



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 24 ISSUE 5 (2026), Page 819 – 837

SOCIO-ECONOMIC INDICATORS TOWARDS SMART AND RESILIENT RURAL DEVELOPMENT

**Low Wai Wah¹, Priscilla Awing Stengle², Wong Kwong Soon³, Wang Chen⁴,
Wong Shi Yee⁵, Loo Siaw Chuing⁶, Tay Ai Chen⁷**

¹*Department of Construction Management, Faculty of Built Environment,
TUNKU ABDUL RAHMAN UNIVERSITY OF
MANAGEMENT AND TECHNOLOGY*

^{2,3}*Department of Civil and Construction Engineering,
Faculty of Engineering and Science,
CURTIN UNIVERSITY MALAYSIA*

⁴*Department of Construction Management, College of Civil Engineering,
HUAQIAO UNIVERSITY*

⁵*Department of Quantity Surveying, School of Built Environment,
UNIVERSITY OF TECHNOLOGY SARAWAK*

⁶*Department of Quantity Surveying, Faculty of Built Environment,
UNIVERSITI MALAYA*

⁷*School of Engineering and Science,
Faculty of Engineering, Computing and Science
SWINBURNE UNIVERSITY OF TECHNOLOGY SARAWAK*

Abstract

Over the years, the United Nations' Sustainable Development Goals (UNSDG) have included rural development as one of the UNSDG indicators. Rural development is important, especially for developing countries with higher rural population. Limited existing literature focus on the underlying indicators in developing a smart and resilience rural. Therefore, this study aims to identify the underlying indicators of smart rural and rural resilience between two rural categories in Sarawak based on the rural communities' perspective. Likert-Scale questionnaires were distributed to seven village communities. This yields a total of 675 valid responses. The study demonstrates that rural categories significantly influence the perceived underlying indicators, emphasising the need for specific strategies to address development gaps between the different rural categories. Adaptive rural policies are needed to cater different characteristics of rural areas to close the rural development gaps.

Keywords: Smart Rural, Rural Resilience, Sustainable, Rural Development, Indicators, Sarawak

¹ Corresponding author. Email: lowwww@tarc.edu.my

INTRODUCTION

Rural development is a priority focus on some global sustainability agendas, such as United Nations' Sustainable Development Goals (UNSDG) (Liu et al., 2024). The aim is to deal with the socioeconomic disparity to strive towards sustainability. Sarawak is the largest state in the Borneo Islands, Malaysia with majority of its population residing in rural areas (Abdullah, 2021). As such, it is indeed important to improve its socioeconomic condition, especially with various rural categories encompassing the region.

Resilience of rural community plays a pivotal role to improve the sustainability of socioeconomic condition of rural areas. In view of the recent trends in smart and resilience direction towards a sustainability urban development. It is worth to look into the smart and resilience concepts in the rural development context. Smart rural is defined as the incorporation of smart technologies towards innovation and promoting a sustainable future for rural communities (Gerli et al., 2022; Guzal-Dec, 2018; Mukti et al., 2022). While rural resilience refers to the rural community's ability to adapt towards socioeconomic changes to improve living quality (Heijman et al., 2019; Li, 2023). Both concepts could contribute to a sustainable rural development. According to Wilson et al. (2018), rural resilience is particularly important in developing countries that are experiencing the transition of the economy such as Malaysia.

Limited existing studies are focused on smart and rural resilience in sustaining the socioeconomic of rural areas. This paper aims to identify the underlying indicators of smart, rural resilience, and sustainable rural development of two rural categories in Sarawak, namely Pedalaman 1 (P1) and Pedalaman 2 (P2). The underlying indicators in this study refer to the fundamental indicators that are likely to influence the development of smart rural and rural resilience. The study is important as it might support the local government in planning the rural development strategies that is tailored to the unique characteristics of the region. The following sections of this paper include literature review, research methodology, results and discussions, and conclusion and future research.

LITERATURE REVIEW

Similar to the smart city concept, smart rural aims to enhance the quality of life of rural communities through governance, social inclusion, and rural economy to achieve sustainable rural development (Aziiza & Susanto, 2020; Shcherbina & Gorbenkova, 2018). The European Union (EU) has demonstrated that smart rural initiatives have the potential to improve rural livelihoods. Past studies such as Naldi et al. (2015) and Panciszko (2021) had derived smart rural indicators that can help to achieve successful implementation of the smart rural initiatives in the EU. Additionally, Indonesia has contributed to numerous studies smart rural studies. For example, Aziiza and Susanto (2020) had proposed a smart rural

model and indicators that is tailored to the unique characteristic of Banyuwangi Regency in Indonesia.

Rural resilience studies are mainly focused on China (Fan et al., 2021; Huang et al., 2018). Past studies have identified rural resilience indicators in various aspects such as economic, governance, social, livelihood, environmental, and technology (Li et al., 2021; Yang et al., 2022; Ye et al., 2023). Review of past studies indicates that the topic of rural resilience is not captured much attention in Malaysia compared to other countries, namely, China and Western regions. Consistently, Zhou et al. (2021) studied on smart cities and they argued that resilience in smart development is relatively a new concept in sustainability development and hence there is lack of studies on how smart development can promote resilience. They also discovered that smart cities development can improve urban resilience but will cause different resilient level. Existing literature in rural resilience is mostly focused on developed countries instead of developing countries or developing countries that are experiencing urban and rural transition (Wilson et al., 2018).

SMART RURAL AND RURAL RESILIENCE INDICATORS

The indicators of smart rural and rural resilience are extracted from relevant literature as shown in Table 1 and 2. The identification of indicators are based on 5 dimensions, namely, resources, technology, environmental, social and economic.

Table 1: References for smart rural indicators.

Indicators	References
Sufficient budget allocated for road construction by the government or municipal	[1], [5]
Sufficient budget allocated for innovation programmes for smart rural development	[1], [6]
Availability of banking or financial infrastructures in the village (e.g.: ATMs)	[1], [7]
Access for employment in recent years	[2], [4]
High job availability within rural area	[3], [7]
Using social media platform to boost business/livelihood	[1], [4]
Wide usage of online or mobile banking among rural residents	[1], [4]
Encouragement of entrepreneurship within rural community	[1], [4]
Income stability	[1], [4]
High employment rate of rural residents	[4], [2]
Business/industry improvement	[1], [4]
Sufficient number of books in the village library	[1], [5]
Efficient online database in the village library	[1], [5]
Active government participation in the village's development	[2], [9]
Digitalisation of governance (e.g.: Malaysia Digital Coordinating Committee (MD-CC) for MyDIGITAL)	[2], [5]

Indicators	References
Active public rural participation with government initiatives	[2], [5]
Access to education	[3], [8]
Access to health facilities	[1], [3]
Governance effectiveness (e.g.: policies, etc.)	[2], [9]
Available ICT services in rural area (e.g.: optimisation of telco towers/ energy grid, etc.)	[1], [3]
Good quality ICT services in rural area	[1], [3]
Digitally empowered rural community	[1], [2], [4]
High number of rural residents voting	[2], [8]
Low dependency ratio of rural area	[2], [8]
Having an emergency plan for natural disasters	[1], [5]
High number of trained people to conduct the emergency plan during natural disasters	[1], [5]
Having domestic animals owned by rural community to be uniquely marked or having a tracking device	[1], [5]
Efficient waste management (domestic waste and sewage)	[1], [2], [3]
Efficient wildlife protection	[1], [3]
Early warning systems for drastic climate changes	[1], [5]
Access to fresh water	[2], [3]
Usage of solar panels within rural housing for personal use	[1], [5]
Abundance in agricultural produce (e.g.: livestock, fishery, farming etc.)	[3], [6]
Having buildings that can withstand harsh weather conditions	[1], [2]
Availability of communication infrastructures (e.g.: telco towers)	[1], [2]
Available internet access with high coverage	[1], [3]
Available multiple mobile networks (e.g.: Digi, Celcom, etc.) reception with cellular/voice/data coverage	[1], [10]
Availability of main road connecting to the village road	[1], [3]
Availability of public transport to the village	[1], [2]
Sufficient storage capacity of village's substation/energy grid (KWh)	[1], [3]
Wide usage of solar powered devices in the village (e.g.: solar panels, solar powered streetlights, etc.)	[1], [5]
Using smart and digital equipment in agriculture production	[2], [4]
Connectivity of village to the national grid	[1], [7]
Predictable and reliable General Practitioner schedule in visiting village clinic or mobile clinic	[1], [7]
Sufficient number of mobile clinics visiting the village	[1], [7]
Using efficient electricity meters (comparing conventional meters, pre-paid meters, and smart meters)	[1], [7]
Large land area earmarked for residential/agricultural/commercial development	[1], [3]
Receiving high level of education	[3], [8]

Note: [1] Maja et al. (2020), [2] Abu-Rayyash & Dincer (2023), [3] Aziiza & Susanto (2020), [4] Mukti et al. (2022), [5] Hussain et al. (2023), [6] Lin & Hou (2023), [7] Kim et al. (2020), [8] Kaye-Blake et al. (2019), [9] Ye et al. (2023), [10] Lopez-Penabad et al. (2022)

Table 2: References for rural resilience indicators.

Indicators	References
Sufficient public security for rural area	[4], [7]
Sufficient financial expenditure on employment in the village	[1], [4]
High savings rate of rural residents	[4], [8]
Income dependence	[1], [2], [4]
Overcoming assets and income poverty	[2], [3]
Diverse economy	[3], [4]
Encouragement of entrepreneurship in agriculture sector	[6], [7]
Stable income	[1], [2], [3]
High employment rate of rural residents	[1], [4]
Business/industry improvement over recent years	[4], [5]
High rural community spirit	[1], [3]
Low crime rate and safety of village	[1], [7]
High rural area population	[1], [2]
Sufficient investment in social services from government (e.g.: rehabilitation for drugs, counselling and psychological support, private sector protection and self-employment protection)	[5], [9]
Access to education	[1], [2], [4]
Access to health facilities	[1], [4]
Governance effectiveness (e.g.: policies, etc.)	[1], [10]
Fast recovery of rural population affected from extreme weather condition	[1], [5]
Low proportion of rural population over 65 years old	[5], [10]
Sufficient number of rural residents voting	[3], [10]
Low dependency ratio of rural	[5], [10]
Food security	[1], [12]
High greenery coverage around the rural area	[4], [9]
Efficient early warning systems for drastic climate changes	[1], [8]
Access to fresh water	[1], [2]
Awareness of rural community towards any change in rural environment	[1], [9]
Having irrigated arable land (land that can be used for agriculture)	[4], [5]
Large area of arable land	[4], [5]
Fast recovery of crops affected from extreme weather condition	[5], [13]
High water resources per capita	[1], [5]
Sufficient usage of fertiliser/pesticides per arable land	[4], [13]
Short commuting distance/ Availability of roads	[4], [8]
Available internet access with high coverage	[1], [2]
Rural household with access to cable, radio, and TV	[2], [4], [5]
Sufficient number of telephones per household	[2], [4]
Sufficient and efficient infrastructure development (e.g.: transportation systems, communication networks, sewage, school systems, etc.)	[1], [2]
Access to electricity via energy grid	[1], [5]
Access to public transport in the rural area	[1], [8]
Available vehicle for personal use	[1], [9]
Sufficient natural disaster relief expense per capita	[5], [7]
Sufficient power generation per capita	[1], [5]
High housing supply	[1], [2]

Note: [1] Kim et al. (2020), [2] Kaye-Blake et al. (2019), [3] Ye et al. (2023), [4] Yang et al. (2022), [5] Li (2023), [6] Mukti et al. (2023), [7] Aziiza & Susanto (2020), [8] Maja et al. (2020), [9] Hussain et al. (2023), [10] Abu-Rayyash & Dincer (2023), [12] Lacirignola et al. (2012), [13] Lin & Hou (2023)

RESEARCH METHODOLOGY

Case study method was used in this research. This method was adopted by past literature in rural development (Abdul-Latiff et al., 2022; Aziiza & Susanto, 2020). The case study was conducted through questionnaires with five-point agreement's Likert Scale. The questionnaires were administered through drop and pick method. The drop-and-pick method enables respondents to fully answer the questionnaire aside from encouraging high response rates (Junod & Jacquet, 2023).

This research compares the rural categories of Pedalaman 1 (P1) and Pedalaman 2 (P2) in Sarawak. P1-category village is a more advanced rural area compared to P2-category village but very few in number. To assure the samples are representative, the case studies for P2-category villages are selected based on the four (4) main geographical regions in Sarawak, namely, Northern (Marudi), Central (Sarikei), Western (Lundu) and Southern (Simunjan) of Sarawak. In view of the research and accessibility constraints as well as limited numbers of P1-category villages, Bario was identified as the main representative P1-category village with the intensive government support in many significant ICT, digitalization and sustainability initiatives such as eBario project.

Respondents were selected through purposive and convenience sampling methods. Convenience sampling is a common sampling method adopted in previous rural studies (Fennell et al., 2018; Mukti et al., 2022). Rural communities from the selected rural areas are invited to participate the survey through the help and consent from the village head or village head representative. An independence sample T-test was used to compare the mean scores of smart rural and rural resilience indicators in improving the socioeconomic of their villages for two rural categories.

ANALYSIS AND DISCUSSION

Demographic Background

A total of 105 responses was received from P1 village while 570 responses were collected from P2 villages. Demographic information of respondents is shown in Table 3. Respondents from both rural categories were quite consistent with low differences in terms of gender and age between the two village categories. Approximately 40% of the respondents are male and 59% are female. Approximately 40% - 50% of the respondents are 50 years old and below. Respondents aged 60 years old and above contributed 51% - 60% of the total responses. The older adults in rural areas usually constituted larger population and they play an important role in driving social innovation in rural areas (Noack & Federwisch, 2020). Additionally, Weck et al. (2022) concluded that engagement of senior citizens play a role in developing a smart living environment. The underlying indicators were analysed through mean and

ranking. High mean value signifies higher ranking, whereas lower mean value signifies lower ranking.

Table 3: Demographic information.

Category	P1		P2	
	Frequency (F)	Percentage (%)	Frequency (F)	Percentage (%)
<i>Age:</i>				
31 – 39 years old	5	4.77%	32	5.61%
40 – 49 years old	10	9.52%	86	15.09%
50 – 59 years old	27	25.71%	159	27.89%
≥ 60 years old	63	60.00%	293	51.40%
<i>Gender:</i>				
Male	43	40.90%	230	40.35%
Female	62	59.10%	340	59.65%
<i>Education level:</i>				
Primary School	44	41.90%	390	68.42%
Secondary School	21	20.00%	164	28.77%
Technical School	0	-	0	-
Diploma	36	34.28%	16	2.81%
Undergraduate	4	3.81%	0	-
Postgraduate or higher	0	-	0	-
Others (none)	0	-	0	-

Source: Authors' Own Source

Results and Discussion

Underlying Indicators of Smart Rural and Rural Resilience

P1 village and P2 villages had perceived different smart rural indicators for its underlying indicators as shown in Table 4. “Access to education” (Mean=3.23), “Connectivity to the national grid” (Mean=3.20), “Information and Communication Technologies (ICT) services” (Mean=3.19), and “Businesses/industries improvement” (Mean=3.19) are the smart rural underlying indicators with higher mean scores for P1 village. Cooke (2006) stated the importance of education and infrastructure for rural development in Sarawak.

Meanwhile, P2 villages prioritised “ICT services” (Mean=3.33), “Sufficient budget for road construction” (Mean=3.32), and “Access to health facilities” (Mean=3.32) and “Sufficient mobile clinics visitation” (Mean=3.32). These indicators were probably chosen due to it being related to the common challenges in less developed rural parts of Sarawak. Wong (2012) pointed out that poor or non-existent roads served as a significant obstacle for rural development, as it restricts the rural communities from access to healthcare and economic opportunities. This shows that the underlying smart rural indicators perceived by P2 villages also reflects this rural categories’ need for road and healthcare improvements as part of their rural development goals.

Table 4: Smart rural underlying indicators.

Dimensions	Indicators	Village categories					
		P1			P2		
		Mean	SD	Rank	Mean	SD	Rank
Economic	Sufficient budget allocated for road construction by the government or municipal	2.89	1.48	35	3.32	1.42	2
	Sufficient budget allocated for innovation programmes for smart rural development	3.03	1.38	20	3.23	1.48	28
	Availability of banking or financial infrastructures in the village (e.g.: ATMs)	2.88	1.34	36	3.16	1.41	44
	Access for employment in recent years	3.17	1.40	5	3.25	1.48	21
	High job availability within rural area	2.86	1.39	39	3.17	1.46	40
	Using social media to improve business	2.98	1.43	27	3.27	1.49	15
	Wide usage of online or mobile banking among rural residents	3.13	1.41	10	3.31	1.44	8
	Encouragement of entrepreneurship within rural community	3.11	1.37	13	3.28	1.48	12
	Income stability	2.94	1.42	31	3.30	1.47	11
	High employment rate of rural residents	2.95	1.39	30	3.25	1.42	21
	Business/industry improvement	3.19	1.39	3	3.28	1.45	13
Social	Sufficient books in the village library	2.81	1.43	44	3.00	1.36	48
	Efficient online database in the village library	2.88	1.47	36	3.15	1.43	46
	Active government participation in the village's development	3.02	1.37	21	3.26	1.46	17
	Digitalisation of governance	2.91	1.40	32	3.05	1.42	47
	Active public rural participation with government initiatives	2.77	1.41	46	3.24	1.50	23
	Access to education	3.23	1.38	1	3.20	1.44	31
	Access to health facilities	3.15	1.45	9	3.32	1.46	3
	Governance effectiveness	2.88	1.39	36	3.16	1.46	43
	Available ICT services in rural area	3.19	1.53	3	3.33	1.49	1
	Good quality ICT services in rural area	3.12	1.31	11	3.25	1.43	19
	Digitally empowered rural community	3.09	1.47	15	3.21	1.48	30
	High number of rural residents voting	3.07	1.36	17	3.32	1.47	5
	Low dependency ratio of rural area	3.01	1.35	23	3.24	1.48	24
Environment	Having an emergency plan for natural disasters	3.08	1.47	16	3.19	1.46	36

Dimensions	Indicators	Village categories					
		P1			P2		
		Mean	SD	Rank	Mean	SD	Rank
Technology	High number of trained people to conduct the emergency plan during natural disasters	2.96	1.43	29	3.24	1.46	24
	Efficient waste management (domestic waste and sewage)	3.17	1.43	5	3.24	1.48	24
	Efficient wildlife protection	3.07	1.37	17	3.17	1.41	39
	Early warning systems for drastic weather condition	2.85	1.35	40	3.25	1.50	20
	Usage of solar panels for personal use	2.79	1.52	45	3.26	1.44	16
	Having buildings that can withstand harsh weather conditions	3.01	1.45	23	3.32	1.46	5
	Availability of communication infrastructures (e.g.: telco towers)	3.02	1.50	21	3.30	1.46	10
	Having domestic animals owned by rural community to be uniquely marked or having a tracking device	2.72	1.34	47	3.20	1.50	31
	Available internet access with high coverage	3.04	1.43	19	3.18	1.49	38
	Available multiple mobile networks (e.g.: Digi, Celcom, etc.) reception with cellular/voice/data coverage	2.83	1.39	42	3.16	1.46	41
	Availability of main road connecting to the village road	3.17	1.41	5	3.27	1.44	14
	Availability of public transport to the village	2.85	1.47	40	3.18	1.41	37
	Sufficient storage capacity of village's substation/energy grid (KWh)	2.90	1.49	34	3.24	1.47	27
	Wide usage of solar powered devices	2.83	1.45	42	3.25	1.47	18
	Using smart and digital equipment in agriculture production	3.12	1.45	11	3.20	1.47	31
	Efficient electricity meters	3.10	1.39	14	3.19	1.45	35
	Connectivity to the national grid	3.20	1.49	2	3.21	1.45	29
Resources	Reliable General Practitioner (GP)	2.91	1.47	32	3.16	1.51	41
	Sufficient mobile clinics visitations	3.01	1.44	23	3.32	1.44	3
	Access to fresh water	3.17	1.40	5	3.19	1.43	34
	Abundance in agricultural produce	3.01	1.33	23	3.15	1.45	45
	Large land area earmarked for multiple development	2.72	1.47	47	3.30	1.46	9
	Receiving higher educational level	2.98	1.40	27	3.31	1.42	7

* Note: SD = Standard Deviation

Source: Authors' Own Creation

Table 5 shows the underlying rural resilience indicators perceived by P1 and P2 villages. P1 village perceived “Overcoming rural poverty”

(Mean=3.23), “High community spirit” (Mean=3.21), “Economic diversity” (Mean=3.17) and “High forest coverage” (Mean=3.17) are the important underlying indicators to enhance rural resilience of their village. Bischoff et al. (2018) highlighted that cooperation and community support are vital for overcoming rural poverty and coping with the challenges of remote living.

Furthermore, having economic diversity is underlying indicator for enhancing rural resilience especially in terms of socioeconomic aspect. Past studies on Sarawak’s rural areas showed that combining traditional economic activities such as farming, with other non-conventional economic activities such as tourism, handicraft, and small businesses might help rural communities handle economic changes (Denham et al., 2015).

For P2 villages, the rural resilience underlying indicators were “Quick recovery from extreme weather” (Mean=3.36), “Irrigation systems in farmlands” (Mean=3.34), and “Direct access to electricity” (Mean=3.34). Floods and other extreme weather conditions frequently disrupt agriculture and livelihoods in Sarawak (Abid et al., 2021). The underlying indicators perceived by P2 villages seem to focus on farming or agriculture as it is the main source of income for these villages, aside from the lack of basic infrastructures. This shows that villages in the P2 category need to explore other economic activities and not solely depend on farming to become more resilient

Table 5: Rural resilience underlying indicators.

Dimension	Indicators	Village categories					
		P1			P2		
		Mean	SD	Rank	Mean	SD	Rank
Economic	Sufficient financial expenditure on employment in the village	2.71	1.37	42	3.24	1.46	17
	High savings rate	3.05	1.49	19	3.32	1.48	5
	Dependency on income	2.93	1.38	33	3.23	1.48	19
	Overcoming rural poverty	3.23	1.43	1	3.21	1.42	25
	Economic diversity	3.17	1.41	3	3.18	1.49	34
	Entrepreneurship in agriculture	2.98	1.42	27	3.11	1.39	42
	Income stability	3.02	1.38	22	3.19	1.47	32
	High employment rate	2.94	1.42	32	3.26	1.47	11
	Improvement in business or industry	3.03	1.32	21	3.30	1.50	8
Social	High community spirit	3.21	1.43	2	3.30	1.44	7
	Lower crime rate	3.06	1.39	18	3.21	1.52	25
	Sufficient public security	3.12	1.35	11	3.12	1.43	40
	High rural population	3.12	1.39	11	3.23	1.39	20
	Sufficient investment in social services from government	3.00	1.47	25	3.21	1.53	28
	Access to education	3.05	1.49	19	3.16	1.40	36
	Access to health facilities	3.00	1.37	25	3.25	1.48	13
	Governance effectiveness	3.07	1.49	17	3.24	1.47	15

Dimension	Indicators	Village categories					
		P1			P2		
		Mean	SD	Rank	Mean	SD	Rank
Environment	Low proportion of elderly population (> 65 years old)	3.12	1.46	11	3.19	1.46	33
	Sufficient voting residents	2.73	1.32	41	3.24	1.49	16
	Low dependency ratio	3.15	1.38	5	3.11	1.37	41
	Efficient early warning systems for weather condition	3.14	1.41	7	3.15	1.49	38
	Quick recovery from extreme weather	3.08	1.44	15	3.36	1.44	1
	High forest coverage	3.17	1.42	3	3.25	1.48	12
	Awareness on changes	2.95	1.41	31	3.14	1.40	39
	Irrigation systems in farmlands	3.15	1.47	5	3.34	1.41	2
	Quick recovery of affected crops from extreme weather	3.08	1.46	15	3.20	1.41	31
	Sufficient usage of fertiliser or pesticides	2.91	1.35	35	3.20	1.44	29
Technology	Short commuting distance to nearest town	3.14	1.34	7	3.29	1.48	9
	Available internet access	2.97	1.38	28	3.20	1.45	30
	Rural household with digital devices	3.02	1.43	22	3.16	1.52	37
	Sufficient and efficient infrastructure development	2.97	1.40	28	3.23	1.48	20
	Access to public transport in the rural area	2.96	1.50	30	3.28	1.49	10
	Sufficient number of telephones per household	2.88	1.42	37	3.24	1.45	17
Resources	Food security	3.14	1.37	7	3.22	1.48	23
	Direct access to electricity	2.77	1.38	39	3.34	1.41	3
	Available vehicle for personal use	2.90	1.49	36	3.22	1.47	22
	Sufficient natural disaster relief expense per capita	2.81	1.40	38	3.17	1.48	35
	Sufficient power generation per capita	2.75	1.40	40	3.24	1.41	14
	High water resources per capita	3.12	1.42	11	3.33	1.41	4
	Access to fresh water	3.13	1.41	10	3.22	1.47	24
	Larger farmland area	2.93	1.36	33	3.30	1.46	6
	High housing supply	3.01	1.41	24	3.21	1.47	25

* Note: SD = Standard Deviation

Source: Authors' Own Creation

Comparison of Mean Differences Between 2 Rural Areas

Before running the independent sample T-test analysis, the skewness and kurtosis for all the indicators were checked for data distribution. Table 6 and 7 indicate the values of skewness and kurtosis are fall within the acceptable range, with skewness values between -1 and +1 and kurtosis values between -2 and +2 (Hair et al., 2027). Smart rural shows minimum and maximum skewness ranged from

-0.304 to 0.002, while the minimum and maximum kurtosis ranged from -1.469 to -1.25. On the other hand, the skewness values for rural resilience ranges from -0.295 to -0.052, while the kurtosis values ranges from -1.448 to -1.211.

Tables 6 indicates the results of independent sample t-test of P1 and P2 rural areas on smart rural. There are significant differences between P1 and P2 rural area on smart rural mainly on economic (EC), environment (EV), technology (TG) and resources (RC) dimensions with 3 or more indicators exhibits differences. Only one indicator under the social (SC) dimension shows significantly difference between the rural areas. The indicators include “Sufficient budget allocated for road construction by the government or municipal” (EC) ($t=-2.865$, $p=0.004$), “High job availability” (EC) ($t=-2.019$, $p=0.044$), “Income stability” (EC) ($t=-2.290$, $p=0.022$), “Active public rural participation with government initiatives” (SC) ($t=-2.980$, $p=0.003$), “Early warning systems for drastic weather condition” (EV) ($t=-2.738$, $p=0.007$), “Usage of solar panels for personal use” (EV) ($t=-3.062$, $p=0.002$), “Buildings that can withstand harsh weather conditions” (EV) ($t=-1.974$, $p=0.049$), “Domestic animals to be uniquely marked or having a tracking device” (TG) ($t=-3.258$, $p=0.001$), “Available multiple mobile networks” (TG) ($t=-2.187$, $p=0.029$), “Availability of public transport” (TG) ($t=-2.194$, $p=0.029$), “Sufficient storage capacity of substation/energy grid (KWh)” (TG) ($t=-2.196$, $p=0.028$), “Wide usage of solar powered devices” (TG) ($t=-2.656$, $p=0.008$), “Sufficient mobile clinics visitations” (RC) ($t=-2.013$, $p=0.044$), “Large land area earmarked for multiple development” (RC) ($t=-3.725$, $p<0.000$) and “Receiving higher educational level” (RC) ($t=-2.203$, $p=0.028$).

Tables 7 indicates the results of independent sample t-test of P1 and P2 rural areas on rural resilience. There are significant differences between P1 and P2 rural area on smart rural mainly on economic (EC), technology (TG) and resources (RC) dimensions with 3 or more indicators exhibits differences. Only one indicator under the social (SC) dimension shows significantly difference between the rural areas. The rural communities from both rural areas demonstrate no difference for indicators under the environment dimension. Indicators that exhibit significantly difference with p-value less than 0.05 include “Sufficient financial expenditure on employment” (EC) ($t=-3.395$, $p=0.001$), “Dependency on income” (EC) ($t=-2.021$, $p=0.045$), “High employment rate” (EC) ($t=-2.041$, $p=0.042$), “Sufficient voting” (SC) ($t=-3.536$, $p=0.001$), “Access to public transport in the rural area” (TG) ($t=-2.018$, $p=0.044$), “Sufficient number of telephones per household” (TG) ($t=-2.345$, $p=0.019$), “Direct access to electricity” (RC) ($t=-3.796$, $p<0.000$), “Available vehicle for personal use” (RC) ($t=-2.082$, $p=0.038$), “Sufficient natural disaster relief expense per capita” (RC) ($t=-2.302$, $p=0.022$), “Sufficient power generation per capita” (RC) ($t=-3.286$, $p=0.001$) and “Large farmland area” (RC) ($t=-2.520$, $p=0.013$). The negative t-

test values demonstrate that the mean values of these indicators for P1 village are significantly lower than P2 villages.

Table 6: Independent sample t-test on smart rural.

Dimensions	Indicators	Skewness	Kurtosis	t-value	p-value (2-tailed)
Economic	Sufficient budget allocated for road construction by the government or municipal	-0.227	-1.293	-2.865	0.004*
	Sufficient budget allocated for innovation programmes for smart rural development	-0.171	-1.351	-1.282	0.200
	Availability of banking or financial infrastructures in the village (e.g.: ATMs)	-0.174	-1.258	-1.909	0.057
	Access for employment in recent years	-0.228	-1.348	-0.477	0.633
	High job availability within rural area	-0.068	-1.355	-2.019	0.044*
	Using social media to improve business	-0.218	-1.348	-1.853	0.064
	Wide usage of online or mobile banking among rural residents	-0.247	-1.293	-1.136	0.256
	Encouragement of entrepreneurship within rural community	-0.222	-1.337	-1.155	0.250
	Income stability	-0.199	-1.359	-2.290	0.022*
	High employment rate of rural residents	-0.190	-1.281	-1.955	0.051
Social	Business/industry improvement	-0.217	-1.315	-0.601	0.548
	Sufficient books in the village library	0.002	-1.259	-1.306	0.192
	Efficient online database in the village library	-0.149	-1.316	-1.792	0.074
	Active government participation in the village's development	-0.175	-1.331	-1.551	0.121
	Digitalisation of governance	-0.048	-1.320	-0.931	0.352
	Active public rural participation with government initiatives	-0.120	-1.425	-2.980	0.003*
	Access to education	-0.160	-1.316	0.210	0.833
	Access to health facilities	-0.230	-1.332	-1.069	0.286
	Governance effectiveness	-0.091	-1.347	-1.851	0.065
	Available ICT services in rural area	-0.304	-1.333	-0.878	0.380
Environment	Good quality ICT services in rural area	-0.253	-1.250	-0.886	0.377
	Digitally empowered rural community	-0.190	-1.362	-0.786	0.432
	High number of rural residents voting	-0.212	-1.348	-1.701	0.091
	Low dependency ratio of rural area	-0.128	-1.358	-1.588	0.114
	Having an emergency plan for natural disasters	-0.152	-1.339	-0.707	0.480
Environment	High number of trained people to conduct the emergency plan during natural disasters	-0.192	-1.344	-1.805	0.072
	Efficient waste management (domestic waste and sewage)	-0.165	-1.377	-0.441	0.659

Dimensions	Indicators	Skewness	Kurtosis	t-value	p-value (2-tailed)
	Efficient wildlife protection	-0.178	-1.281	-0.716	0.474
	Early warning systems for drastic weather condition	-0.157	-1.393	-2.738	0.007*
	Usage of solar panels for personal use	-0.177	-1.350	-3.062	0.002*
	Having buildings that can withstand harsh weather conditions	-0.267	-1.322	-1.974	0.049*
Technology	Availability of communication infrastructures (e.g.: telco towers)	-0.243	-1.316	-1.809	0.071
	Having domestic animals owned by rural community to be uniquely marked or having a tracking device	-0.116	-1.374	-3.258	0.001*
	Available internet access with high coverage	-0.151	-1.381	-0.874	0.383
	Available multiple mobile networks (e.g.: Digi, Celcom, etc.) reception with cellular/voice/data coverage	-0.057	-1.363	-2.187	0.029*
	Availability of main road connecting to the village road	-0.201	-1.303	-0.671	0.502
	Availability of public transport to the village	-0.167	-1.299	-2.194	0.029*
	Sufficient storage capacity of village's substation/energy grid (KWh)	-0.177	-1.394	-2.196	0.028*
	Wide usage of solar powered devices	-0.127	-1.412	-2.656	0.008*
	Using smart and digital equipment in agriculture production	-0.153	-1.372	-0.467	0.640
	Efficient electricity meters	-0.245	-1.298	-0.542	0.588
	Connectivity to the national grid	-0.186	-1.334	-0.080	0.937
Resources	Reliable General Practitioner (GP)	-0.079	-1.467	-1.570	0.117
	Sufficient mobile clinics visitations	-0.244	-1.297	-2.013	0.044*
	Access to fresh water	-0.235	-1.268	-0.143	0.887
	Abundance in agricultural produce	-0.105	-1.319	-1.009	0.315
	Large land area earmarked for multiple development	-0.197	-1.374	-3.725	0.000*
	Receiving higher educational level	-0.168	-1.316	-2.203	0.028*

* Note: p-value = Significant level

Source: Authors' Own Creation

Table 7: Independent sample t-test on rural resilience.

Dimensions	Indicators	Skewness	Kurtosis	t-value	p-value (2-tailed)
Economic	Sufficient financial expenditure on employment in the village	-0.110	-1.356	-3.395	0.001*
	High savings rate	-0.238	-1.381	-1.757	0.079
	Dependency on income	-0.137	-1.374	-2.021	0.045*
	Overcoming rural poverty	-0.265	-1.253	0.108	0.914
	Economic diversity	-0.142	-1.388	-0.081	0.935
	Entrepreneurship in agriculture	-0.118	-1.266	-0.889	0.374

Dimensions	Indicators	Skewness	Kurtosis	t-value	p-value (2-tailed)
Social	Income stability	-0.143	-1.330	-1.103	0.271
	High employment rate	-0.197	-1.366	-2.041	0.042*
	Improvement in business or industry	-0.210	-1.372	-1.870	0.063
	High community spirit	-0.226	-1.308	-0.580	0.562
	Lower crime rate	-0.156	-1.429	-1.038	0.301
	Sufficient public security	-0.139	-1.301	0.053	0.958
	High rural population	-0.233	-1.227	-0.728	0.467
	Sufficient investment in social services from government	-0.168	-1.448	-1.291	0.197
	Access to education	-0.182	-1.281	-0.780	0.436
	Access to health facilities	-0.191	-1.358	-1.711	0.089
	Governance effectiveness	-0.218	-1.363	-1.120	0.263
	Low proportion of elderly population (> 65 years old)	-0.156	-1.366	-0.400	0.689
	Sufficient voting residents	-0.138	-1.364	-3.536	0.001*
	Low dependency ratio	-0.151	-1.211	0.263	0.793
Environment	Efficient early warning systems for weather condition	-0.140	-1.369	-0.051	0.959
	Quick recovery from extreme weather	-0.295	-1.268	-1.843	0.066
	High forest coverage	-0.259	-1.332	-0.531	0.595
	Awareness on changes	-0.169	-1.260	-1.276	0.203
	Irrigation systems in farmlands	-0.271	-1.261	-1.246	0.213
	Quick recovery of affected crops from extreme weather	-0.207	-1.307	-0.798	0.425
	Sufficient usage of fertiliser or pesticides	-0.128	-1.294	-1.890	0.059
Technology	Short commuting distance to nearest town	-0.244	-1.329	-0.988	0.325
	Available internet access	-0.141	-1.336	-1.484	0.138
	Rural household with digital devices	-0.120	-1.423	-0.891	0.373
	Sufficient and efficient infrastructure development	-0.161	-1.376	-1.669	0.096
	Access to public transport in the rural area	-0.232	-1.381	-2.018	0.044*
	Sufficient number of telephones per household	-0.162	-1.336	-2.345	0.019*
Resources	Food security	-0.186	-1.334	-0.492	0.623
	Direct access to electricity	-0.208	-1.283	-3.796	0.000*
	Available vehicle for personal use	-0.154	-1.374	-2.082	0.038*
	Sufficient natural disaster relief expense per capita	-0.052	-1.392	-2.302	0.022*
	Sufficient power generation per capita	-0.201	-1.265	-3.286	0.001*
	High water resources per capita	-0.284	-1.243	-1.394	0.164
	Access to fresh water	-0.175	-1.349	-0.530	0.596
	Larger farmland area	-0.203	-1.327	-2.520	0.013*
	High housing supply	-0.135	-1.347	-1.308	0.191

* Note: p-value = Significant level

Source: Authors' Own Creation

CONCLUSION

The findings show that the different rural development advancements levels between Pedalaman 1 (P1) and Pedalaman 2 (P2) in Sarawak was reflected in the perceived underlying indicators. The underlying indicators perceived by P1 village community reflect its advanced development, compared to P2 villages that the perceived underlying indicators are related to agriculture and basic infrastructures. This shows that the differences in rural categories affect the underlying indicators in the context of smart rural and rural resilience.

The implications of this study provide insight to the relevant government agencies in strategizing appropriate initiatives in implementing rural development policies. For example, to improve smart and rural resilience of P2-category villages, rural development initiatives should be focused on improving accessibility through ICT and new technologies, agriculture practices and technologies, improving social and physical infrastructure and improving the accessibility and facilities of rural health facilities. On the other hand, smart and rural resilience of P1-category villages can be enhanced by prioritising initiatives focus on improving accessibility through ICT and new technologies, intensify and diversity rural economy, strengthening community cohesion, forest conservation and improving educational access and facilities. The academic implication of this study includes the contribution towards identifying the smart rural and rural resilience underlying indicators in different rural categories in Sarawak.

Moreover, future studies can consider other rural categories in Sarawak such as the Pedalaman 3 (P3) category since this study only include the P1 and P2 categories. Besides, future studies may need to include more villages in the P1 category for a more comprehensive finding as this study only include one village in this category.

ACKNOWLEDGEMENT

The research was supported by the Ministry of Higher Education (MOHE) through the Fundamental Research Grant Scheme (FRGS) and Tunku Abdul Rahman University of Management and Technology (TAR UMT).

REFERENCES

- Abdul-Latiff, A. M., Jaapar, A., & Mat Isa, C. M. (2022). Factors influencing governance practices in rural development projects: A case study of rural road project in Malaysia. *Journal of Construction in Developing Countries*, 27(2), 1-36. <https://doi.org/10.21315/jcdc-11-20-0245>
- Abdullah, R. G. (2021). Multi-local living and new rural household structures - An insight from Sarawak, Malaysia. *International Journal of Academic Research in Business and Social Sciences*, 11(14), 154-163. <https://doi.org/10.6007/ijarbss/v11-i14/8558>

- Abid, S. K., Sulaiman, N., Wei, C. S., & Nazir, U. (2021). Flood vulnerability and resilience: Exploring the factors that influence flooding in Sarawak. *IOP Conference Series: Earth and Environmental Science*, 802(1), 012059. <https://doi.org/10.1088/1755-1315/802/1/012059>
- Abu-Rayash, A., & Dincer, I. (2023). Development and application of an integrated smart city model. *Heliyon*, 9(4), e14347. <https://doi.org/https://doi.org/10.1016/j.heliyon.2023.e14347>
- Aziiza, A. A., & Susanto, T. D. (2020). The smart village model for rural area (Case study: Banyuwangi Regency). *IOP Conference Series: Materials Science and Engineering*, 722(1), 012011. <https://doi.org/10.1088/1757-899X/722/1/012011>
- Bischoff, S., Wojewska, A. N., Vinding, M. E., & Jehl, S. (2018). Adaptation of livelihood strategies in light of rural change and development in Sarawak: A case study of Menuang. https://sluse.dk/project/malaysia_adaptation_of_livelihood_strategies_in_the_light_of_rural_change_menuang.pdf
- Cooke, F. M. (2006). Recent Development and Conservation Interventions in Borneo. *State, Communities and Forests in Contemporary Borneo* (pp. 3-21). ANU E Press.
- Denham, C. E., Damsø-Jørgensen, L., Mason, M. W., Musinguzi, P., & Mages, C. (2015). Diversification of livelihood strategies in rural Sarawak: A case study of Serubah Ulu. https://sluse.dk/project/malaysia_diversification_of_livelihood_strategies_serubah_ulu.pdf
- Fan, J., Mo, Y., Cai, Y., Zhao, Y., & Su, D. (2021). Evaluation of community resilience in rural China—taking licheng subdistrict, guangzhou as an example. *International Journal of Environmental Research and Public Health*, 18(11), 5827. <https://doi.org/10.3390/ijerph18115827>
- Fennell, S., Kaur, P., Jhunjhunwala, A., Narayanan, D., Loyola, C., Bedi, J., & Singh, Y. (2018). Examining linkages between smart villages and smart cities: Learning from rural youth accessing the Internet in India. *Telecommunications Policy*, 42(10), 810-823. <https://doi.org/https://doi.org/10.1016/j.telpol.2018.06.002>
- Gerli, P., Navio Marco, J., & Whalley, J. (2022). What makes a smart village smart? A review of the literature. *Transforming Government: People, Process and Policy*, 16(3), 292-304. <https://doi.org/10.1108/tg-07-2021-0126>
- Guzal-Dec, D. (2018). Intelligent development of the countryside—the concept of smart villages: assumptions, possibilities and implementation limitations. *Economic and Regional Studies (Studia Ekonomiczne i Regionalne)*, 11(3), 32-49. <https://doi.org/10.22004/ag.econ.291913>
- Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2027). A primer on partial least squares structural equation modeling (PLS-SEM) (4th ed.). Sage.
- Heijman, W., Hagelaar, G., & Van Der Heide, M. (2019). Rural resilience as a new development concept. In *EU Bioeconomy Economics and Policies: Volume II* (pp. 195-211). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-28642-2_11
- Huang, X., Li, H., Zhang, X., & Zhang, X. (2018). Land use policy as an instrument of rural resilience - The case of land withdrawal mechanism for rural homesteads in

- China. *Ecological Indicators*, 87, 47-55.
<https://doi.org/10.1016/j.ecolind.2017.12.043>
- Hussain, S., Ahonen, V., Karasu, T., & Leviäkangas, P. (2023). Sustainability of smart rural mobility and tourism: A key performance indicators-based approach. *Technology in Society*, 102287.
<https://doi.org/https://doi.org/10.1016/j.techsoc.2023.102287>
- Junod, A. N., & Jacquet, J. B. (2023). Insights for the drop-off/pick-up method to improve data collection. *Society & Natural Resources*, 36(1), 76-88.
<https://doi.org/10.1080/08941920.2022.2146821>
- Kaye-Blake, W., Stirrat, K., Smith, M., & Fielke, S. (2019). Testing indicators of resilience for rural communities. *Rural Society*, 28(2), 161-179.
<https://doi.org/10.1080/10371656.2019.1658285>
- Kim, G., Kang, W., & A. Lee, J. (2020). Knowledge structures and components of rural resilience in the 2010s: Conceptual development and implications. *Sustainability*, 12(22), 9769. <https://doi.org/10.3390/su12229769>
- Lacirignola, C., Dernini, S., Capone, R., Meybeck, A., Burlingame, B., Gitz, V., . . . Belsanti, V. (2012). Towards the development of guidelines for improving the sustainability of diets and food consumption patterns: the Mediterranean Diet as a pilot study. *Options Méditerranéennes. Série B, Études et Recherches* (No.70), 1-70 (En), 71-72 (Fr).
- Li, Y. (2023). A systematic review of rural resilience. *China Agricultural Economic Review*, 15(1), 66-77. <https://doi.org/10.1108/CAER-03-2022-0048>
- Li, Y., Song, C., & Huang, H. (2021). Rural resilience in China and key restriction factor detection. *Sustainability*, 13(3), 1080. <https://doi.org/10.3390/su13031080>
- Lin, S., & Hou, L. (2023). SDGs-oriented evaluation of the sustainability of rural human settlement environment in Zhejiang, China. *Heliyon*, 9(2), e13492. <https://doi.org/https://doi.org/10.1016/j.heliyon.2023.e13492>
- Liu, D., Li, F., Qiu, M., Zhang, Y., Zhao, X., & He, J. (2024). An integrated framework for measuring sustainable rural development towards the SDGs. *Land Use Policy*, 147, 107339. <https://doi.org/10.1016/j.landusepol.2024.107339>
- López-Penabad, M. C., Iglesias-Casal, A., & Rey-Ares, L. (2022). Proposal for a sustainable development index for rural municipalities. *Journal of Cleaner Production*, 357, 131876.
<https://doi.org/https://doi.org/10.1016/j.jclepro.2022.131876>
- Maja, P. W., Meyer, J., & Solms, S. v. (2020). Development of smart rural village indicators in line with Industry 4.0. *IEEE Access*.
<https://doi.org/10.1109/access.2020.3017441>
- Mukti, I. Y., Iacob, M. E., Aldea, A., Govindaraju, R., & van Hillegersberg, J. (2022). Defining rural smartness and its impact: A systematic literature review. *Journal of the Knowledge Economy*, 13(2), 956-1007. <https://doi.org/10.1007/s13132-021-00736-7>
- Naldi, L., Nilsson, P., Westlund, H., & Wixe, S. (2015). What is smart rural development? *Journal of Rural Studies*, 40, 90-101.
<https://doi.org/10.1016/j.jrurstud.2015.06.006>
- Noack, A., & Federwisch, T. (2020). Social innovation in rural regions: Older adults and creative community development. *Rural Sociology*, 85(4), 1021-1044.

- Panciszko, B. (2021). The reasons of the implementation of the concept of smart villages in the European Union. *Przegląd Politologiczny*, (4), 37-48. <https://orcid.org/0000-0003-3480-3189>
- Shcherbina, E., & Gorbenkova, E. (2018, June). Smart city technologies for sustainable rural development. In *IOP Conference Series: Materials Science and Engineering* (Vol. 365, No. 2, pp. 022039). IOP Publishing. <https://doi.org/10.1088/1757-899X/365/2/022039>
- Wilson, G. A., Hu, Z., & Rahman, S. (2018). Community resilience in rural China: the case of Hu Village, Sichuan Province. *Journal of Rural Studies*, 60, 130-140. <https://doi.org/10.1016/j.jrurstud.2018.03.016>
- Wong, B. W. K. (2012). Logging road, transportation and outward migration in Sarawak: The local perspective of Marudi Town. *TeSSHJ*, 154-167. <https://ir.unimas.my/id/eprint/5239/1/logging%20road.pdf>
- Yang, M., Jiao, M., & Zhang, J. (2022). Spatio-temporal analysis and influencing factors of rural resilience from the perspective of sustainable rural development. *International Journal of Environmental Research and Public Health*, 19(19), 12294. <https://doi.org/10.3390/ijerph191912294>
- Ye, W., Wang, Y., Wu, K., Yang, X., Yang, Q., & Liu, Q. (2023). Exploring the rural transformation of the Loess Plateau from a perspective of community resilience: A case study from the Jiaxian County, northwestern China. *Applied Geography*, 154, 102919. <https://doi.org/10.1016/j.apgeog.2023.102919>
- Zhou, Q., Zhu, M., Qiao, Y., Zhang, X., & Chen, J. (2021). Achieving resilience through smart cities? Evidence from China. *Habitat International*, 111, 102348. <https://doi.org/10.1016/j.habitatint.2021.102348>

Received: 10th August 2026. Accepted: 13th August 2026