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Land Use Analysis in Terms of Farmland Protection in the Czech Republic

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Abstract

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The agricultural land acreage in Central Europe, including the Czech Republic, rapidly decreases. This study presents the trends of agricultural land acreage reduction in the period 1966–2013, with respect to the 1990 milestone (political changes triggering a rapid loss of agricultural land for construction purposes). The analysis is based on the cadastral register data. Particularly serious is the rapid reduction of arable land – 25 ha per day. Furthermore, the actual built up area seems to be larger than show the records on the construction land in the cadastral register. There is an obvious discrepancy between the real state and the cadastral data, so the actual reduction of arable land in the Czech Republic may be even greater. Unfortunately, some municipalities responsible for the urban planning process are obviously not interested in land protection. Based on their quality, the Czech land protection law classifies the soils into 5 protection classes. The areas with the first and second class soils should not be used for construction purposes. However, the study revealed the law is frequently neglected from the part of municipalities and the areas of best quality soils have often been sealed by construction. The present study also attempted to enumerate the financial losses from crop production associated with the land take. The ineffective land protection is a very serious Europe-wide problem.

Keywords: agricultural land management; agricultural land protection; land take; land use change; rapid reduction of farmland; soil sealing; cadastral register; urbanization

Soil sealing is defined as permanent covering of the land surface by buildings, infrastructures or any impermeable artificial material. It has been identified as a major threat in the Soil Thematic Strategy of the European Commission (European Commission 2006), both in terms of permanent loss of soil as a resource and for its important impacts on soil functionality. A review by Scalenghe and Ajmone Marsan (2009) summarizes the relevance of soil sealing as an impact pathway of human activities on the environment. The soil sealing in urban areas is perceived as a driver of flood risks in many contexts (Pitt 2008; Malucelli *et al*. 2014).

Despite the existence of the agriculture land protection law (Law No. 334/1992 Coll.), land protection in the Czech Republic seems to be ineffective.

Very similar problems have existed in many countries. Despite a shrinking population, soil sealing and land consumption have a rising tendency in Europe (Artmann 2014a). The present land acreage consumed by soil sealing in Austria is estimated at 15–25 ha per day (Nestroy 2006). In China, for example, Liu *et al*. (2015) reported that the Chinese land policy aimed at controlling construction land growth and preventing cultivated land loss proved to be a double failure. The control–protection relationship is not simply "control for protection," as claimed in official discourse; rather, farmland protection is also a slogan and excuse used by the government to restrain the excessive land expropriation in the urban fringe to avoid or mitigate farmland degradation, urban land waste, and social unrest.

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The China's National General Land Use Plan (2006–2020) fails to control arable land loss during its midterm phase. More specifically, 1 657 868.82 ha of arable land have additionally been lost due to ineffectiveness of the mentioned plan (Xu *et al*. 2015).

The greatest problem for land protection in the Czech Republic is land take and soil sealing. The soil is destroyed irreversibly. Possible reasons are economic, social, and paradoxically also biological. The main reasons are economic, because many owners prefer an immediate profit from the land. The quick profit from the land is given by the large difference between the price of agricultural land and the price of building plots. At a price 200 CZK per m^2 (a rather lower price for the building plot), the farmer would have to work for 150 years to take the same profit, with the current subsidies for "only" 100 years (based on data of the Research Institute of Agricultural Engineering (VUZT), http://www.vuzt.cz/index.php?I=A37).

Many brownfields in urban areas of towns and villages are not used for building purposes, and are ignored, but new buildings are constructed on "green fields", because it is cheaper than to reclaim brownfield sites.

The economic reasons are closely connected with social aspects. A typical feature of today is the fading out relationship to land and country.This fact is also confirmed by Lokocz *et al*. (2011) who presented compelling evidence that local residents' attachment to the rural landscape is a strong motivation for being engaged in land stewardship and preservation efforts to sustain rural places and economies.

One of the social reasons is that land protection is looked upon as an obstacle for business by many people (businessmen, municipalities).

The next reason is the massive food import, and therefore many people do not think about the primary role of land for food production. But the most serious reason is the strong building lobby.

The typical system of expansion of towns and villages is called suburbation (industrial and residential). It is typical for the historical development of European towns, but currently this process is unregulated in the Czech Republic.

The present authors agree on the fact that in the case of land protection, the politicians operate directly and very strongly, either positively or negatively. In 1998, facing a substantial loss of farmland in the reform era, the Chinese government established a highly centralized land management system to guarantee its capacity to meet the domestic food needs. In order to maintain high-speed economic growth, local governments in China made great efforts to circumvent the stringent constraint on land use by launching various innovative land management schemes. Among these efforts, Zhejiang's rewarded land conversion quotas (RLCQ) trading scheme, a program similar to the transfer of development rights (TDR) in Western countries, has attracted a lot of policy and scholarly attention (Zhang *et al*. 2014).

Another reason is the paradoxical attitude of biologists (environmentalists). Many of them consider agricultural land worthless from the biological variability point of view, which is supported by the method for assessing the biotopes. This method focuses on ecological quality of the environment; each biotope is granted a specific number of points appraised in CZK. This method was originally developed in the Hessen region in Germany (Anonymous 1992). In the Czech Republic, the number of points for agricultural land is very low in comparison to other biotopes (Seják & Dejmal 2003).

MATERIAL AND METHODS

The data for the examined period 1966–2013 used in this study were taken from the cadastral register, and also from the Statistical Yearbook of Land Soil Resources of the Czech Republic (http://www.cuzk.cz/Periodika-a-publikace/Statisticke-udaje.aspx).

Concerning the 1990 to 2013 period, it should be mentioned that the political and social situation turnover in 1989 intensified the pressure for land take and soil sealing (new warehouses, halls for industry, trade and also construction of new residential areas).

According to the cadastral law (Act No. 256/2013 Coll.), the Czech Geodetic and Cadastral Office keeps evidence on several land types: agricultural land, forest land, water areas, and also construction land. The construction land register covers built-up areas and courtyards and other areas. Agricultural land includes the following land categories, namely arable land, vineyards, gardens, permanent grassland (meadows and pastures), hop-gardens, and orchards.

The acreages of land types for years 1993 and 2013 are presented in Table 1 (http://www.cuzk.cz/Periodika-a-publikace/Statisticke-udaje.aspx).

The data for this study were obtained for the entire Czech Republic, and also separetely for the five districts: Havlíčkův Brod, Klatovy, Olomouc, Prague-East, and Znojmo.

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For the purpose of following the trends of land use changes, especially the conversion of agricultural land to construction land, a regression analysis was used.

A simple linear regression is the least squares estimator of the linear regression model with single explanatory variable.

The function of regression line is expressed by the equation:

$$y = \beta_0 + \beta_1 x$$

where:
y – acreage
x – year

The exact regression line is obtained by specifying the coefficients β_0 and β_1 using the Least Squares method:

$$\sum_{i=1}^{n}(y_i - Y_i) = 0$$

$$\sum_{i=1}^{n}(y_i - Y_i)^2 = \min$$

where:
Yi – balanced value selected on the regression line (Hindls *et al*. 2003)

To ensure that the chosen regression line aptly describes the investigated relationship, the coefficient of determination (r^2) was used.

The independent variable is the year and the dependent variable is the acreage of the land type.

Table 1. The acreages of individual land types for the years 1993 and 2013 (in ha)

Type of land	1993	2013
Arable land	3 175 204	2 993 236
Hop-gardens	11 422	10 355
Vineyards	15 691	19 562
Gardens	158 015	163 320
Orchards	50 409	46 393
Permanent grassland	872 269	991 523
Agricultural land	4 283 010	4 224 389
Forest land	2 629 075	2 661 889
Water area	158 106	163 965
Built-up areas and courtyard	127 409	131 800
Other areas	688 817	704 507
Non-agricultural land	3 603 407	3 662 231
Total	7 886 417	7 886 619

Because of a marked difference between the data for the period before and after the year 1990, the data were examined for the entire period 1966–2013 plus various equations were calculated separately for the period until 1990 and since 1990.

Based on the fact that the increasing use of arable land for construction purposes is the primary cause of arable land loss, the arable land changed for construction purposes was set as a dependent variable, and the factors like socio-economic conditions, implementation of planning, arable land changed for transportation purposes, year dummy variable were assessed as independent variables. A fixed panel data model was taken as the basis for constructing the regression equation (Xu *et al*. 2015).

RESULTS

This study follows the trends in land use change, especially the conversion of agricultural land to construction land.

The supposed trend since 1966 is a steady decline of agricultural land and steady rise of construction land acreage. The changes of the land type acreage for each period are stated in Table 2. The results are also shown in Figure 1, changes of the land type acreage before 1990 are given in Figure 2a and those after 1990 in Figure 2b.

An interesting observation is that while the acreage of agricultural land, especially of arable land, shows a rapid increase, that of building land has grown just little, not as much as would be expected considering the visibly built-up landscape.

The authors assume there is a discrepancy between the records in the cadastral register and reality. This means that not every built-up area is registered as a building plot – it may still be registered as an agricultural land.

The same fact was confirmed on the example of five districts (Klatovy, Prague-East, Havlíčkův Brod, Znojmo, Olomouc). It was found out that in the Klatovy and Olomouc districts the building area officially (based on cadastral data) reduces, despite the occurrence of further built-up areas. In the Olomouc district this situation can be explained, at least in part, by a probable change in the records of land inside the military areas. The other military areas are now registered as permanent grassland. The data are reported for the situation after the year 2006. The changes are presented in Table 3.

The changes of land type acreage after 2006 are also presented in Figure 3a (for Olomouc, Prague-East,

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Table 2. The trends of changes of the land type acreage for the periods 1966–2013, 1966–1990, and 1990–2013

	Change of acreage (ha/year)					Daily change (ha/day)	
	1966–2013	R^2	1966–1990	R^2	1990–2013	after1990	R^2
Vineyards	↑200	0.83	↑380	0.92	↑220	↑0.60	0.80
Gardens	↑410	0.96	↑520	0.93	↑270	↑0.75	0.98
Permanent grassland	↑2100	0.27	↓6050	0.96	↑6040	↑16.50	0.81
Hop-gardens	↑33	0.36	↑120	0.93	↓50	↓0.15	0.90
Orchards	↓190	0.85	↓50	0.10	↓240	↓0.65	0.95
Arable land	↓8495	0.95	↓3900	0.86	↓9100	↓25.00	0.96
Agriculture land	↓5900	0.93	↓9060	0.98	↓2880	↓7.90	0.87
Forest land	↑1470	0.95	↑1310	0.94	↑1640	↑4.50	0.96
Water area	↑645	0.91	↑1050	0.99	↑279	↑0.75	0.94
Built-up areas and courtyard	↑485	0.92	↑680	0.99	↑198	↑0.55	0.81
Other areas	↑3630	0.87	↑6030	0.95	↑765	↑2.10	0.43

R^2 = determination coefficient; ↑ – rise of acreage; ↓ – decline of acreage

and Znojmo districts) and in Figure 3b (for Klatovy and Havlíčkův Brod).

The next objective of this study was to ascertain if the municipalities adhere to the soil protection law No. 334/1992 Coll., which defines five classes of soil protection. Soils belonging to the first and second class are the best-quality soils, which are strictly protected, and should be taken for construction only exceptionally in the case of public interests (e.g. railways, roads, etc.). Medium-quality soils belong to the third class and may be taken for building purposes, the same as the lower quality soils in classes 4 and 5.

The situation concerning this objective was analyzed in the town of Znojmo based on data provided by the municipality and processed using the program ArcGIS.

The results indicate that the municipality does not adhere to the terms given by law, and in its urban planning the protection of the best soils is not reflected.

The reason why the higher reduction of the best soils has been recognized consists mainly in the historical settlement. The biggest towns where building activity is the most intensive are placed on the best soils. Another reason is the structure of the towns. It

Table 3. Changes of acreage of individual land types after 2006 in five Czech districts (in %)

	Havlíčkův Brod	Klatovy	Olomouc	Praha	Znojmo
Agricultural land	–0.0261	–0.00685	–0.1335	–0.0955	–0.07419
Forest land	0.0110	0.0063	0.1944	–0.0026	0.03434
Water areas	0.0035	0.0021	–0.0003	0.0086	0.00209
Built-up areas and courtyard	0.0001	0.0011	–0.0088	0.0221	–0.00190
Other areas	0.0114	–0.0027	–0.0517	0.0671	0.03967

Table 4. Estimate of losses from agricultural activities due to land grab

	Agriculture area			
	corn + beet	potato	potato + mountain	total
Profit (CZK/ha)	12279	13037	4377	
Area (%)	31	59	10	
Land take (ha/year)	2829	5384	912	
Loss/year/CZK	35 000 000	71 000 000	4 000 000	109 000 000
Loss of better quality soils per year (CZK)		9 126		119 000 000
Loss over 25 years (CZK)				2 975 000 000

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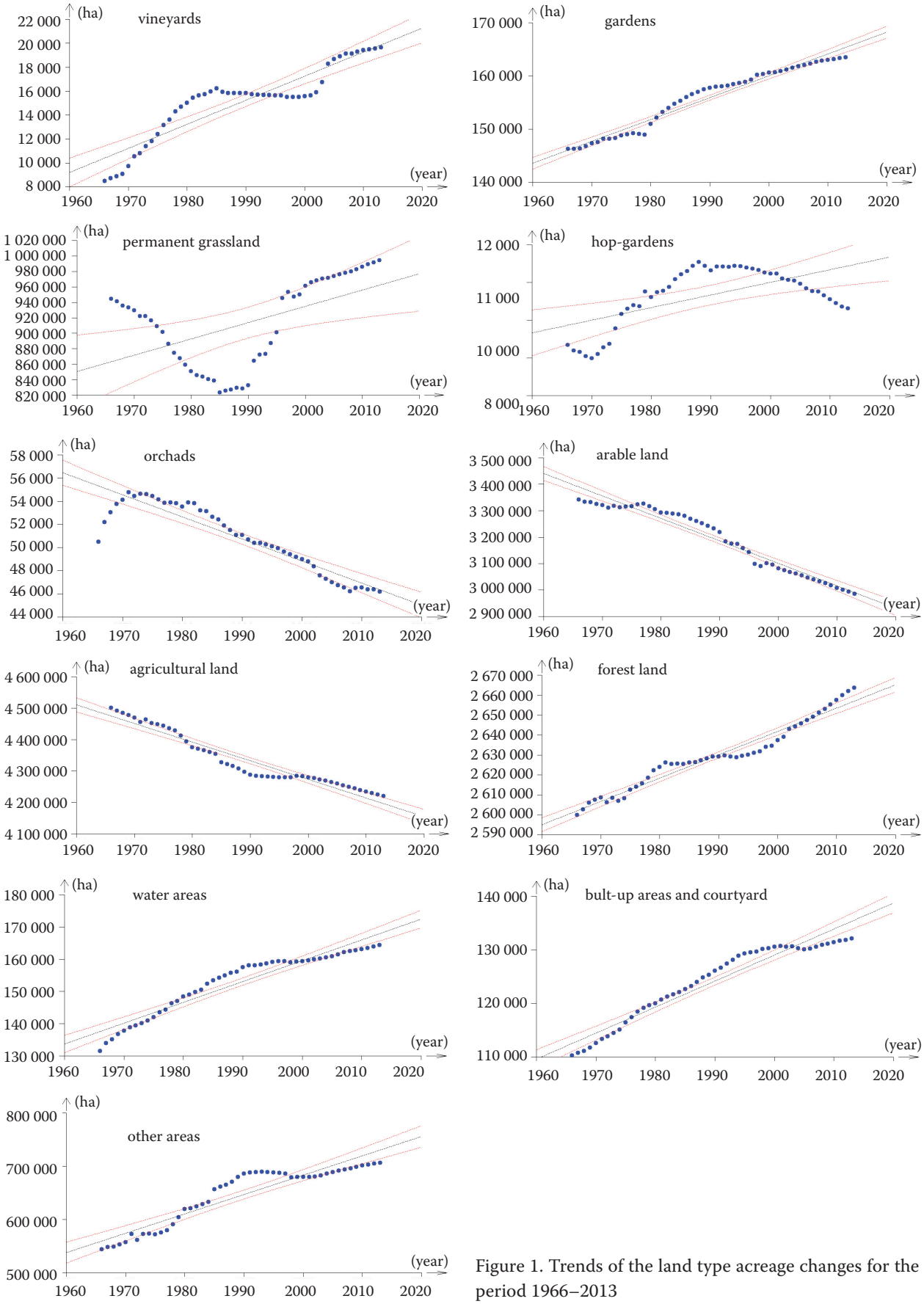

Figure 1. Trends of the land type acreage changes for the period 1966–2013

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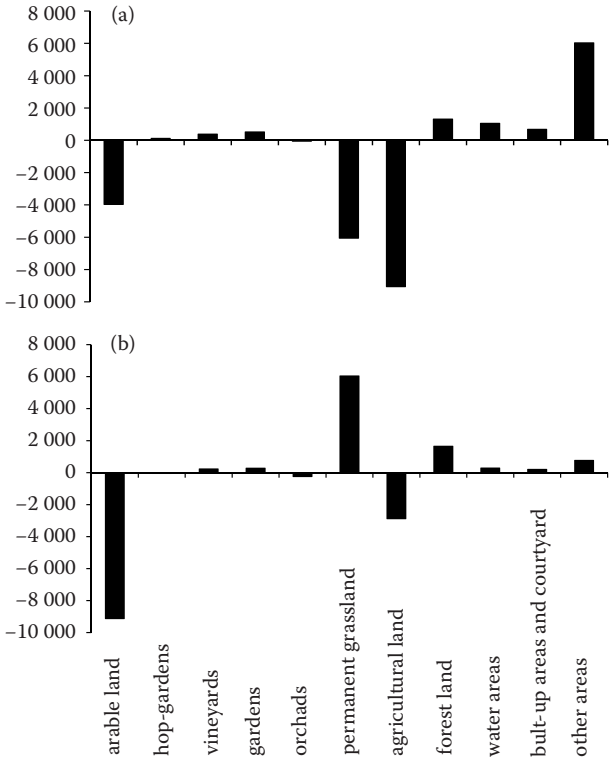

Figure 2. Changes of the land type acreage for the period 1966–1990 (a) and 1990–2013 (b) (in ha/year)

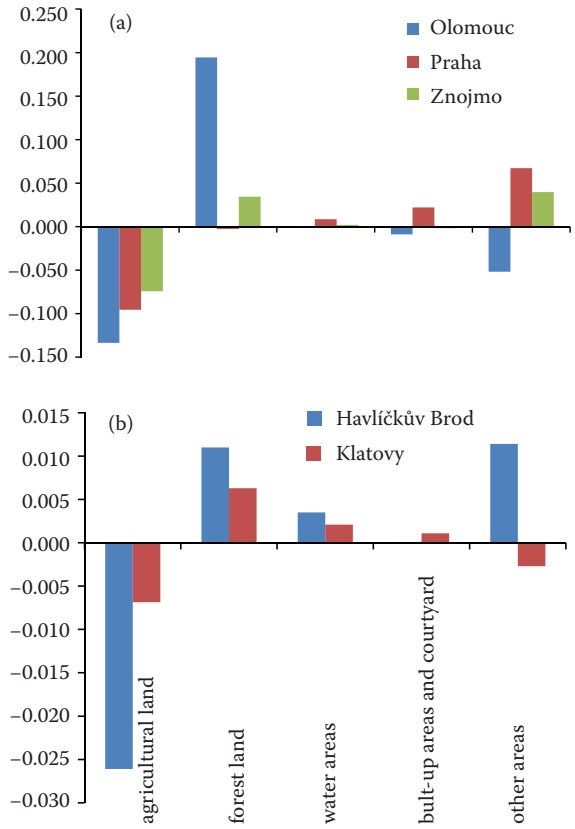

Figure 3. Changes of the land type acreage in the districts of Olomouc, Prague-East, and Znojmo (a) and Havlíčkův Brod and Klatovy (b) for the period 2006–2013 (in %)

is inconvenient to build industrial zones and residential areas at remote locations so the building process continues at the existing sites. Next reason is the indifference of officials on soil quality and probably low awareness of urban designers. The results are presented in Figures 4 and 5.

The financial loss from agricultural production was calculated on the basis of information about the economic production. For the calculation, the 2014 price of winter wheat was chosen because it is the most planted crop in the Czech Republic.

The Czech Republic is divided into four basic categories according to climate and planted crops. These categories consist of areas of corn, beet, potato, and moutains. For each area, profit in CZK was calculated according to the results of the Research Institute of Agricultural Engineering (VUZT) (http://www.vuzt.cz/index.php?I=A37). We may state that the agriculture industry loses approximately 119 000 000 CZK every year, it means almost 3 000 000 000 in 25 years. This calculation was made without subsidies. The results are presented in Table 4.

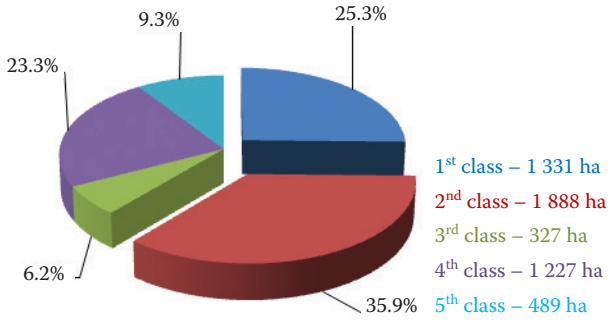

Figure 4. Acreage of built-up areas by different soil protection classes (1–5)

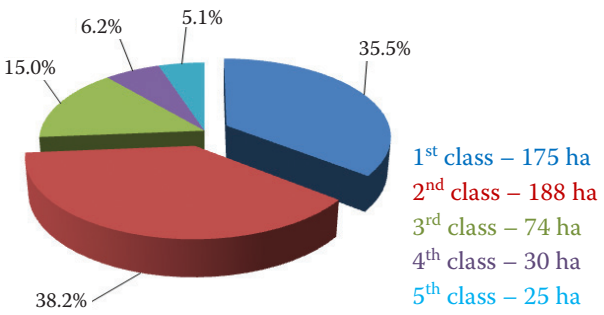

Figure 5. Acreages designed for construction purposes for the individual soil protection classes (based on the Znojmo urban plan)

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DISCUSSION

Many European countries face the problem of a rapid soil reduction, especially of that of better quality. In the surroundings of Madrid, likewise around Prague, an irreversible and rapid soil loss has been observed (Rodríguez *et al*. 2007).

Losing the richest soils (catalogued as class A) from the alluvial soils of the Henares River has been reported (Monturiol & Alcalá 1990). A rapid decrease of best quality soil has been observed also in the Czech Republic where the biggest towns, with the greatest loss of land, were founded on the best soils (Kozák *et al*. 2010).

The role of soils in supporting ecosystems and natural capital needs greater recognition. The lasting legacy of the International Year of Soils in 2015 should be to put soils at the centre of policy supporting environmental protection and sustainable development (Smith *et al*. 2015). A number of large existential environmental challenges have been recognized for the sustainable development of humanity and the Earth. These are Food Security, Water Security, Energy Security, Climate Change Abatement, Biodiversity Protection, and Ecosystem Service Delivery (Bouma & McBratney 2013).

When one analyses these environmental challenges we can recognize that soil has a part to play in all of these (Herrick 2000).

Since the implementation of the 30-ha target project in Germany, a decrease in land take from 130 ha per day in 1997–2003 to 93 ha per day in 2006–2009 was observed (Artmann 2014a). However, the German Federal Environmental Agency assumes that these trends result from the global economic crisis and its effects on construction activities (Federal Environmental Agency 2010).

Currently the Czech Republic has 147 industrial zones, built for case of rapid industrial growth. Others zones are planned (http://www.risy.cz/cs/vyhledavace/prumyslove-zony).

A mix of legal-planning and economic-fiscal responses is less efficient because of lacking economic-fiscal strategies for protecting the soil (Artmann 2014a, b). Combining economic-fiscal and land use planning instruments is supposed to be especially efficient in reducing land take (Nuissl & Schroeter-Schlaack 2009). In some European countries, e.g. Slovakia, Poland or Bulgaria, levy fees must be paid when taking the agricultural land. The fee increases according to the quality of the soil aiming to protect high quality soils (European Commission 2012). The Czech Republic has a similar system. When taking the agriculture land, fees are paid according to the soil quality, too. But this system is not fully effective because many exceptions are permitted.

Based on the results, the authors suggest that there is a discrepancy between the records in the cadastral register and the reality. This situation is also confirmed by Olbrichová (2008), who pointed to a discrepancy between the records of the Czech Geodetic and Cadastral Office (ČÚZK) and those of the Czech Statistical Office (ČSÚ). Both institutions exhibit a difference in acreage. For example, in 2004, according to the ČSÚ, the Czech Republic had 4 264 573 ha of farmland, while according to the ČÚZK it had 4 269 218 ha. The difference makes 4 645 ha only for the year 2004.

It should be noted that the Czech Republic is not alone to show such data discrepancy. Bouma *et al*. (1998) state that the inaccuracy of data has not only local, but also global implications. Without proper documentation, an accurate prognosis is unfeasible, and so it can easily happen that the land "will disappear altogether".

This fact has also significant practical implications. All state institutions operate just with the data provided by the ČÚZK (building offices, Ministry of the Environment, Ministry of Agriculture). The Ministry of the Environment of the Czech Republic authorizes changes in using the farmland.

The difference in the records can be explained by two factors. The first is the delay in the cadastral registrations, when the change in land use is announced late (even years after the completion of construction, or after the acceptance). In other words, the building has been standing long, but the land has still been registered as agricultural. The second important factor is the information gap, when the ČÚZK does not know that the land was taken off the agricultural fund. Obligatory reports on these changes ended in the mid-nineties and it means that the ČÚZK will always register a larger acreage of farmland than the ČSÚ, which regularly monitors every change. Now the farmers themselves are obliged to report all changes accurately and truthfully to the ČSÚ.

CONCLUSIONS

This study has pointed out the rapid and concerning decrease of arable land acreage – 25 ha per day, i.e. approximately 40 football fields per day, 15 000 per year.

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The study also pointed out the difference between the actual state and the state registered by the cadastral register exhibiting a small increase of built-up areas. This means that the huge loss of arable land per day may actually be even higher.

The study confirmed that the soil protection law No. 334/1992 Coll. is not respected in the Czech Republic; the lands with the best credit rating soils (1st and 2nd class protection) are used for building purposes. The urban plannig maps calculate with the areas of the best soils for building purposes in the future, too.

There is an apparent lack of interest in using brownfields, as the building at "greenfields" sites is cheaper than to reconstruct brownfield sites.

In the Czech Republic, a quality updated information system registering the loss of agricultural land is missing. The institutions protecting agricultural land have no exact data, which would become generally acceptable arguments for tightening protection of agricultural land.

Taking off the best soils like Chernosols, Luvisols (Kozák *et al.* 2010) is very irresponsible and can have very serious future consequences. A crucial task for the society (not only farmers and environmentalists) is to focus on water retention in the soil. Removing land for construction purposes increases the risk of water scarcity every day. Lack of water is related to food production, price, availability, and social problems.

References

Anonymous (1992): Richtlinien zur Bemessung der Abgabe bei Eingriffen in Natur und Landschaft. Wiesbaden, Hessisches Ministerium für Landesentwicklung, Wohnen, Landwirtschaft, Forsten und Naturschutz.

Artmann M. (2014a): Institutional efficiency of urban soil sealing management – from raising awareness to better implementation of sustainable development in Germany. Landscape and Urban Planning 131: 83–95.

Artmann M. (2014b): Assessment of soil sealing management responses, strate-gies and targets towards ecologically sustainable urban land use management. Ambio, 43: 530–541.

Bouma J., McBratney A.B. (2013): Framing soils as an actor when dealing with wicked environmental problems. Geoderma, 200–201: 130–139.

Bouma J., Varrallyay G., Batjes N.H. (1998): Principal land use changes anticipated in Europe. Agriculture, Ecosystems and Environment, 67: 103–119.

European Commission (2006): Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Brussels: Commission of the European Communities. Thematic Strategy for Soil Protection. Brussels, European Commission.

European Commission (2012): Guidelines on Best Practice to Limit, Mitigate or Com-pensate Soil Sealing. Luxembourg, European Union.

Federal Environmental Agency (2010): Information 26 October 2010. Increase in Settlement and Transport Areas between 1993 and 2009. Available at http://www.umweltbundesamt.de/rup/veroeffentlichungen/zunahme.pdf

Herrick J.E. (2000): Soil quality: an indicator of sustainable land management? Applied Soil Ecology, 15: 75–83.

Hindls R., Hronová S., Seger J. (2003): Statistics for Economists. 3rd Ed. Prague, Professional Publishing. (in Czech)

Kozák J., Němeček J., Borůvka L., Kodešová R., Janků J., Jacko J., Hladík J. (2010): Soil Atlas of the Czech Republic. Prague, CULS.

Liu T., Liu H., Qi Y. (2015): Construction land expansion and cultivated land protection in urbanizing China: Insights from national land surveys, 1996–2006. Habitat International, 46: 13–22.

Lokocz E., Ryan R., Sadler A.J. (2011): Motivations for land protection and stewardship: Exploring place attachment and rural landscape character in Massachusetts. Landscape and Urban Planning, 99: 65–76.

Malucelli F., Certini G., Scalenghe R. (2014): Soil is brown gold in the Emilia-Romagna region, Italy. Land Use Policy, 39: 350–357.

Monturiol F., Alcala L. (1990): Map of Potential Capacity – Agricultural Use of the Community of Madrid. Scale 1: 200 000. 1st Ed. Madrid, C.A.M. – C.S.I.C. (in Spanish)

Nestroy O. (2006): Soil sealing in Austria and its consequences. Ecohydrology and Hydrobiology, 6: 171–173.

Nuissl H., Schroeter-Schlaack C. (2009): On the economic approach to the con-tainment of land consumption. Environmental Science & Policy, 12: 270–280.

Olbrichová A. (2008): Crop versus concrete. Economist, 52: 46–49. (in Czech)

Pitt M. (2008): The Pitt Review – Learning Lessons from the 2007 Floods. London, Cabinet Office. Available at http://webarchive.nationalarchives.gov.uk/20080906001345/cabinetoffice.gov.uk/thepittreview.aspx

Rodríguez P.M., González M.E.P. (2007): Changes in soil sealing in Guadalajara (Spain): Cartography with LANDSAT images. Science of the Total Environment, 378: 209–213.

Scalenghe R., Ajmone Marsan F. (2009): The anthropogenic sealing of soils in urban areas. Landscape and Urban Planning, 90: 1–10.

doi: 10.17221/163/2015-SWR

Seják J., Dejmal I. (2003): Evaluation and Assessment of Biotops of the Czech Republic. Prague, Český ekologický ústav. Available at http://fzp.ujep.cz/Projekty/VAV-610-5-01/HodnoceniBiotopuCR.pdf (in Czech)

Smith P., House J.I., Bustamante M., Sobocká J., Harper R., Pan G., West P., Clark J., Adhya T., Rumpel C., Paustian K., Kuikman P., Cotrufo M.F., Elliott J.A., McDowell R., Griffiths I.R., Asakawa S., Bondeau A., Jain A.K., Meersmans J., Pugh T.A.M. (2015): Global change pressures on soils from land use and management. Global Change Biology, doi 10.1111/gcb.13068.

Xu G., Huang X., Zhong T., Chen Y. Wu C., Jin Y. (2015): Assessment on the effect of city arable land protection under the implementation of China's National General Land Use Plan (2006–2020). Habitat International, 49: 466–473.

Zhang W., Wang W., Li X., Ye F. (2014): Economic development and farmland protection: An assessment of rewarded land conversion quotas trading in Zhejiang, China. Land Use Policy, 38: 467–476.

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