

INTERNET COVERAGE AND SMART RURAL DEVELOPMENT: THE CASE STUDY OF VOJVODINA, SERBIA

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ABSTRACT

Rural areas in Serbia have been facing a continuous decline over the last few decades. Population decline and emigration of the youth has been followed by reduced labor market opportunities, limited access to the services and emptying of the rural areas. Smart village concept emphasizes the use of information and communication technologies in rural development. This paper focuses on 4G internet coverage in Vojvodina, Northern Serbia, and its relationship with the level of rurality of the municipalities in order to assess whether a higher share of rural population is associated with lower levels of internet coverage. The results indicate that 4G coverage is widely available across settlements, regardless of their classification as urban or ‘other’, suggesting no significant relationship between rural population share and internet coverage. Future research on smart rural development should investigate demographic characteristics of rural population, education levels and access to the digital technologies. The development of effective smart village strategies requires consideration of the specific characteristics and challenges of rural settlements.

Keywords: Smart villages, Rural settlements, Digital development, Serbia

INTRODUCTION

Although the world population is projected to grow by the end of the century, this growth is not evenly distributed among the countries or settlements. The countries projected to grow through 2054 are located in Africa, North and South America, Asia, and Australia. Most countries in Europe, including Serbia, have reached the peak of population before 2024 (United Nations [UN], 2024). Additionally, rural areas are more likely to face population decline, emigration of younger population and rapid population ageing (Newsham & Rowe, 2025). As a result, local labour market is not as attractive to either investors nor remaining population, causing further emigration and decline (Komorowski, 2024). This process leads to creating “almost self-perpetuating circle effect” (Komorowski, 2024, 1), where the lack of human capital results in the lack of services and job opportunities (Komorowski, 2024; Loewen & Streifeneder, 2025), marginalization of the communities and hollowing the rural areas (Li et al., 2019). As focusing solely on economic development of rural areas does not result in satisfactory results, the innovative and community-based approaches are needed to address the challenges of rural decline (Dax & Fischer, 2017). In order to face these challenges, the European Union [EU] issued the document *EU Action for Smart Villages* in 2017.

A term “smart village” covers the rural settlements where local communities use information and communication technologies (ICT) to improve their life quality (European Commission, 2017). Smart

villages are built on the principles of smart (technological) infrastructure, sustainable energy, consideration of local traditions and economy, communities and institutional support (Smart Rural 27, n.d.) (Figure 1). The research on smart villages starts with the analysis of availability of digital services and internet coverage, as these are necessary conditions for further smart development (Komarowski & Stanny, 2020). Integrating ICT infrastructure in rural development can improve communal services, decrease rural marginality (Ofori et al., 2025), and strengthen social relationships through local projects and platforms (Piekut & Rybaltowicz, 2024).

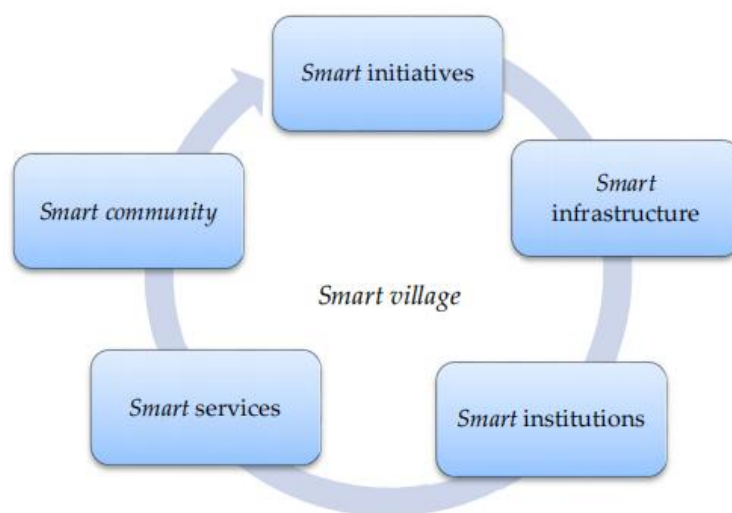


Figure 1: Main elements of smart villages (Komorowski & Stanny, 2020)

In Serbia, rural decline has been a long-term process. Rapid industrialization and urbanization processes in the previous century lead to rural abandonment, and subsequently population ageing and decline in services availability (Živanović et al., 2021; Živanović et al., 2022; Bubalo Živković et al., 2024). Nowadays, rural population accounts for 38% of the Serbian population. Demographic data reveal that the average age, ageing index and share of the elderly have been steadily increasing between the 2011 and 2022 population censuses. Although Vojvodina and the Belgrade region have a little more favorable demographic conditions than the other regions in Serbia, rural decline is evident and remains one of the crucial challenges in contemporary society (Institute of Economic Sciences, 2025). Utilizing quantitative research on smart villages in Serbia can improve theoretical knowledge on the condition of Serbian villages, further allowing for the creating smart development strategies through legal and institutional frameworks (Tošić & Živanović, 2022; Gajić et al., 2025).

This paper examines 4G internet coverage in Vojvodina, Northern Serbia, and its correlation with the share of rural population, with the aim of assessing whether adequate internet access is available in rural areas as a fundamental prerequisite for the development of smart villages.

DATA SOURCES AND METHODS

Study Area

With an area of 21,614 km², the Autonomous Province of Vojvodina is located in northern Serbia (Figure 2). Vojvodina is composed of 7 Areas and 45 local self-government units (LAU 1), of which 8 are Cities and 37 are municipalities. According to the 2022 Population Census, Vojvodina had the population of 1,740,230 inhabitants. The largest urban settlement and the administrative center of the province is Novi Sad, with 260,438 inhabitants. Rural population accounted for 38.18% of the total population (Statistical Office of the Republic of Serbia [SORS], 2023).

Data

For the research of internet coverage, the data from Regulatory Agency for Electronic Communications and Postal Services (RATEL) was utilized (RATEL, n.d.). The analysis is based on 4G signal coverage data obtained from three internet service providers in Serbia for the third quarter of 2025. Signal strength is expressed in dBm, where lower (more negative) values indicate weaker signal levels.

The 2022 Census of population (SORS, 2023) data were used for the analysis of rural population. All settlements in Serbia are administratively divided into urban and “other” settlements. Both municipalities and Cities comprise settlements belonging to each of these categories within their administrative boundaries. In this paper, “other” settlements will be considered rural, as they belong to non-urban type of settlements (Bubalo Živković et al., 2024).

Methodology

The analysis of internet coverage was conducted using QGIS 3.40.4 software. Following data acquisition from RATEL (n.d.), the original datasets were processed into raster (.tif) format to enable spatial analysis. The weakest internet coverage was assigned a value of 0, while the strongest was assigned a value of 3. Data from each provider were initially processed separately and subsequently merged into a single layer by calculating the arithmetic mean of their values. This resulting layer was then reclassified into integer values ranging from 0 to 3, using equal interval classification.

The area of each coverage class at the municipal level was calculated using the zonal histogram tool. After completing the GIS analysis, the data were exported in .xlsx format. Data on the rural population were then incorporated into the same dataset, and a correlation analysis was performed between the share of areas with the highest level of internet coverage and the share of the rural population.

RESULTS AND DISCUSSION

After the geospatial analysis, a map of internet coverage in Vojvodina was obtained (Figure 2). The pattern of excellent Internet coverage mostly corresponds to the settlement pattern in Vojvodina, and it covers about a third of the territory (33.30%). Good internet coverage accounts for 60.43% of the territory. On the other hand, acceptable and unacceptable internet coverage are observed across a significantly smaller portion of the territory, representing only 2.35% and 3.92% of the territory, respectively. The municipalities with the highest share of unacceptable coverage are Šid (southwest), as it is a bordering municipality, and Kovin (southeast), due to the remoteness of the Special Nature Reserve [SNR] “Deliblatska peščara”.

The correlation between the share of excellent internet coverage in the municipality and rural population indicates a negligible relationship ($r = 0.02$) (Table 1). This finding reveals that the level of excellent internet coverage is not directly associated with rurality across municipalities in Vojvodina. The results suggest that high-quality internet coverage has primarily been developed to ensure coverage of settlements. This indicates that the spatial distribution of coverage is more closely aligned with the location of settlements than with their administrative classification. Furthermore, the predominantly flat terrain of Vojvodina does not significantly influence signal strength, with only minor variations observed in areas with more pronounced relief and protected areas, such as Fruška Gora, the Vršac Mountains, and SNR “Deliblatska peščara”. Other European countries, such as the Czech Republic, exhibit a similar situation (Vaishar & Štátná, 2019). The authors suggest that it is not the lack of digital infrastructure in the rural areas that hinder the smart rural development. Rather, it is the lack of human capital, depopulation and smaller share of digitally literate population living in the villages (Vaishar & Štátná, 2019).

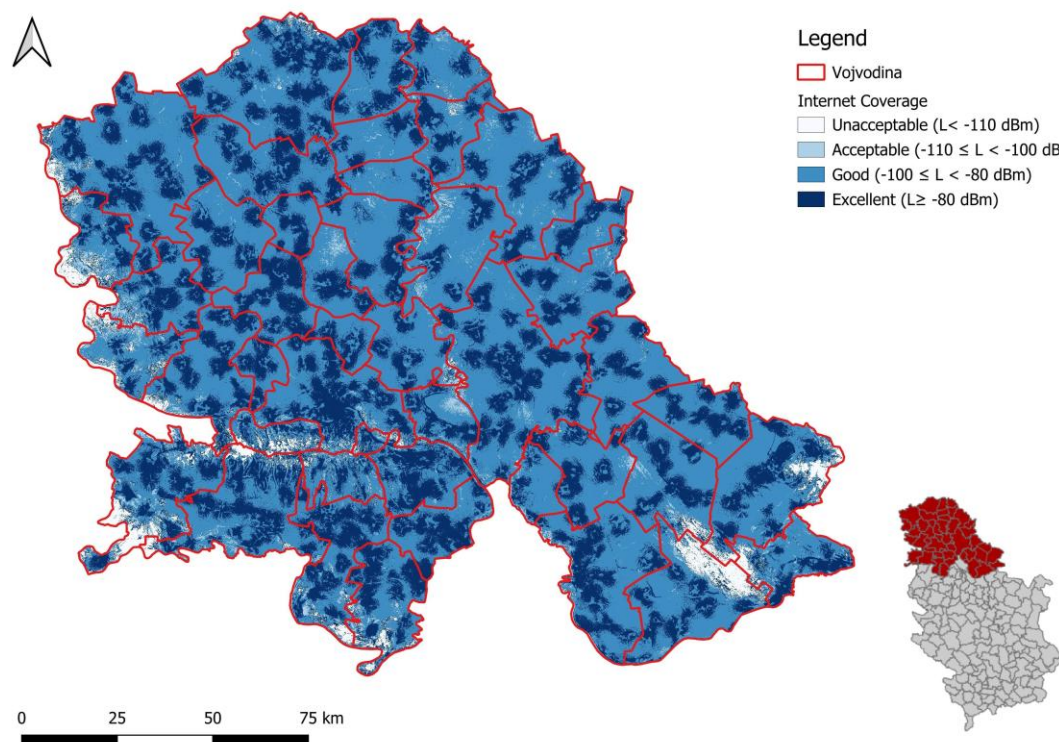


Figure 2: 4G Internet coverage in Vojvodina

Table 1: Internet coverage and the share of rural population in Vojvodina

LAU 1	Excellent Internet coverage	Share of rural population	LAU 1	Excellent Internet coverage	Share of rural population
Novi Sad	48.75	16.88	Sremska Mitrovica	43.24	44.69
Bač	23.01	61.46	Indija	52.67	43.72
Bačka Palanka	38.75	47.22	Irig	31.43	58.00
Bački Petrovac	47.20	54.60	Pećinci	45.23	100
Beočin	36.83	47.57	Ruma	47.55	42.93
Bečej	28.91	36.47	Stara Pazova	50.92	70.28
Vrbas	53.22	42.92	Šid	37.83	54.76
Žabalj	24.81	64.58	Pančevo	36.49	25.16
Srbobran	28.17	26.89	Alibunar	31.56	58.44
Sremski Karlovci	48.28	0.00	Bela Crkva	33.67	48.40
Temerin	38.08	10.49	Vršac	32.26	29.73
Titel	36.58	67.66	Kovačica	33.81	74.51
Sombor	32.70	40.96	Kovin	28.64	58.70
Apatin	31.17	36.89	Opovo	22.25	56.17
Kula	29.49	37.89	Plandište	35.52	100
Odžaci	40.75	69.69	Subotica	40.89	23.98
Kikinda	24.81	34.96	Bačka Topola	38.03	54.51
Ada	15.51	7.61	Mali Idoš	40.66	100
Kanjiža	38.22	59.95	Zrenjanin	32.96	36.50
Novi Kneževac	22.73	34.07	Žitiste	26.80	80.99
Senta	23.41	19.50	Nova Crnja	27.89	100
Čoka	31.38	63.55	Novi Bečej	17.02	44.85
			Sečanj	26.41	82.08

CONCLUSION

This paper studies the relationship between internet coverage and rurality in Vojvodina. Although internet coverage is one of the most important foundations of the smart rural development, it represents only its initial step. As the rural settlements in Vojvodina are generally well-covered, the next step should be designing the strategies for smart rural development. Future research should consider demographic characteristics of rural settlements (average age, ageing index, etc.), education levels of rural population, computer/digital literacy, and the access to the digital technologies. With the knowledge of the unique characteristics of the settlements, the specific strategies may be developed in order to address the main challenges and highlight the positive characteristics of each settlement.

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