Multi-scale evaluation of an urban long-term land use changes - the Prague case study

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INTRODUCTION

Urban land cover and land use change (LCLUC) is the most irreversible and human dominated form of land use. On the one hand urbanization brings many socioeconomic benefits such as more job opportunities, GDP and knowledge creation and efficient resource use, on the other hands urbanization also influences changes in land cover, hydrological systems, biogeochemistry, climate, and biodiversity (Grimm et al., 2008). Urban areas affect local climate resulting in higher polution and temperatures (Arnfield, 2003). Urban LCLUC is one of the most important driver of habitat loss and species extinction (McKinney, 2008). The expansion of build up is a complex of functional changes (Antrop, 2004) – possitive or negative- that largerly influence the environment (e.g. fragmentation of natural areas, climate chage, changes in population structure, job opportunities, education).

Seto et al. (2011). Tato meta-analysis of 326 studies that have used remotely sensed images to map urban land conversion. According to the results of this study India, China, and Africa have experienced the highest rates of urban land expansion, and the largest change in total urban extent has occurred in North America during the last three decades.

Bičík a Kupková (2006) zkoumali dlouhodobé změny využití ploch v pražské městském regionu na základě statistických dat a starých map. Statistické zhodnocení strukturálních zmen využití ploch v Pražském mestském regionu dokumentuje Prahu jako oblast intenzívní urbanizace a suburbanizace. Zastavené plochy se v období 1845 – 2000 rozšírily z 1,1 % na cca 8,1 % a ostatní plochy zastoupené povětšinou dopravní infrastrukturou z 3,4 % na 29,9 % z celkové výmery území. Novodobá suburbanizace se v pražské metropoli začala plně prosazovat zhruba od poloviny 90. let 20. století . Za hlavní znaky tohoto procesu lze považovat rozvoj nízkopodlažní zástavby na okraji původních venkovských sídel a rozvoj areálů komerční zástavby kolem dopravních uzlů a linií (Ouředníček, Bičík, Vágner, 2007). Rezidenční suburbanizace (Ouředníček, 2007) i komerční suburbanizace (Sýkora, Ouředníček, 2007) se projevují v zázemí Prahy zhruba se stejnou intenzitou, mají však odlišný vliv na sociální i fyzické prostředí metropolitní oblasti. Rezidenční suburbanizace se uskutečňuje z počátku především v nejatraktivnějších lokalitách a postupně se rozšiřuje i do dopravně i obslužně méně vybavených sídel. Suburbanizace je doplňována i dalšími pohyby obyvatelstva, které představují zhruba 1/3 migračních zisků zázemí Prahy (Ouředníček 2003).

ŠVEDA a VIGAŠOVÁ (2010) examined land use changes of major Slovak cities (with more than 50 thousand inhabitants) during the period from 2000 to 2008. The expansion of urban functions into the adjacent landscape causes a shift in the centre of gravity between core and periphery outside the cities and thus enables the emergence of a new structure of spatial organization which transforms vast areas of adjacent land. The biggest centres expand their influence at the expense of their hinterland, where the original function (agriculture, forestry) has been replaced with new services (trade, services, logistics and housing). During the period from 2000 to 2008, the extent of built-up areas in the monitored cities increased by 5.66%, while the extent of agricultural land decreased by 1.35%. The suburbanization is one of the contemporary phenomena, which significantly transforms the landscape around major cities. The impacts of this phenomenon are clearly visible in the area surrounding the capital of the Slovak Republic – Bratislava. Šveda (2011) investigated the largest land use changes have occurred on the edge of the compact city and along the highway corridors by growth in built-up areas, the loss of agricultural land and increase of land use fragmentation in period 1990-2006.

Throughout the history of the Earth it can be said that it has got many different ways of use. Morover, it was a cause of many wars because of strategic and vital importance for life and it is considered as a rich source of food as well.

Currently, overuse of the land creates concern by a shortage of resources for its negative impact and possible social destabilization. The study of the historical evolution of the soil is one of the goals to understand and improve existing systems of land treatment as well as the future.

In recent years there has been an increase in the use of the antique maps on the treatment of the ground. Thanks to the emergence of the technology that allows run an analysis faster and more accurate of what we want to obtain, by means of the GIS systems Information with much more detail and different scales such as cadastral maps.

In Czech Republic this technique is used since the first half of the 19th century which has allowed to know the changes in the land since then to our current era with relative accuracy. They are also a great help, in addition to observe changes in the soil, to see geomorphological, hydrological changes or for example socioeconomic changes. This report describes the historical land-use changes since the mid 19th century until the beginning of the 21st century in four regions of the Czech Republic, the first 2 of our study are in the cadastral area of Prague, these are Libuš/Lhotka and Vysočany and the other 2 are 2 regions adjacent to the metropolitan area of Prague a few kilometres from the border of the city. Both of regions are called Rudna and Cestlice.

The main objective is based on a study of the use of the soil in these regions by analyzing its changes over time thanks to a GIS, comparing to the different changes due to the different location of the zones, as well as the comparison between them finding out the reasons for such changes by a look back at the history of this city.

History and Demography

Prague is the capital of the Czech Republic, before it was capital of the Kingdom of Bohemia, Czechoslovakia. It is also the capital of the region of Bohemia. Situated on the banks of the Vltava River, has approximately 1.2 million inhabitants, which makes the city the most populated in the country.At the beginning of the 20th century the

population reached 850,000 inhabitants in 1930. Currently the population of Prague is approximately 1,200,000 inhabitants, representing more than 10% of the population of the country. The city had a population explosion during the 19th century due to its economic and cultural flourishing. If we include the suburbs that were not part of Prague, the population went from little more than 157,000 inhabitants in 1850 to more than 500,000 in 1900. Since then there was a moderate grew until the 1980's, and from that time the population has stabilized.
They make it one of the 20 most visited cities in the world.

Prague is located in the heart of Europe, less than 500 kilometres from the Baltic, North and Adriatic seas. The city belongs to Central Bohemia region and mainly occupies the region of Poberounska soustava andthe northest corner is a small part of the area of Česka table. Within the Czech Republic, Prague is slightly displaced to the Northwest of the geographic center of the country. The erosion and the processes of sedimentation on both banks of the Vltava River are the main cause of the relief of the city. The maximum altitude of the city is 399 meters, in the District of Zličín, West of the city, and the minimum altitude is of 177 meters on the northern edge of the city, where the River leaves it. Therefore the maximum altitude difference is 222 meters in a relatively small area.

To understand better the land use changes we will make a brief review of the history of Prague since the mid-19th century until today to see how those changes have been able to affect.

- In the middle of the 19th century Czech Republic was under Austro-Hungarian rule and Prague became the Centre of Czech nationalism.
- In 1918, as a consequence of the first world war, Czechoslovakia was founded, and the new President of the Republic Tomáš Masaryk Prague became the seat of Government and capital of the Czech State.
- Between 1939 and 1945 Hitler's army occupied the city of Prague.
- In 1945 the U.S. army bombed the city to confuse it with Dresden.
- After the second world war, the Czech Republic became part of the Communist bloc, under the protection of the Soviet Union.
- In 1968 break out the spring of Prague, a movement that sought to reform the unchanging Soviet socialism, which was harshly surprised with the invasion of the armies of the Covenant of Varsovia.
- On December of 1988, the Soviet Prime Minister Mijaíl Gorbachov announced the so-called Sinatra doctrine the countries of Eastern Europe could do what they consider suitable.
- At the end of 1989, with the fall of the Berlin wall, Prague abandoned socialism in what was called the Velvet revolution.
- Prague was the center of the velvet revolution that led to the fall of communism in the country.
- In 1993, it was decided to make a peacefull dissolution of Czechoslovakia and its division in the Czech Republic and Slovakia. Prague became the capital of the Czech Republic.
- In August 2002 the Vltava river overflowed with more than 5100 m^3/s flow causing serious damage in the city. It was needed two years to recover.

Then we are going to briefly describe 4 areas of study.

Libuš/lhotka is the first area of our study, is a cadastral area on the outskirts of the South of Prague, which constitute a small part of the territory of the region of Prague-Libuš. About five thousand inhabitants live here. Before connecting to Prague in 1968 it

had a 1.955 inhabitants. Today there live approximately 10000 inhabitants. The total area of the city is 5.24km².

Meanwhile, Lhotka, limited to Branik on the North, in the North and East Krc, Libuš South and West Kamyk and Hodkovičky, is a cadastral area of Prague which are included in the city of Prague 4. The municipality lies at an altitude of xxx m and has an area of 1.05 km² and second place we run Vysočany, is one of the districts and the area of land in the district circuit Praha 9 has a population of 15000 inhabitants covering an area of 6.07 km²

Secondly we find Vysočany, it is one of the neighborhoods and the area of land in the district Praha 9 circuit has a population of 15,000 inhabitants with an area of 6.07 km².

Rudna, the third region of our study, is a town about 3 km from the western border of Prague and about 7 km south of Hostivice, Plateau undulating on the border of the Prague plateau and Kladenské Board. From July 1, 1974 he succeeded it in relation to the expansion of the capital city of Prague, in the district Prague-West. The city is located near the part of the highway from Highway D5 from Prague to Plzeň, in its western part, an extensive industrial area and warehouse. At the beginning of 2012, had 4.662 inhabitants. Rudna territory's population has increased considerably since 1886, between 2001 and 2008, the population increased due to extensive housing construction and migration related from 3075 more than 4200. The municipality lies at an altitude of xxx metres and covers an area of 8.19 km².

The fourth area of study is the Čestlice village, is located in the District of Prague-East, the central County. It covers about sixteen kilometers southeast of the city center, and six kilometres to the West of the city of Řičany. There live about six hundred inhabitants. The municipality lies at an altitude of 309 metres and covers an area of 4.42 km²

METHODS

An extensive, exceptionally detailed and long-term database (LUCC UK Prague) created and used at the Faculty of Natural Sciences of the Charles University forms the foundation for our evaluation. The database uses data on area of individual land-use categories of all cadastral units in Czechia for the years 1845, 1948, 1990 and 2000. These years represent key milestones of Czechia and to a certain extent also Central European, history in the political, social and economic sense (Jeleček 2002; Bičík, Jeleček 2005). The original data had to be adjusted for all the four years in order to ensure territorial and temporal comparability of land-use categories used (Bičík et al. 2001, Bičík and Jeleček 2003 etc.). There are about 13,000 cadastral units in the Czech Republic. However, some of them changed their area during the past 160 years, some were newly created, some ceased to exist. Therefore, the primary database of cadastral units was “consolidated” into slightly less than 9,000 “comparable territorial units” (CTUs) comparable in size in different periods. The area of almost all thus modified units during the observed more than 160 years has not changed by more than 1%. The average area of thus modified 8,903 BTUs is 8.9 km2 . In individual years, different categorization of land-use was used (for example 1845: 56 categories; 2000: 12), the original data for individual cadastral territories had to be consolidated in order to create a comparable structure. This structure consists of 8 basic categories – arable land (AL), permanent cultures (PC – orchards + gardens + vineyards + + hop-fields), meadows (Me), pastures (Pa, currently registered as permanent grassland – PGL), forests (For), water areas (WA), built-up areas (BuA), and other (O). These basic categories can be “grouped” in various ways; we mostly use three aggregate categories –

agricultural land (AgL: AL+PC+Me+Pa), forest areas (FA) and remaining areas (RA: WA + BuA +O). In essence, this simplification provides temporal comparability of data for the entire period observed. These modifications made it possible to obtain a data set of 8,903 CTUs for each year, 1845, 1948, 1990 and 2000, of the given dimension of eight area categories, fully comparable in terms of time and territory. Other characteristics were added to this database providing complementary information about the CTUs (average altitude, inclination official price of agricultural land, rate of exposure, etc.). This article does not make it possible to apply all the methods used to evaluate land-use changes using this database. We therefore limited ourselves to a comparison of the development in share of selected categories and a calculation of a change index between 1845 and 2000 (the year 1845 denotes an aggregate set of data obtained for individual cadastral units in Czechia by cadastral mapping throughout 1826–1843). 32 Two basic methods were used. The first one was used to evaluate the percentage changes of the share of selected categories (AL, PGL, Fo, BuA and O) between 1845 and 2000. This means that we evaluated categories with the largest area share in most CTUs and, at the same time, with the most significant changes in the share. Such a selection of categories also makes it possible to evaluate the potential influence on the rainfall-runoff situation. Furthermore, overall changes were evaluated, both in terms of prevailing trends of the overall land-use structure, and in terms of the change index. The change index has been introduced and used in numerous papers (Bičík et al. 1994, 2004, 2005 etc.). The indicator reflects the intensity of land-use changes irrespective of the direction of global changes. It evaluates the total percentage of area (out of the CTU total area) where change in land-use occurred between the two years mentioned, based on balance comparison of the initial and final year.The article makes use of LUCC UK Prague database (Bičík et al. 1996, 2003), an extensive geodatabase designed to evaluate spatial land-use development of individual comparable territory units (CTUs – based on the cadastral units), for the years 1845, 1896, 1948, 1990, 2000 and 2010. We applied long term development data of land-use (1845–1948–1990–2000) in four classes (arable land, grassland, built up areas, other areas) and one index (Change index shows share of changed land-use classes from the whole size of territorial unit). These data were cliped for Prague, Prague-West and Prague-East district.

In this field, describes research methods that were applied when data for whole cadastral areas were taken into consideration. Apart from that, detailed land use analyses within selected cadastral areas have been carried out; the model areas represent different types of areas in Prague and surounding. These detailed analyses enabled to trace landscape changes by plots and to assess structural changes. Maps from the so called “stable cadaster” (mid-19th century), current land use maps (scale 1:5,000), and current aerial photographs were used. Land use changes in model areas were detected using GIS. Results show:
1) type of change
2) exact place where changes took place.

The results of this method bring quantitative data as well as spatial information and are more precise than pure quantitative analyses based on numerical data only. In the past, this method was used in a number of studies including Mares (2000), Kolar (2000), Stych (2001) and Kupková(2001).

The information incorporated into the GIS have been classified according to the original scale of obtaining and the thematic area to which it belongs to obtain a correct management of databases. In order to avoid displacement errors each thematic layer incorporated is presented in a common spatial reference system.

We used the program ArcMap 10.1, this program is the main component of Esri's ArcGIS suite of geospatial processing programs, and is used primarily to view, edit,

create, and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps. In our case we had to update different zones for try to define this areas as real and current as possible.

All data used to work in ArcMap, have been georeferenced in the system of cadastral trigonometric network (JTSK), it's a network of geodetic control points created in the years 1920-1957 for the territory of the former Czechoslovakia.
This network is the a base of geospatial coordinates S-JTSK (Krovak East North), and it was a source of basic data for current land cover mapping. The Czech coordinate system S-JTSK is based on the oblique projection conical Krovak, it was designed to pre-war in Czechoslovakia. It has remained in Czech Republic, and there is in use with success to the present day.
To realize the vector cadastral maps of each area of study and to work in ArcGis, we link this program with the WMS server that provided us the 'Geoportal CUZK' (http://geoportal.cuzk.cz/WMS_ORTOFOTO_PUB/WMService.aspx) to display the orthophoto more current that we will use to work. And on them, we check it that our current land use classification is right. So we digitize to modify some parts in each one of the areas of study to update the map, in order to provide us the most current data possible about the land uses.

The digitizing is the way of transforming spatial data of cartographic documents to most frequently used in GIS. In our work, we have used the digitalization on the screen, it called vectorization. All of that for use in software ArcGIS 10.1. In reference to the orthophoto, we did polygons (territories and objects area) and lines (linear objects) through the raster maps. In addition, GIS software is able to calculate the areas of these map objects because there are the fundamental data for monitoring the land uses to be able to see which quantity of land have changed, the land cover changes or changes in the landscape and so carry out the analysis long term land use changes.

The orthophoto was processed for the entire territory of the country. Presents an image composed of aerial reconnaissance photographs orthogonalization (ASP), and their accuracy and map projection meets all requirements. The orthophoto shows us all characteristics and structures visible in the territory which were present at the time when the aerial reconnaissance photographs were taken. The orthophoto was taken on a scale of 1: 5000, and the pixel size was 0.5 m until the year 2008. From 2009 these are produced with a pixel size of 0, 25 m, causing a significant increase in the quality of the product.

First, compatibility of land use classes must have been secured. The table 1 shows all land use classes (subclasses) analyzed in all examined years and used in each case study.

Table 1: Land use classification.

Aggregate land use classes	Basic land use classes	Detailed land use classes
I. Agricultural land (AL)	1. Arable land (AL)	1.1 Arable land
		1.2 Arable land, not cultivated
	2. Permanent cultures (PC)	2.1 Hopyards
		2.2 Vineyards
		2.3 Gardens
		2.4 Second homes with gardens
		2.5 Orchards
	3. Permanent grassland (PG)	3.1 Meadows
		3.2 Pastures
		3.3 Permanent grassland, not used
II. Forest areas (FA)	4. Forest areas (FA)	4.1 Broad-leaved forests
		4.2 Mixed forests
		4.3 Coniferous forests
		4.4 Mountain pine
III. Other areas (OA)	5. Water areas (WA)	5.1 Water areas
	6. Built-up areas (BA)	6.1 Residential housing / yards
		6.2 Second homes / yards
		6.3 Factories, material production / yards
		6.4 Other types of buildings / yards
	7. Remaining areas (RA)	7.1 Field boundaries
		7.2 Swamps
		7.3 Dispersed trees, shrubs
		7.4 Public green space
		7.5 Sport, leisure time
		7.6 Devastated areas
		7.7 Solidified surface
		7.8 Other

Source:LUCC Database Czechia, Ordinance No. 190/1996 (Act No. 265/1992 Sb.)

In reality, to assign the proper land use class to individual piece of land may pose a problem and the same applies when it comes to exact spatial definition. Individual experience of the persons who carried out the mapping may play a certain role, too. In order to make the mapping as precise as possible, also aerial photographs were used.
We will see in detail the processing step of cartographic data to pass to detect changes of the land use:

- Maps were digitized using a large-scale scanner.

- The digital images were edited (trimming, resolution adjustment, etc.)
Maps were transformed into a unified coordinate system. Topol software that includes correctly georeferencedmap sheets (prostorově správně umístěný listoklad) of "stable cadaster" and maps 1:5,000 (field mapping) was used. In some cases, the method of identical points was employed. Cadastral boundaries, major crossings, dykes, corners of important buildings (churches etc.) were used in order to identify reliable reference points on the source and corrected maps. In such a way, the deviation did not exceed 5 metres.

- Individual patches of land were visually interpreted and vectorized in ArcGIS to ESRI shaperile format. The minimal mapping unit was 4 m2. Identifiers were attributed according to the legend.

- Areas of land use classes in selected years were calculated.

- Orthophoto was used for update the most current land uses maps of each case study.

- Spatial overlay of vectorized layers was made and land use changes were identified.

- Share of areas where a land use change occurred during the examined period of time was calculated and precise position defined.

- Tables and maps documenting the above mentioned changes were created.

Results of this analysis are presented in Conclusion field. Figures and tables present the extent of stable areas (no land use change) and changing patterns of land use. The land use in observed years is shown in maps . Thus, spatial pattern of land use change is well demonstrated.

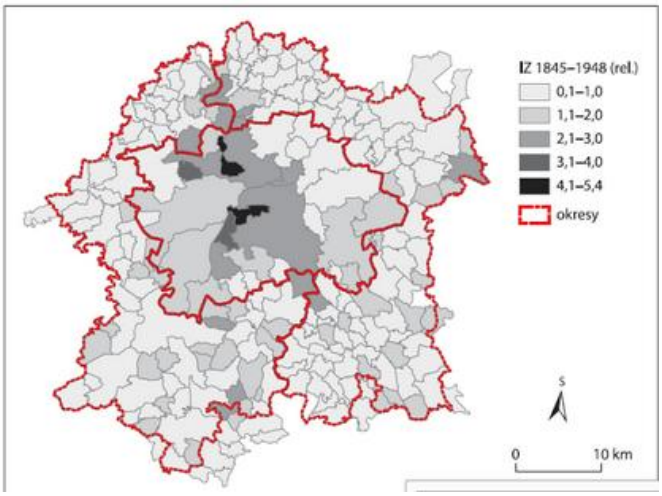
RESULTS

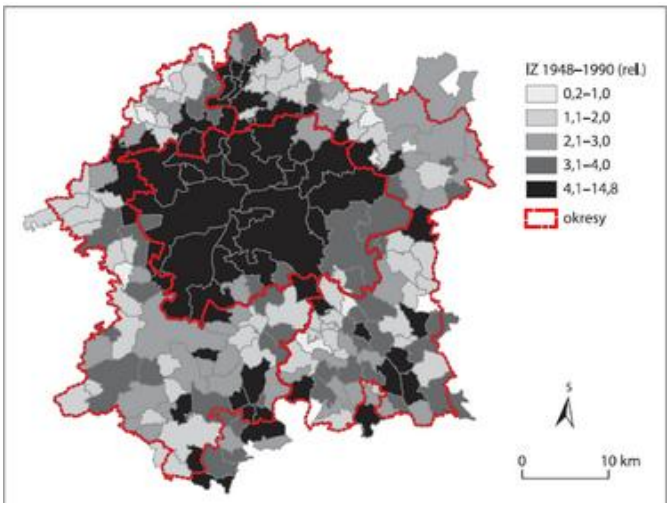
Maps and tabels from LUCC database

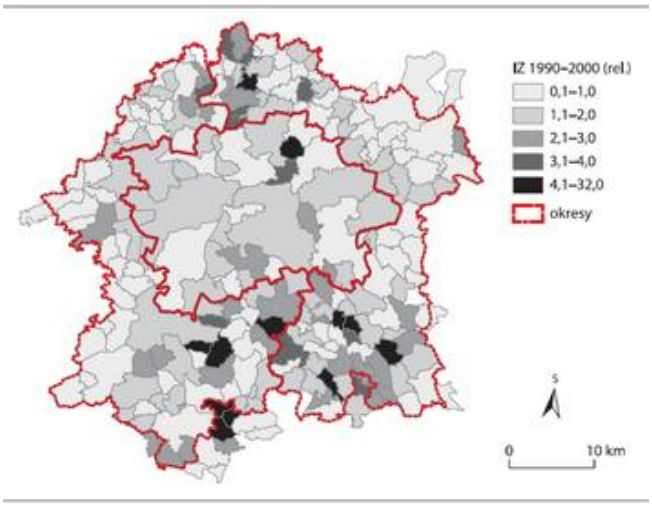
Tab. 3.1 Vývoj využití krajiny v Praze

	1845		1948		1990		2000	
Kategorie ploch	ha	%	ha	%	ha	%	ha	%
Orná půda	47 251,7	72,4	42 798,7	65,6	26 795,2	41,1	26 360,1	40,4
Trvalé kultury	1 802,4	2,8	5 878,9	9,0	5 873,7	9,0	5 867,7	9,0
Louky	2 787,1	4,3	1 787,7	2,7	716,8	1,1	683,7	1,0
Pastvina	4 774,8	7,3	1 646,4	2,5	426,9	0,7	404,1	0,6
Zemědělská půda	56 616,0	86,8	52 111,7	79,8	33 812,6	51,8	33 315,6	51,1
Lesní plochy	4 554,1	7,0	4 919,2	7,5	5 889,8	9,0	5 856,3	9,0
Vodní plochy	1 104,9	1,7	889,0	1,4	1 316,6	2,0	1 313,3	2,0
Zastavěné plochy	731,5	1,1	2 924,0	4,5	4 666,1	7,1	5 265,0	8,1
Ostatní plochy	2 232,2	3,4	4 426,1	6,8	19 576,2	30,0	19 476,6	29,9
Jiné plochy	4 068,6	6,2	8 239,1	12,6	25 558,9	39,2	26 054,9	39,9
Celkem	65 238,7	100,0	65 270,0	100,0	65 261,3	100,0	65 226,8	100,0

…to calculate year 2015

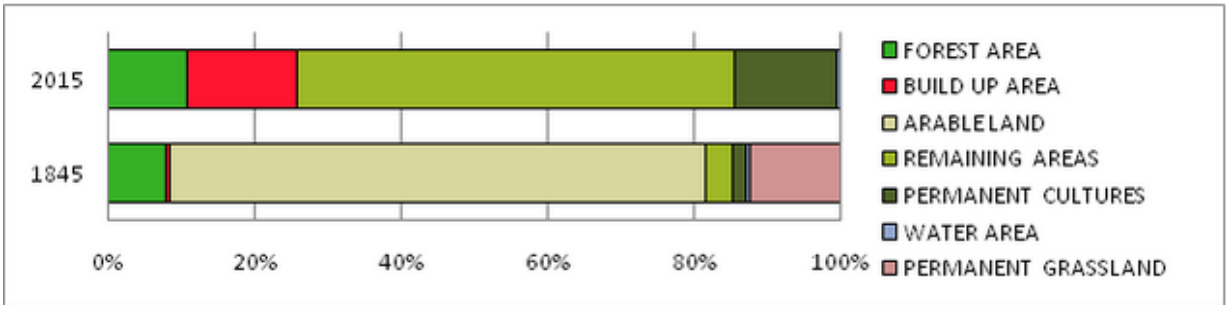






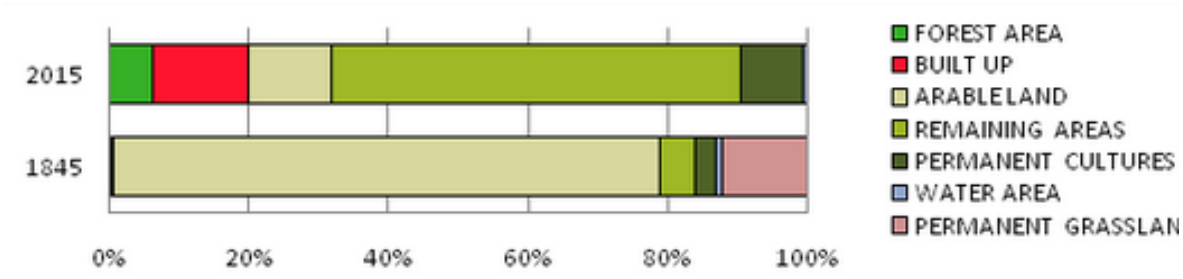
Index of change 1990-2010

- **Libus.**



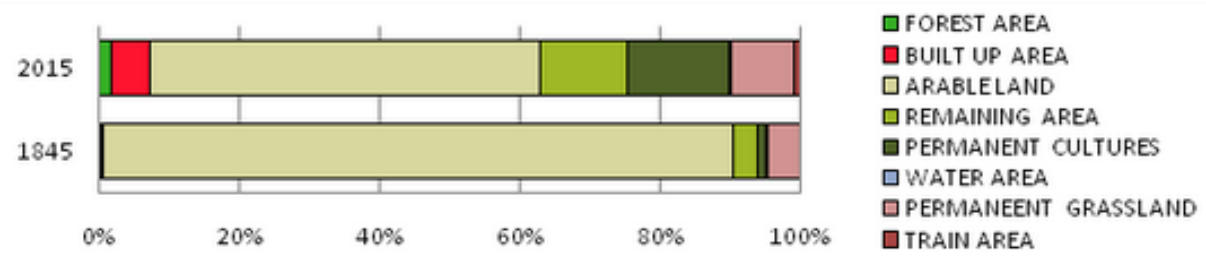
Σ=966,24 ha	ARABLE LAND	PERMANENT CULTURES	PERMANENT GRASSLAND	FOREST AREA	WATER AREA	BUILT-UP AREA	REMAINING AREA	TOTAL
ARABLE LAND	-	114,91	-	28,95	0,16	126,45	431,97	702,44
PERMANENT CULTURES	-	2,22	-	1,07	-	3,11	10,28	14,46
PERMANENT GRASSLAND	-	9,65	-	34,01	2,84	9,62	63,46	119,58
FOREST AREA	-	2,42	-	36,75	0,02	4,52	32,42	39,38
WATER AREA	-	0,24	-	1,31	1,69	0,14	1,52	3,21
BUIT-UP AREA	-	0,37	-	0,33	-	0,87	1,79	2,49
REMAINING AREA	-	3,52	-	2,14	0,10	3,61	26,51	9,37
TOTAL	0,00	131,11	0,00	67,81	3,12	147,45	541,44	890,93

- **Vysočany.**



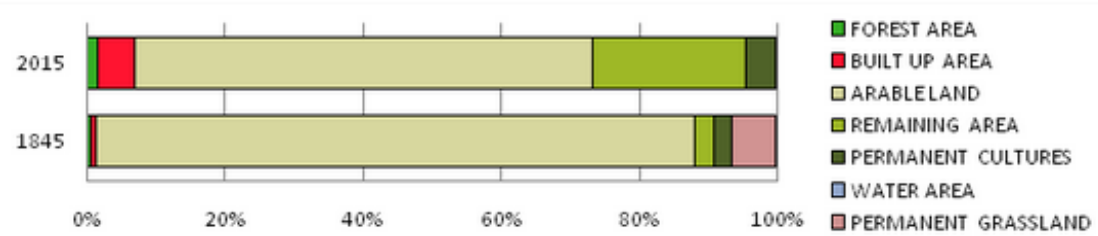
Σ=1366,90 ha	ARABLE LAND	PERMANENT CULTURES	PERMANENT GRASSLAND	FOREST AREA	WATER AREA	BUILT-UP AREA	REMAINING AREA	TOTAL
ARABLE LAND	160,06	87,87	-	38,75	0,77	154,90	623,60	905,89
PERMANENT CULTURES	-	6,79	-	1,52	0,05	9,36	25,20	36,13
PERMANENT GRASSLAND	1,22	18,88	-	37,94	4,54	13,55	68,08	144,22
FOREST AREA	-	-	-	0,87	-	0,69	2,33	3,02
WATER AREA	-	0,37	-	0,13	4,54	0,36	4,22	5,08
BUIT-UP AREA	-	0,39	-	0,05	-	2,22	3,58	4,02
REMAINING AREA	2,92	4,86	-	4,67	0,14	7,92	50,09	20,50
TOTAL	4,14	112,37	0,00	83,07	5,50	186,79	727,01	1118,87

- **Rudna**



Σ=892,79 ha	ARABLE LAND	PERMANENT CULTURES	PERMANENT GRASSLAND	FOREST AREA	WATER AREA	BUILT-UP AREA	REMAINING AREA	TRAIN AREA	TOTAL
ARABLE LAND	482,93	132,70	76,85	8,74	0,94	50,41	96,56	6,69	372,89
PERMANENT CULTURES	-	4,76	0,62	-	0,07	-	3,67	0,04	4,39
PERMANENT GRASSLAND	14,97	11,32	4,77	3,86	1,06	2,26	6,18	0,10	39,76
FOREST AREA	0,08	0,24	0,28	1,88	-	0,04	0,20	-	0,85
WATER AREA	0,15	0,99	0,12	0,03	0,47	0,09	0,67	0,02	2,07
BUIT-UP AREA	-	0,88	-	-	-	1,47	0,53	-	1,42
REMAINING AREA	5,48	6,89	2,03	0,44	0,07	2,06	15,09	0,07	17,04
TRAIN AREA	-	-	-	-	-	-	-	-	0,00
TOTAL	20,68	153,02	79,89	13,08	2,14	54,87	107,82	6,92	438,42

- **Cestlice**



Σ=441,54 ha	ARABLE LAND	PERMANENT CULTURES	PERMANENT GRASSLAND	FOREST AREA	WATER AREA	BUILT-UP AREA	REMAINING AREA	TOTAL
ARABLE LAND	268,02	8,67	0,51	4,87	0,01	20,28	80,91	115,25
PERMANENT CULTURES	0,50	6,04	-	-	-	1,72	2,82	5,04
PERMANENT GRASSLAND	18,46	2,21	-	0,08	-	0,69	7,18	28,61
FOREST AREA	0,89	-	-	1,55	-	-	-	0,89
WATER AREA	-	-	-	-	0,11	0,00	0,14	0,14
BUIT-UP AREA	0,03	1,48	-	-	-	0,59	0,88	2,39
REMAINING AREA	5,25	0,98	0,00	0,21	-	0,58	5,96	7,03
TOTAL	25,14	13,33	0,52	5,16	0,01	23,26	91,93	159,35

Huge changes on the agricultural land , conversion of arable land into built up areas (Ruda change matrix)

The graph and the matrix table of Rudna show the intensity of land use/landscape changes during the analyzed period. Intensive land use changes have been recorded in Rudna. Originally it had been primarily an agricultural area, but later favourable geographical location and extraction of raw materials transformed part of the arable land into built-up and remaining areas. In the past arable land was fragmented into great many small plots whereas at present rather large fields are typical. This radical change was caused by collectivization in the 1950s: in the same time a big cooperative farm was established here.

Though after 1990 many original owners have claimed the land stolen by the Communists, only the few (re) started farming -much of this private land has been leased to big agricultural companies. Fields in the immediate vicinity of the village are under a strong pressure from developers, who look for places suitable for new housing projects. From the environmental standpoint the current state is worse previously - large fields (some exceeding 100 hectares) are prone to erosion, biodiversity has been reduced significantly.

Due to poor and vaguely enforced regulations, part of the high quality land with good soils has been built over and large residential areas and commercial developments originated. In 1840 arable land covered some 90% of the municipal area: at present it still dominates but the share shrank to just 50%.

The early suburbanization after 1990 was boosted by favourable geographical location near the major highway that is connecting Prague with Pilsen and Germany. As residential housing, as well as commercial development was experiencing a real boom, land use structure began to change rapidly. At the moment, built-up land covers more than 5% of the municipal area (in 1840 it was just 0.3%). The so called remaining areas - in this very case mostly roads and plots with solid surface like parking lots –account for 14%. The boom of residential housing also caused an important increase in permanent cultures, mostly gardens (from 1.2% to 17%).

Forests continue to play only a minor role. Only a f to 17ew patches of poor agricultural land have been afforested. Though meadows and pastures have also increased in size (from 4.7% to 9.1%) their importance also remains low. Meadows and pastures, however, are no longer found along water streams where they functioned as an anti-erosion elements, but rather tend to concentrate close to the houses having more of an aesthetic function. Such a change has negative effects on the landscape stability. Wetlands along the creeks have been drained and often turned into arable land. This artificial drainage combined with a rapid spread of solid surfaces in the course of the past two decades makes the water discharge much faster.

Two contradictory processes can be observed in Rudna the past 60 years in terms of landscape changes. To a large extent, different approaches towards land protection under different regimes are responsible for that. The agrarian policy under communism encouraged self-sufficiency, i.e. arable land was highly valued. As a result, wet meadows and pastures were often drained (also in the case study area) in order to be later converted into arable land. Consequently, many anti-erosion elements in the landscape that had helped to prevent floods ceased to exist. The strict protection of arable land, however, was eased after 1990, and large expanses of high quality arable land were taken by developers just within months. Ironically, meadows and pastures with important ecological functions had been drained first and replaced by low quality

arable land just a few years later, however, large quantities of high quality arable land disappeared to make place for housing, warehouses. and new transportation lines.

DISCUSION AND SUMARY

The municipality is likely to be influenced by a favourable geographical location, just on the doorstep of Prague, also in the near future. At the moment there are residential areas as well as services and some industry; important transportation lines criss-cross the area. Rudna is part of Stredocesky kraj (Central Bohemian Region), i e. the municipality is eligible for European Union funds (GDP per capita in Central Bohemia is still below 75% of the EU average). This fact may further accelerate the pressure on agricultural land, which may become an easy prey for developers, be they after housing, industry. warehouses, or transportation lines. The D5 motorway links Prague and Central Bohemia with Germany, which is the most important Czech trade partner. Consequently it's likely that within 10-15 years some agricultural land will be converted into non-agricultural use; these changes, however, will probably be dictated from the national level rather than by local authorities. Much of the agricultural land around Rudna is of high quality and for this reason, non-agricultural activities should primarily take place in areas with the least quality soils. As most of the land is under the plough now and there is a lack of environmentally valuable areas (forests, meadows, pastures, water bodies), the latter should be increased, possibly at the expense of the worst agricultural land. In practical terms, however, it is likely that the pressure of property developers will remain high, which may rather result in an increase of built-up land and remaining areas. Whether this will happen or not will largely be in the hands of municipal authorities.