

Modelling the Coverage of Public Utility Providers

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1 ABSTRACT

The decreasing financial resources of many Styrian municipalities, particularly the small ones, lead policy makers to rethink funding allocations. Policy makers considered the inter-municipal use of public utility providers as well as the creation of regional authorities. These arrangements should provide for a more efficient and cost reduced usage of public utility providers. Due to these facts, the division 16 of the provincial government in Styria launched the project “Modelling the coverage of public utility providers”. Within the scope of the project an ArcGIS Plugin was developed for modelling the coverage as well as for modelling the degree of capacity utilization of public utility providers in Styria. The results of the analysis provide transparent information about an optimized spatial distribution of public utility providers which creates the base planning criteria for the intended inter-municipal use of these facilities.

2 INITIAL SITUATION IN STYRIA

“Among all Austrian provinces, Styria has the smallest community structure: 76 municipalities have less than 500 residents, 196 fewer than 1000 and 407 municipalities have less than 2000 inhabitants. In 2009, approximately 200 municipalities attained negative annual accounts. This has to be equalised by funding allocations. The majority of these municipalities are small.” (www.kleinezeitung.at, 16.12.2010).

Policy makers need to rethink funding allocations because of the decreasing financial resources of many municipalities in Styria. Already in 2006, the inter-municipal use of public utility providers as well as the creation of regional authorities were considered by different projects. Regional authorities are meant to consist of small adjacent municipalities with a corporate administration. In 2011, an administrative reform started with the scope to achieve sustainable cost and spending reductions. Until now, planning and spatial distribution of public utility providers was done by Styrian municipalities on their own. In the future it will be necessary to achieve planning as well as usage of public utility providers on an inter-municipal basis. This will lead to an optimized spatial distribution and furthermore to cost and spending reductions. An essential part to realise these reforms successfully is to actively involve the affected population as well as the policy makers in all major decisions. The results of the analysis provide transparent information about an optimized spatial distribution of public utility providers which builds the base planning criteria for the intended inter-municipal use of public utility providers. These transparent results should assure the arrangements will be widely accepted by the population.

3 MODEL FUNDAMENTALS

The model is based on the data of three main input parameters. The first parameter contains information about the capacities of public utility providers for different domains e.g. kindergarden, primary school, hospitals and so on. The second main parameter consists of demographic characteristics which are represented by a grid dataset with a spatial resolution of 250 m. The third main input parameter is a street graph which was exported from the GIP (Graph Integration Platform). There is one optional parameter for the analysis, i.e. named regions. These regions are used to distinguish between travel times depending on the spatial structure.

3.1 Public Utility Providers

This parameter contains information about the capacities of public utility providers for different domains which are a matter of public interest, e.g. kindergarden, primary school, municipal office, hospitals and so on. This information is provided by a component of the spatial information system Styria which is still under

construction and is stored in a point dataset. At present the capacities represent the current ones which are in use instead of the actual available ones.

3.2 Demographic Characteristics

This parameter consists of demographic characteristics which are represented by a grid dataset with a spatial resolution of 250 m. It is also necessary to use demographic characteristics with a spatial resolution on a local level for data preparation due to the data privacy policy. Both datasets are provided by Statistik Austria. On the level of the grid dataset demographic characteristics like age groups will be provided if there are more than 31 principal residences. In Styria the majority of the 250 m grid cells do not hold any detailed information about demographic characteristics. Due to this fact it is necessary to generate a hybrid dataset based on the grid dataset as well as on the local level dataset. The calculation of the number of people per age group and grid cell with less than 31 principal residences is shown in Figure (1).

$$A_{i,k_y} = \left(\frac{A_{i,l_y} - \sum_{l_y=1}^n A_{i,l_y}}{\sum_{k_y=1}^m H_{k_y}} \right) * H_{k_y}$$

A_i ... number of people per age group i
 k_y ... grid cells < 31 principal residences of municipality y
 l_y ... grid cells \geq 31 principal residences of municipality y
 H ... principal residences

Fig. 1: calculation of the number of people per age group and grid cell with less than 31 principal residences

3.3 Street Graph

The street graph represents the area-wide, homogeneous motorized as well as the non-motorized individual transport. This dataset was exported from the Graph Integration Platform (GIP). The street graph has to be slightly modified to be used within the model.

3.4 Regions

The spatial density of public utility providers depends on the area. In rural areas there are not as much public utility providers as located in urbanized areas. Because of this the spatial structure can also be involved for the calculation. There are three main areas: inner alpine, outer alpine and central area.

4 MODELLING THE COVERAGE OF PUBLIC UTILITY PROVIDERS

4.1 Model Algorithm

The model algorithm is based on the calculation of service areas for the different public utility providers and the spatial distribution of demography of the domain specific population group inside this calculated service areas. Depending on the reviewed domain it is important to distinguish between the accessibility and coverage of public utility providers. For example the domain “education” focuses on accessibility whereas the domain “public order” which covers the topics “police”, “fire departments” as well as “ambulances”, focuses on the coverage. As part of the model, service areas as well as origin-destination cost matrices are calculated on the base of the modified street graph. The calculation itself is based on the Dijkstra algorithm (Dijkstra 1958). The centroids of the grid cells which provide demographic data are the origin or destination points, depending on the preselected domain. Another input dataset contains the point locations of public utility providers.

It is an iterative process. There are several steps: first, the algorithm chooses the grid cell with minimum travel time. Second the algorithm subtracts the number of people that need to be supplied from the total available capacity of the assigned public utility provider. Third, the remaining capacity is stored temporarily. Forth, the algorithm assigns the classification value of the coverage of public utility providers to the currently processed grid cell. The workflow of the algorithm is shown in Algorithm (1).

grid cells outside service area: coverage = not supplied
sorted cost matrix, travel time ascending
for travel time $w = 1$ to n of grid cells R of public utility provider I_y
if capacity of $I_y \geq$ number of people need to be supplied in R : coverage = supplied
else if capacity $I_y = 0$: coverage = inadequately supplied
else: coverage = partially supplied

Algorithm 1: Assignment of the classification of the coverage of public utility providers per grid cell

The algorithm distinguishes between four different classification values: a grid cell is classified as “not supplied” if it is outside any service area. A grid cell is classified as “supplied” if it is inside of a service area and the public utility provider has enough capacities to supply this grid cell. If a grid cell is inside of a service area but the underlying public utility provider’s capacity is equal to zero, the grid cell is classified as “inadequately supplied”. Last but not least, if a grid cell is inside of a service area but the public utility provider has not enough capacities to supply this grid cell although the capacities are greater than zero, the grid cell is classified as “partially supplied”.

4.2 Software implementation

With the release of ArcGIS® Desktop 10 the concept of Add-Ins was established. This concept allows easy distribution of self-developed Add-Ins via shared folders, e-mail or download link. The conceptual model was implemented as an ArcGIS Plugin for the release of ArcGIS® Desktop 10. The implementation was done in C# on the basis of the Microsoft.NET 3.5 Framework.

The calculations are mostly based on the functionalities of the ArcGIS® Geoprocessing library. The calculation and classification of the coverage of public utility providers is based on the self developed and implemented algorithm, shown in Algorithm 1. The methods and functionalities of the ArcGIS® Network Analyst library are used for the creation of the network dataset, as well as for calculation of the service areas and cost matrices. The service areas and the cost matrices are based on the GIP street graph which will be periodically updated.

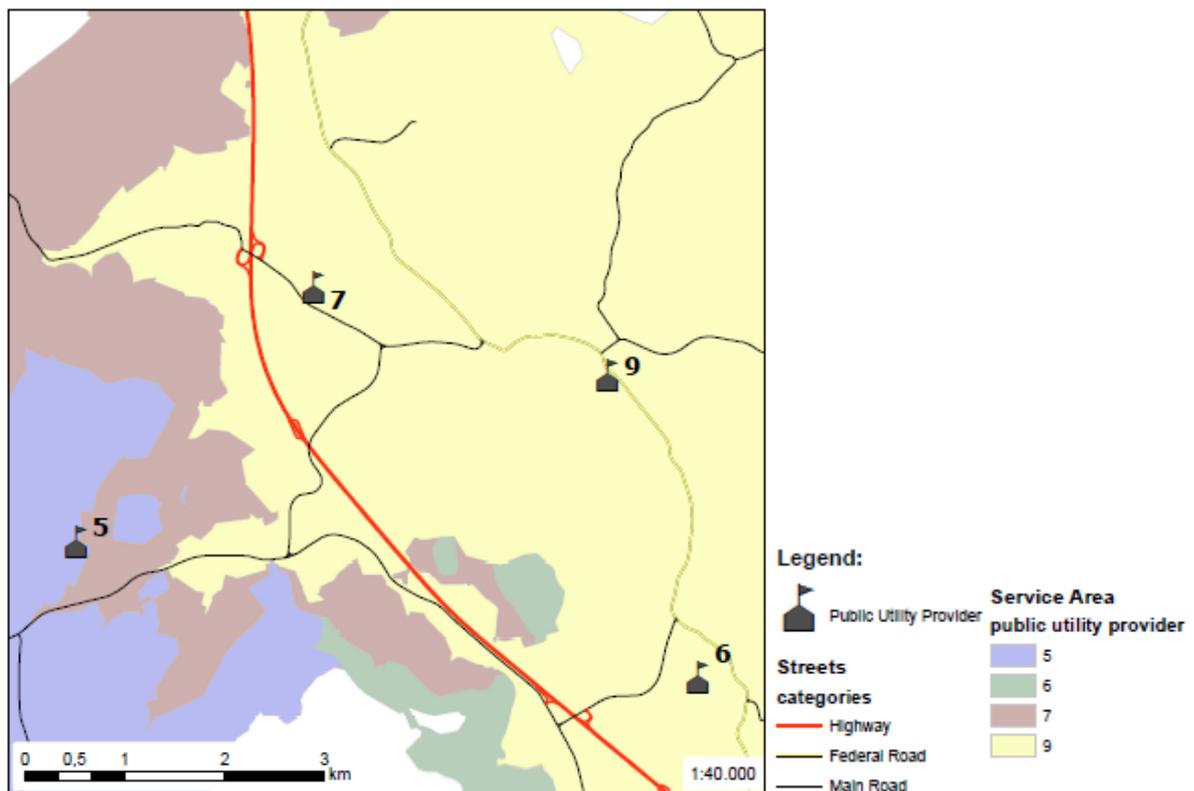


Fig. 2: Service Areas of kindergarden in Kalsdorf near Graz

4.3 Results

The results of the executed algorithm are a grid dataset representing the degree of capacity utilization with a spatial resolution of 500 m, as well as the capacity utilization of each individual public utility provider. In addition, the service areas are also available. The following figures show the results of the calculations. The example is chosen from the domain “education” – “kindergarden”. The region is located in Kalsdorf near Graz. The configurable parameters are: 5 minutes driving time (individual motorized traffic) without any regionalization. The result showing the calculated service areas is shown in figure 2. The result containing the degree of capacity utilization is shown in figure 3.

As shown in figure 2, the service areas are overlapping each other. Although, as shown in figure 3, not all of the demographic micro cells are supplied. Most of the micro cells have no demand which means that there are no children aged 3 to 5. These cells are shown in grey. Some of the demographic micro cells are inadequately supplied or partially supplied, shown in orange and yellow. The farthest micro cells are not supplied, shown in red.

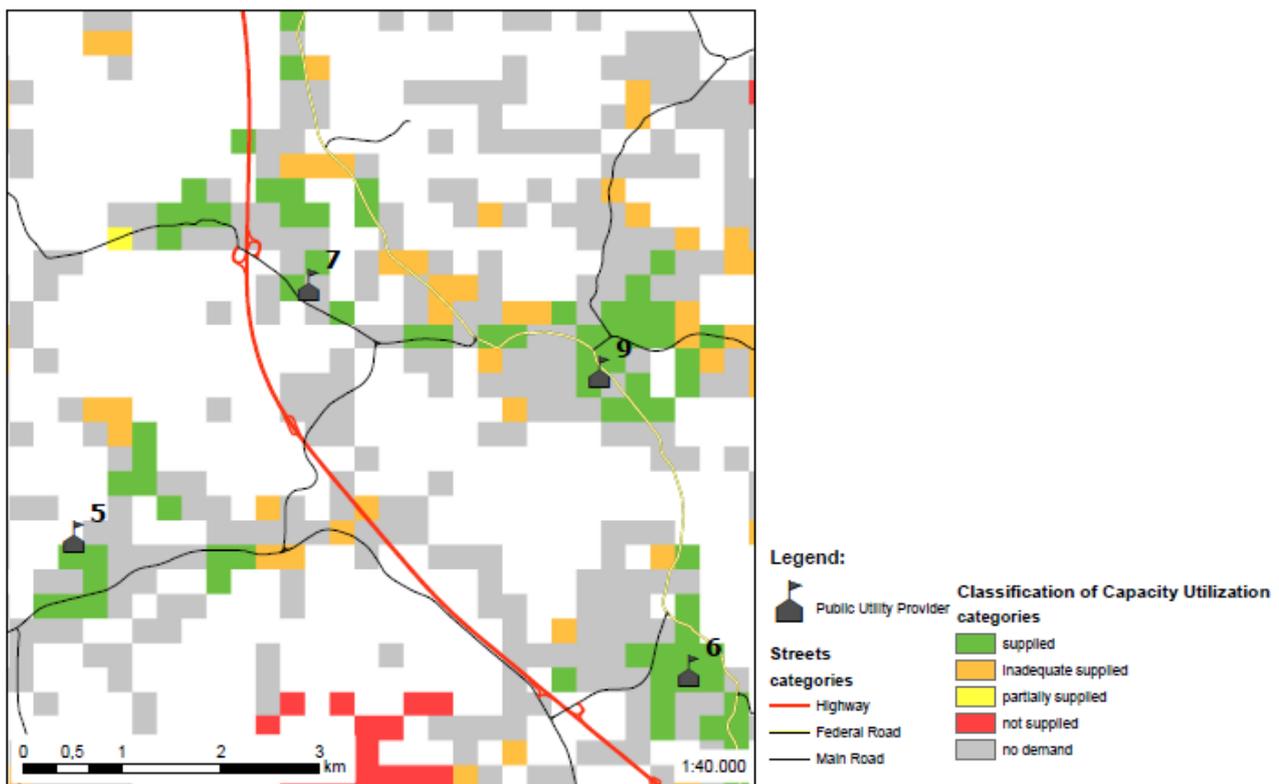


Fig. 3: Classification of capacity utilization of kindergarden in Kalsdorf near Graz

5 CONCLUSION

First estimations and evaluations of the employees of the provincial government in Styria determined that the developed tool is feasible and offers new opportunities for the intended inter-municipal planning. Due to the fact that the spatial information system Styria is currently under construction, not all public utility providers are digitally represented yet. Furthermore, the recorded capacities represent the current capacities in use, not the available capacities. For this reason it is essential to analyze the results critically. However, the employees of the provincial government in Styria can use this interactive tool to generate transparent information about an optimized spatial distribution of public utility providers which builds the base planning criteria for the intended inter-municipal use of public utility providers.

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