GIS APPROACH IN ASSESSING THE RURAL SPACE ACCESSIBILITY – CASE STUDY: VASLUI COUNTY, ROMANIA

Ema CORODESCU [1]

ABSTRACT:
The present article focuses on quantifying the rural space accessibility in Vaslui County, Romania, by employing GIS techniques, aiming to propose a new accessibility index. In order to reach this purpose, the accessibility index took into consideration variables related to distance, slope of the routes and public transport availability, which were calculated and spatially modeled. Finally, the employed methodology emphasized a particular spatial pattern of the general accessibility in Vaslui County, denoting important disparities.

Key-words: *network distance, routes average slope, public transport, Synthetic Accessibility Index, spatial inequalities.*

1. INTRODUCTION

Accessibility is a key concept of the actual territorial planning strategies as it represents a major driving force of the socio-economic development of a region (Farrington & Farrington, 2005; World Bank, 2008). Due to its complexity and its various approaches, the accessibility is a notion subjected to more definitions (Roșu, Blăgeanu & Iacob, 2013), but it generally represents the potential of a population for reaching spatially distributed services, being a conjunction between transportation network and the geographical distribution of the activities (Paez, Scott & Morency, 2012).

In order to briefly present the main approaches of the accessibility through different pieces of research, a first binary delimitation should be mentioned, objective accessibility vs. self-perceived or self-reported one; many studies focused on comparing these two main types of accessibility (Curl, Nelson & Anable, 2013; Hawthome & Kwan, 2013) etc. Nevertheless, the greatest part of the research as well as the present study is oriented to quantify the objective accessibility. Subsequently, the objective accessibility was differently approached (Paez, Scott & Morency, 2012), based either on origin (Sharkey, Han & Huber, 2009; Parks, 2004) or destination (Grengs, 2001; Mao & Nekorchuk, 2013) etc. At the same time, finer analyses were performed by certain authors, in order to adequately calibrate accessibility models with different parameters or assessing a particular type of accessibility, such as: calculating the time-distance (Ahlstrom, Pilesjo & Lindberg, 2011), estimating the travel cost (Bulai & Ursu, 2012), measuring the topographic accessibility (Iațu & Muntele, 2009), calculating the touristic accessibility (Costache & Popescu, 2013) etc.

Many authors particularly associated the concept of accessibility to rural spaces: Moseley (1979) considered the accessibility as being "a rural challenge" while Phillips and Williams (1984) argued that social disparities in rural areas are primarily related to inequalities in accessibility.

[1] *Alexandru Ioan Cuza University, Faculty of Geography and Geology, Department of Geography, 700506, Iași, Romania, ema.corodescu@gmail.com*

According to Hanson (1986) the accessibility is composed of two main components: proximity of the service taken into account and the mobility of the population involved. Thus, the present study aims to propose a Synthetic Accessibility Index for the rural areas, based on both components. Consequently, the proximity was quantified by two elements – road network distance to the nearest town and the average slope of the route to the respective towns while the mobility was measured by the number of bus routes crossing the village per 1000 inhabitants. These elements were spatially modeled and processed into the GIS environment, in order to obtain the spatial distribution of the final indicator and the specific territorial inequalities.

2. STUDY AREA

Vaslui County is located in the eastern part of Romania, belonging to the North-East Region. The topographic conditions are mainly represented by hills and broad valleys, included in the Bîrlad Catchment (Băcăuanu et al, 1980), frequently affected by geomorphological processes, such as landslides, torrents and gullies and sheet wash (Zăvoianu, Herișanu & Cruceru, 2012).

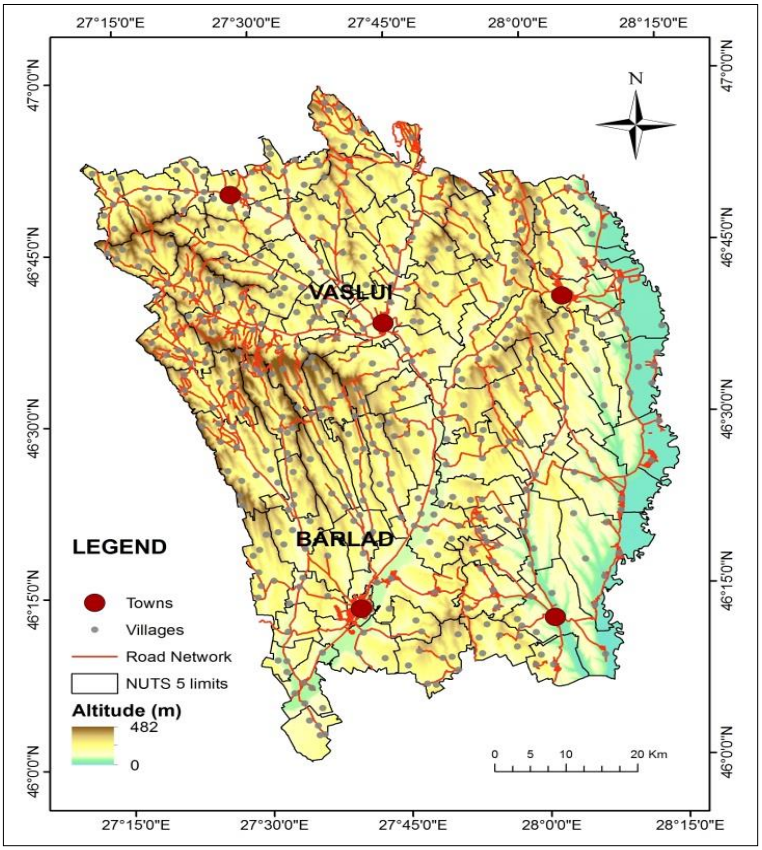

Fig. 1 Study area.

These topographic conditions impose a particular drainage of the county territory, the majority of flows being oriented along the Bîrlad Valley (Tudora & Muntele, 2010).

Concerning economic development, Vaslui County is considered one of the poorest regions in Europe, due to the sub-standard accommodation, facing lack of sanitation and other basic facilities, all these problems being highly connected to the general poor accessibility of the area (Bartlett & Consultancy, 2010). Furthermore, this county holds 231.203 rural inhabitants, representing 61.63% of the county population (INS, 2012). Consequently, Vaslui County represents a difficult area in terms of accessibility, so it is suitable for testing the accessibility index proposed in the present study.

3. METHODOLOGY

The methodology included three main steps (**Fig. 2**): building the necessary database, Synthetic Accessibility Index (SAI) mathematical formalization and creating GIS workflow for calculating the indicator.

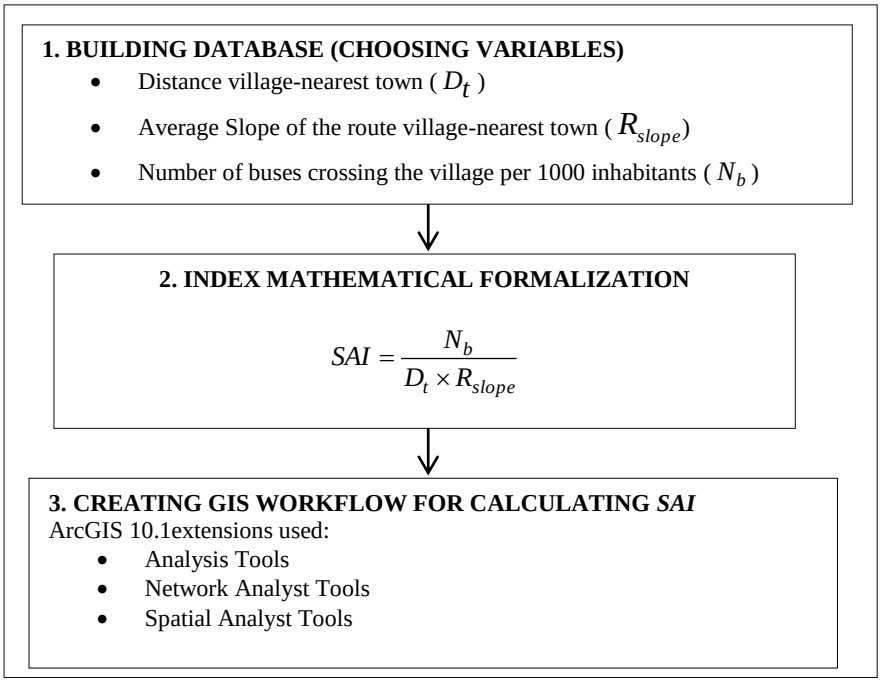

Fig. 2 The main steps of the study.

Database creation focused on the use of relevant and easy available data. The scientific literature provides a wide range of variables employed; for instance, a road connectivity index (RAODCI) was calculated by Rusu, Man and Moldovan (2013) in a study related to Banat region of Romania:

$$RAODCI = RQ + RT + RD$$

Where RQ – the rank and quality of the roads, RT – data regarding traffic and RD – the distance to the nearest central places

The present study proposes a complementary measure of the accessibility. Thus, the nearest town was used as destination for modeling the potential accessibility, considering that the current activities, having the highest incidence, require a movement to the nearest town. In order to assess the easiness of reaching this destination, two variables were taken into consideration: the network distance between the village and the nearest town (real distance) and the average slope of the route (as a physical barrier for the accessibility). Subsequently, the number of buses crossing the village per 1000 inhabitants was chosen as a favorable factor for the accessibility. Its importance is obvious, as the absence of personal vehicle transport is able to create important disparities among the population (Banister, 1983); hence, the role of public transport is essential in assuring the basic spatial and territorial cohesion in Romanian rural space. In order to perform this analysis, the following datasets (from different sources) were employed: road network, rural and urban settlements of Romania, 30 m – resolution digital elevation model for Romania (Geospatial, 2013), the number of buses crossing each village (Mersul autobuzelor, 2013) and the population of each village (INS, 2012).

The three variables were integrated in a mathematical formula (**Fig. 2**) by simply dividing the number of buses crossing the village per 1000 inhabitants (proportional variable) by the multiplication between the network distance to the nearest town and the average slope of the route (inversely proportional variables):

$$SAI = \frac{N_b}{D_t \times R_{slope}}$$

Where: *SAI* – Synthetic Accessibility Index, N_b – number of buses crossing the village per 1000 inhabitants; D_t – distance from each village to the nearest town; R_{slope} – average slope for the village-nearest town route.

The most important part of the methodology consisted of elaborating the GIS workflow for calculating the indicator, using ArcGIS 10.1 software (**Fig. 3**).

Firstly, the Closest Facility Tool from Network Analyst extension was used in order to compute network distance from each village to the nearest town, using a network dataset (Nicoară, 2011). The resulted routes were *converted from polyline to line* and *summarized by IncidentID field* (**Fig. 3**), in order to create a line dataset having one and only one spatial object for each incident (village). Subsequently, the slope was computed from digital elevation model; the values of the resulted raster were associated to the respective road segment from the previous line dataset, by means of *Zonal Statistics as Table* (the average slope was calculated) (**Fig. 3**). Finally, the routes containing the necessary attributes (village-town distance – derived from *Closest Facility layer* and average slope – calculated by means of Zonal Statistics as Table) were joined to the village dataset (containing census

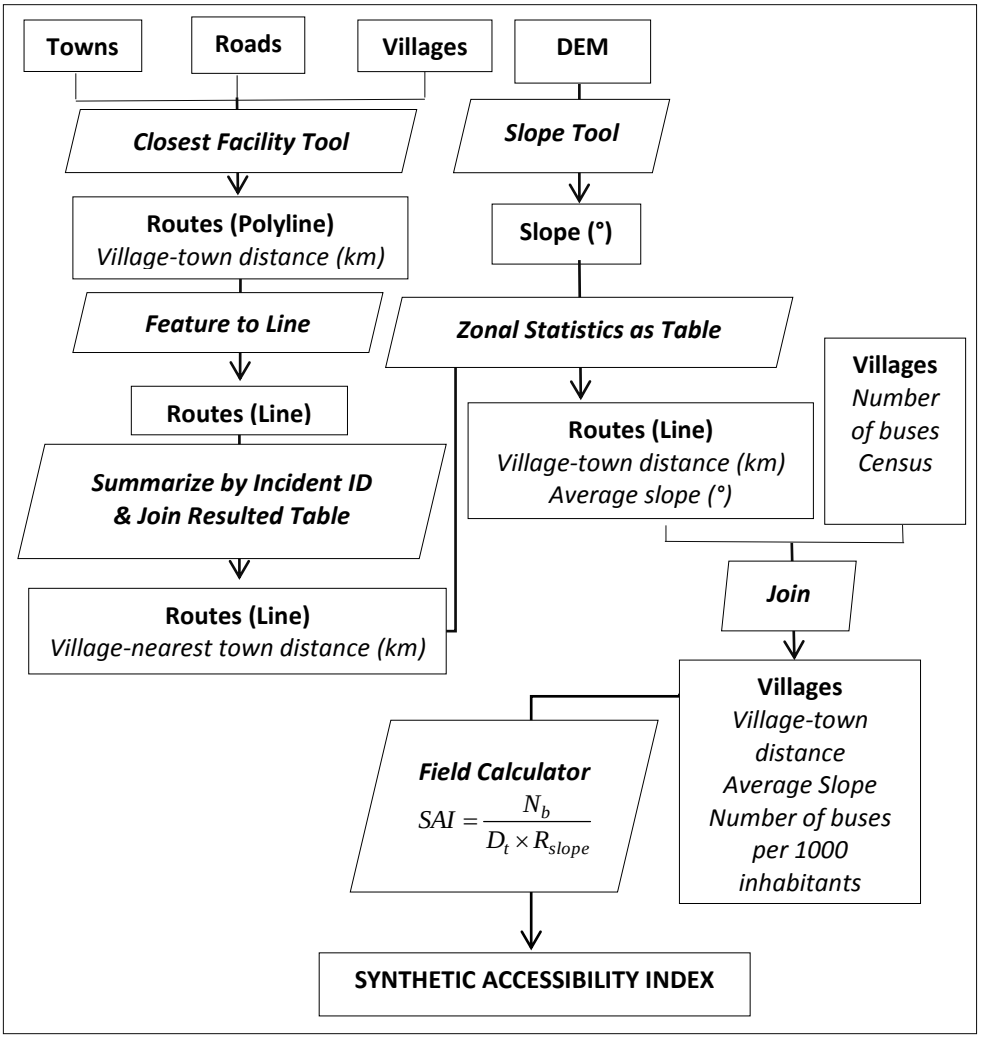

Fig. 3 GIS workflow for computing SAI.

and number of buses data). The Synthetic Accessibility Index was then calculated for each village, according to the proposed formula (**Fig. 3**).

4. RESULTS AND DISCUSSIONS

Firstly, the applied methodology offered an overview on the spatial inequalities related to the different components of the accessibility. Thus, each variable highlights different particularities of the study area, proving its efficiency and its complementarity to the others in assessing the final accessibility (**Fig. 4**).

The accessibility to public transport – quantified by the number of buses crossing the village per 1000 inhabitants – releases an overall under-served county, where most of the villages have less than 1 bus per 1000 inhabitants (**Fig. 4a**). Besides this, internal disparities can be noticed. Consequently, the best access to public transport is assured along the major axis Bîrlad-Vaslui, prolonged to the north along DN 24 national road; this axis represent the major direction of drainage for all types of flows. At the same time, the proximity of the towns on the western side (Negreşti, Vaslui, Bîrlad) is well-served, while the Prut valley has a medium accessibility. On the contrary, Huşi and Murgeni towns have a very poor-serviced proximal area, as their urban force is considerably lower. Other extended areas of low service in public transport cover the north-eastern part of the county – Tutovei Hills, as well as the northern and southern extremities (**Fig. 4a**). However, this spatial configuration should be approached in relation to the morphological and functional particularities of the rural network of the zone; for instance, the rural habitat of the north-eastern part is mostly composed by small, "hollow-like villages", situated at small distance to one another (Ungureanu, 2007). Hence, the accessibility to public transport of the neighbor village is sometimes higher than the present index shows.

The distance from each village to the nearest town (**Fig. 4b**) represents a good indicator of the overall spatial and hierarchical structure of the county. The two poles - Vaslui and Bîrlad prove their dominant position, as they are surrounded by a dense crown of villages. The secondary urban cores (Huşi, Negreşti, Murgeni) assure a good urban accessibility for the proximal villages. This spatial hierarchy is manifested by individualizing two relatively contiguous areas of urban proximity in the northern and southern part of the county, leaving place for an extended void of urban facilities in the eastern, central and extremely-northern part of Vaslui County (**Fig. 4b**).

The spatial distribution of the average slope of the village-town routes (**Fig. 4c**) is highly connected to the geomorphological features, particularly to those related to micro-relief. Consequently, a dominant gradient cannot be observed, nor supposed, as the slope is a result of a variety of geomorphological processes and factors and its importance for the present study does not stay in its causative processes, but in its role in increasing or diminishing the accessibility of a certain route (Ebener et al, 2005).

By integrating these three factors into the proposed formula, the SAI was calculated for all the villages of the county (**Fig. 5**). This index is able to better articulate the major features of the accessibility in Vaslui County. First of all, it offers a finer image over the spatial hierarchy: Bîrlad town has the largest ring of high accessibility, which gradually loses its intensity along with the distance to the town; Vaslui structures a smaller and less accessible ring of villages around it, while the other towns fail to create the same spatial pattern and are surrounded by villages with medium or low accessibility. Then, the role of the major axes is better emphasized by the SAI, as DN 24 national road axis, as well as several segments along the Prut valley or the Negreşti-Vaslui road constitutes continuous belts of high or medium accessibility, following a linear pattern. Finlay, this index manages to delimitate the hot-spots with accessibility deficit: the eastern part of the county- Tutovei Hills, suffering from natural isolation and lacking a real urban polarization, as well as an adequate service of public transport; several interstitial spaces in the center of the county and the northern extremity (Nicoreşti Piedmont).

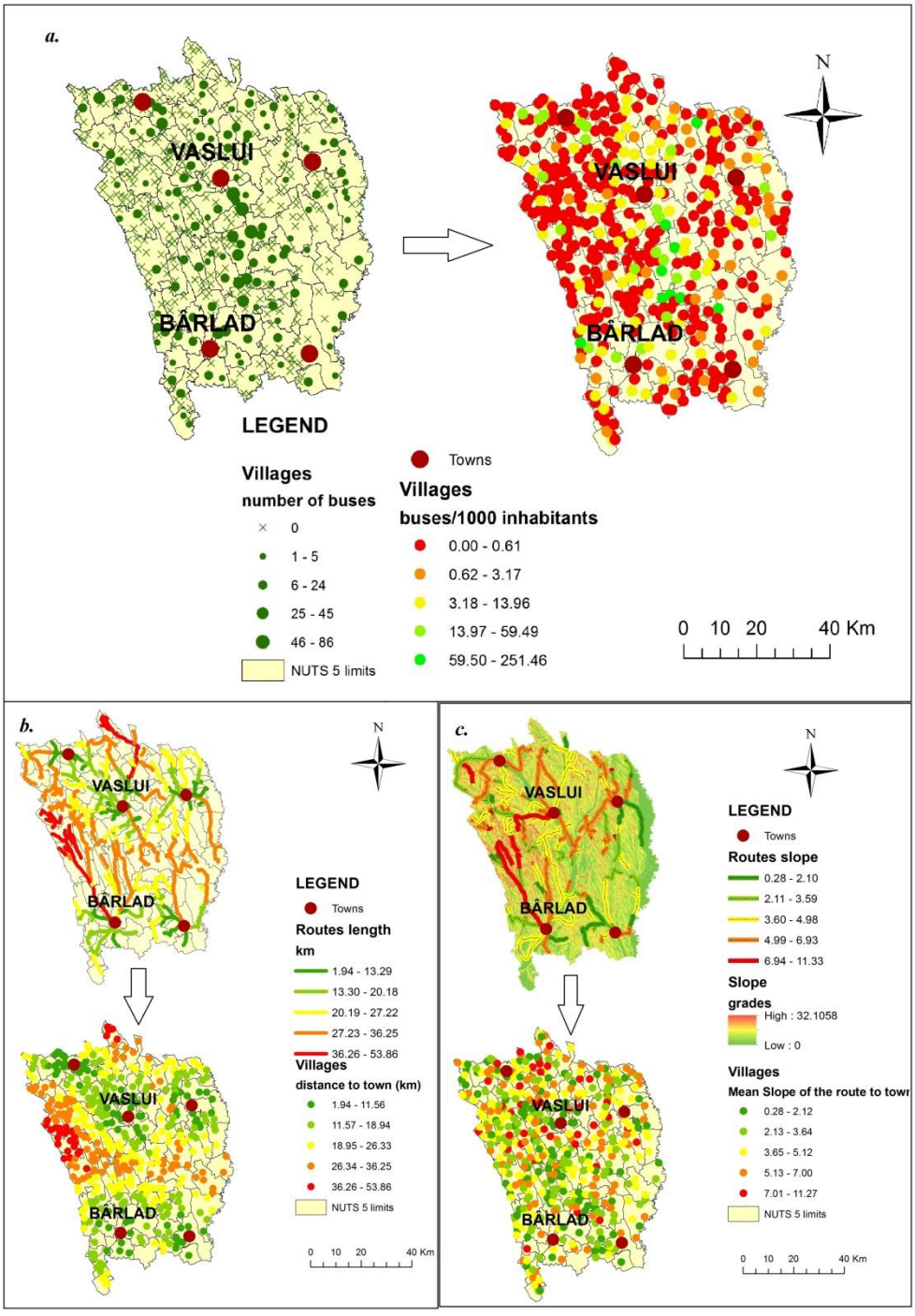

Fig. 4 Spatial distribution of the variables used for calculating SAI.

Different features of the spatial inequalities were highlighted by means of the employed variables and of the final index, as the frequency of villages per class of accessibility was different for each variable (**Fig. 6**). In order to compare the distributions of the 4 variables represented, the *Quantiles Method* was employed for creating the 5 classes (Pumain & Béguin, 2010). The number of buses per 1000 inhabitants is the most important factor affecting the accessibility, as an overwhelming majority of the villages are situated in the first class, with lower accessibility; then, the frequency of villages follows a sharp decrease, excepting a small peak for medium accessibility which is, however, unrepresentative in comparison to the first category. The route slope has a peak on the second class, corresponding to an intermediate level of accessibility (between low and medium), while the extreme values (both high and low) are reduced in their numbers. The town-village distance follows a harmonious curve, having a peak on the medium values. The SAI curve has a tendency to diminish the disparities between its component variables; however, the final index still gathers the highest number of villages in the first class (the lowest accessibility), followed by the marginal intermediate classes (the second and the forth), while the medium-accessibility class and the highest-accessibility class have the lowest frequency.

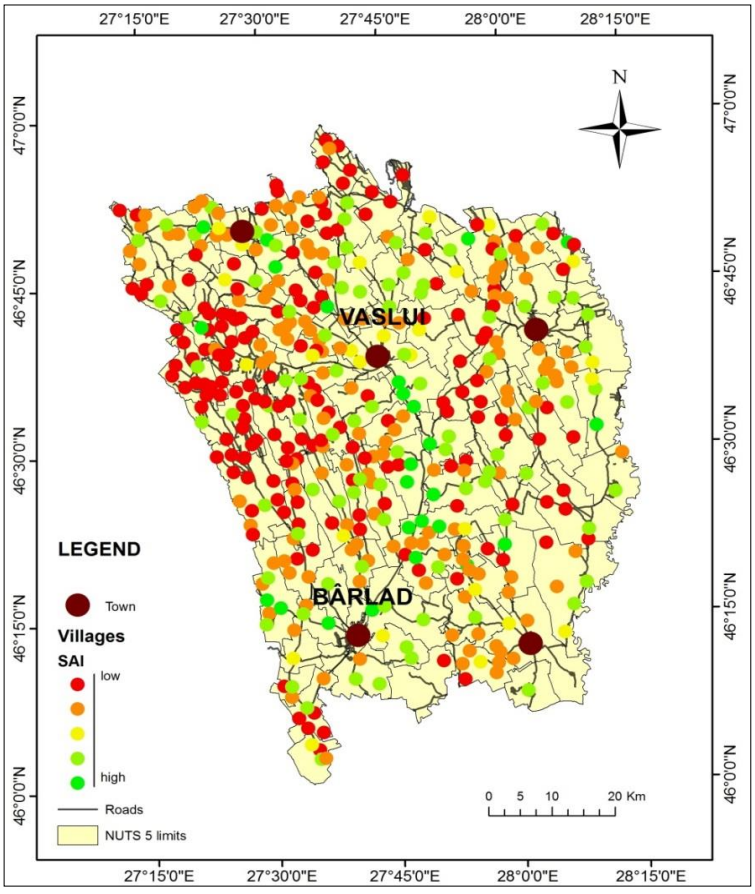

Fig. 5 Spatial distribution of Synthetic Accessibility Index (SAI).

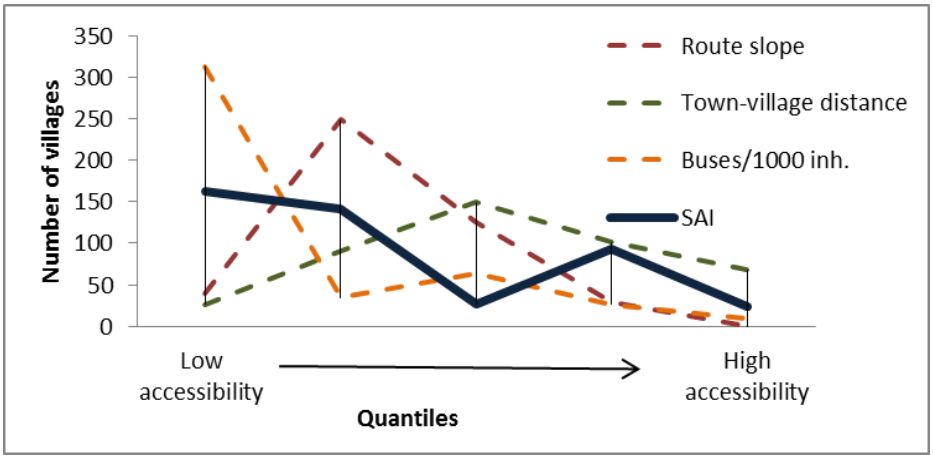

Fig. 6 Frequency of villages per accessibility class for the three variables and the SAI.

5. CONCLUSIONS

In conclusion, the paper presented a manner of assessing the general rural accessibility in Romania and tried to verify its explicative force by analyzing an extensively-studied area. The Synthetic Accessibility Index was able to identify the vulnerable areas in terms of accessibility (Tutovei Hills, Nicorești Piedmont, intermediate areas); these areas often overlap the rural structures that had faced a long history of spatial isolation, which was manifested by a poor communal development too (Tudora & Muntele, 2010). The great advantage of the employed index is represented by the integration of the three major driving forces of the rural accessibility: proximity to services – calculated by the distance to the nearest town, availability of transport – calculated by the number of buses per 1000 inhabitants and natural accessibility – calculated by the medium slope of the routes.

On the other hand the limitations of the study are numerous too: the urban status is relative measure for services, as many small towns may not supply neither the basic urban functions while some developed rural centers may better polarize their proximal area; the bus transport is not the single form of public transport able to serve the villages, but it is relevant enough for the studied county; the natural accessibility may be better assessed by more complex indexes.

Nevertheless, the present study represents at least a summary view over the rural accessibility and a starting point for future research, which should focus on two main objectives: choosing a higher number of relevant variables, in order to assess the general accessibility in a more complete manner and more rigorously formalizing the mathematical and statistical approach of the accessibility concept.

The pursuit of such a demarche is not only interesting from a geographical point of view, but also represents an answer that the geographic scientific community should offer to the major concerns of the Romanian and European territorial policy, as the accessibility is one of the major factors playing an essential role into the accomplishment of the territorial cohesion objective. Furthermore, rural areas should represent a major priority in

every strategy concerning accessibility, due to their demographic and farming potential and to the importance of this spatial scale; a sustainable territorial development should focus on developing all spatial scales as well as on finding the relationships between these levels.

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