most problematic type of development. It is a sprawling of extensive forms of development (thoughtlessly located residential and commercial areas) into an open landscape (Galster *et al.* 2001; Johnson 2001).

In addition to the publications which evaluate land use changes throughout the Czech Republic and in the wider European context (e.g. Bičík & Jeleček 2009; Bičík *et al.* 2015; Feranec *et al.* 2017), the attention in the field of land take studies has been focused on Prague as the largest Czech city (e.g. Spilková & Šefrna 2010; Stachura *et al.* 2015; Pazúr *et al.* 2017). Other regions have been given much less attention so far and therefore we are focusing on the Hradec Králové Region, which makes it possible to compare the use of agricultural land (and its losses/takes) across diverse natural conditions, ranging from fertile lowlands to the highest mountains in the Czech Republic.

Soil loss affects its production and non-production functions (Uhel 2006). In particular, good quality land has a great importance for food production and takes of this land can threaten the food security of future generations (Chen 2007, Kibblewaithe *et al.* 2012), which is contrary to the basic principle of sustainable development (Act No. 17/1992 On the Environment, §6). It is also the retention capacity of the landscape, through the reduction of which the risk of water scarcity increases (Janků *et al.* 2016a). Other non-production soil functions include e.g. soil biodiversity (soil as a gene reservoir), carbon sequestration (soil as a carbon sink) and water purification.

In order to avoid uncontrolled land take and negative impacts on the environment, management strategies and experience with the practical implementation of soil protection at a regional and local level are necessary (Janků *et al.* 2016b). However, opinions on effective soil protection differ substantially in literature. Schetke *et al.* (2012) considered the spatial planning to be the most effective tool, as a process integrating the protection of natural resources and landscape with urban development (investors' interests etc.). On the other hand, Nuissl and Schroeter-Schlaack (2009) concluded that economic and fiscal instruments in combination with spatial planning are the most effective. The legal limits of soil protection are less effective without economic strategies encouraging soil protection.

Although the soil of the 1st and 2nd protection class of agricultural land resources (ALR) should not be built up as far as possible, in accordance with Act No. 334/1992 (Agricultural land of the 1st and 2nd protection class may be withdrawn only in cases where other public interest outweighs the public interest in the protection of the agricultural land resources), municipalities do not often respect this legal provision and many exceptions are permitted by ALR protection authorities. The positions of these authorities in the spatial planning process have also been relatively weakened. Janků *et al.* (2016a) summarized general social and economic reasons for insufficient protection of quality land: high profit from land sales on building plots; cheaper construction on greenfields and disinterest in brownfields; strong construction lobby; high food imports. Local factors are also important, including the attitude to spatial planning. A study of the area on the outskirts of Prague showed that only 9 out of the 22 localities investigated managed to protect the most fertile soils (Stachura *et al.* 2015).

Preserving the highest quality land for agricultural production is also the objective of the Czech Ministry of Agriculture (MoA), as stated in the department's strategy with an outlook until 2030 (Ministry of Agriculture of the Czech Republic 2016). For this purpose, the Research Institute for Soil and Water Conservation has developed an interactive tool "Land Use Limits" (https://limitypudy.vumop.cz/). The application allows to analyse the availability of land in lower protection classes according to specified parameters and provides information on development areas and (agro)brownfields in the area of interest. The main benefit of the application is that new investment and development plans can be objectively assessed also with regard to the protection of good-quality agricultural land. The MoA expects that the application will become a tool for objective assessment of the materials for the quantitative protection of agricultural land.

The main goal of this article is to evaluate the problem of extensively delimited buildable areas on the highest quality agricultural land and related questions, such as: To what extent the share of the soils included in the most protected classes (on the total area of the municipality) is really related to the share of best quality soils on planned buildable areas? Could the less fertile land be used for construction (e.g. with the help of the "Land Use Limits" tool)? How does the extent of delimited buildable areas correspond to the estimate of future agricultural land takes?

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MATERIAL AND METHODS

The Hradec Králové Region is located in north-eastern Bohemia. It has an area of 4759 km^2, with 551 000 inhabitants. This region was selected due to the diversity of natural conditions and the relative completeness of the spatial planning data analysed.

On the basis of selected Planning Analytical Materials (PAM) data, buildable and redevelopment areas from the Hradec Králové Region (available for 352 municipalities), we can more realistically assess the extent of potential future land take of agricultural land, including the quality of this land. Not all the land within the administrative boundaries of the cities or in their immediate surroundings is intended to be built (which, on the contrary, is a premise of the estimation of Janků *et al.* 2016b).

Land registry (Cadastre of Real Estate (CRE)) and Land Parcel Identification System (LPIS, MoA CR) data were used to assess the extent of utilized agricultural land. According to the CRE data (2017), arable land accounts for almost 40% of the region's area, agricultural land for 58%. Built-up and remaining areas occupy 9% of the total area; the rest consists of forests (31%) and water bodies (1.6%). The CRE registers by approximately 21 700 ha of arable land more than the LPIS. Arable land, according to LPIS, occupies 34% of the region's total area.

Also data on the Population Census (Czech Statistical Office) processed in the geographical database ArcČR 500 (Ver. 3.2, 2014) and Evaluated Soil-Ecological Unit (ESEU; BPEJ in Czech) database (State Land Office) were used. Each ESEU is assigned average official price (in CZK/m^2 according to Decree No. 441/2013), point-index value of agricultural land (indicator of the soil productive potential, on a scale from 0 to 100) and protection class of ALR (5th to 1st). The higher point-index value is generally (but not automatically) associated with the higher class of ALR protection. Approaches to soil quality assessment were discussed in more detail e.g. by Novák *et al.* (2010). The average point-index value of agricultural land in the region (weighted by the area of the given productivity) is 68 points for the 1st protection class of ALR, 60 for 2nd, 45 for 3rd, 38 for 4th and 18 for 5th class. The average productive potential of the region's land is 48 points.

Data were analysed in the GIS (ArcMap Ver. 10.4, 2016) and then using the Pearson correlation coefficient in R software (Ver. 3.4.2, 2017). In addition, one of the spatial statistics methods – geographically weighted regression (GWR) was used (Fotheringham *et al.* 2002). It is a local form of linear regression for the evaluation of phenomena where functional relationships between variables differ in different spatially defined areas (so called spatial non-stationarity and heterogeneity). The method can also be used to determine if this type of phenomenon is involved.

RESULTS AND DISCUSSION

Planned buildable areas versus soil protection. According to the analysed data of the PAM (2016), 11 993 hectares of the area for potential construction (i.e. 10 674 ha of buildable areas, then redevelopment areas and other areas where the phenomenon is not marked in the source data) are located in the Hradec Králové Region. There are 43 410 ha of built-up areas in the region; these are built-up areas of municipalities (including gardens, orchards and smaller areas of arable land within the settlements). This area is very close to the area of the built-up and remaining areas in the region according to cadastral data (43 128 ha in 2016). Unlike the built-up area in the PAM, these areas also include roads and "remaining areas" outside the settlements.

Some municipalities located in fertile agricultural areas argue with the necessity to build up good-quality land because no other suitable land is available (see, for example, Master plan of Jičín: https://www.mujicin.cz/uzemni-plan-jicin-opatreni-obecne-povahy-r-2010/d-1102927, in Czech). Therefore, it was evaluated to what extent the share of the soils included in the 1st and 2nd protection classes of ALR out of the total area of the municipality is really related to the share of best quality soils on planned buildable areas (Figure 1). It has been shown that there is a very pronounced variability among municipalities, e.g. in municipalities with about 30–50% of land classified as the 1st and 2nd protection class of ALR are buildable and redevelopment areas delimited from 0 to 100% in these highest classes of ALR protection. In the above-mentioned town of Jičín the share of soils in the 1st and 2nd protection class of ALR out of the total area (79.6%) is slightly higher than the share of these fertile soils in the buildable area (74.2%). The correlation is not affected by outliers, the association is strong, r = 0.80.

A very strong linear relation between the average point-index value of agricultural land in the municipality and in the planned buildable and redevelopment areas located in the same municipality (Figure 2) is evident in the evaluation. The association is extremely strong, r = 0.95.

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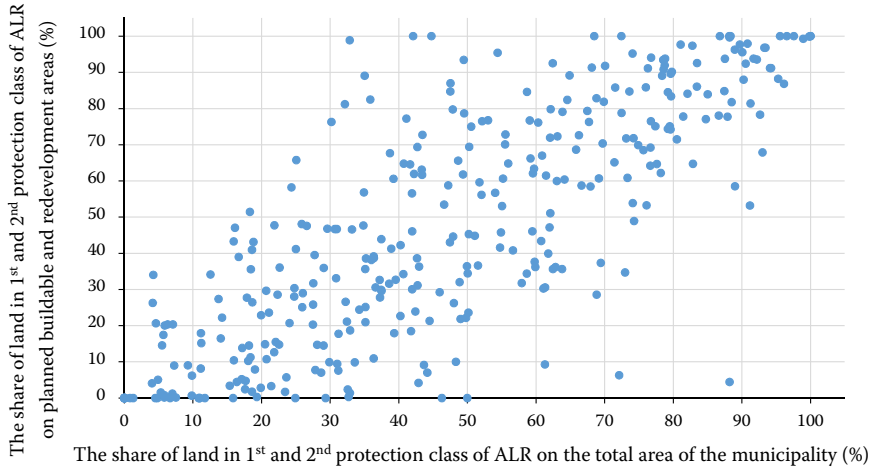

Figure 1. Land in the 1st and 2nd protection class of agricultural land resources (ALR) in the municipalities of the Hradec Králové Region and in their planned buildable (and redevelopment) areas

Municipalities with no planned buildable and redevelopment areas (or with less than 0.1 ha of these areas, i.e. small overlaps) are excluded; only land with assigned ESEU code was evaluated; sources: PAM (2016); ESEU (2017)

For further data analysis, geographically weighted regression (GWR) has been used. An independent variable is the share of land classified in the 1st and 2nd protection class of ALR in the municipality. A dependent variable is the share of such quality soils (1st and 2nd class) in planned buildable areas. An adaptive kernel type was used. This explains 55% (R^2, coefficient of determination) of the variance of dependent variable. Figure 3 shows the standardized residuals of this regression model. The spatial clustering of high or low residuals is not apparent from the cartogram. This was also confirmed by the analysis of spatial autocorrelation of standardized residuals using Moran's I statistic. On the contrary, a significant clustering of residuals would indicate a misspecification of the model, for example, the existence of an omitted explanatory variable.

The GWR for average point-index value of agricultural land provides similar results. The results of both GWRs show that higher deviations from the model value, both positive and negative, are not spatially clustered but are located in mutual neighbourhood (e.g. the area north of Hradec Králové). Higher positive and negative deviations are found more often in the more fertile western part of the region. There is a higher pressure on good-

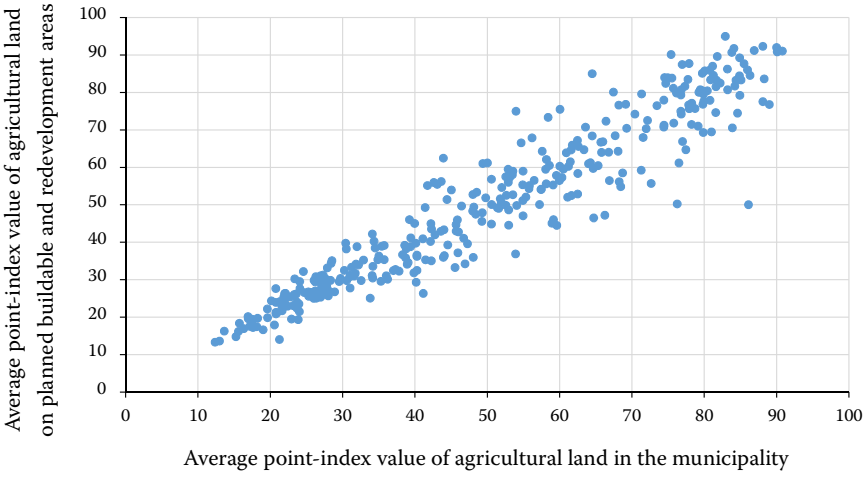

Figure 2. The average point-index value of agricultural land in the municipalities of the Hradec Králové Region and in their planned buildable (and redevelopment) areas

See the note to Figure 1; sources: PAM (2016); ESEU (2017)

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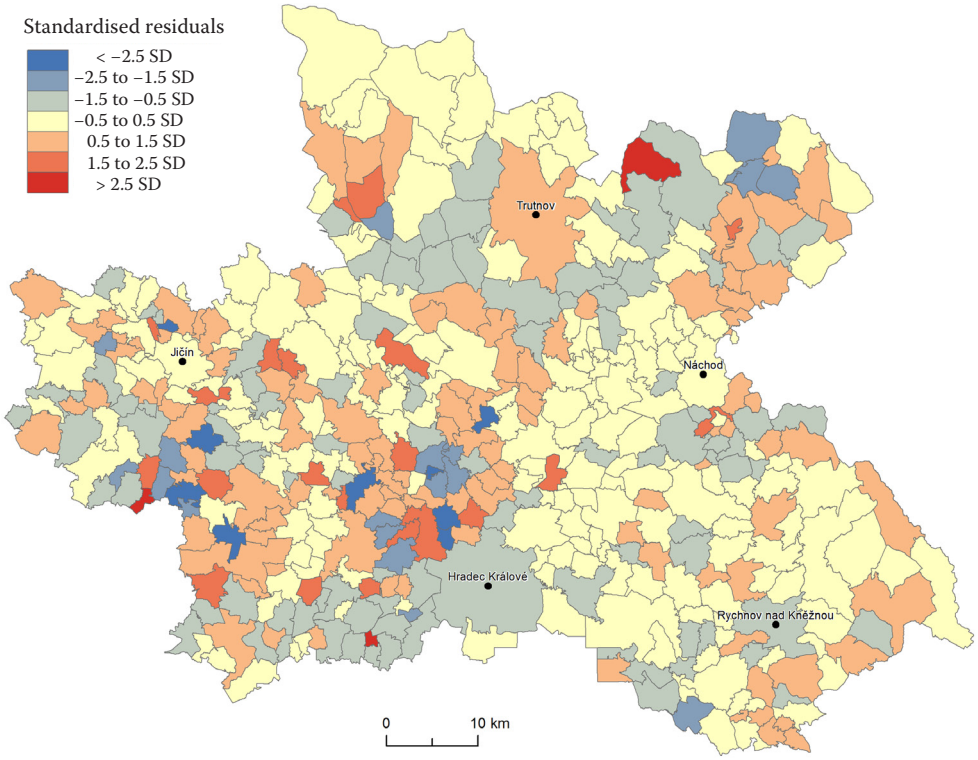

Figure 3. Standardized residuals of geographically weighted regression (GWR); independent variable: the share of land classified in the 1st and 2nd protection class of agricultural land resources (ALR) in the municipality, dependent variable: the share of these good-quality soils on planned buildable areas

SD – standard deviation; sources: ARCDATA PRAHA (2014); PAM (2016); ESEU (2017)

quality land, which is either intended for development or protected on the basis of local factors (including spatial planning and its stakeholders). Selected municipalities with significant deviations should be further explored in prospective follow-up research.

Estimation of future developments. Between 1999 and 2017, the acreage of built-up and remaining areas in the Hradec Králové Region increased by an average of 117.4 hectares per year, according to the Cadastre of Real Estate data. If the built-up and remaining areas are to expand at the same rate as in the last 18 years, 1527 ha of (mostly) agricultural land will be taken in the region by 2030. However, if these areas are to expand at the same rate as in the last seven years (after a slowdown in 2010), the agricultural land will be reduced by 1326 ha in 2030. The specific period of the 1990s transformation will not be repeated, so it is not included in the projections of future development.

Buildable areas (phenomenon 117 in PAM) are currently delimited in municipalities very generously – if this trend continued, they would be built up in 91 years (according to the development in the period 1999–2017, or in 105 years according to the development in 2010–2017). In the case of all areas for potential development, this would be a period of 102 years (or 118 years). In the Hradec Králové Region there are 718.8 hectares of brownfields according to other obtained documents (from the years 2010–2015). Upon total reuse of brownfields, their area would suffice to cover the growth of built-up and remaining areas for 6 years (or 7 years respectively).

Furthermore, for comparison (e.g. with the work of Janků *et al.* 2016b), the land potentially most endangered by land take, located within the settlement area (of all settlements, not just the regional and former district's centres) or within a short distance from it, has been analysed. Due to the significant differences between cadastral data and LPIS, results from both sources are shown (Table 1).

Within a short distance of 100 m from the built-up area, one fifth of the agricultural land is located, and up to 200 m even more than half of the agricultural land is located. An interesting finding is the clear convergence of the area of arable land according to LPIS to values in CRE with increasing distance from the built-up areas (see the last column of Table 1).

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Table 1. Agricultural and arable land in the built-up area of municipalities and at selected distances from it in the Hradec Králové Region (in %)

Registered area		LPIS		CRE		Proportion LPIS/CRE[1] (arable land)
		agricultural land	arable land	agricultural land	arable land	
In the built-up area		0.8	0.2	6.6	1.1	15.2
At a distance from the built-up area to	50 m	8.0	5.9	10.4	7.7	67.8
	100 m	19.7	15.2	22.8	17.9	74.7
	200 m	50.4	40.4	53.6	44.7	79.8
Total[2] (ha)		236 580	163 503	270 390	185 187	88.3

LPIS – Land Parcel Identification System; CRE – Cadastre of Real Estate; [1]calculated from the respective absolute areas according to both data sources; [2]in the whole territory of the region; agricultural land in CRE includes the class of (mostly non-agricultural) gardens

Sources: PAM (2016); CRE (2017); LPIS (2017)

However, a detailed comparison of data sources goes beyond the scope of this article.

DISCUSSION

The data and methods used, of course, have their limitations. Apart from the time-consuming requirement of obtaining PAM from municipalities, the problem is their incompleteness, i.e. the missing digital data on the buildable areas in some municipalities. Another problem with the data sources is the substantial difference in the registered area of agricultural land according to CRE and LPIS.

These deficiencies in the available data sources are particularly important because of the lack of accurate data on the area of agricultural and arable land. Without accurate data it is not possible to assess the extent of land takes and to take adequate measures (Bouma *et al.* 1998). Lack of good and up-to-date data on agricultural land losses could even be an argument for weakening the protection of agricultural land (Janků *et al.* 2016a).

CONCLUSION

The lifestyle of people is becoming more and more demanding in terms of the size of the built-up areas, which is reflected, for example, by reducing the number of people living in one household, increasing the sales area per inhabitant, building new transport structures, especially for car traffic etc.

In the Hradec Králové Region, between 1991 and 2011 (according to the census), the population increased by only 1608 persons (from 552 809 to 554 417 persons), i.e. by 0.3%. On the other hand, the extent of built-up and remaining areas increased in the period 1990–2010 by 1660 ha (from 40 819 to 42 479 ha), i.e. by 4.1% (according to the cadastral data). Similarly, there has been a decoupling of trends in population and land consumption at the European level (Artmann 2014).

The extensively delimited buildable (and redevelopment) areas in the Hradec Králové Region with an area of 11 993 ha thus contrast with the projection of the Czech Statistical Office, according to which the population of the region will decrease significantly: to 547 thousand in 2020, 535 thousand in 2030, and to 502 thousand in 2050 (see https://www.czso.cz/csu/xh/projekce_poctu_obyvatel_do_roku_2050, in Czech).

The data evaluated in this article show that one of the objectives of the Strategy of the Ministry of Agriculture (2016) – the preservation of fertile land for sustainable agricultural production in the future – will not be easy to fulfil. Lands included in the 1st and 2nd protection class of ALR account for 48% of the delimited buildable and redevelopment areas (which are located on the soils recorded in the ESEU system, i.e. 11 538 ha out of a total of 11 993 ha)! This is even a higher share than the share of land included in the 1st and 2nd protection class out of the total agricultural land in the Hradec Králové Region (45%). It is therefore clear that the current rules on the protection of fertile agricultural land (based on Act No. 334/1992) are not sufficient.

Due to the considerable extent of planned buildable and redevelopment areas, even on the most fertile soils, it will be necessary to solve the problem that some municipalities have already encountered in trying to reduce the unnecessarily large (and not yet used) buildable areas. It is the compensation payment to the landowners for the removal of their plots from the buildable area (according to the valid version of the Building Act). The development of ways of more effective protection of the best soil, the role of local

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factors in their application and other related issues are already topics for follow-up research.

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