



RESEARCH

Beyond Signal Coverage: Assessing Urban–Rural Inequality in Digital Infrastructure in Sumedang Regency

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Abstract

Equitable access to digital technology and services depends on more than network coverage. In areas with diverse geographical characteristics and levels of connectivity, gaps in digital infrastructure remain a challenge. This study assesses urban–rural inequality in digital infrastructure across the sub-districts of Sumedang Regency, using a descriptive quantitative approach combined with policy document analysis. The quantitative analysis draws on 2025 sub-district data on cellular internet network availability, the distribution of Base Transceiver Stations (BTS), mobile signal strength, and supporting communication facilities. The policy document analysis reviews the Sumedang Regency RPJMD, relevant regional strategic plans, and national policies on digital infrastructure development and digital transformation to identify equity challenges and government responses. The results show that most villages and sub-districts are already covered by 4G/LTE networks, yet sub-districts still differ in network conditions, BTS availability, signal strength, and supporting communication facilities. Administrative network coverage alone therefore does not capture the real differences in digital infrastructure between urban and rural areas. The policy analysis identifies four key challenges: geographical conditions, regional connectivity, uneven network availability, and the need for stronger telecommunications infrastructure in relatively remote areas. The local government has responded by developing telecommunications infrastructure, improving regional connectivity, expanding digital-based public services, and supporting digital transformation. These findings call for needs-based planning that looks beyond signal coverage and considers geographical characteristics, network conditions, BTS availability, signal quality, and supporting facilities when setting digital infrastructure development priorities.

Keywords Digital infrastructure; Digital divide; Spatial inequality; Sumedang Regency; Urban-rural disparity; Policy response.

INTRODUCTION

Digital technology has become an important part of social, economic, and governmental activities, making digital infrastructure a fundamental component of digital transformation. Access to reliable communication networks and internet services enables communities to obtain information, use public services, participate in economic activities, and engage in digital society. However, digital infrastructure is not distributed evenly across regions. Geographical conditions, population density, settlement patterns, and regional economic characteristics can influence the availability and development of telecommunications infrastructure (Mohammed et al., 2026; Röller & Waverman, 2001). Therefore, digital infrastructure equity is not only a technological issue but also an important spatial dimension of regional development.

The issue becomes more pronounced in differences between urban and rural areas. Urban areas generally have higher population concentrations and economic activity, which can create stronger demand and incentives for infrastructure development, while rural areas may face lower population density, difficult terrain, and higher infrastructure deployment costs (Prieto-Egido et al., 2022a; Situmorang et al., 2023). Studies in Indonesia have identified persistent rural–urban disparities in digital access and emphasized the relationship between ICT development and rural transformation (Situmorang et al., 2023; Wijaya et al., 2020). Thus, the digital divide needs to be understood not only through individual access or digital skills, but also through differences in the spatial availability of infrastructure.

Previous research further demonstrates that the digital divide has multiple dimensions. It can involve differences in physical access to technology, the ability to use digital technologies, and the benefits obtained from them (Dieu Nguyen, 2025). Spatial and temporal variations in digital inequality have also been identified in Indonesia. In rural areas, limitations in broadband and telecommunications infrastructure can constrain opportunities for communities to participate in digital activities (Jaya et al., 2024; Kartiasih et al., 2023). These findings indicate that infrastructure availability represents an important initial dimension for understanding spatial digital inequality before examining differences in digital use and outcomes.

Digital infrastructure is also increasingly associated with regional development and socio-economic opportunities. Research has shown that digital infrastructure can support rural digitalization, economic participation, and sustainable development (Hauptman et al., 2023; XIE & ZHU, 2025a). In Indonesia, internet access has also been associated with poverty reduction and rural community welfare (Gunawan, 2021; Yokota et al., 2025). Nevertheless, the existence of infrastructure does not automatically indicate the extent to which communities use digital services or obtain economic and social benefits. Consequently, identifying disparities in infrastructure provision remains an important preliminary step in assessing digital inequality.

The sub-districts of Sumedang Regency differ in geographical conditions, population density, settlement characteristics, and connectivity to other areas, which makes the regency a suitable setting for examining this issue. These differences can shape how telecommunications infrastructure and supporting digital facilities are distributed. The issue also bears on the regional development agenda. The Sumedang Regency Regional Medium-Term Development Plan 2025–2029 includes digitalization among the regency's development priorities (Sumedang Regency Government, 2025a). The 2025–2029 Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics stresses ICT

infrastructure development, digital public services, data utilization, and the strengthening of digital human resources (Sumedang Regency Government, 2025b). A regional digitalization agenda, however, does not guarantee that digital infrastructure is spread evenly across sub-districts (Sumedang Regency Government, 2025a).

Regional data indicate differences in cellular network conditions, Base Transceiver Station (BTS) availability, signal strength, and supporting communication facilities across sub-districts. Such differences suggest that aggregate conditions at the regency level may conceal localized disparities in digital infrastructure provision. Therefore, assessment of digital infrastructure equity should consider multiple infrastructure indicators rather than relying solely on the existence of internet networks.

Although previous studies have examined rural–urban digital divides, broadband access, and the spatial dimensions of digital inequality, relatively limited attention has been given to the distribution of digital infrastructure and supporting facilities at the sub-district level within a regency. This localized perspective is important for local governments because infrastructure planning requires information about areas with relatively limited provision. Therefore, this study aims to identify variations in digital infrastructure availability across sub-districts in Sumedang Regency and examine their relationship with demographic and urban–rural characteristics. The analysis considers cellular network availability, BTS presence, signal strength, and supporting communication facilities, and relates the empirical findings to regional policy directions to assess the relevance of existing policy responses.

This study contributes to the discussion of spatial digital inequality by focusing on digital infrastructure provision as an initial dimension of the digital divide, rather than directly measuring internet use, digital skills, or socio-economic outcomes. The findings are expected to provide an empirical basis for identifying areas requiring further attention and supporting regional digital infrastructure planning based on local needs and spatial characteristics.

RESEARCH METHODS

2.1 Research Design and Analytical Framework

This study follows a descriptive design that combines quantitative analysis with a review of secondary documents (Mao & Huo, 2023). The two components answer different questions. The quantitative component asks where digital infrastructure is more or less available across the sub-districts of Sumedang Regency, using four groups of indicators: the availability of cellular internet networks, the presence of Base Transceiver Stations (BTS), mobile signal strength, and communication facilities that support digital activities. The document component asks how the local government frames this condition, by adding information on digital infrastructure and identifying the policy context, the challenges, and the government responses related to digital infrastructure equity.

The research proceeded in five stages:

1. **Network availability.** We identified differences in internet network availability between sub-districts based on the number of villages receiving 5G/4G/LTE signals and the number receiving 3G/H/H+/EVDO signals.
2. **Network infrastructure.** We examined BTS presence and mobile signal strength to describe the condition of network infrastructure in each sub-district.

3. **Supporting facilities.** We added data on internet cafés, post offices or auxiliary post offices, private courier and expedition companies, and computer and internet facilities in village offices to complete the picture of digital infrastructure readiness in each area.
4. **Policy interpretation.** We interpreted the quantitative findings through documents on digital infrastructure development and provision to identify equity issues and the government's responses to existing conditions.
5. **Synthesis.** We compared the empirical findings, previous research, and policy responses to identify policy gaps and to formulate policy implications that respond more closely to the needs of each area.

Two terms need to be defined at the outset. First, *digital infrastructure availability* refers to the existence of communication networks and supporting facilities that can enable digital access at the regional level (Oughton et al., n.d.). Second, *variation between sub-districts* refers to differences in this availability that help identify areas with relatively limited infrastructure. The study does not measure digital access directly, because it does not use data on internet use, internet speed, service costs, ownership of digital devices, digital literacy, or the economic capacity of households to use digital services. Nor does it test a causal relationship between urban or rural characteristics and digital access.

2.2 Study Area and Unit of Analysis

The study covers Sumedang Regency in West Java Province. The regency consists of 26 sub-districts with different geographical conditions and levels of connectivity (BPS-Statistics Indonesia Sumedang Regency, 2026), which makes it a suitable setting for examining variation in digital infrastructure between areas. Some sub-districts, such as Jatinangor, Cimanggung, South Sumedang, and North Sumedang, lie close to activity centers and urban areas. Other sub-districts have more rural characteristics and lie farther from these centers (BPS-Statistics Indonesia Sumedang Regency, 2026).

The sub-district is the main unit of analysis. Village-level data, covering both rural villages and urban villages, are used to describe the digital networks and supporting facilities found within each sub-district and are then aggregated to the sub-district level. This two-level structure allows the analysis to show differences in digital infrastructure between areas inside the regency, not only the overall condition of Sumedang Regency as a whole.

2.3 Data Sources and Collection

All data are secondary and were collected through document review. The sources fall into two groups: (1) statistical sources that describe existing conditions, namely regional statistical publications and village potential data, and (2) policy sources that describe the government's direction, namely the regional development plan, sectoral planning documents, and regulations on digital transformation and the electronic-based government system. Using several sources allows the study to describe digital infrastructure conditions between areas and, at the same time, to trace the government's policy direction in supporting the development and equal distribution of digital infrastructure in Sumedang Regency. Table 1 lists each source, the data taken from it, and its role in the analysis.

Statistical sources. The main data on existing conditions come from *Sumedang Regency in Figures 2026* and *Village Potential Statistics of Sumedang Regency 2024* (BPS-Statistics Indonesia Sumedang Regency, 2024, 2026). *Sumedang Regency in Figures 2026* provides information on internet

networks and communication facilities up to 2025. It reports the number of villages by availability of 5G/4G/LTE and 3G/H/H+/EVDO cellular internet signals for 2024–2025 and the number of post offices or auxiliary post offices by sub-district for 2021–2025. *Village Potential Statistics 2024* serves as supporting data at the village level and records BTS presence, mobile signal strength, internet cafés, post offices or auxiliary post offices, private courier and expedition companies, and computer and internet facilities in village offices.

Policy sources. Three planning documents are used to understand the direction of digital development and the government's response to digitalization issues. The Sumedang Regency Regional Medium-Term Development Plan 2025–2029 (Sumedang Regency Government, 2025a) is used to identify regional development directions and priorities related to digitalization and infrastructure equity. The 2025–2029 Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics of Sumedang Regency (Sumedang Regency Government, 2025b) is used to examine more specific sectoral policies on information and communication technology (ICT) infrastructure and digital transformation. The Master Plan for the Electronic-Based Government System of Sumedang Regency 2021–2025 (Sumedang Regency Government, 2021) is used to identify strategies and targets for the electronic-based government system and the need for regional digital government infrastructure.

Handling different reference years. The sources refer to different years, and each is used according to its own publication year or period of validity. Data for 2025 describe the most recent internet network conditions reported in *Sumedang Regency in Figures 2026*, while *Village Potential Statistics 2024* provides supporting information on infrastructure characteristics and facilities at the village level (BPS-Statistics Indonesia Sumedang Regency, 2024, 2026). Planning documents and regulations are read according to their respective periods of validity (Sumedang Regency Government, 2021, 2025a, 2025b). Because the years differ, the data are not combined into a single index and are not used to draw conclusions about change over time. They are used side by side to complete the description of infrastructure conditions and the relevant policy context.

Table 1. Data Sources, Data Types, and Their Relevance to the Study

No.	Document / Data Source	Data Type	Data Obtained	Relevance to the Study
1	<i>Sumedang Regency in Figures 2026</i>	Quantitative	Area, population, population density, number of post offices or auxiliary post offices by sub-district (2021–2025), and cellular internet signal availability by village (2024–2025)	Describes the availability of communication facilities and internet networks between areas
2	<i>Village Potential Statistics of Sumedang Regency 2024</i>	Quantitative	BTS presence, mobile signal strength, internet cafés, post offices or auxiliary post offices, private courier and expedition companies, and computer and internet facilities in village offices	Describes digital infrastructure conditions and supporting facilities at the village level
3	Sumedang Regency Regional Medium-	Policy document	Regional development directions and priorities	Identifies development directions and policies

	Term Development Plan 2025–2029		related to digitalization and infrastructure	related to digital infrastructure equity
4	2025–2029 Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics of Sumedang Regency	Policy document	Sectoral strategies, programs, and targets related to ICT and digital transformation	Identifies sectoral responses to infrastructure and digital transformation needs
5	Master Plan for the Electronic-Based Government System of Sumedang Regency 2021–2025	Policy document	Development strategies and targets for the electronic-based government system, including digital government infrastructure	Identifies the development direction of digital government infrastructure

Source: Processed by the authors, 2026

2.4 Indicators

Table 2 sets out the indicators used in the quantitative analysis, grouped into three dimensions. Network availability is the core dimension, while network infrastructure and supporting facilities provide additional information on the condition of digital infrastructure in each sub-district.

Table 2. Indicators of Digital Infrastructure Availability

Dimension	Indicator	Source	Role in the Analysis
Network availability	Number and proportion of villages receiving 5G/4G/LTE signals; number and proportion of villages receiving 3G/H/H+/EVDO signals	<i>Sumedang Regency in Figures 2026</i>	Main indicator of cellular internet network availability
Network infrastructure	Number and proportion of villages with a BTS; mobile signal strength in each village	<i>Village Potential Statistics 2024</i>	Supporting information on network infrastructure conditions
Supporting facilities	Internet cafés; post offices or auxiliary post offices; private courier and expedition companies; computer and internet facilities in village offices	<i>Village Potential Statistics 2024; Sumedang Regency in Figures 2026</i> (post offices by sub-district, 2021–2025)	Availability of facilities that support digital activities at the local level

Source: Processed by the authors, 2026

2.5 Data Analysis

The study combines descriptive quantitative analysis and qualitative document analysis. Used together, they identify differences in digital infrastructure availability between urban and rural areas in Sumedang Regency and examine the development direction and policy response of the local government to digital infrastructure inequality (Xie & Zhu, 2025). Descriptive quantitative analysis was chosen because the study aims to describe distribution patterns and differences in availability

between areas, not to test causal relationships or build predictive models. Document analysis was chosen because the policy and planning context of digital development cannot be explained by statistical data alone (Dai, 2025).

2.5.1 Descriptive Quantitative Analysis

The quantitative analysis followed four steps.

Step 1: Compilation. We compiled village-level data on cellular internet signal coverage, BTS presence, mobile signal strength, and communication and digital facilities, and tabulated them by sub-district.

Step 2: Grouping. We grouped the sub-districts by urban and rural characteristics, distinguishing sub-districts close to activity centers and urban areas from sub-districts with more rural characteristics that lie farther from these centers, as described in Section 2.2. Data on 5G/4G/LTE and 3G/H/H+/EVDO networks describe the availability of cellular internet networks. BTS presence and signal strength provide supporting information on network infrastructure. Internet cafés, post offices or auxiliary post offices, private courier and expedition companies, and computer and internet facilities in village offices describe the supporting facilities available for digital activities at the local level.

Step 3: Calculation. For each indicator, we calculated the number and the proportion of villages in each sub-district that have a given infrastructure characteristic, using Equation (1):

$$P_{ij} = (n_{ij} / N_j) \times 100\% \quad (1)$$

where P_{ij} is the proportion of villages in sub-district j with characteristic i , n_{ij} is the number of villages in sub-district j with that characteristic, and N_j is the total number of villages in sub-district j . Where relevant, the same proportion was calculated for Sumedang Regency as a whole using Equation (2), and this regency value served as the comparator for locating each sub-district relative to the overall condition of the regency:

$$P_{i, \text{regency}} = (\sum n_{ij} / \sum N_j) \times 100\% \quad (2)$$

Step 4: Comparison. We compared the values across sub-districts and between the urban and rural groups to identify sub-districts or groups with relatively higher or lower levels of digital infrastructure availability. A sub-district with a proportion above the regency value is read as having relatively higher availability for that indicator, and one below it as having relatively lower availability.

This analysis is descriptive and illustrates patterns of disparity. It does not judge whether an area meets or fails a particular digital service quality standard, because the available data do not cover all aspects of network quality, such as actual internet speed, network capacity, connection stability, or levels of public internet use.

2.5.2 Qualitative Document Analysis

The document analysis covered the Sumedang Regency Regional Medium-Term Development Plan 2025–2029, the 2025–2029 Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics, and the Master Plan for the Electronic-Based Government System of Sumedang Regency 2021–2025 (Sumedang Regency Government, 2021, 2025a, 2025b), together with relevant national regulations on digital transformation and the electronic-based government system. We

reviewed these documents to identify development directions, issues, targets, programs, and government strategies related to digitalization and digital infrastructure equality. The relevant information was extracted and grouped thematically into four issues:

1. equality of digital networks and infrastructure;
2. affordability and expansion of digital access;
3. strengthening of government digital infrastructure and services; and
4. transformation and integration of digital services.

Regulations on telecommunications and networks served as normative references, where relevant, to give context to the infrastructure conditions identified in the quantitative analysis.

We then used the results of the document analysis to assess how well the identified infrastructure disparities align with the development directions and policy priorities of the local government. Areas with limited digital infrastructure were compared with the priorities, targets, and programs in the planning documents to see whether these issues have received attention in policy planning. This step does not measure policy effectiveness in a causal sense. It shows how far digital infrastructure disparities have been accommodated in regional development planning and which aspects may still need stronger policy support.

2.5.3 Integration of Findings

In the final step, we integrated the quantitative and document analyses to build a fuller picture of digital infrastructure disparities in Sumedang Regency. Differences in network availability, BTS presence, signal strength, and supporting facilities between urban and rural areas formed the empirical basis for understanding regional needs, while the policy documents provided the context of the local government's direction and response. We also compared the findings with previous studies on the digital divide and the urban–rural digital divide to identify similarities and differences (Sadyrtidinov, 2023). Combining the two approaches shows not only where digital infrastructure disparities occur but also how these conditions relate to development directions and to the need for more equal digital infrastructure in Sumedang Regency.

RESULTS

3.1 A Regency of Contrasts: Population, Area, and Settlement Type

The 26 sub-districts of Sumedang Regency differ markedly in area, population size, population density, and the mix of urban and rural villages they contain. These differences shape how much digital infrastructure each sub-district needs and how many people a given facility has to serve. For this reason, the analysis starts by describing the characteristics of each sub-district, including its urban or rural classification, before turning to the distribution of digital infrastructure (Table 2).

Table 2. Demographic and Spatial Characteristics of Subdistricts in Sumedang Regency

Subdistrict	Population (people)	Area (km ²)	Population Density (people/km ²)	Urban Villages	Rural Villages	Classification
Jatinangor	101,493	31.60	3,212	12	0	Urban
Cimanggung	91,399	55.55	1,645	9	2	Urban
Tanjungsari	90,737	44.86	2,023	10	2	Urban
Sukasari	33,263	41.82	795	4	3	Urban

Sumedang Selatan	66,191	50.70	1,306	7	4	Urban
Rancakalong	40,966	55.07	744	10	0	Urban
Sumedang Utara	103,373	30.40	3,400	13	0	Urban
Ganeas	26,282	22.90	1,148	3	5	Rural
Situraja	43,801	43.23	1,013	9	6	Urban
Cisitu	31,455	65.03	484	3	7	Rural
Darmaraja	35,939	49.38	728	8	4	Urban
Cibugel	25,170	59.52	423	1	6	Rural
Wado	43,987	84.27	522	7	3	Urban
Jatinunggal	46,775	72.12	649	5	4	Urban
Jatigede	21,946	106.24	207	1	10	Rural
Tomo	23,033	84.74	272	5	3	Urban
Ujung Jaya	32,050	86.23	372	3	6	Rural
Conggeang	28,296	106.98	264	3	9	Rural
Paseh	38,294	31.62	1,211	4	6	Rural
Cimalaka	64,855	43.29	1,498	13	1	Urban
Cisarua	20,882	17.71	1,179	7	0	Urban
Tanjungkerta	34,086	43.72	780	7	5	Urban
Tanjungmedar	26,679	60.67	440	2	7	Rural
Buahdua	31,954	107.68	297	4	10	Rural
Surian	11,705	70.88	165	1	7	Rural
Sumedang Regency	1,195,531	1,558.72	767	—	—	—

Source: Processed by authors, 2026

In 2025, Sumedang Regency had 1,195,531 residents and an average density of 767 people/km² (BPS-Statistics Indonesia Sumedang Regency, 2026). Population is spread very unevenly across sub-districts. North Sumedang is the most populous, with 103,373 residents, followed closely by Jatinangor (101,493), Cimanggung (91,399), and Tanjungsari (90,737). Surian sits at the other end of the scale with 11,705 residents.

Density follows a similar pattern. North Sumedang and Jatinangor are the most densely settled sub-districts, at 3,400 and 3,212 people/km², while Surian is the least dense at 165 people/km². Several sub-districts combine a large area with a thin population. Buahdua covers 107.68 km² but has only 297 people/km², and Jatigede covers 106.24 km² with 207 people/km² (BPS-Statistics Indonesia Sumedang Regency, 2026). The regency therefore ranges from sub-districts where people are packed closely together to sub-districts where settlements are scattered over a wide area.

These demographic differences matter for digital infrastructure, since its development depends on demographic and geographical conditions such as how the population is distributed and what the terrain is like (Czernich et al., 2011; Jianjun & Dapeng, 2025). A sub-district with a large, dense population is likely to need more infrastructure than one with a small, dispersed population.

Each sub-district is also classified as urban or rural, and this classification serves as the spatial context for checking whether regional characteristics are associated with the pattern of digital infrastructure availability (Klimenko et al., 2023; Peng & Dan, 2023). The classification is used only to group sub-districts for the descriptive analysis that follows, not to establish causal relationships. Taken together, the data show a clear contrast between dense, highly populated sub-districts such as North Sumedang and Jatinangor and sparsely populated sub-districts such as Jatigede, Buahdua, and Surian. This contrast is the starting point for comparing the distribution of digital infrastructure across sub-districts.

3.2 Near-Universal 4G Coverage, Uneven BTS Presence

Telecommunications networks reach most of Sumedang Regency, but they are not spread evenly across sub-districts. Of the 277 villages in the regency, 199 have a Base Transceiver Station (BTS) and 78 do not, which means about 71.8% of villages host a BTS. Network infrastructure is therefore present in most of the region, yet a number of villages still have no BTS within their own administrative boundaries. Table 3 presents BTS presence, mobile signal strength, and 5G/4G/LTE availability for each sub-district.

Table 3. BTS Presence and Mobile Signal Conditions by Sub-district in Sumedang Regency

Sub-district	With BTS	Without BTS	Total Villages	Villages with BTS (%)	Very Strong Signal	Strong Signal	Weak Signal	No Signal	5G/4G/LTE 2024	5G/4G/LTE 2025
Jatinangor	10	2	12	83.3	8	4	0	0	12	12
Cimanggung	10	1	11	90.9	0	11	0	0	11	11
Tanjungsari	12	0	12	100.0	4	8	0	0	12	12
Sukasari	6	1	7	85.7	0	7	0	0	7	7
Pamulihan	9	2	11	81.8	6	5	0	0	11	11
Rancakalong	7	3	10	70.0	4	6	0	0	10	10
South Sumedang	13	1	14	92.9	7	7	0	0	14	14
North Sumedang	13	0	13	100.0	3	10	0	0	13	13
Ganeas	4	4	8	50.0	7	1	0	0	8	8
Situraja	9	6	15	60.0	2	12	1	0	15	15
Cisitu	7	3	10	70.0	0	8	2	0	10	10
Darmaraja	3	9	12	25.0	5	6	1	0	11	11
Cibugel	5	2	7	71.4	0	7	0	0	7	7
Wado	8	2	10	80.0	0	10	0	0	8	10
Jatinunggal	6	3	9	66.7	1	7	1	0	9	9
Jatigede	5	6	11	45.5	5	3	3	0	11	11
Tomo	6	3	9	66.7	1	8	0	0	9	9
Ujungjaya	6	3	9	66.7	0	9	0	0	9	9
Conggeang	9	3	12	75.0	5	6	1	0	11	12
Paseh	7	3	10	70.0	1	9	0	0	10	10
Cimalaka	11	3	14	78.6	7	7	0	0	14	14
Cisarua	5	2	7	71.4	7	0	0	0	7	7
Tanjungkerta	8	4	12	66.7	3	9	0	0	12	12
Tanjungmedar	7	2	9	77.8	0	7	2	0	8	8
Buahdua	9	5	14	64.3	4	9	1	0	13	12
Surian	4	5	9	44.4	0	5	4	0	8	9
Sumedang Regency	199	78	277	71.8	80	181	16	0	270	273

Source: Processed by the authors, 2026

BTS presence varies widely between sub-districts. In absolute terms, South Sumedang and North Sumedang have the most villages with a BTS (13 each), followed by Tanjungsari (12) and Cimalaka (11). Darmaraja has the fewest, with a BTS in only 3 of its 12 villages, while Ganeas and Surian each have 4.

The picture sharpens when BTS presence is expressed as a share of villages. Every village in Tanjungsari and North Sumedang has a BTS. South Sumedang (92.9%) and Cimanggung (90.9%) also rank high. The lowest shares are in Darmaraja (25.0%), Surian (44.4%), Jatigede (45.5%), and Ganeas (50.0%). Distribution therefore has to be read from both the absolute count and the share of administrative areas that host a BTS.

Absolute counts tend to be higher in sub-districts that simply have more villages, and a high count does not by itself mean that coverage is wide or even. Darmaraja and Tanjungsari both have 12 villages, yet only 3 villages in Darmaraja have a BTS compared with all 12 in Tanjungsari. For this reason, the share of villages with a BTS serves as an additional indicator for comparing sub-districts on a proportional basis.

Mobile signal conditions add another layer. Across the regency, 181 villages report a strong signal, 80 a very strong signal, and 16 a weak signal, and no village is recorded as having no signal at all. A village without its own BTS can still receive mobile service, because the signal may come from towers located in neighboring areas.

Mobile internet is close to universal. The number of villages with 5G/4G/LTE networks rose from 270 in 2024 to 273 in 2025. Network presence, however, is not the same as network quality, because availability data say nothing about connection speed, capacity, stability, or the experience of actual users (Janardhanan et al., 2026).

Sumedang Regency thus shows two conditions at once. Mobile internet is widely available, and no village lacks a mobile signal. BTS distribution, on the other hand, remains uneven, with some sub-districts hosting a BTS in every village and others in only a small share of their villages. Connectivity is widespread, but the physical telecommunications infrastructure behind it is not spread evenly, which remains an issue for regional digital infrastructure development (Shen et al., 2025).

3.3 Measuring Infrastructure against the Population Served

Absolute figures do not reveal whether infrastructure keeps pace with the number of people it serves. A populous sub-district may have more villages or more facilities, yet still carry a heavier population burden than its neighbors. To capture this, the study compares infrastructure with population using two indicators: the number of residents per village with a BTS, and the number of villages with a BTS per 10,000 residents. Both indicators offer a descriptive view of how infrastructure distribution relates to population (Anselin, 1995). Table 4 reports the results.

Table 4. BTS Availability Relative to Population by Sub-district in Sumedang Regency

Sub-district	Population (people)	Total Villages	Villages with BTS	Residents per Village with BTS (people)*	Villages with BTS per 10,000 Residents**
Jatinangor	101,493	12	10	10,149	0.99
Cimanggung	91,399	11	10	9,140	1.09
Tanjungsari	90,737	12	12	7,561	1.32
Sukasari	33,263	7	6	5,544	1.80
Pamulihan	66,191	11	9	7,355	1.36
Rancakalong	40,966	10	7	5,852	1.71
South Sumedang	80,920	14	13	6,225	1.61
North Sumedang	103,373	13	13	7,952	1.26
Ganeas	26,282	8	4	6,571	1.52
Situraja	43,801	15	9	4,867	2.05
Cisitu	31,455	10	7	4,494	2.23
Darmaraja	35,939	12	3	11,980	0.83
Cibugel	25,170	7	5	5,034	1.99
Wado	43,987	10	8	5,498	1.82
Jatinunggal	46,775	9	6	7,796	1.28
Jatigede	21,946	11	5	4,389	2.28
Tomo	23,033	9	6	3,839	2.61
Ujungjaya	32,050	9	6	5,342	1.87
Conggeang	28,296	12	9	3,144	3.18
Paseh	38,294	10	7	5,471	1.83
Cimalaka	64,855	14	11	5,896	1.70
Cisarua	20,882	7	5	4,176	2.39
Tanjungkerta	34,086	12	8	4,261	2.35
Tanjungmedar	26,679	9	7	3,811	2.62
Buahdua	31,954	14	9	3,550	2.82
Surian	11,705	9	4	2,926	3.42

Sumedang Regency	1,195,531	277	199	6,008	1.66
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Population divided by the number of villages with a BTS

Number of villages with a BTS divided by population, multiplied by 10,00

Source: Processed by the authors, 2026

Across the regency, 199 of 277 villages have a registered BTS. With 1,195,531 residents, this works out to about 6,008 people for every village with a BTS, but the figure differs sharply between sub-districts. Darmaraja carries the heaviest burden, with about 11,980 residents per village with a BTS, followed by Jatinangor (10,149) and Cimanggung (9,140). A large population, in other words, does not always come with a correspondingly high share of villages that host a BTS.

Surian has the lowest figure, about 2,926 residents per village with a BTS, followed by Conggeang (3,144) and Buahdua (3,550). Fewer residents are linked to each village with a BTS in these sub-districts. This should not be read as better digital infrastructure, because the indicator ignores network capacity, coverage area, and actual use. Infrastructure availability and digital access are related, but they are separate dimensions of the digital divide (Hollimon et al., 2025).

The second indicator points in the same direction. The regency average is about 1.66 villages with a BTS per 10,000 residents. Surian has the highest value (3.42), followed by Conggeang (3.18) and Tanjungmedar (2.62). Darmaraja has the lowest (0.83), with Jatinangor (0.99) and Cimanggung (1.09) close behind. Sub-districts with larger populations thus tend to carry a heavier population burden for each village with a BTS than sub-districts with smaller populations.

Assessing digital infrastructure equity therefore requires looking at population size and infrastructure distribution together (Czernich et al., 2011). North Sumedang has the second-largest population in the regency (103,373 residents), and all 13 of its villages have a BTS, giving about 7,952 residents per village with a BTS. Darmaraja has far fewer residents (35,939), but only 3 of its 12 villages have a BTS, which produces a much heavier burden of about 11,980 residents per village with a BTS. Population size alone does not describe infrastructure availability; where the infrastructure is located also matters (Ito & Ohnishi, 2020; Udnoor et al., 2020).

The reverse appears in some less populated sub-districts. Surian, the smallest by population with 11,705 residents, has a BTS in 4 of its 9 villages, which yields a relatively high 3.42 villages with a BTS per 10,000 residents. A higher infrastructure-to-population ratio still does not guarantee better digital service, because the indicators here do not capture BTS capacity, the number of users, network speed, or signal coverage across space. Earlier studies stress that the digital divide spans several dimensions, including access to infrastructure, connection quality, and the ability to benefit from digital technology (Ito & Ohnishi, 2020; Peng & Dan, 2023).

The proportionality of digital infrastructure to population therefore differs across sub-districts. Some densely populated sub-districts carry a high population burden for each village with a BTS, while some sparsely populated sub-districts carry a lower one. These results offer an initial basis for identifying where infrastructure may not match population characteristics. Measuring the extent of digital access inequality would require further assessment of spatial coverage, network capacity, service quality, and actual internet use (Ito & Ohnishi, 2020).

3.4 Urban and Rural Sub-districts: Absolute versus Relative Availability

Urban and rural characteristics can shape the distribution of digital infrastructure. Urban areas usually concentrate population and economic activity, which raises demand for telecommunications

services. Rural areas tend to have lower densities and more scattered settlements, which can make network provision harder and more costly (Prieto-Egido et al., 2022). The urban and rural classification is therefore used to test whether digital infrastructure in Sumedang Regency differs by regional character (Table 5).

Table 5. BTS Availability and Population Characteristics in Urban and Rural Sub-districts of Sumedang Regency

Classification	Number of Sub-districts	Average Population (people)	Average Villages with BTS	Residents per Village with BTS*	Villages with BTS per 10,000 Residents**
Urban	16	57,606	8.5	6,777	1.48
Rural	10	27,383	6.3	4,347	2.30
Sumedang Regency	26	45,982	7.7	6,008	1.66

Total population of the group divided by the total number of villages with a BTS in the group

Total number of villages with a BTS in the group divided by the total population of the group, multiplied by 10,00

Source: Processed by the authors, 2026

The comparison shows a revealing pattern. Urban sub-districts have an average population of about 57,606, roughly twice the average of 27,383 in rural sub-districts. Urban sub-districts also have more villages with a BTS on average (8.5) than rural ones (6.3). In absolute terms, digital infrastructure is more concentrated in urban areas.

The pattern reverses once population is taken into account. Urban sub-districts have about 1.48 villages with a BTS per 10,000 residents, whereas rural sub-districts reach 2.30. Urban areas have more villages with a BTS, but they also have a much larger population to serve, so their ratio is lower than in rural areas.

This finding matches earlier work showing that urban–rural differences are an important dimension of the digital divide. Rural areas often face difficulties in infrastructure provision linked to population density, scattered settlements, and the economic feasibility of expanding networks (Sanchez-Arias et al., 2023), and network development has been shown to help reduce digital gaps in rural communities (Park et al., 2019).

The results do not, however, support the assumption that urban areas always have better digital infrastructure. Urban sub-districts in Sumedang have more villages with a BTS on average, yet their infrastructure-to-population ratio is lower than that of rural sub-districts. Digital infrastructure equity cannot be judged from the absolute number of facilities alone; the relative distribution of infrastructure must also account for population characteristics (Czernich et al., 2011).

Urban–rural differences also need to be read beyond infrastructure availability. The digital divide is multidimensional and covers connection quality, patterns of use, affordability, and the ability to benefit from digital technology, not only physical access to infrastructure (Sheila & Fahmi, 2024; Shuang et al., 2026). The higher ratio in rural sub-districts therefore does not mean that the digital divide is smaller there. It shows that BTS infrastructure is relatively more available compared with the population served, while other dimensions of digital access require additional data.

3.5 Challenges Identified in Regional Planning Documents

The quantitative results show that digital infrastructure availability varies across sub-districts in terms of distribution, infrastructure-to-population ratios, and urban–rural characteristics (BPS-Statistics Indonesia Sumedang Regency, 2026). Statistical data cannot explain the planning factors and development challenges behind these variations, so the analysis turns to the Sumedang Regency

Regional Medium-Term Development Plan 2025–2029 and the 2025–2029 Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics, read together with the Master Plan for the Electronic-Based Government System (Sumedang Regency Government, 2021, 2025a, 2025b). The review identifies four challenges to digital infrastructure equity in Sumedang Regency: (1) unequal availability of digital infrastructure between areas, (2) the need to expand networks in line with population growth and regional development, (3) unequal ICT infrastructure and connectivity, and (4) limited supporting capacity for digital transformation.

3.5.1 Unequal Availability of Digital Infrastructure between Areas

The quantitative results show that digital infrastructure is not spread evenly across sub-districts, and the differences remain when availability is compared with population size. Populous sub-districts do not always have proportionally more infrastructure, while some less populated sub-districts show higher infrastructure-to-population ratios. Equity in digital infrastructure therefore depends on the population served, not only on the absolute number of facilities.

This result connects directly to the development issues set out in the Regional Medium-Term Development Plan. The plan names equitable and high-quality digital infrastructure as a development issue, covering ICT infrastructure development, readiness for sustainable digital transformation, and equitable access to digital services. It also acknowledges unequal access to basic infrastructure and services, including telecommunications, and calls for infrastructure development that is equitable both geographically and socio-economically (Sumedang Regency Government, 2025a).

The plan's policy directions include wider network coverage, faster internet access, stronger telecommunications networks, and ICT infrastructure development as part of improving access to basic infrastructure and services (Sumedang Regency Government, 2025a). The research findings and the planning document therefore point the same way: the study finds differences in infrastructure availability between sub-districts, and the local government recognizes connectivity equity as a development need.

This agreement does not mean the gaps have been closed. The plan still treats digital connectivity and infrastructure equity as part of the 2025–2029 development agenda (Sumedang Regency Government, 2025a), which shows that equity in digital infrastructure remains an ongoing challenge that calls for continued intervention, not a goal already reached.

3.5.2 Expanding Networks in Line with Population Growth and Regional Development

The second challenge is to keep digital infrastructure development in step with population dynamics and regional development. Population size differs considerably between sub-districts, and areas with larger concentrations of people may need more network capacity to support community, government, education, and economic activities.

The Regional Medium-Term Development Plan addresses this directly. It projects rising population density in Jatinangor, Cimanggung, Tanjungsari, and Pamulihan as housing demand grows within the Bandung Metropolitan Area. Density is also expected to stay concentrated in the urban sub-districts of North Sumedang, South Sumedang, and Cimalaka. The plan further projects rising density in Buahdua, Ujungjaya, and Tomo in connection with the development of the Triangle Area (Sumedang Regency Government, 2025a).

These trends carry implications for connectivity. The plan identifies telecommunications and information networks that reach the whole region as an important need as the population and socio-economic activity grow, supported by strategies to widen network coverage and raise internet access speeds (Sumedang Regency Government, 2025a).

Digital infrastructure development in Sumedang Regency is therefore dynamic. Existing infrastructure has to meet current demand while anticipating population growth and the rise of new activity centers. The differences in population size and infrastructure-to-population ratios found in this study are relevant here, because they show that infrastructure needs are not the same in every area.

3.5.3 Unequal ICT Infrastructure and Connectivity

The third challenge concerns how ICT infrastructure and connectivity are distributed and integrated. The Regional Medium-Term Development Plan reports considerable progress in network infrastructure, including fiber-optic coverage that reaches 277 villages, yet it continues to list connectivity equity on the development agenda (Sumedang Regency Government, 2025a). Expansion so far has not removed the need for further network development and quality improvement.

The Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics reinforces this point. It names uneven and poorly integrated government ICT infrastructure as a sectoral challenge and notes limited internet bandwidth, gaps in supporting Network Operation Center (NOC) infrastructure, and the need to expand ICT infrastructure through village internet, intra-government networks, data centers, and command centers (Sumedang Regency Government, 2025b).

Digital infrastructure equity in Sumedang thus has at least two dimensions. For communities and regions, the challenge is to expand telecommunications networks and internet access. For government, it is to distribute and integrate the ICT infrastructure that supports digital public services. Infrastructure development has to address the capacity of network facilities to support connectivity and service integration, not only their number.

The Strategic Plan responds with strategies to expand ICT infrastructure, including village internet, intra-government networks, data centers, and command centers, and stresses ICT infrastructure that is equitable, reliable, and sustainable (Sumedang Regency Government, 2025b). The infrastructure differences identified in this study therefore correspond to policy issues the local government already recognizes.

3.5.4 Limited Supporting Capacity for Digital Transformation

The fourth challenge concerns the capacity needed for digital infrastructure to work effectively. Digital transformation depends on adequate human resources, management systems, application integration, and information security, not only on physical infrastructure (Sumedang Regency Government, 2021, 2025b). The Strategic Plan names the limited number of ICT management staff in regional government agencies as a sectoral problem. It also notes that public service applications are not yet fully standardized and that implementation of the Electronic-Based Government System remains below its potential (Sumedang Regency Government, 2025b).

Better digital infrastructure therefore has to go hand in hand with stronger institutional capacity and human resources. Infrastructure delivers limited benefits without competent ICT management and integrated systems. This is especially important for government digital

transformation, because regional governments must provide integrated, secure, and accessible digital services as well as network infrastructure.

The Strategic Plan responds with strategies to strengthen community digital literacy, raise the digital capacity of civil servants, integrate digital government services, strengthen information security, and apply the architecture of the Electronic-Based Government System. Its policy direction also covers data centers, command centers, system interoperability, and the digital competencies of regional civil servants (Sumedang Regency Government, 2025b).

At the community level, the Regional Medium-Term Development Plan indicates that digital transformation in Sumedang Regency has moved fairly quickly. The regency's 2024 score on the Indonesian Digital Society Index fell in the high category and ranked among the better results in West Java Province (Sumedang Regency Government, 2025a). The Strategic Plan, however, still reports that digital literacy is uneven across the community (Sumedang Regency Government, 2025b). A strong aggregate score does not mean that every community is equally ready for digital technology, so infrastructure development needs to be paired with efforts to raise digital literacy and community capacity.

These four challenges show that digital infrastructure equity in Sumedang Regency involves more than adding network infrastructure. It also concerns where infrastructure is located, how it adapts to population and regional development, how much capacity networks have, and how strong human resources and digital governance are. The quantitative findings describe infrastructure differences between sub-districts, while the Regional Medium-Term Development Plan and the Strategic Plan supply the policy context for the challenges and the government's responses.

The infrastructure differences found in this study cannot be read directly as differences in community digital access. The study does not measure network quality, signal coverage, internet speed, the distance between residents and infrastructure, service costs, or the use of digital technology. The findings are better understood as differences in the potential availability of digital infrastructure between areas, which may contribute to differences in digital access. The planning documents are then used to examine how the local government responds to these challenges through its policies and programs.

3.6 How the Local Government Responds

The Sumedang Regency Government has responded to the challenges of digital infrastructure equity with policies that expand ICT networks, improve internet access, build the capacity of communities and government staff, and develop digital governance. These responses are set out in the Regional Medium-Term Development Plan 2025–2029 and elaborated in the 2025–2029 Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics. Table 6 summarizes the challenges and the corresponding responses.

Table 6. Digital Infrastructure Challenges and Government Policy Responses in Sumedang Regency

Challenge	Government Policy Response
Unequal digital access and infrastructure between areas	Expanding broadband networks to remote areas, widening internet coverage and raising access speeds, developing village internet, and improving telecommunications networks

Limited and underperforming ICT infrastructure	Developing equitable, reliable, and sustainable ICT infrastructure; mapping ICT infrastructure needs; developing regional data centers and command centers; and strengthening intra-government networks
Limited digital literacy and human resource capacity	Strengthening community digital literacy, educating the public on safe and productive technology use, raising the digital capacity of civil servants, and providing training and certification in informatics and cybersecurity
Weak integration of digital services and governance	Integrating public service applications, carrying out government digital transformation in line with the architecture of the Electronic-Based Government System, developing the Regional Government Service Integration System, and improving the Digital Government Index score
Weak data management and information security	Developing the Regional One Data initiative, standardizing metadata and improving data interoperability, improving sectoral statistics, strengthening information security governance, applying security standards, and building cybersecurity human resource capacity

Source: Processed by the authors, 2026

Table 6 shows that the Sumedang Regency Government does not treat digital infrastructure equity purely as a matter of network availability. Its responses also address the capacity of supporting infrastructure, community capacity, service integration, data governance, and information security, which amounts to a fairly comprehensive approach to regional digital transformation.

Network expansion. The government responds to unequal digital access and infrastructure by widening network coverage. The Regional Medium-Term Development Plan 2025–2029 includes the completion and strengthening of ICT infrastructure as part of developing the digital ecosystem, including the expansion of broadband networks to remote areas (Sumedang Regency Government, 2025a). This direction is backed by strategies to widen coverage, raise internet access speeds, and improve telecommunications networks. It matches the finding that infrastructure availability differs between sub-districts, so government policy explicitly addresses spatial inequality in connectivity. Whether these policies actually improve equity still needs to be assessed against the real growth of infrastructure in each area (Sheila & Fahmi, 2024; Shuang et al., 2026).

Supporting infrastructure. The government responds to limited ICT infrastructure by developing and strengthening supporting infrastructure. The Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics describes regional government ICT infrastructure as neither evenly distributed nor fully integrated (Sumedang Regency Government, 2025b). Its responses include mapping ICT infrastructure needs, developing village internet, strengthening intra-government networks, and building data centers and command centers, with the aim of making ICT infrastructure more reliable and sustainable. The government is therefore strengthening the infrastructure behind digital government services as well as expanding networks.

Literacy and human resources. Limited digital literacy and human resource capacity are addressed by building the capacity of communities and government staff. The Regional Medium-Term Development Plan treats digital literacy as an important part of readiness for digital transformation, and the Strategic Plan includes stronger community digital literacy as one of its strategies (Sumedang Regency Government, 2025a, 2025b). These policies are carried out through education on safe and productive technology use, community empowerment, and improving the digital capacity of civil servants. The Strategic Plan also provides training and certification in informatics and cybersecurity. The government thus recognizes that expanding digital infrastructure must go together with stronger user capacity so that digital technology can be used productively. This fits the wider understanding of the digital divide, which extends beyond physical

infrastructure to users' skills and their ability to benefit from digital technology (Sheila & Fahmi, 2024; Shuang et al., 2026).

Service integration. The government responds to weak integration of digital services by strengthening the Electronic-Based Government System and system integration. The Strategic Plan notes that the use of public service applications is not yet standardized and that adoption of the Electronic-Based Government System remains below its potential (Sumedang Regency Government, 2021, 2025b). Policies therefore aim to integrate public service applications, develop the Regional Government Service Integration System, build data centers and command centers, and carry out digital transformation in line with the architecture of the Electronic-Based Government System. The government's digitalization agenda is thus directed at better connections between systems and better public services, not only at providing digital applications.

Data and information security. Problems of data quality and information security are addressed by strengthening digital governance. The Strategic Plan notes that sectoral data are not yet fully integrated, data quality varies, and information security capacity is limited (Sumedang Regency Government, 2025b). The government responds by developing the Regional One Data initiative, standardizing metadata, improving data interoperability between regional government agencies, and coordinating with BPS-Statistics Indonesia and other data producers. On security, the policy directions include stronger information security governance, more cybersecurity staff capacity, the application of information security standards, and a higher score on the Information Security Index. These directions are in line with the national agenda for digital transformation and the integration of digital services, so Sumedang's digital transformation policies also address the quality, security, and sustainability of digital systems.

The policy responses of the Sumedang Regency Government are broadly aligned with the challenges identified in this study. Differences in digital infrastructure availability between sub-districts are addressed through broadband expansion, wider internet coverage and faster access, and the development of village ICT and internet infrastructure (Mohammed et al., 2026; Shuang et al., 2026). Challenges related to user capacity and the quality of digital public services are addressed through stronger digital literacy, better human resource capacity, service integration through the Electronic-Based Government System, the Regional One Data initiative, and stronger information security systems (Sumedang Regency Government, 2021, 2025b).

The Regional Medium-Term Development Plan and the Strategic Plan, however, set out development directions and government commitments. They do not prove that digital infrastructure equity has been achieved at the sub-district level. The quantitative findings of this study offer an initial spatial description of digital infrastructure and a basis for identifying areas where infrastructure is relatively limited. Further evaluation is needed to determine whether these policies reduce disparities in infrastructure availability and improve actual digital access across sub-districts. The distinction matters, because the presence of infrastructure does not automatically translate into meaningful digital access or effective use of digital technology (Greiman et al., 2025; Szalavetz, 2022).

DISCUSSION AND IMPLICATIONS

Digital infrastructure in Sumedang Regency is not spread evenly. Sub-districts differ in the amount of telecommunications infrastructure and supporting digital facilities they have, which means their capacity to provide digital connectivity also differs. This matters because the need for connectivity depends on more than population size. Regional characteristics, population density, and whether a sub-district lies within an urban or rural development area

all shape that need (Kasimov et al., 2021; Peng & Dan, 2023). Sub-districts with urban characteristics and higher density tend to have stronger infrastructure support, whereas rural sub-districts are more likely to face limits in infrastructure provision (Deng et al., 2025; Duanmu et al., 2025). These results answer the first and second research questions. The distribution of digital infrastructure across Sumedang is not yet uniform, and demographic and spatial characteristics help explain why provision varies. Population size alone cannot account for digital infrastructure needs, because equal connectivity also depends on geographical conditions, settlement patterns, and the level of regional development (Udnoor et al., 2020). The most important new finding concerns the gap between coverage and capacity. Almost all villages and sub-districts in Sumedang are recorded as covered by 4G/LTE networks, so the regency looks close to equal if coverage is the only measure. Once BTS availability, signal strength, and supporting communication facilities are examined, clear differences between sub-districts appear, and rural sub-districts tend to sit at the weaker end. We describe these areas as covered but underserved. This finding shows that administrative coverage figures, which are commonly used to report progress in digital development, can hide inequality in the infrastructure that sits behind the signal.

Previous research supports the view that the digital divide has a spatial dimension and is closely tied to regional characteristics. Studies in Indonesia have found gaps in access to digital technology between urban and rural areas, and other work has linked ICT development in rural areas to regional transformation and infrastructure development (Wijaya et al., 2020; Yokota et al., 2025). The variation found in Sumedang also agrees with research that calls for monitoring how the digital divide is distributed across space and over time. Earlier studies show that the divide differs between urban and rural settings, and the concept itself now extends beyond physical access to include differences in technology use and in the benefits people gain from it (Sanchez-Arias et al., 2023; Xie & Zhu, 2025). In Indonesia, internet access has been associated with household socio-economic conditions, which makes infrastructure availability an important precondition for technology use and for narrowing digital gaps (Rajagukguk et al., 2024; Situmorang et al., 2023).

This study differs from research that measures internet access or technology use directly. It focuses on the distribution of digital infrastructure availability at the sub-district level and does not measure internet speed, network quality, access costs, levels of internet use, or the socio-economic benefits of digital technology. For this reason, the results do not demonstrate a full digital divide. They identify spatial variation in infrastructure availability, which serves as an early indication of an infrastructure gap between areas. The originality of this study rests on three points. First, it works at the sub-district scale within a single regency, whereas much of the literature compares urban and rural areas as two broad groups or examines internet use, socio-economic impacts, or frameworks for monitoring the digital divide at national or provincial level. Second, it looks beyond coverage by combining several supply-side indicators, namely cellular network availability, BTS distribution, signal strength, and supporting communication facilities, so that differences hidden behind near-universal 4G

coverage become visible. Third, it places these indicators alongside the regional policy documents that guide digital development in Sumedang, namely the RPJMD 2025–2029 and the Strategic Plan of the Office of Communication, Informatics, Encryption and Statistics 2025–2029. This allows the study to identify sub-districts with different levels of infrastructure availability and, at the same time, to check whether policies already address them through broadband network expansion, better internet coverage and speed, village internet development, stronger ICT infrastructure, and improved digital literacy and human resource capacity (Gunawan, 2021; Wijaya et al., 2020). The study contributes in three ways. Conceptually, it shows that the equality of digital infrastructure at the regional level cannot be judged from aggregate availability alone; differences in regional needs and characteristics, and their link to development policy, must also be considered. Methodologically, it offers a descriptive framework based on routinely published village and sub-district data that local governments can repeat to track infrastructure gaps over time. Practically, it gives Sumedang Regency an initial empirical basis for needs-based digital infrastructure planning, in which demographic conditions, spatial characteristics, infrastructure distribution, and connectivity needs in each area guide the choice of intervention priorities.

Setting the empirical findings against previous research and the government's policy response shows that the regency still has room to strengthen its approach to digital infrastructure equality. The local government has already placed telecommunications development, better connectivity, and the digitalization of services on its development agenda (BPS-Statistics Indonesia Sumedang Regency, 2024; Sumedang Regency Government, 2025a, 2025b). Yet infrastructure availability still varies between sub-districts. Needs are not the same everywhere once regional characteristics, population size, population density, and urban–rural differences are taken into account (Akberdina et al., 2023). Policy should therefore aim beyond adding more infrastructure overall. It should also make sure that infrastructure is distributed in line with population needs and spatial characteristics, with particular attention to areas where digital infrastructure remains limited. Table 7 summarizes the challenges, the government's responses, and the resulting policy implications.

Table 7. Challenges, Government Policy Responses, and Policy Implications for Digital Infrastructure Equality in the Regency Sumedan

Challenge	Government Policy Response	Policy Implications
Unequal distribution of digital infrastructure between sub-districts	Development and equalization of telecommunications infrastructure, as well as improvement of the quality and reach of digital services	Development priorities should consider inter-regional disparities rather than relying only on aggregate achievements at the regency level. Regions with relatively low infrastructure availability should receive greater attention in intervention priorities.
Urban–rural digital infrastructure gap	Strengthening connectivity and digital infrastructure to support development equality and rural digitalization	Infrastructure development should adopt an urban–rural equity approach by giving greater attention to rural areas or areas that remain geographically and spatially underserved.
Geographical constraints and inter-regional connectivity	Improvement of inter-regional connectivity and development of infrastructure and services based on regional characteristics	Telecommunications network planning should consider geographical conditions, settlement patterns, and inter-regional connectivity so that infrastructure development is not concentrated only in areas with high population density and economic potential.

Infrastructure limitations and digital service quality	Development of telecommunications networks, improvement of service coverage, and strengthening of supporting infrastructure for digitalization	Policy should gradually shift from merely increasing infrastructure availability toward improving service quality and reliability, particularly in areas that already have infrastructure but may still experience limitations in coverage or service capacity.
Differences in digital infrastructure needs between regions	Development of public service digitalization and utilization of information technology within government organizations and public services	Infrastructure planning should adopt a <i>needs-based planning</i> approach that considers population size, population density, regional characteristics, infrastructure distribution, and community needs for digital services.

Source: Processed by authors, 2026

Responding to sub-district differences. Digital infrastructure planning should respond more closely to differences in need between sub-districts. Because infrastructure is not spread evenly across Sumedang, growth at the regency level does not guarantee equal availability in every sub-district. Development priorities should therefore account for gaps between areas by identifying the sub-districts with relatively low infrastructure availability. This approach follows the perspective of digital spatial inequality, which treats location and regional characteristics as central to understanding the digital divide (Akberdina et al., 2023; Kourtidou et al., 2025). Studies in Indonesia have shown that gaps in digital access have a spatial dimension, so policies aimed at equality should look at variation between areas and not only at national or regional averages (Kartiasih et al., 2023; Yokota et al., 2025).

Closing the urban–rural gap. Development should pay more attention to the gap between urban and rural areas. Urban and rural characteristics affect how telecommunications infrastructure is supplied and developed (Prieto-Egido et al., 2022c). Urban areas usually concentrate population, economic activity, and demand for digital services, which gives operators stronger incentives to build there. Rural areas with lower density face higher investment and development costs. For Sumedang, this points to the need for an urban–rural equity approach when setting priorities. Earlier studies confirm that the urban–rural digital divide remains a key obstacle to equitable digital access (Kerras et al., 2024; Maurya et al., 2025; Prieto-Egido et al., 2022a).

Accounting for geography and connectivity. Planning should consider geographical characteristics and connectivity between areas. The government’s plans to improve connectivity and to develop infrastructure and services suited to regional characteristics show that spatial factors are already part of its policy direction. The variation found in this study suggests, however, that geography needs to be stated more explicitly when priorities are set. Sub-districts with difficult terrain, scattered settlements, or weak links to other areas may need a different development approach from urban areas. Research on ICT development has stressed the importance of understanding rural contexts (Kerras et al., 2024; Prieto-Egido et al., 2022c). Network planning should therefore include spatial conditions instead of relying only on population size to estimate infrastructure needs. Moving from availability to meaningful access. Equality in digital infrastructure depends on service quality and on the capacity of infrastructure to support community activities, not only on whether infrastructure exists. Because this study relies mainly on secondary data, it describes differences in availability between sub-districts. An area that already has infrastructure cannot automatically be assumed to enjoy equal digital access. Network quality, service capacity, connection stability, and people’s ability to use technology all shape the experience of digital access (P et al., 2025).

The digital divide also extends to differences in technology use and in the benefits people gain from it (P et al., 2025). Regional policy should gradually move from providing infrastructure toward ensuring meaningful digital access that takes service quality and use into account. Planning based on need. Priorities for digital infrastructure should follow a needs-based planning approach. Population size and

density can serve as initial indicators of potential need, but neither is enough on its own. A sparsely populated area may still have high needs if its network is limited or if its terrain makes digital services hard to reach. A densely populated area, on the other hand, may need more infrastructure because demand for digital services is higher. Planning should combine demographic indicators, regional characteristics, infrastructure conditions, and gaps between areas. This approach matches research that proposes monitoring the digital divide across space and time and studies linking the divide to urban–rural contexts and regional characteristics (Maruseva & Kroll, 2026; Petkovski & Vranić, 2025).

Taken together, the main policy implication is that Sumedang needs a needs-based approach to digital infrastructure equality that is sensitive to spatial characteristics. The Sumedang Regency Government can combine population size, population density, urban–rural characteristics, digital infrastructure distribution, and geographical conditions as initial criteria for selecting priority areas. These criteria can be built into the connectivity and digitalization policies already set out in regional planning documents, so that infrastructure development aims to reduce gaps between sub-districts, not only to expand the total amount or coverage of networks. Analysis based on secondary data has to be supplemented with information on the quality and accessibility of digital services if the government wants to set priorities more precisely. Further analysis could include internet speed, network quality and stability, village-level signal coverage, internet use, service prices, and the time or cost people need to obtain access. Data on socio-economic conditions and community digital literacy are also needed to separate gaps in infrastructure availability from gaps in technology use (Maruseva & Kroll, 2026; Petkovski & Vranić, 2025). The findings of this study can therefore serve as a starting point for identifying priority areas for digital infrastructure equality. More precise interventions and capacity building will require spatial data, network quality data, and community socio-economic data to be brought together.

CONCLUSION

This study finds that digital infrastructure in Sumedang Regency varies between sub-districts and does not follow population size or density. Some sub-districts with larger populations have relatively better infrastructure, while several low-density areas, especially rural ones or those with difficult terrain, still face clear limitations. Although almost all villages and sub-districts are recorded as covered by 4G/LTE networks, differences in BTS availability, signal strength, and supporting facilities show that coverage figures alone hide real gaps between areas. These results agree with earlier studies showing that the digital divide in Indonesia has spatial and urban–rural dimensions (Chang et al., 2023; Kartiasih et al., 2023; Peng & Dan, 2023; Yokota et al., 2025). The policy documents identify four main challenges: uneven distribution between areas, the urban–rural gap, geographical and connectivity constraints, and limits in the availability and quality of digital infrastructure. The government has responded through telecommunications development, better connectivity, supporting infrastructure, and stronger digital government services, but these policies are not yet closely matched to the conditions and needs of each sub-district. The study contributes by showing that the link between demographic characteristics and digital infrastructure is not linear and that gaps in infrastructure availability must be separated from gaps in access and use. For planners and the Sumedang Regency Government, a combination of population size,

population density, urban–rural characteristics, infrastructure distribution, geographical conditions, and regional connectivity can serve as an initial screening tool for identifying priority sub-districts. This mapping should be integrated with existing policies on telecommunications, connectivity, and service digitalization so that development targets reduce gaps between sub-districts, not only raise totals at the regency level.

This study relies on secondary data and therefore describes differences in infrastructure availability, not inequality in digital access itself. It does not measure network quality, internet speed, network capacity, detailed signal coverage, access costs, levels of internet use, or the time and distance people need to reach digital services. Its findings should be read as an early indication of gaps between areas, not as a full picture of the digital divide in Sumedang. Future research could add network performance data such as speed, stability, and capacity, together with household surveys on internet use, costs, and digital literacy, to distinguish gaps in availability from gaps in use. Studies could also map infrastructure at the village level, follow changes over several years, and assess network needs and development feasibility in priority sub-districts. Combining spatial data, network quality data, and community socio-economic data would help the government design more precise interventions and support more equitable access to, and use of, digital technology in Sumedang Regency.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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