Due to the suburbanisation process, it is becoming more difficult to properly define rural and urban areas in the Czech Republic. This delimitation problem has been intensively studied in Europe, including the Czech Republic, for decades, but only so-called ‘crisp’ rules have been set for the categorisation of urban and rural. This is no longer satisfactory because of substantial population movements. Our research focuses on applying fuzzy set theory to the delimitation of rural and urban areas and on the subsequent advanced cartographic visualisation. We used the principles of fuzzy regulation, or fuzzy inference systems, on socio-economic data to show the transitional character of municipalities. The generated Main map is at scale of 1:500,000, whereas secondary maps are at scale of 1:2,500,000. Map visualisation of municipalities in the Czech Republic provides a very unique combination of geographical information science, cartography and modern geo-computational methods. Information perception via a map is an adequate way to analyse geographic information, and the problem of delimiting rural and urban areas can be suitably visualised using these methods.

**Keywords:** suburbanisation process; rural and urban areas; fuzzy inference system; GIS

1. Introduction

Due to the suburbanisation process, it is becoming more difficult to properly define rural and urban areas in the Czech Republic. In order to move forward, we first have to define what urban and rural areas are to distinguish between them. There is no universal definition of such areas, and an on-going suburbanisation process in the Czech Republic makes the definition problem even more complex. Therefore, we also provide a brief description concerning the suburbanisation process and how it is related to urban and rural spatial patterns. Furthermore, suburbanisation is often connected with the term urban–rural continuum. According to Halfacree (2009), the concept of the urban-rural continuum added flexibility to the categorisation of settlements, as it explicitly allowed rural characteristics to be found in largely urban places and urban characteristics to occur in rural places. Based on the above characteristics of urban and rural space, it is very difficult to distinguish between such spaces. These conceptual developments have clouded our ability to differentiate the urban and rural and delimitation of these areas (and their intermediate space) is still of interest to many researchers.
Definitions of urban areas (often forming cities) vary from author to author, and theoretical approaches are discussed. One of the most general definitions describes cities simply as the place where people meet and return on a daily basis (Mayer, 1971). Frey and Zimmer (2001) mention that cities, in the sense of administrative demarcation, are bounded contiguous urban areas. There are interrelated factors, e.g. population size, population density, economic function or labour supply and demand, which play a role in defining a city (Frey & Zimmer, 2001). The authors also denote three elements that best differentiate between rural and urban character – economics, ecological elements and social character. Generally, urban areas include larger towns and cities that are highly and more densely populated (a relative descriptor that varies from country to country), they have condensed and compact built-up areas, and specific demographic, employment and social structures (Sýkora, 1993). Additionally, urban areas provide various functionalities (administrative, public service, transportation, etc.), and they are distinctive for their inner-diversity.

In comparison, rural areas or landscapes are, in general, outlying settlements and territories of open landscape. They form a matrix of small and isolated house-buildings, agricultural and water areas, forests, local road networks and other spatial features. Typical characteristics of rural areas include low population density, small settlements or villages, higher employment in agriculture and lifestyles that have a close connection to the surrounding environment (Mze Čr, 2007; Perlin, 2010; Pezzini, 2001). Some of these aspects of rural areas may differ over time. Sometimes these changes evolve into new characteristics and may even change the classification of the area. Woods (2005) mentions that there are four groups of different approaches in rural area definitions: (1) descriptive definitions, (2) socio-cultural definitions, (3) rural as locality and (4) rural as social representation. Woods (2005) claims that a significant aspect of rurality is the perception of the rural space itself by the people living there. According to Clout (1976), rural geography is primarily concerned with the land-use component consisting of farmlands, forests, water and settlements. These segments are further analysed by using quantitative indicators (rural population, employment structure, range of services, etc.). In the Czech Republic, rural areas are (according to Chromý, Jančák, Marada, & Havlíček, 2011) regions defined primarily by their (1) geographical location, (2) spatial order/scale and (3) regional differentiation of functional areas or structural characteristics (settlements, society). Jančák, Havlíček, Chromý, and Marada (2008) defines rural areas in regards to territorial human and social capital. Regions with lower human and social capital are considered to be rural areas, which commonly occur close to regional borders and far from regional centres.

Urban growth and the consequent suburbanisation processes, which are currently on-going in the Czech Republic, are affecting villages and small settlements surrounding larger towns and cities. Generally, suburbanisation is the process of urbanisation affecting the outer parts of the larger town or city with lower-density residential, commercial, and industrial development beyond the city. Many authors are examining suburbanisation issues. For example, Gregory et al. (2009) describes suburbanisation as a process whereby people, housing, industry, commerce, and retail extend beyond traditional urban areas, forming dispersed landscapes that are still connected to cities by commuter ways. Various definitions of suburbanisation are listed by Mace (2009), who largely defines suburbanisation as a process linked with (1) the growth and accessibility of the mass public transit system and car use, (2) the outward movement of industry and (3) the spatial expression of capital seeking new investment opportunities. The primary spatial result of suburbanisation (in terms of expansion) are suburbs, which are described by Champion (2001) as residential spaces that are dependent on the city centre’s occupational, shopping and recreational facilities.

Similarly, in the case of the Czech Republic, suburbanisation is characterised by people commuting from the suburbs to the city centre (Novák & Sýkora, 2007; Urbánková & Ouředníček,
new residential built-up areas (family houses) and new functionality of these areas (primarily serving residential, commercial and service purposes). The transformation of urban areas due to suburbanisation is further discussed in Šykora and Ouředníček (2007), who conclude that suburbanisation changes an urban area’s physical morphology, functional land-use pattern and socio-spatial structure. Another extensive study examining suburbanisation in the Czech Republic is provided by Kostelecký and Čermák (2004). The suburbanisation process significantly affects the rural settlement structure in the Czech Republic such that former rural areas are becoming more urban-like, strengthening certain aspects of urban areas in socio-economic terms. It is therefore necessary to reconsider the status of the rural areas to properly deliver financial and other support.

This paper and map focus on the delimitation of rural and urban municipalities; however, there is no uniform definition of a rural area (Binek et al., 2007). It is possible to find many authors and institutions that define rural areas (e.g. Cloke & Edwards, 1986; DEFRA, 2011; Du Plessis, Beshiri, Bollman, & Clemenson, 2002; Mze Čr, 2007; U.S. Census Bureau, 2010), but these definitions vary from author to author and from country to country.

The only widely accepted international definition of rural and urban areas comes from the Organisation for Economic Co-operation and Development (OECD). Their definition is based on the proportion of the population that lives in the territory with a population density of less than 150 persons per km² (Čsú, 2008; OECD, 1994). This methodology has been reviewed in OECD literature (OECD, 2005). The borders are set by means of Boolean algebra, by sharp or ‘crisp’ numbers. This abrupt and strict classification does not reflect the real situation and is driven by one simple criteria — total population in a region. Mostly, administrative boundaries are used during the process of demarcation of urban and rural areas. It is the first and foremost step because of the easy access to information for these units (Frey & Zimmer, 2001). This demarcation is often neither accurate nor adequate; however, given the accessibility and accuracy of statistical data, it is frequently the only possible option.

A similar procedure for the delimitation of rural regions and municipalities has been followed in the Czech Republic. It is driven by a different, but equally simple criterion — municipalities with less than 2000 inhabitants are considered rural. Financial support from the Czech government, which is based upon the classification of an area, follows this same criterion. Thus, it is important to determine which municipalities are truly rural. A comprehensive attempt to delimit rural and urban municipalities in the Czech Republic using socio-economic indicators was performed by the Czech Statistical Office (Čsú, 2008). They used a multi-criterion scoring method following Czech laws to define rural and urban areas in the Czech Republic for eight scenarios.

Another approach to assess the structure of settlement and regional processes in the Czech Republic was introduced by the Urban and Regional Laboratory in its methodology for defining suburban areas in the Czech Republic (Ouředníček, Špačková, & Novák, 2012). Using the municipality methodology, the Czech Republic is divided into cities, suburban communities and the remaining (rural) settlements. Cities are defined as municipalities with populations greater than 10,000 and suburban areas are defined according to migration (number of new inhabitants) and the intensity of residential construction. Building upon this delineation, one of the most complex approaches to delimitate urban and rural areas was conducted by Perlín (2010). In this study, the author categorised rural areas, according to population density and employment structure, as being (1) significantly rural, (2) predominantly rural or (3) the remainder, which are urban areas. In another paper, Perlín, Kučerová, and Kučera (2010) delimited rural areas into eight subtypes (e.g. developing rural areas, problematic rural areas, recreational rural areas and others), offering detailed descriptions of each subtype.
However, all of these approaches are based on crisp values (integers) in the sense of Boolean logic. Municipalities are therefore classified as either rural or urban (or as their subtype), which is not always desirable because the method does not reflect a real status. This problem can be solved using fuzzy sets and fuzzy logic theory, which allows for a blending of the transition between two adjacent classes via fuzzy degrees of membership. The fuzzy approach serves as a robust tool in rural or urban area delimitation modelling in GIS. It provides an effective technique to model reality using vagueness and uncertainty instead of strict Boolean logic. Since their formal introduction by Zadeh (Zadeh, 1965), fuzzy sets and fuzzy logic have been used in many fields of science including geoinformatics. It is not the aim of this paper to introduce fuzzy sets and logic theory (for more information on this topic, see Bělohlávek, 2002; Klir & Yuan, 1996; Novák, 1989; Verstaete et al., 2007), instead our goal is to produce a map using a fuzzy inference system (FIS) in an antecedent analysis.

The map was the motivation of the analysis presented here. The map is the final output of the original approach that used fuzzy logic theory to address the rural and urban area delimitation problem. The aim of the map was to visualise, in an illustrative way, what the fuzzy degree of membership was for each municipality in the Czech Republic. The dominant feature of the map sheet is the Main map, which identifies the fuzzy membership degree of the municipalities. Seven secondary maps depict the fuzzy membership of municipalities by individual indicators.

2. Methods

The classical mathematical (Boolean) logic allows only two states of elements of the set to occur — yes/1 or no/0. Thus, the element belongs to one set or the other. Fuzzy logic theory defines a degree of membership for each element, which allows partial membership in each state. The degree of membership from the interval 0–1 is assigned to each element in the case of type 1 fuzzy sets (see Bělohlávek, 2002; Klir & Yuan, 1996; Novák, 1989). It is possible, then, to determine the municipality’s membership to rural or urban areas. One can evaluate the municipality as being more or less rural-like or urban-like and compare municipalities with each other. Such a technique was also exploited in the study regarding vulnerability evaluation in case of environmental research (Tucek et al., 2014).

It is the aim of fuzzy regulation to substitute a human-expert way of thinking for a ‘reasonable’ number of base rules (Schlegel, 2002). This number depends on the number of input variables and the fuzzy membership functions. The core aspect of the fuzzy regulator is represented by the FIS (e.g. Mamdani & Assilian, 1975; Takagi & Sugeno, 1985), which contains a specific algorithm assigning new, ‘fuzzified’ values to input variables. Many authors have written on the subject of fuzzy regulators, base rules and linguistic variables (Guney & Sarikaya, 2009; Jassbi et al., 2007; Schlegel, 2002; Talašová, 2003).

Because the results from the Czech Population and Housing Census conducted in 2011 were not available at the time of this study, the socio-economic indicators available from the Czech Statistical Office (CZSO) were used. The data were selected from the recent CZSO publications concerning rural area issues (Čsú, 2008, 2009; Štěpnička & Kuprová, 2008) for possible comparison. All of the indicators and threshold values (Table 1) were vetted by experts from the CZSO and academic specialists in consultation of the topic across the Czech Republic. Weight values (Table 1) were set based on the results of correlation and principal component analyses (PCA) of input indicators, which were consequently confirmed by several experts in rural geography, geoinformatics and quantitative geography; thus, indicators no. 1 and no. 2 hold a higher importance in the FIS. The relevant, quantitative socio-economic datasets were generally selected using the last day of the year 2010, except for no. 3 (related to 2006), no. 4 (1997–2010) and no. 5 (1993–2010).
One of the first steps was to perform a fuzzification process. The numerical values of input variables had to be transformed into linguistic variables of fuzzy numbers according to the fuzzy membership function:

$$\mu_{\tilde{A}} = \begin{cases} 
1 & x \geq b \\
\frac{x - a}{b - a} & a < x < b \\
0 & x \leq a
\end{cases}$$

(1)

where $\mu_{\tilde{A}}$, $a$ and $b$ are threshold values, and $x$ is the current indicator value. Formula (1) shows that we used a simple linear fuzzy membership function to fuzzify crisp numbers.

If a municipality’s fuzzified indicator value is greater (or lower) than the threshold, depending on the current indicator, full membership to an urban (or rural) area is assigned to the municipality. This process was performed using the FIS for every input indicator. We used the Mamdami FIS, the scheme of which is depicted in the presented map.

The second step was to apply base rules as a substitute for an expert’s thinking and experience. Overall, there were 254 base rules and here we provide the first 10 rules:

**[Rules]**

1. 1 1 1 1 1 1 1 (1): 1
2. 1 1 1 1 1 1 2, 1 (0.9): 1
3. 1 1 1 1 1 1 2, 2 (0.1): 1
4. 1 1 1 1 1 2 1, 1 (0.9): 1
5. 1 1 1 1 1 2 1, 2 (0.1): 1
6. 1 1 1 1 1 2 1 1, 1 (0.95): 1
7. 1 1 1 1 1 2 1 2, 2 (0.05): 1
8. 1 1 1 1 1 2 1 1 1, 1 (0.9): 1
9. 1 1 1 1 2 1 1 1, 2 (0.1): 1
10. 1 1 2 1 1 1 1 1, 1 (0.9): 1

The base rules in the FIS allow for the transformation of fuzzified values of the input indicator into output space. In this FIS, crisp input values were transformed through the fuzzification process into linguistic variables. The fuzzy inference algorithm selected input variables, stored the rules in the fuzzy rule base and defined the output as a fuzzy set.

---

Table 1. Input socio-economic indicators with threshold and weight values.

| Input indicator                                      | Rural areas | Urban areas | Expert weights |
|------------------------------------------------------|-------------|-------------|----------------|
| 1. Total population                                  | 1300        | 3700        | 0.35           |
| 2. Total population per built-up area                | 3200        | 6800        | 0.20           |
| 3. Flats in family houses per total number of permanently occupied flats (in %) | 92          | 68          | 0.10           |
| 4. Number of completed flats per 1000 inhabitants    | 6           | 54          | 0.10           |
| 5. Population change (in %)                          | -3.53       | 11.23       | 0.05           |
| 6. Driving distance to the county seat (normalised in metres) | 1600        | -5600       | 0.10           |
| 7. Urbanised areas per overall municipality area (in %) | 0.7         | 4.3         | 0.10           |

*Note: Driving distance (indicator no. 6) is obtained by calculating the distance from the municipality to the county seat using the road network. Urbanised areas (indicator no. 7) are built-up areas and patches that are man-made/artificial.*
Subsequently, the output fuzzy set was defuzzified back to a crisp number, which represented the fuzzy degree of membership for each municipality, using the Centre of Gravity method (Figure 1). These principles were also used for all input indicators separately to depict individual fuzzy degrees of membership for every single municipality.

A common form of map legend was used. The size of the map labels was set to preserve legibility in compliance with the acceptable graphic map content. The maps were also supplied with other features such as tables, texts or pictures to support the reader’s understanding. In the map, the darker the violet colour the higher the degree of membership to an urban area.

3. Conclusions

The map delimits municipalities into rural or urban areas according to the fuzzy degree of membership. This is important due to the fact that substantial changes in population movement in recent years have resulted in rapid suburbanisation in Central and Eastern Europe. Suburbanisation processes are most significant in areas close to large cities such as Prague, Brno and Ostrava. Typical clusters of urban-like municipalities occur in the neighbourhoods of large cities (Gernon & Peck, 2007), but specific conditions in the Czech Republic have resulted in the formation of large settlements without regard for the proximity of large cities. This is typical for the northwest and southeast regions of the Czech Republic. On the contrary, the most rural-like areas are at the county borders, especially in the central part of the Czech Republic. These areas have another aspect in common — the relatively long distance to the nearest large city or town. According to previous research (Musil & Müller, 2006), this isolation results in little or no motivation for people to live in these regions because of the increase in the cost of living, the dependence on public or personal transportation, unemployment, and other factors. In future research, methods could be improved by using uncertainty measurements on the geographical data as proposed by Tucek et al. (2009).

Additional information has been provided via the secondary maps and it is now possible to evaluate the rurality or urbanity of municipalities according to individual indicators. This new

![Figure 1](image-url)
method will allow identification to be based more on reality and will not bind municipalities or rural areas to a ‘yes’ or ‘no’ answer.

Software

A Mamdani Fuzzy Inference System was used to determine the degree of membership of municipalities to the rural and urban areas. Its inference system was built using the open source software Octave 3.2.4 with Fuzzy Logic Toolkit 0.2.4 package. Spatial data and maps were maintained and created in ArcGIS 10 for Desktop. Final desktop publishing and map sheet designing were performed using Adobe Illustrator CS4 and Adobe InDesign CS4.

Data

The degree of membership calculation was based on statistical data that was provided by CZSO. Seven indicators were included in the calculation and listed in Table 1. This statistical survey comes from the period 1993 to 2010.

The spatial framework of thematic data was mediated using a polygon data layer for the administrative areas of Czech municipalities from The National Topographic Database Data200.

The same database was a source for the topographic base of the map, which is represented by a point data layer of municipalities with city status. The status of Czech municipalities was determined from a database published by CZSO. This information is current as of 1/1/2011.

Acknowledgements

The article was created within the projects CZ.1.07/2.3.00/20.0170 and CZ.1.07/2.4.00/31.0010 and was supported by the European Social Fund and the state budget of the Czech Republic. The authors also thank to the grant PrF_2013_024 of Palacký University in Olomouc. The authors thank Jiří Sedoník for his involvement in the map making.

References

Bělohlaček, R. (2002). *Fuzzy relational systems: Foundations and principles*. New York, NY: Kluwer Academic/Plenum Publishers.

Binek, J., et al. (2007). *Venkovský prostor a jeho oživení*. Brno: Georgetown.

Český Statistický Úřad. (2008). *Variants in zone VENKOVA and their representation in statistical indicators in the years 2000 až 2006*. Praha: Český statistický úřad.

Český Statistický Úřad. (2009). *Postavení venkova v Pardubickém kraji*. Pardubice.

Champion, T. (2001). Urbanization, suburbanization, counterurbanization and reurbanization. In R. Paddison (Ed.), *Handbook of urban studies* (pp. 143–160). London: Sage Publishing.

Chromý, P., Jančák, V., Marada, M., & Havlíček, T. (2011). Venkov – žitý prostor: Regionální diferenciac a percepcie venkova představiteli venkovských obcí v Česku. *Geografie, 116* (č. 1), s.23–45.

Cloke, P., & Edwards, G. (1986). Rurality in England and Wales 1981: A replication of the 1971 index. *Regional Studies*, 20, 289–306.

Clout, H. D. (1976). *Rural geography: An introductory survey*. Oxford: Pergamon Press.

Defra. (2011). *Introduction to the Rural-Urban Definition*. Retrieved from https://www.gov.uk/government/publications/the-rural-urban-definition

Du Plessis, V., Beshiri, R., Bollman, R. D., & Clemenson, H. (2002). *Definitions of “Rural”*, Agriculture and Rural Working Paper Series, Working Paper 61, Statistics Canada. Retrieved from http://purl.umn.edu/28031.

Frey, W. H., & Zimmer, Z. (2001). Defining the city. In R. Paddison (Ed.), *Handbook of urban studies* (pp. 14–36). London: Sage Publishing.

Gernon, T., & Peck, S. (2007). Mapping past and future patterns of European urbanisation. *Journal of Maps*, 10.4113/jom.2007.68, pp. 88–97.

Gregory, D., et al. (2009). *The dictionary of human geography* (5th ed., p. 1072). Singapore: John Wiley & Sons.
Guney, K., & Sarikaya, N. (2009). Comparison of Mamdani and Sugeno Fuzzy Inference System Models for Resonant Frequency Calculation of Rectangular Microstrip Antennas. Retrieved from http://www.jpier.org/PIERB/pierb12/04.08121302.pdf

Halfacree, K. H. (2009). Urban–rural continuum. In R. Kitchin & N. Thrift (Eds.), International encyclopedia of human geography (pp. 119–124). Oxford: Elsevier.

Jančák, V., Havlíček, T., Chromý, P., & Marada, M. (2008). Regional differentiation of selected conditions for the development of human and social capital in Czechia. Geografie, 113(3), 269–284.

Jassbi, J., et al. (2007). Transformation of a Mamdani FIS to First Order Sugeno FIS. Retrieved from http://www2.uninova.pt/ca3/en/docs/07C-FUZZIEEE.pdf

Klir, G. J., & Yuan, B. (1996). Fuzzy sets and fuzzy logic: Theory and applications. Upper Saddle River, NJ: Prentice Hall.

Kostelecký, T., & Čermák, D. (2004). Metropolitan Areas in the Czech Republic – Definitions, Basic Characteristics, Patterns of Suburbanisation and Their Impact on Political Behaviour. Sociological Studies, 4(3). ISBN 80-7330-064-8.

Mace, A. (2009). Suburbanisation. In R. Kitchin & N. Thrift (Eds.), International encyclopedia of human geography (pp. 77–81). Oxford: Elsevier.

Mamdani, E. H., & Assilian, S. (1975). An experiment in linguistic synthesis with a fuzzy logic controller. Int. J. Man-Mach. Stud., 7, 1–13.

Mayer, H. M. (1971). Definitions of “City”. In L. S. Bourne (Ed.), Internal structure of the city: Readings on space and environment (pp. 28–31). Toronto: Oxford University Press.

Musil, J., & Müller, J. (2006). Vnitřní periferie České republiky, sociální soudržnost a sociální vyloučení. CESES FSV UK.

Mze Čr. (2007). Program rozvoje venkova České republiky na období 2007–2013. Praha: Ministerstvo zemědělství ČR.

Novák, V. (1989). Fuzzy sets and their applications. Bristol: Adam Hilger. ISBN 0-85274-583-4.

Novák, J., & Sýkora, L. (2007). A city in motion: Time-space activity and mobility patterns of suburban inhabitants and structuration of spatial organisation in Prague metropolitan area. Geografiska Annaler B: Human Geography, 89B(2), 147–168.

OECD. (1994). Creating rural indicators for shaping territorial policy. Paris: OECD.

OECD. (2005). The state of rural policy. Paris: OECD.

Ouršedniček, M., Špačková, P., & Novák, J. (2012). Metodika sledování rozsahu rezidenční suburbanizace v České republice. Praha: Univerzita Karlova v Praze, Přírodovědecká fakulta.

Perlin, R. (2010). Theoretical approaches of methods to delimitace rural and urban areas. European Countryside, 4, 182–200.

Perlin, R., Kučerová, S., & Kučera, Z. (2010). Typologie venkovského prostoru Česka. Geografie, 115(2), 161–187.

Pezzini, M. (2001). Rural policy lessons from OECD countries. International Regional Science Review, 24(1), 134–145.

Schlegel, M. (2002). Fuzzy regulátor. Plzeň. Retrieved from http://www.rexcontrols.com/downloads/clanky/flcu_tutor.pdf

Štěpnička, J., & Kuprová, L. (2008). Vymezení venkova na základě multikriteriálního hodnocení. Pardubice, 2 p. Manuscript.

Sýkora, L. (1993). Teoretické přístupy ke studiu města. In L. Sýkora (Ed.), Teoretické přístupy a vybrané problémy v současné geografii (pp. 64–99). Praha: Univerzita Karlova.

Sýkora, L., & Ouršedniček, M. (2007). Sprawling postcommunist metropolis: Commercial and residential suburbanisation in Prague and Brno, the CzechRepublic. In M. Dijst, E. Razin, & C. Vazquez (Eds.), Employment deconcentration in European metropolitan areas: Market forces versus planning regulations (pp. 209–234). Dordrecht: Springer.

Takagi, T., & Sugeno, M. (1985). Fuzzy identification of systems and its applications to modeling and control. IEEE Transactions on Systems, Man, and Cybernetics, 15, 116–132.

Talašová, J. (2003). Fuzzy metody v kriteriálního hodnocení a rozhodování. Olomouc: Vydavatelství Univerzity Palackého. ISBN 80-244-0614-4.

Tucek, P., et al. (2009). Regular use of entropy for studying dissimilar geographical phenomena. Geografie-Sborník CGS, 114(2), 117–129.

Tucek, P., Caha, J., Janoška, Z., Vondráková, A., Samec, P., Bojko, J., & Vozenílek, V. (2014). Forest vulnerability zones in the Czech Republic. Journal of Maps, 10(1), 179–182.

Urbaňková, J., & Ouršedniček, M. (2006). Vliv suburbanizace na dopravu v Pražském městském regionu. In M. Ouršedniček (Ed.), Sociální geografie Pražského městského regionu (pp. 79–95). Praha:
Univerzita Karlova v Praze, Přírodovědecká fakulta. Katedra sociální geografie a regionálního rozvoje.

U.S. Census Bureau. (2010). Urban and Rural Classification. Retrieved from https://www.census.gov/geo/reference/urban-rural.html

Verstaete, J., et al. (2007). Fuzzy regions: Theory and applications. In A. Morris & S. Kokhan (Eds.), Geographic uncertainty in environmental security (pp. 1–17). Dordrecht: Springer.

Woods, M. (2005). Rural geography: Processes, responses and experiences in rural restructuring. London: Sage Publishing. ISBN: 9780761947608.

Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8, 338–353.