

Article

# Impact of Suburbanisation on Sustainable Development of Settlements in Suburban Spaces: Smart and New Solutions

Petr Hlaváček <sup>1,\*</sup> , Miroslav Kopáček <sup>1</sup>  and Lucie Horáčková <sup>2</sup> 

<sup>1</sup> Department of Regional Development and Public Administration, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Usti nad Labem, Moskevská 54, 40096 Usti nad Labem, Czechia; miroslav.kopacek@ujep.cz

<sup>2</sup> Department of Finance and Accounting, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Usti nad Labem, Moskevská 54, 40096 Usti nad Labem, Czechia; lucie.horackova@ujep.cz

\* Correspondence: petr.hlavacek@ujep.cz; Tel.: +420-475-284-910

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**Abstract:** The aim of this article is to evaluate the impact of suburbanisation on the development of settlements with an emphasis on environmental aspects that need to be addressed in the process of extensive growth of municipalities in suburban regions. In the theoretical part, the article evaluates the processes of suburbanisation and their environmental impact. On a methodological level, municipalities in the suburban zone were first defined on the basis of driving distances. These municipalities were subjected to an analysis of the intensity of residential suburbanisation by calculating a multicriteria indicator from five selected criteria. In the second part of the analysis, a questionnaire survey of mayors was carried out in the particular municipalities. The responses were evaluated using the Likert scale method, and then statistically significant dependencies were sought among individual phenomena and environmental problems which need to be solved by the municipal management due to the growth of municipalities. It was found that the mayors consider changes in the landscape character to be among the most significant impacts of suburbanisation in the territory. A change in the rural character of municipalities because of the construction of urban-type houses is perceived as being very problematic. Another serious problem is the insufficient capacity of technical infrastructure such as sewerage and waste-water treatment. The costs of ensuring the quality of the environment and of public spaces, which are, in many cases, beyond the economic possibilities of municipalities, are also increasing significantly. The article also includes specifications of selected smart solutions and procedures that can help preserve the quality of the environment.

**Keywords:** suburbanisation; environment; smart solutions

## 1. Introduction

Suburbanisation is currently one of the most significant problems, but there are other challenges for many larger cities [1]. The stimuli for movement of the population to suburban areas [2] and villages are primarily driven by efforts to improve the quality of life [3]. At present and in general terms, the suburbs are very difficult to define [4], and it is equally difficult to delimitate rural and nonrural municipalities and areas [5]. Currently, some studies already point to the fact that it is no longer appropriate to use the traditional division of urban spaces into a central and suburban area [6,7], because the current world is already in the posturban phase [8]. According to such studies, it is suitable to reflect on new challenges, such as greater emphasis on the quality of the environment, the conservation of biodiversity and the use of new technologies that reduce energy consumption or ensure the production of energy from renewable sources.

The space between the countryside and the city is very specific in terms of its functioning [9], so it is inaccurate to identify it as urban or rural, but it is good to perceive it as specific and unambiguously characteristic [10,11]. Very often, urban edges tend to be degraded due to strong development dynamics and territorial demands [12]. Suburbanisation is currently affecting almost all parts of the world, with problems, but the spatial structures and intensity of this process are different [13]. Europe is suitable for observing the different developments of suburbanisation, as there are states that can be described as traditionally capitalist, where suburbanisation has been going on for a long time [14–16], and postsocialist states, where suburbanisation began as a result of socio-political changes around the year 1990 [5,17–19]. In the postsocialist states, the impacts of suburbanisation are only beginning to be felt at present. The essence of this article is to contribute to the scientific knowledge in this area with the example of selected municipalities in the Czech Republic.

The aim of the article is to evaluate the impact of suburbanisation on the development of settlements with an emphasis on environmental aspects that need to be addressed in the process of extensive growth of municipalities in suburban regions. Furthermore, the goal is to find out, through a questionnaire survey and interviews with mayors, which changes are taking place in the area of the environment and other selected aspects associated with ensuring an adequate quality of the environment in municipalities. A subordinate aim of the article is to identify the basic problems and identify the current challenges that suburbanisation brings, and to recommend possible solutions to ensure the sustainable development of municipalities around larger cities.

## 2. Suburbanisation in the Context of Environmental Aspects and Sustainability—Basic Problems

Suburbanisation in the metropolitan region stimulates very rapid changes [20], which may cause problems in all three main pillars of sustainability, i.e., economic, environmental and social [21]. The problematic part is that while maintaining economic development, it is very difficult to reduce additional land consumption [22]. In the OECD countries between 2001 and 2011, the trend of the decentralisation of population prevails in the analysis of mechanical population movements within functional urban areas, with population growth not taking place directly in existing cores but usually in their immediate vicinity, in places with low population densities [23], while such residents do not have to be from the core city, but also from other cities [24,25]. In addition, if there are more municipalities in the immediate background of the city, their spatial interaction in terms of expansion may occur within neighbouring municipalities, as individual municipalities are competing for new inhabitants, thus significantly promoting the growth of the core city [26]. In the suburbanisation process, residential populations are very often increasing at the periphery of cities, but the increase in new jobs in these areas is generally not the same, and thus, strategies based on polycentric development very often fail [27]. Such development is actually encouraged by transport systems (public transport systems, motorways, railways, etc.) that contribute to population mobility, including transport to work [28,29]. On the other hand, a lack of transport links through suburban areas could create supply problems for those areas [30].

On a global scale, suburbanisation takes place relatively quickly in terms of time, which often results in relatively rapid changes in different fauna and flora societies due to anthropogenic interventions, and thus, induced changes in the area, which may cause changes which are very difficult to reverse, e.g., in terms of the diversity, abundance and overall composition of the society [31] and the structure of individual food chains [32]. Suburbanisation also extensively affects watercourses and their ecosystems, and the more populated the area (e.g., the higher the density of population and built-up areas, networking by transport and technical infrastructure), the more difficult and costly it is to restore watercourses [33]. In the suburbanisation process, dependence on individual car transport has always increased significantly [34], with cars also significantly determining the morphology of these spaces [4].

Suburbanisation can also disrupt and alter the landscape-specific features of historical evolution [35,36] by changing agricultural land into building plots [37]. Constantly emerging suburban zones are also being addressed in many countries in terms of carbon mitigation, with some cities

(e.g., Sydney) showing that suburban households have a comparable carbon footprint compared to those in densely-populated city centres, and that it is therefore appropriate to stimulate changes in the consumption behaviour of residents [38], as suburban households may account for up to 50% of the total carbon footprint of national households [39]. There is a good example of Katowice in Poland, which shows that areas with good agricultural conditions are less subject to suburbanisation than areas where conditions for agriculture are not so good [40].

Within the areas affected by the suburbanisation process, the proportion of agricultural land is generally reduced, while land for housing and related services for residents and industrial use is increasing [40]. It is very problematic for municipal budgets when suburbanisation takes place in a form with a low population density [41]. Suburbanisation can also cause the spatial segregation of the population [2,42] and adversely affect the collective quality of life [3]. Therefore, it is important to coordinate and plan suburban development in order to achieve smart growth [43]. The suburban population tends to be segregated from other residents, and to be relatively socially homogeneous without mutual social links [44], with the quality of life in the suburbs being affected by geographical conditions as well as intracommunity relations and residents' participation in public life in the municipality [3]. In many cases, families from cities move to municipalities where communities are poorer, thereby raising the socio-economic level of these communities [45]. Furthermore, higher environmental quality, low population density, and cheap land prices are an incentive to move [46]. It is also important to take into account the fact that suburbanisation may widen disparities between districts in a city [47]. In addition, in some cities, urbanisation may no longer only concern the peripheral parts of cities, but it may also lead to inner-city suburbanisation [17,48,49].

### *2.1. Suburbanisation—Possible Solutions and Challenges for the Future*

Climate change brings new challenges for suburbanisation. Municipalities will need to disseminate sustainability elements into their development. According to Yigitcanlar et al. [50], the smart city concept is a means of shaping sustainable forms of settlement, for example in the construction of sustainable green and blue infrastructure. New types of building constructions built in suburban areas must be more environmentally friendly.

Other challenges include the better use of the advantages of urban and rural housing [51] and the harmonisation of both forms of housing in suburban areas. The creation of specifically functioning spaces on the border of urban and rural areas should be an incentive for policy-making and planning at the level of whole regions and of the functional delimitations of the city [52], because suburbanisation brings new challenges for the functioning of cities and municipalities [53]. Therefore, it is important to take into account the specific features of urban edges and adjacent areas [7]. It is advisable to promote compact policies and strategies that establish and allow further construction in suitable places, rather than a liberal, laissez-faire approach. This can lead to construction, regardless of the environmental impact and resource efficiency [13].

Environmental aspects [54] should also be included in the classical spatio-temporal aspects that currently map and evaluate suburbanisation. For example, the continual monitoring of pollution within the Smart Cities concept can help not only address but also prevent environmental problems [55]. At present, cities and their hinterlands are no longer seen as a part of the ecological crisis, but rather as an area where it is appropriate and possible to apply innovative patterns of sustainable consumption in terms of smart growth [56] and smart environment [57]. Smart environment is basically a classic physical environment which is enriched with monitoring, control, communication and computing capabilities throughout, from which knowledge of the environment is acquired and further used in order to reflect the needs and preferences of the local inhabitants [58].

A sufficient and high-quality transport infrastructure will generally reduce the population in the core city [59] while contributing to the increase in the population of its periphery [60]. The sustainability of suburbanisation will be enhanced by a greater decentralisation of cities. Decentralisation of employment will stimulate decentralisation of housing. It would improve workers' access to

employment [61], as the spatial structure of a city is a significant determinant of its ecological footprint [62]. Reducing the share of individual car traffic in the total traffic volume in a city could also reduce the relocation of workplaces to the central areas of cities, which usually have restricted traffic zones [63]. If workers demanded reserved parking spaces, which companies would have to pay for, employees could have smaller salaries, which would stimulate the use of public transport [64].

Clearly-defined green belts around cities [65] could also serve as a tool of eliminating excessive and uncontrollable suburbanisation that is close to nature, while the nondeforestation of suburban areas can also contribute to preserving their original character [66]. While maintaining the original character and values of the landscape, it is more likely to create a new identity and keep the existing one [67]. This can also be supported by regulations concerning the preservation of site morphology, such as fixed parameters for the construction and appearance of a new house, its dimensions and the built-up area, etc. However, on the basis of the intensity and quantification of changes in land use, it is possible to predict possible areas with a higher suburbanisation rates in the future [68].

In order to reflect changes in the territory, it is advisable to create monitoring frameworks whose mission is to assess changes in land use in relation to urbanisation, mainly on two levels: (1) the efficiency (or inefficiency) of land use, and (2) the dispersion of development and activities [13]. Overall, it is advisable to set certain growth limits, which may not definitively eliminate new arrivals, but may reduce newly built-up areas and encourage growth by densifying the construction of buildings [16,69]. If the urban background develops unevenly, it is advisable in nondeveloping areas to primarily support investment in transport infrastructure, which will support secondary growth with the sale of land and support for the construction of real estate [53].

## 2.2. Specifics of Suburbanisation in European Postsocialist States

In the postsocialist countries of Central Europe, suburban areas have become suitable housing habitats, as it is possible to build a house at a relatively low cost relative to the availability of a larger city centre [70,71], and thereby improve the quality of life [72]. In many cases, massive economic developments and shortcomings in institutional frameworks have resulted in the inefficient use of land in suburbs [73]. The suburbanisation process started largely after the socio-political changes around 1990 [5,17–19], while the growth of the peripheries of larger cities increased as a result of societal changes that allowed for the free movement of people and companies and the resetting of regulatory frameworks [21]. This mechanical movement of the population is also referred to as “back-to-the-village”, and is stimulated by the deindustrialisation, deurbanisation and ruralisation of urban economies [17,18].

Individual suburbs, in terms of residential parks, may have different approaches to the functioning and reception of new residents, with the basic three being: (1) closed—there is a strong gated community, (2) semiclosed—separated from the city but internally unclosed and (3) open—not separate from the city, and there are no barriers for the local community [74]. In some postsocialist countries, suburbanisation has resulted in social polarisation [42,71,75] among the richer, newly-arriving population and the indigenous community, which is usually less affluent [72]. Polarisation may not only concern socio-economic aspects; it may also comprise demographic polarisation [76].

Suburbanisation generally changes the character of rural landscapes and the form of rural communities due to intensive construction activity [51]. However, the suburbanisation process not only affects municipalities in terms of urban and architectural aspects, but also in terms of functionality, e.g., in the area of the necessary development of civic amenities and the provision of public services [77], for example by increasing the expenditures of individual municipalities as a result of suburbanisation [78]. The rapid growth and uncontrolled development of municipalities can make the development of a given settlement unsustainable; spatial conflicts can arise, the functions of individual plots may be in conflict, and the costs of transport and technical infrastructure may be unsustainable [70]. In addition to costs, an insufficient capacity for technical infrastructure, in particular waste water treatment plants, may be a problem [79]. The lack of fully public spaces can

also be a problem, so activities usually carried out in public spaces can also take place in other places which are only available to the public under certain circumstances and for a definite period of time [80]. Suburbanisation may not only concern permanent housing, but there may be significant seasonal population shifts in some cities [19], with seasonal population growth causing problems, for example, in waste water management [81].

### 3. Materials and Methods

Procedures for measuring the development of suburbanisation are mostly associated with the analysis of a larger number of data from different areas, often with the addition of methods of quantitative and qualitative research. Quantitative geographical methods are often used to measure the development of suburbanisation, monitoring the degree of consistency or difference of selected data or their changes over time. Literature mapping the development of suburbanisation often uses indicators such as statistical changes in population growth, density, spatial geometry, accessibility [82] or connectivity [83].

The monitoring and mapping of land use change and statistical analysis of selected demographic, environmental, economic and infrastructural data are very common [84]. In the qualitative dimension, sociological methods of data collection are often used, such as expert interviewing and interviews with local residents, photographic documentation and the mapping of community life. The use of a surveys [85] makes it possible to identify the attitudes of the population to the specific impacts of suburbanisation or to evaluate the aesthetic measures and environmental changes brought about by new construction. The methods use IT systems for qualitative and quantitative analysis to analyse large volumes of different data, including visualisation [86], mapping or suburbanisation development models [87]. Technologies and methods for creating satellite images of remote sensing are also used to create visual schemes for suburbanisation development.

The Ústí nad Labem Region is one of the higher territorial self-governing units of the Czech Republic. This is a region that is naturally polycentric in terms of functional links between settlements, as there are five core cities with a population of around 50,000 and more, all of which are statutory cities according to the Municipalities Act [88]. Namely, the statutory cities that were the subject of the present research were Děčín, Chomutov, Most, Teplice and Ústí nad Labem, as the core cities and municipalities in their hinterland, which were categorised for research purposes according to their respective suburban zones. Suburban zones of individual statutory cities were delimited for the purpose of the research [78] by a maximum of 25 min from the centre of a municipality to the centre of the statutory city. The Mapy.cz application was used to find a set of municipalities located within driving distance. If one of the municipalities was in two suburban zones, it was included in the suburban zone of the statutory city to which the arrival time by car was lower. If it was found that the suburban zone by its delimitation extends to another region or beyond the borders of the Czech Republic, then the affected municipalities outside the Ústí Region were not included in the research. For this type of research, it would be advisable to use other population data, such as commuting to work and schools. However, this data was not used, due to the fact that the data in the Czech Republic are obtained only through the census, which takes place every 10 years; the last census took place in 2011, so the data are not currently up to date. Moreover, some authors point out that these data of the Czech Statistical Office are not entirely accurate and complete [89].

From the group of 349 municipalities in the Ústí Region (out of the total of 354 municipalities in the region, 5 municipalities were excluded as they were core statutory cities), 176 municipalities (50.4% of the analysed municipalities) were integrated into individual suburban zones according to the commuting time. The suburban zone of Ústí nad Labem consisted of 51 municipalities; in the case of Chomutov, it was 34 municipalities. Subsequently, the suburban zone of Most and Teplice consisted of 31 municipalities, while the least municipalities were registered for Děčín, namely 29. The remaining municipalities of the region were excluded from the research, as it can be assumed that the higher driving distance would create a more rural setting and, therefore, that residential

suburbanisation would have a smaller impact on these municipalities. The municipalities which were categorised according to their membership in individual suburban zones of the respective statutory cities were further subjected to an analysis of the intensity of residential suburbanisation by calculating a multicriteria indicator [90], which, over time, reflected the development of four subindicators (Table 1).

**Table 1.** Description of subindicators related to the multicriteria indicator.

Subindicator	Definition
Change in population	This indicator reflected the relative change in the population over the ten-year period, from 31 December 2006 to 31 December 2016, with 2006 taken as the base (100%).
Change of urbanised land area	The calculation of this indicator was based on the calculation of the change in the share of urbanised area in the whole area of the municipality for the period of ten years from 31 December 2006 to 31 December 2016, while paying attention to components of land which can be described as urbanised-built-up areas and courtyards, gardens and other areas [91].
Intensity of housing construction	The calculation of this indicator was based on the average of ten annual values, which are the share of the total number of completed dwellings and the number of inhabitants in the municipality, from 2007 to 2016.
Change in the number of economic entities	The calculation of this indicator was analogous to the calculation of population change, except that the base of the calculation (100%) was 2013, so the intended, more relevant ten-year time series was not analysed, but only the three-year time series. The reason was a change in the methodology for data processing by the Czech Statistical Office in 2013, and so the data in a ten-year time series are not completely comparable. However, given the fact that this indicator is rather marginal (complementary) for the subject, a shorter time series is not an obstacle.

The values of the individual subindicators were subsequently standardised, so that for each subindicator, the municipality with the highest value was assigned the value 100; in contrast, the municipality with the lowest value was assigned a value of 0. The standardisation was performed according to the following formula:

$$x = \frac{x_i - x_{min}}{x_{max} - x_{min}} \times 100 \quad (1)$$

where:

$x$ : standardised indicator value

$x_i$ : individual value of the municipality

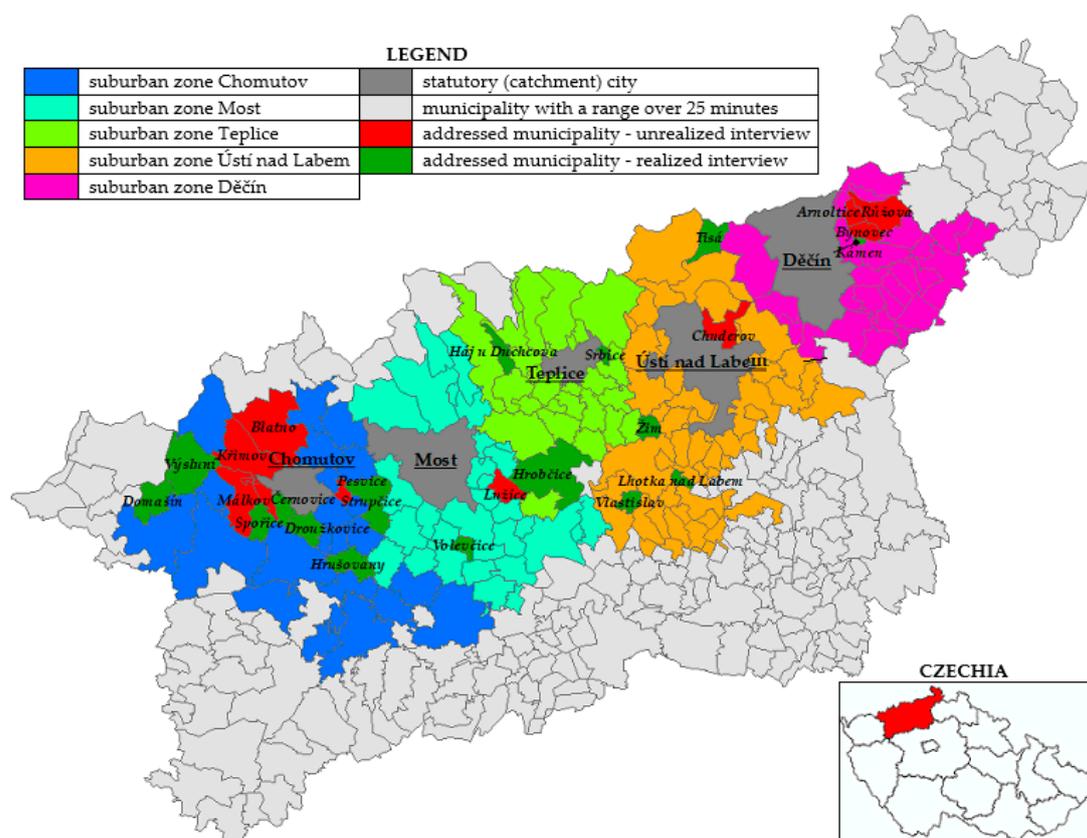
$x_{max}$ : maximum value of the subindicator in the whole analysed file (among all municipalities)

$x_{min}$ : minimal value of the subindicator in the whole analysed file (among all municipalities)

Based on the four standardised values thus obtained for each subindicator, a modified multicriteria indicator was calculated for all 176 municipalities analysed (Figure 1), and according to the value of the multicriterial indicator, the municipalities were ranked in descending order according to the intensity of territorial development of the municipality, or the degree of intensity of residential suburbanisation. The municipality which reached the highest intensity of territorial development of all five suburban zones was placed first. The advantage of this selection of municipalities is the possibility of making mutual comparisons of individual municipalities through standardised values, regardless of different population size. The disadvantage of this procedure and this method is the fact that the dispersion of the data file (either in terms of maximum or minimum) can be very easily and often very significantly deviated by an extreme value, and only for one municipality, they are the basis for the calculation of the multicriterial indicator.

For the next phase of the research, this group of municipalities served as a basis for addressing mayors with a request for an interview with municipalities, which, according to the research methodology, showed the highest intensity of suburbanisation. The mayor is often the “only employee” of the municipality in the Czech Republic because the municipalities are fragmented into small municipalities. The mayor therefore has a comprehensive overview of the functioning and development of his/her municipality, and often also stays in office for more than one mandate. In order to obtain information from the mayors, the interview was selected as the main research

method. The disadvantage of the interview is that, in addition to the facts, it can also contain a number of subjective attitudes of the respondent.



**Figure 1.** Suburban zones of statutory cities of the Ústí nad Labem Region, indicating the addressed municipalities for interview.

During the period from June 2018 to October 2018, a total of 25 municipalities were asked to be interviewed in accordance with the aforementioned criteria, with 17 mayors agreeing to be interviewed. Subsequently, the interview was held in 15 municipalities (Table A1). In two municipalities where an interview was promised, it failed to take place, due to the mayors of these municipalities having been busy. The final number of analysed municipalities (15) is not very high, but within the interviews, we could observe certain parallels that mutually confirmed similar problems and challenges within the functioning of individual municipalities. In addition, the sample of 25 municipalities for the local investigation included municipalities which were very similar in terms of type and function; therefore, the survey, carried out in 15 municipalities, was sufficient to provide relevant conclusions.

A semistructured format interview was held with the mayor (Table A2) containing 13 questions with a time limit of 30 min. A semistructured format interview is based on questions being predetermined and open. The advantages of this type of interview include that predetermined questions eliminate the interviewer's influence and improve the possibility of further analysis. The disadvantage is the standardisation of the interview, which can reduce the nature and flexibility of the interview [92]. Interviews were conducted in the field by one interviewer, with a total of only two interviewers to ensure the highest level of equal leadership and interviewing. The mayor of the municipality was always interviewed on the basis of prepared questions concerning the area of population, the territorial development of the municipality and the management of the municipality.

Eleven questions (Table 2) were selected for this interview from studies that discussed the environmental impact of the suburbanisation process [21,31–34,39,62], which were further divided into two categories. The first category included four questions concerning the territorial development

of the municipality. In particular, the mayors were asked about the issue of increasing the share of possible built-up areas in their municipality, and about the changes in the landscape and architectural characteristics of the municipality as a result of new construction [22,35–37,40,51,66]. The second category consisted of seven questions concerning the expenditure side of the municipal budget, i.e., by asking mayors how the identified environmental impacts caused by the suburbanisation process affected the expenditure side of the municipal budget [41,78].

**Table 2.** Analysed questions in the interview.

Category	Question	Question Code
territorial development	Is the share of built-up areas growing in their municipality?	A1
	Is the share of possible built-up areas growing in their municipality?	A2
	How does new construction change the landscape character of your municipality?	A3
	How does new construction change the architectural character of your municipality?	A4
municipal budget expenditures	Due to the influence of growth processes, do you spend more money on waste-water removal, treatment and sludge management?	A5
	Due to the influence of growth processes, do you spend more money on care for the appearance of the municipality and public greenery?	A6
	As a result of the impact of growth processes, do you spend more money on other infrastructure issues (mainly parking areas and parking lots)?	A7
	As a result of the growth processes, do you spend more money on repairing and managing local roads?	A8
	Due to the influence of growth processes, do you spend more money on public lighting?	A9
	Due to the influence of growth processes, do you spend more money on collecting and transporting municipal waste?	A10
	Due to the influence of growth processes, do you spend more money on changing heating technologies (gasification)?	A11

In the interview, the mayors were first asked by the interviewer to express the degree of agreement or disagreement with the question in Table 2. This degree of agreement or disagreement was tested using the Likert scale with an even number of possible answers [93,94], specifically, with four possible responses where each mayor could only choose one response option. The choices were the following: “I totally disagree”, “I reject”, “I rather agree”, and “I totally agree” [92]. In the Likert scale, the neutral degree in the form of “I cannot answer” was not used because the interview was conducted with mayors whose municipalities were identified by a multicriteria indicator of the rate of development dynamics, which, according to the nature of the question, excluded such an option. The nonuse of a neutral response is permissible as it depends on the nature of the research whether or not the neutral response is relevant to the conclusions of the research [95]. Open-type questions were chosen not only to determine the extent of the mayor’s approval or disagreement with the questioned issue, but also to obtain additional commentary thereon. The mayors were then asked for additional comments after expressing their agreement or disagreement with the issue. Selected additional comments were used for the final discussion.

The Likert scale was also chosen because of the possibility of gaining the so-called power of opinion by assigning an integer rating to the individual response variants [92]. Thus, each response variant was assigned a numeric value. “Totally disagree” was assigned the value 1, “Reject” was assigned the value 2, “Rather agree” was assigned the value 3, “Totally agree” was assigned the value 4. Selected variants of mayors’ answers to each question in Table 2 were then encrypted under each numeric value assigned to the response variants. Using the Likert scale, a response matrix was created containing quantitative characteristic now.

In order to fulfil the objective, it was also necessary to investigate the relationship between individual quantitative variables, and to find a pair of variables with the most significant interdependence. For this reason, a correlation analysis was used to describe the strength of dependence between variables [96]. The inability of the correlation analysis to imply causality between variables was not a limitation in the research, as there was no need to establish causality between variables for

the conclusions of the research. Because of the questioning of each mayor of the municipality on eleven issues, a simple correlation analysis was not used, which only describes the relationship between two variables; rather, a multidimensional correlation analysis was used through the correlation matrix, which makes it possible to describe the relationship between multiple variables, which is crucial for this research. A processed source matrix of the mayors' answers was used for its preparation; the correlation matrix including measure of significance (Table 3) of the resulting correlation coefficients is shown in Table 4.

**Table 3.** Relation of quantity  $T$  and  $W$  and measure of significance of the pair correlation coefficient.

Relation of Quantity $T$ and $W$ at Value $\alpha$	Degree of Significance of the Pair Correlation Coefficient
$T < W$ , when $\alpha = 0.05$	*
$T > W$ , when $\alpha = 0.05$	**
$T > W$ , when $\alpha = 0.01$	***
$T > W \wedge (T - W > 1)$ , when $\alpha = 0.01$	****

**Table 4.** Results of significance tests for individual paired correlation coefficients.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
A1	-										
A2	0.31 **	-									
A3	0.43 ***	-0.15 *	-								
A4	0.37 ***	-0.13 *	0.74 ****	-							
A5	0.81 ****	0.41 ***	0.44 ***	0.21 *	-						
A6	0.43 ***	0.42 ***	0.36 ***	0.51 ****	0.52 ****	-					
A7	0.12 *	-0.19 *	0.03 *	0.05 *	0.09 *	0.14 *	-				
A8	-0.14 *	0.10 *	-0.50 ****	-0.36 ***	-0.16 *	-0.41 ***	0.31 **	-			
A9	0.31 **	0.07 *	0.34 ***	0.42 ***	0.12 *	0.56 ****	0.01 *	-0.17 *	-		
A10	-0.39 ***	-0.80 ****	0.14 *	0.33 **	-0.49 ****	-0.30 **	0.06 *	0.00 *	-0.05 *	-	
A11	0.40 ***	0.21 *	-0.08 *	0.07 *	0.14 *	-0.23 *	-0.36 ***	0.19 *	-0.04 *	-0.02 *	-

Note: The meaning of the stars is explained in the Table 3.

The significance test was used to determine the significance of individual correlation coefficients for  $r$ . The main advantage of the significance test  $r$  is the ability to compare a test criterion with a critical value at a given significance level, which makes it possible to evaluate whether a particular correlation coefficient can be considered sufficiently strong and relevant for the baseline group ( $\rho$ ). Already from the correlation matrix in Table 4, it is evident that paired correlation coefficients were created, so the formula was chosen for the calculation of the test criterion ( $T$ ) [97]:

$$T = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2} \quad (2)$$

where:

$T$ : test criterion

$r$ : the correlation coefficient

$n$ : number of degrees of freedom

The resulting test criterion value had to be compared with the critical value ( $W$ ), the formula of which is defined for this research [97]:

$$W = \{T \mid |T| \geq t_{1-\frac{\alpha}{2}} \times (n-2)\} \quad (3)$$

where:

$W$ : critical value

$T$ : test criterion

$n$ : number of degrees of freedom

$\alpha$ : level of importance

First, the individual values of paired correlation coefficients were subjected to the significance test for  $r$  for  $\alpha = 0.05$ . If  $T < W$ , the null hypothesis  $H_0$ , given by  $H_0: \rho = 0$ , was rejected, and thus, the alternative hypothesis  $H_1$  was given, given by  $H_1: \rho \neq 0$  [98]. An asterisk (\*) was added to the pair correlation coefficient value in Table 4 that met this requirement. Furthermore, because of its insignificance, this paired correlation coefficient for the population was not tested. The remaining pair correlation coefficients for which the null hypothesis  $H_0$  was accepted at  $\alpha = 0.05$  were subjected to the significance test for  $\alpha = 0.01$ . Two asterisks (\*\*) were assigned to the values of paired correlation coefficients where the null hypothesis  $H_0$  was rejected at  $\alpha = 0.01$ , and thus, the alternative hypothesis  $H_1$  was accepted. The remaining pair correlation coefficients for which the null hypothesis  $H_0$  at  $\alpha = 0.01$  was accepted were further analysed to determine whether  $T - W > 1$ ; if so, the values of these pair correlation coefficients were assigned four stars (\*\*\*\*). For paired correlation coefficients where the null hypothesis  $H_0$  at  $\alpha = 0.01$ , but  $T - W < 1$ , was accepted, only three asterisks (\*\*\*) were assigned to their values. For the sake of clarity, the relationship between  $T$  and  $W$  at different  $\alpha$  values is shown in Table 3.

The aim of the significance tests was primarily to find pairs of questions with a strong, and therefore the most significant, interdependence. For this research, these are the pairs of questions whose paired correlation coefficients were assigned four stars in Table 4.

#### 4. Results

The most significant dependencies were found in changes of landscape character due to suburbanisation. According to the mayors, the landscape character of the suburbanised areas is greatly influenced by the new construction and its architectural design. The incorporation of new buildings into the landscape layout and the character of settlements are therefore important factors in their development. “We try to maintain the rural character of the old buildings, but completely new buildings have been created and are being built in new locations” [99].

In contrast, the construction of transport infrastructure, which is currently one of the most important sources of air pollution, is perceived more negatively. “We need to take care of the problems of roads and parking, because no one has previously anticipated that at present the level of car use will reach such a degree” [100]. According to the mayors of municipalities, the landscape is also influenced by the positively managed processes of waste-water disposal and treatment and quality care for public greenery, and thus, also for public space in municipalities. “Our municipality currently has very little of its own public space, e.g., we do not have a village square etc., so with the development of our municipality and the arrival of new people it is necessary to plan to build some wider facilities, especially those where they could meet” [101]. The growth of built-up areas has led to an increase in waste-water disposal expenditures; the correlation analysis shows a very significant dependence among the monitored topics (at a critical value of 0.01). The provision of the required waste-water disposal and treatment capacities is often a problem. “We have sewage and waste-water treatment plants, but we are currently addressing the problem that we are on the edge of the capacity. Despite the realised increase in the capacity, it is not enough, which limits us in further development” [99]. The growth of the built-up areas and new construction also changes the architectural and urban character of the municipalities. “The changing nature of our community is already starting to bother our citizens, so we have begun to regulate the individual parameters of buildings already in land contracts, and so it is predefined how the house should look” [102]. In order to maintain a harmonious environment as a result of these urban changes, higher care for the appearance of municipalities, public space and greenery is also necessary. “As the population grows, we need to increase the number of public maintenance workers, as the areas we maintain are constantly expanding” [103]. A very frequent dependence was also found between the growth of built-up areas in the municipality and

higher costs of care for public greenery, change of the surrounding landscape or higher costs of waste disposal and the introduction of new technologies for heating.

## 5. Discussion

Research has shown that suburban areas are infused by a number of different processes [11]. Municipalities have to respond to these processes in order to ensure that their inhabitants have a sustainable condition for living. For planning, it is also important to reflect on the specific needs of both the old and the new population [35]. It is appropriate to set up monitoring frameworks [13] for the municipality, which will provide local representatives with feedback on the overall development of the territory, the efficiency of land use [13,73] and thus, the basis for decisions on further development. If a municipality entails significant growth of population and buildings, it is advisable to set, through institutional frameworks (e.g., territorial plan, regulatory plan), nonexceedable limits for territorial development [69]. Municipalities do not resort to significant limits in the early stages of suburbanisation, because they often compete with other municipalities for new inhabitants [26], and so many municipalities do not make any significant regulation until the capacity of the municipality is fulfilled. However, the interest of developers, as well as individuals, in land and real estate in the municipality can predict in the future a higher degree of development dynamics and pressure on a municipality [68], and thus, it is possible to predefine institutional frameworks and control mechanisms in the municipality development [16].

Municipal development takes place at the expense of undeveloped land [37,40], and overall, it is very difficult to reduce further land use [22], but it can at least always steer construction to appropriate places through the tools at its disposal [13]. For the municipality, it may be positive in the short term that the number of residents with a permanent residence inhabit the area, and thus, that tax revenues are increasing, but in terms of long-term development, if, for example, new residents build houses in unsuitable places or build-up is poorly concentrated [16,69], it can be very negative for the municipality's sustainable development. In addition, intensive construction activity changes the nature of the rural landscape and the character of rural municipalities [51]. Municipalities are also under pressure in terms of providing civic amenities and public services [77], such as sufficient technical infrastructure capacity, especially waste-water treatment plants [79], which significantly increases the spending of individual municipalities as a result of suburbanisation [78]. The situation in municipalities with low population densities is the most complicated [41].

To maintain the quality of the environment in suburban communities, the solution is to apply smart approaches and modern technologies, which are currently being developed in the Smart Cities concept, as stable and diverse ecosystems are central to maintaining a healthy environment in a fast-paced suburban space. In Czech conditions, municipalities and towns may follow the recommendations of the Smart Cities methodology, which also deals with the environment cavity. In the suburbs, the solution is to develop adaptive development strategies that ensure the protection of all environmental compartments. In order to map the development of the quality of the environment, it will be necessary to have a functional system of measuring environmental data in urban areas. Data on specific airborne concentrations should be automatically evaluated and available online. For example, pollutants from transport contribute to air pollution and photochemical smog, and thus, burden urban regions and surrounding areas.

In the development of municipalities, it is also necessary to create a functional system of green and blue infrastructure, ensuring an adequate share of green and water areas in relation to the built-up part of municipalities. Their environmental importance, which contributes to biodiversity and the resilience of cities, also complements their positive impact on the social dimension of the functioning of municipalities, which, according to Braat et al. [104], helps with the growth of social cohesion. Smart solutions in the spatial deployment of green and water infrastructure will also help to reduce temperature and emissions growth. An example can be resting zones with vegetation, which will increase the quality of public areas and localities. The efficient use of rainwater and treated waste-water

or the use of heat from waste-water using smart technologies are new opportunities for the development of settlements in suburbanised areas.

The risk of municipalities in the suburbs is also their uncoordinated extensive transport growth. “Most citizens have a car, and a single car is no longer enough in the family today. The problem is that there are not enough parking lots and our current legislation has not gone far enough to regulate the vehicle owner’s relationship to the public space. This means that citizens have nowhere to park their cars and they believe that it is the responsibility of the municipality to set up parking spaces for them” [103]. This confirms that residents of suburban areas are significantly dependent on individual cars as a means of transportation [34], while the creation of new parking spaces may also change the appearance of public spaces [4]. The question is whether, in the short term, it is advisable to solve the problem of parking through the continuous construction of new parking spaces. The lack of parking spaces can also act as a means of regulating further development, which, of course, needs to be accompanied by well-executed traffic signs and controls. In the transportation sector, emphasis should also be placed on reducing the growth of noise and pollution. Also, the production of renewable energy, planned and built in municipalities in suburbanised areas, will reduce air pollution and CO<sub>2</sub> production, and will contribute to reducing the carbon burden.

Investments for the implementation of similar measures are higher in comparison with the costs of the existing territorial development of the municipalities, but in the long term, they will contribute to maintaining or increasing the quality of life of inhabitants and maintaining biodiversity in urban and rural areas of suburban areas. A number of preventive measures, including public investment planning, should be implemented in the municipal plans of municipalities, which will ensure the implementation of projects and measures to achieve the objectives in the environmental development of municipalities.

## 6. Conclusions

The development of municipalities in the background of large settlements in a suburbanised area is a long-term process that will bring further social, environmental, economic, urban, architectural and other requirements for the coordination of municipal development. Based on the selection of a representative group of municipalities located in the suburban area, interviews were conducted with the mayors of the municipalities in which the impact of suburbanisation on the development of municipalities was monitored, focusing on the environmental area of municipal development. In expert interviews, most attention is drawn to landscape change as a negative impact of suburbanisation and to increases in costs related to the growth of municipalities. Transforming rural settlements into suburban areas also entails certain risks, such as the problem of the conflict of traditional and modern values or rural and urban lifestyles, or the burden of traffic [105]. Another serious problem is the insufficient capacity of technical infrastructure such as sewerage and waste-water treatment. It is also important to take into account the risk of unfinished and underdeveloped infrastructure [106].

The research also found that municipal management is aware of a number of environmental risks that would further limit the extensive growth of settlements. In particular, the process of maintaining sustainable urban development requires greater regulation of local governments and stricter planning [107]. Another solution in the development of suburban communities is to create a green belt that will activate a new element in the suburban landscape and fulfil an environmental and socio-economic function in the ecosystem of local services, such as mobility, water supply, recreation and culture [108]. On the other hand, in many countries, there is no wider territorial regional planning, but Kubeš [109] considers the lack of metropolitan planning for more local and regional authorities to be explicitly inappropriate and impractical. Individual municipalities should pay attention not only to monitoring the impact of the suburbanisation process on the municipality and its functioning [13], but also to creating regulations that will guide development [13,73]. Municipalities should regulate new development or the arrival of new inhabitants, even at a time when new residents want and need their community. In the longer term, the short-term positive phenomenon of the arrival of new

inhabitants may be replaced by higher demands on the municipality in terms of ensuring an adequate standard of living for their inhabitants [51,77–79].

Municipal management should also address, in a coordinated manner, the quality of the environment in the built-up areas of municipalities, as, for example, insufficient investment in greening the public space leads to increased noise and pollution [110]. Smart technologies are an important means for providing and online reporting on up-to-date environmental data, or creating a multipurpose system of green and blue infrastructure to reduce the burden from the growth of built-up areas. The result of the implemented measures should be to ensure the required level of environmental quality of municipalities and their background, together with conditions for the further urban and population growth of settlements, which is usually inevitable in the suburbanisation zone.

Some limitations can be identified in the research. The set of questions in the questionnaire survey could have focused on a wider range of issues examining sustainability and the living conditions in settlements, including the mapping of implemented measures and projects to increase sustainability. It would be interesting to evaluate the applied smart solutions; however, according to the information found, the implementation of smart solutions is still in the initial phase in small municipalities in the Czech Republic.

Further research should focus on mitigating the negative impact of urban development in suburban areas. Also, the increasing dynamics of suburbanisation should follow other development trends as rural areas turn into suburban ones, whether, for example, there is any differentiation in the development of suburbanised regions in postsocialist countries compared to development in Western Europe in terms of biodiversity conservation and environmental quality in and around communities.

Another research topic could be an analysis of the attitudes of indigenous and new inhabitants, their value frameworks, the opinions on the development of municipalities, and the need to implement environmental measures at the cost of reducing the quality of different lifestyles. It would also be desirable to define a representative set of indicators and a methodology for a comprehensive assessment of the impact of suburbanisation on the development of municipalities in order to compare selected municipalities or regions.

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## Appendix A

**Table A1.** Municipalities forming a research sample of municipalities according to the set methodology criteria.

Name of Municipality	LAU2 Code	Suburban Zone	Date of Interview
Domašín	563048	Chomutov	26 June 2018
Droužkovice	563056	Chomutov	21 June 2018
Háj u Duchcova	567523	Teplice	18 June 2018
Hrobčice	567566	Teplice	18 June 2018
Hrušovany	563072	Chomutov	9 July 2018
Kámen	546453	Děčín	17 July 2018
Lhotka nad Labem	565113	Ústí nad Labem	30 July 2018
Spořice	563340	Chomutov	28 August 2018
Srbice	567833	Teplice	1 August 2018
Strupčice	563358	Chomutov	11 September 2018
Tisá	568309	Ústí nad Labem	8 June 2018
Vlastislav	565873	Ústí nad Labem	11 June 2018
Volevčice	546437	Most	26 October 2018
Výsluní	563498	Chomutov	26 June 2018
Žim	567884	Ústí nad Labem	18 July 2018

**Table A2.** Particulars of Mayor–respondents with whom interviews were conducted.

Name of Municipality	LAU2 Code	Particulars of Mayor			
		Age	Gender	Time in Office	Full-Time
Domašín	563048	52 years	female	20 years	no
Droužkovice	563056	60 years	male	28 years	yes
Háj u Duchcova	567523	64 years	male	16 years	yes
Hrobčice	567566	44 years	female	8 years	yes
Hrušovany	563072	50 years	male	8 years	yes
Kámen	546453	51 years	male	8 years	no
Lhotka nad Labem	565113	38 years	male	3 years	no
Spořice	563340	52 years	male	8 years	yes
Srbice	567833	56 years	male	12 years	yes
Strupčice	563358	40 years	male	14 years	yes
Tisá	568309	66 years	male	8 years	yes
Vlastislav	565873	54 years	female	4 years	no
Volevčice	546437	41 years	male	1 year	no
Výsluní	563498	55 years	female	4 years	no
Žim	567884	61 years	male	16 years	yes

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