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SPATIAL-BASED SMART COMMUNITY INFRASTRUCTURES MODEL OF SMART ECONOMY SUSTAINABILITY IN SMART VILLAGE ENVIRONMENT

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Abstract: Due to the disparity in resources between rural and urban areas of Indonesia, the rate of rural poverty has increased to 12.29% as of March 2022. One of the potential answers to the problem of widespread poverty in rural areas is the establishment of a "smart economy," which would be underpinned by a robust "smart community". The purpose of this research is to construct a spatial-based smart community infrastructure model through the application of a dynamic spatial analysis methodology. This model is intended to facilitate resource strengths mapping to establish smart villages. In the development process of this model, a Causal Loop Diagram approach is utilised, taking into account infrastructure, institutional, and policy variables. The kernel density clustering technique is combined with the classification of potential smart communities, resulting in three categories of potential smart communities: very potential, potential, potential, and fairly potential. The accuracy of the model is validated through an economic conditions assessment of the hamlet. This work presents a significant contribution linked to the possible smart community model that is connected with village infrastructure circumstances in the pursuit of developing a smart economy within a sustainable smart village.

Keywords: Dynamic spatial, classification, clustering, sustainable, smart village.

Introduction

The global economy, including that of Indonesia, has been negatively impacted as a result of the COVID-19 pandemic as a result of the phenomenon of pandemic. According to information that was made available by the Central Statistics Agency (BPS) in January 2021, the number of people in the working-age population who were laid off as a result of the COVID-19 epidemic reached 2.56 million. As a result of the economic hardship brought on by the pandemic, many people who had been living in the city were compelled to relocate to rural areas. Some city dwellers who move to rural areas ultimately decide to pursue careers in the agricultural industry. During the epidemic, the number of persons employed in the agricultural sector in Indonesia dramatically increased, going from 36.71 million people (constituting 27.53 percent of the overall population) in August 2019 to 41.13 million people (constituting 29.76 percent of the total workforce) in August 2020. The victims of layoffs have the option of moving to a rural area and finding work in the agricultural sector. This is an attractive choice for them because the agricultural sector offers a greater chance of long-term sustainability than living in a city without a source of income.

The effects of ruralisation present an excellent opportunity to improve the development of villages. Iskandar (2020) suggests that the development of villages in Indonesia can contribute to the realisation of Sustainable Development Goals (SDGs) in 2030 by a factor of up to 74%. This goal is supported by aspects relating to both the region and the population. From a geographical point of view, rural areas make up 91% of Indonesia's total land mass. Population-wise, it is reinforced by the fact that 43 percent of Indonesia's total population lives in rural areas. Since the year 2020, the Village Sustainable Development Goals have also been established by the Ministry of Villages, Development of Disadvantaged Regions and Transmigration of the Republic of Indonesia (Kemendesa PDTT RI). These goals have been put into action through the reform of the Village Development Index (IDM) assessment, which is based on the Village Sustainable Development Goals. Because it is provided with more specific data, the Village SDGs play a significant role in determining the success of village development in Indonesia (Tosida *et al.,* 2020a). This is because the Village SDGs have been developed. The IDM status can be broken down into five distinct categories, which are respectively referred to as Advanced, Independent, Developing, Disadvantaged, and Very Disadvantaged. IDM conditions in Indonesia in 2021 include the following: advanced village reach by 10.2% and independent village reach by 15.5%; the majority of villages are in developing status (50.9%); the rest of the villages are either underdeveloped (15.7%) or very underdeveloped (7.6%) (Directorate General of Village and Rural Development, 2022).

The Kemendesa PDTT RI is highly aggressive when it comes to supporting the development of villages, and one of the most prominent programs that it offers is called the Smart Village Program. Both the Decree of the Village Development and Information Agency, Disadvantaged Regions and Transmigration (BPI DTT) Number 37 of 2021 and the Decree of the BPI of the Kemendesa PDTT RI Number 55 of 2022 regarding the determination of village loci intelligent have served to bolster the smart village program that the Kemendesa PDTT RI initially started. Both decrees concern the determination of village loci intelligent. The BPI DTT has chosen a total of 350 localities to participate in the smart village program's implementation in 2021 and 1000 villages to participate in the program's implementation in 2022. This initiative's goal is to have attained the capability of constructing smart villages in a total of two thousand villages across the territory of Indonesia by the year 2023. This goal will be accomplished if the initiative is successful. This program, which has been given the name "smart village," is the response to the question of how to encourage the proliferation of digital technology that has spread throughout the village area. The Kemendesa PDTT Research Institute, managed by BPI, is actively committed to promoting and supporting innovative village projects by harnessing the power of digital technology. The primary objective is to address the unique challenges faced by rural communities and facilitate the development of effective solutions. This Smart Village Program that is now being executed has another program that works in conjunction with it called the Program for Strengthening Governance and Village Development for 2021-2024.

The viability of the smart village program is an essential component in the growth of the village as well as the accomplishment of the Sustainable Development Goals (SDGs) for the community. Infrastructure factors are said to have an impact on the long-term viability of smart villages (Phahlamohlaka *et al.,* 2014; Phahlamohlaka *et al.,* 2016; Sutriadi, 2018; Assumpcao *et al*., 2019). Nevertheless, the infrastructure in question does not solely exist within the context of facilities and other types of infrastructure. In addition, in order for infrastructure to be capable of ensuring the long-term viability of smart villages, it is necessary for there to be support from institutional and regulatory bodies (Tosida *et al.,* 2022b). The number of specific studies that have been conducted in relation to the viability of smart villages from an infrastructure point of view in order to stimulate smart community activities in smart village environments in Indonesia is still quite limited. In general, studies on smart villages in Indonesia continue to discuss the fundamental concept (Mishbah *et al.,* 2018; Ella & Andari, 2018; Andari & Ella, 2021), a description of the implementation of smart villages and their relation to social, economic, cultural, and regulatory analysis (Sutriadi 2018; Santoso *et al.* 2019), a partial study through the village Geographic Information System (GIS) (Adi & Heripracoyo 2018; Afnarius *et al.* 2020).

An innovation in the form of a spatially-based quantitative model was proposed to use as a measurement of the potential of a smart community for a smart economy within the context of a smart village environment through the circumstances imposed by infrastructure. Our proposed infrastructure consists of infrastructure, institutions, and rules all working together. In the smart economy case study known as "smart village," which is located in Kabandungan District, Sukabumi Regency, West Java, the model has been put into action. The most important aspects of this investigation are based on previous research (Sutriadi, 2018). The integrity of the community, cultural norms, regional planning, economic facilities, readiness of technology, politics, and stakeholders are some of the characteristics that are included here. Through the utilisation of a geographical approach and study of decision support systems, we conducted additional research and made a substantial contribution. The benefit of this research is that it will provide recommendations to stakeholders, in particular village, sub-district, and district governments, and even the central government, to prepare smart communities and strategies for strengthening infrastructure in villages (covering infrastructure, institutions, and regulations), which will allow for the development of a smart economy in an environment that is compatible with smart villages. Based on this model, it is feasible to extend benefits to other villages, thereby setting up smart economies or smart villages in general across the West Java region or in other parts of Indonesia that share similar features and resources as this particular area.

Literature Review

According to the Systematic Literature Review (SLR) of 50 articles about smart villages (Tosida *et al.,* 2022b), which was managed through the text search facility of NVivo Plus 12, 7 articles discuss "smart community," 16 articles discuss "infrastructure," 25 articles that discuss discussing "ICT infrastructure," 20 articles that discuss "institutional," and 34 articles that discuss "policies." The relationship between the articles that are based on the keyword "ICT infrastructure" is illustrated in the diagram shown in Figure 1. A diagram of the relationships between articles based on the keyword "policies" and relevant infrastructures is shown in Figure 2, and a diagram of the relationships between articles based on the keyword "institutional" and related infrastructures is shown in Figure 3.

According to Figure 1, the conversation regarding the keyword "ICT infrastructure" among the researchers working on the smart village concentrates on the convergence of infrastructure and resources, which includes access and use. These resources consist of human resources and basic infrastructure (relating to access to food, health, education, and transportation as well as energy and mother), both of which are integrated with ICT infrastructure, and these are the primary criteria for establishing smart villages. The internet network and all of the devices connected to it make up part of the ICT infrastructure. Also included are ICT management and application content. In point of fact, Larsen & Estes (2019) and Maja *et al.* (2020) discuss how ICT-based bank access application technology will be the driving force behind the creation of smart villages.

Figure 2 presents a component of the smart village infrastructure that is related to policy. This component demonstrates that the researchers concentrated their efforts on the proposed policy framework, which was integrated with the culture as well as the external limits of each region. In order to formulate policies that are congruent with the objectives of village development, careful consideration must be given to issues of content, connection, and capital. Because of this, policies need to include funding for programs that create capacity for

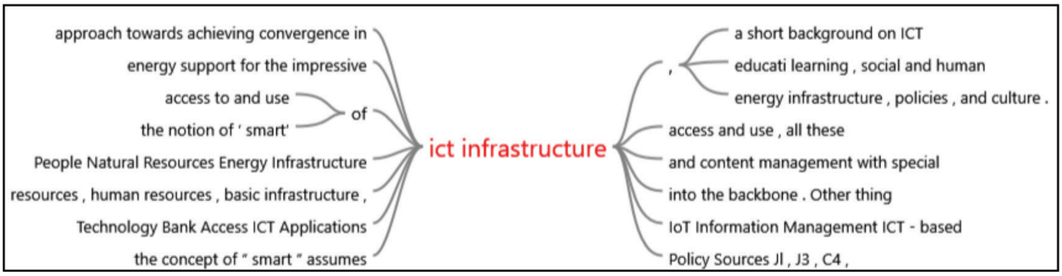

Figure 1: Diagram of the relationship between articles based on the keyword "ICT infrastructure"

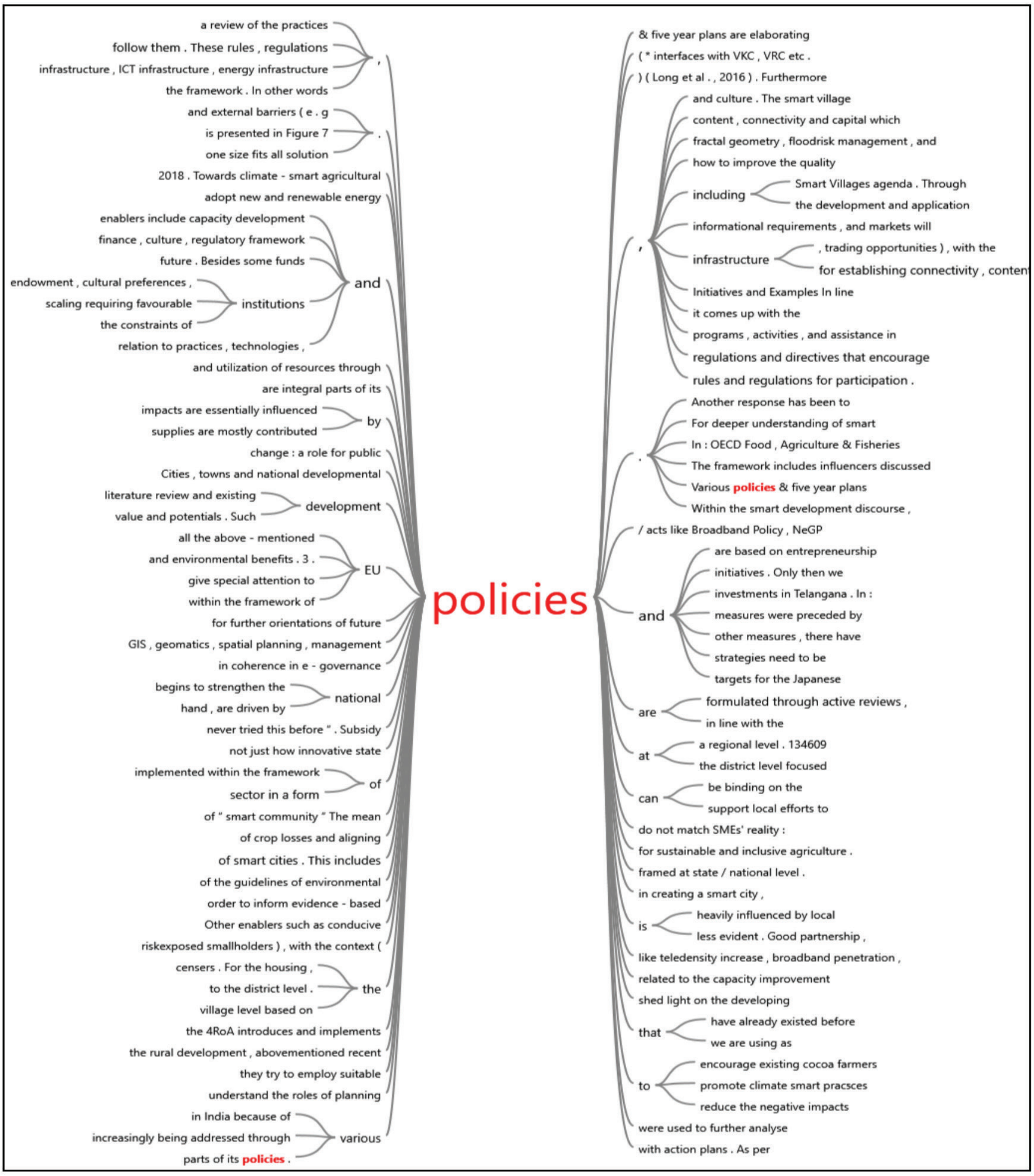

Figure 2: Diagram of the relationship between articles based on the keyword "policies"

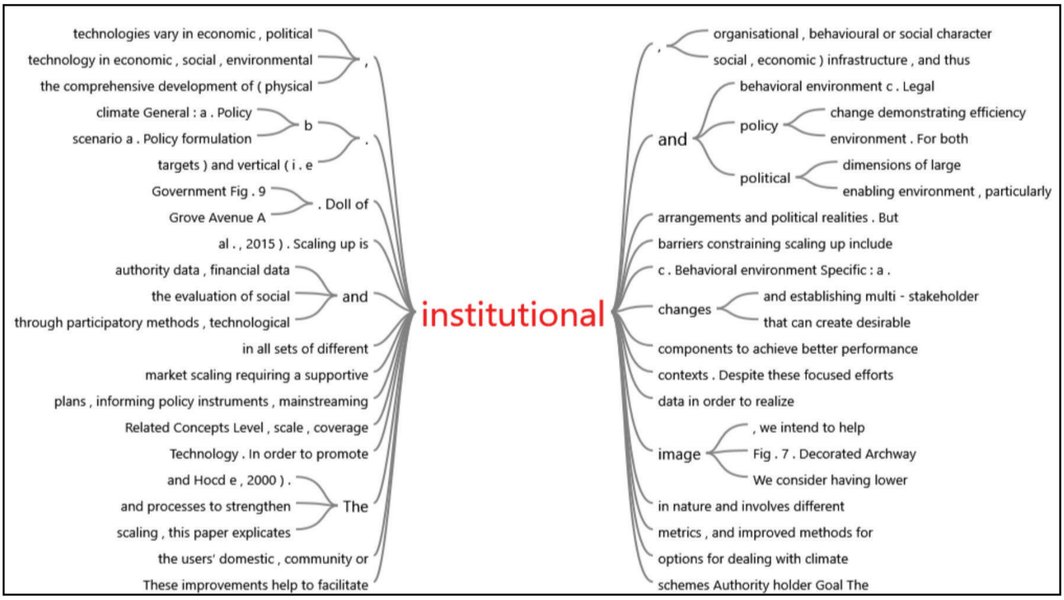

Figure 3: Diagram of the relationship between articles based on the keyword "institutional"

enablers who are related to communities in the village. It is intended that this would result in citizen initiatives in the search for creative solutions to problems that are already present in the community and that these projects will eventually receive support from the relevant parties. According to Phalamohlaka *et al.* (2014), sustainable village innovation will eventually be able to develop a smart community. The structure for the village fund, which can come from either within the village or outside of it, is very closely tied to the smart village policies. In order to be able to deliver benefits to the environment, the primary attention will be placed on the finance policy for the creation of smart villages.

Institutional support at all levels of local, regional, national, and internationaln became the focal point of the conversation that predominated SLR under the heading "institutional" (Figure 3). The establishment of institutions that are robust in terms of their organisational, behavioural, and social natures will be the primary objective of the creation of the infrastructure for smart villages. Institutions in smart villages need to be bolstered by technological aspects that are adapted to the economic level of the population and gain political support from the local government, private sector, academics, and the media (Sutriadi, 2018; Tosida *et al.,* 2022b). This support can come from any combination of the following: academics, media, private sector, and academics.

Importantly, based on the relationship diagram between the papers associated with the keywords infrastructure, facilities, ICT, policies, and institutions, the main variables required for the analysis of the potential of a smart community to build a sustainable smart economy in an environment suitable for a smart village can be elaborated. This is the most important thing. The findings of this research demonstrate that the potential for smart communities needs backing from the primary infrastructure factors, which might take the shape of infrastructure, institutions, and laws. Physical infrastructure variables need to be supported by fundamental facilities such as roads, marketplaces, schools, and the internet. Additionally, basic agricultural facilities in the form of irrigation, as well as non-physical facilities in the form of activities using social media for the economy, are also required. The institutions that are in question include not only formal institutions such as cooperatives or Village-Owned Enterprises (BUMDes), as well as banks, but also non-formal institutions such as communities, farmers, and micro small medium enterprises (SMEs), as well as private players and large industries. These policies include official policies at the levels of the central government and regional governments (beginning at the district, subdistrict, and village levels), as well as policies on the strength of customs and policies regarding collaboration with universities.

Research Methods

Types and Data Sources

This research makes use of primary data, which comes from the outcomes of interviews (in-depth interviews) and questionnaires filled out by subject matter experts. The term "experts" refers to professionals working in national mass media, academia, and members of government at all levels, from the subdistrict to the district to the ministry, who are familiar with the grading system for infrastructure model variables applicable to smart communities. In addition to this, we make use of primary data collected at the research site in the Kabandungan Sub-district of the Sukabumi Regency in the West Java Province of Indonesia. Primary data consists of 11 different infrastructure variables. These variables are as follows: marketplaces, schools, Base Transceiver Stations (BTS) and optical Distribution Point (ODP), banks, cooperatives, farmer organisations, Micro Small Medium Enterprises (MSMEs) groups, communities, customs, collaboration with academics, and regulations. The secondary data that we obtained linked to infrastructure variables from the Geospatial Information Agency (BIG) – the National Innovation Research Agency (BRIN) consists of three variables. These variables include the spatial data of roads, rivers or irrigation, and land cover. The primary data that we obtained related to infrastructure variables came from the National Innovation Research Agency (BRIN). Other secondary data that we acquired from the findings of a study questionnaire on citizens' readiness for a smart economy (Tosida *et al.,* 2020b; Tosida *et al.,* 2022a) is associated with social media activities for the economy.

Expert Respondents

When selecting respondents for the study, it was important to take into account how well the individuals understood the issues that were being investigated in the research topic. In this particular research endeavour, there were a total of five knowledgeable individuals who participated as respondents. In the subject of spatial infrastructure modelling, valid respondents have to be persons who are either masters or specialists in their respective fields, and they also have to represent a variety of linked parties. This is a necessity. Because of this, the respondents chosen for this survey include socio-computational experts, representatives from agriculture, community experts at the district level, community experts at the central level, and representatives from the mass media.

Methodology

This research is qualitative and quantitative analytical research that intends to construct a spatially based smart community potential infrastructure model for a smart economy to be used in an environment that is similar to a smart village. The study framework depicted in Figure 4 is the one that we employ. The scope of our possible model for the infrastructure of smart communities is laid out in a knowledge graph, which may be found in Figure 5. In Figure 6, we provide an in-depth breakdown of each stage of the research process.

The process of classifying potential smart communities involves summing up the weights of all factors and finding the range of values for the three classes of potential smart communities (quite potential, potential, and very potential). This results in a classification of the potential smart communities as either quite potential, potential, or very potential. According to Mora-Garcia *et al.* (2015), the method of kernel density is used to carry out the process of smart community potential clustering. The following

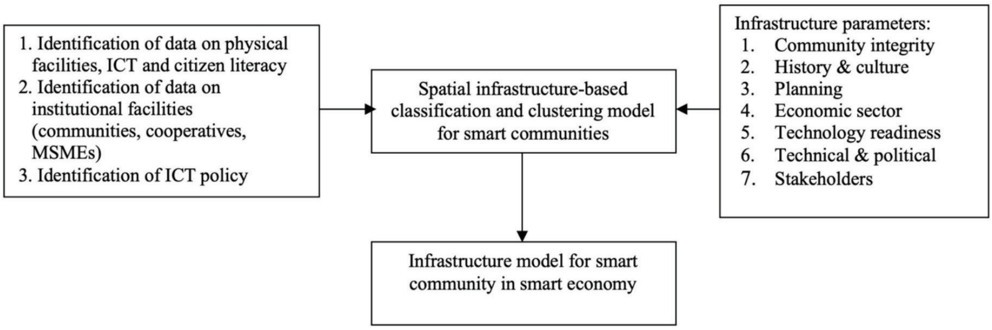

Figure 4: Research framework

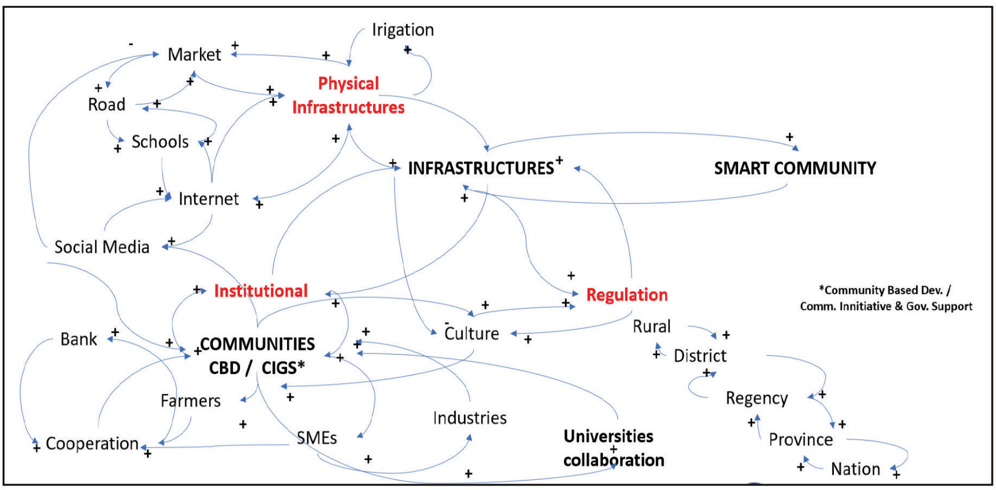

Figure 5: Causal Loop Diagram (CLD)

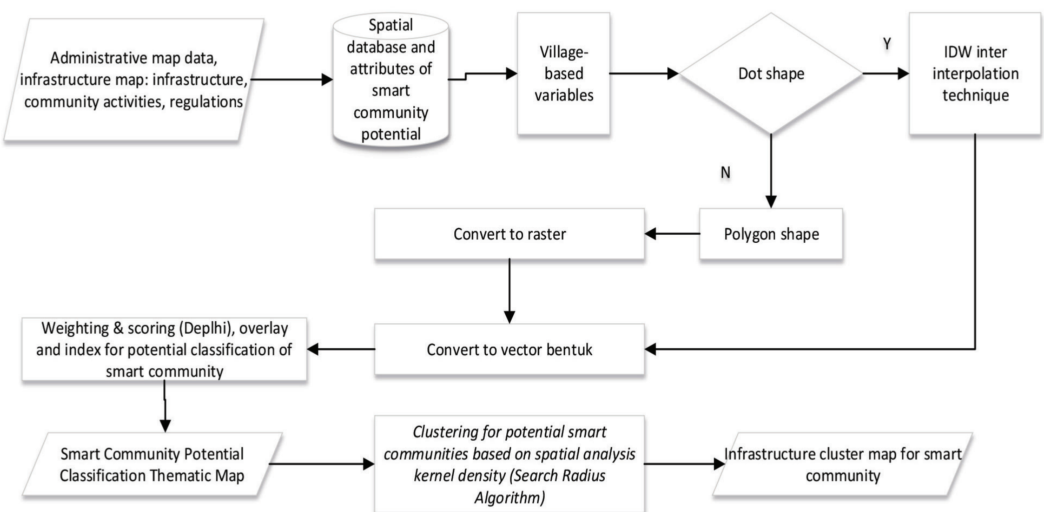

Figure 6: Detail of research stages

steps are what need to be taken in order to get an idea of the spectrum of possible classifications for smart communities:

(1) Determination of the maximum value

Max value = The highest value on variable$_1$ + The highest value on variable$_2$ +....+ The highest value on variable$_{14}$ (1)

(2) Determination of the minimum value

Min value = The Lowest value on variable$_1$ + The Lowest value on variable$_2$ +....+ The lowlest value on variable$_{14}$ (2)

(3) Determination of Interval Class (IC)

$$IC = \frac{Max\ value - Min\ value}{Number\ of\ classes} \quad (3)$$

(4) Determination of range in each class

(a) Border of the lower class "quite potential" = Min value (4)

(b) Border of upper class "quite potential" = Min value + IC – Min weight (5)

(c) Border of upper class "potential" = (Border of upper class "quite potential" + 0.01) + IC – Min Weight (6)

(d) Border of lower class "very potential" = Border of upper class "potential" + 0,01 (7)

(e) Border of upper class "very potential" = Max value (8)

Results and Discussion

Score, weight and index of smart community classification model in the smart economy – smart village

We decided to conduct our research in the Kabandungan Sub-district of the Sukabumi Regency in the West Java Province of Indonesia (Tosida *et al.,* 2022a). This sub-district serves as a pilot project for the establishment of smart villages. Figure 7 depicts the location of the research, and Figure 8 presents a map illustrating the distribution of the various types of infrastructure. The scores and weights for the infrastructure model variables for smart communities are displayed in Table 1 as a consequence of the findings of the score and weighting measures that were carried out using the Delphi technique. Smart village development

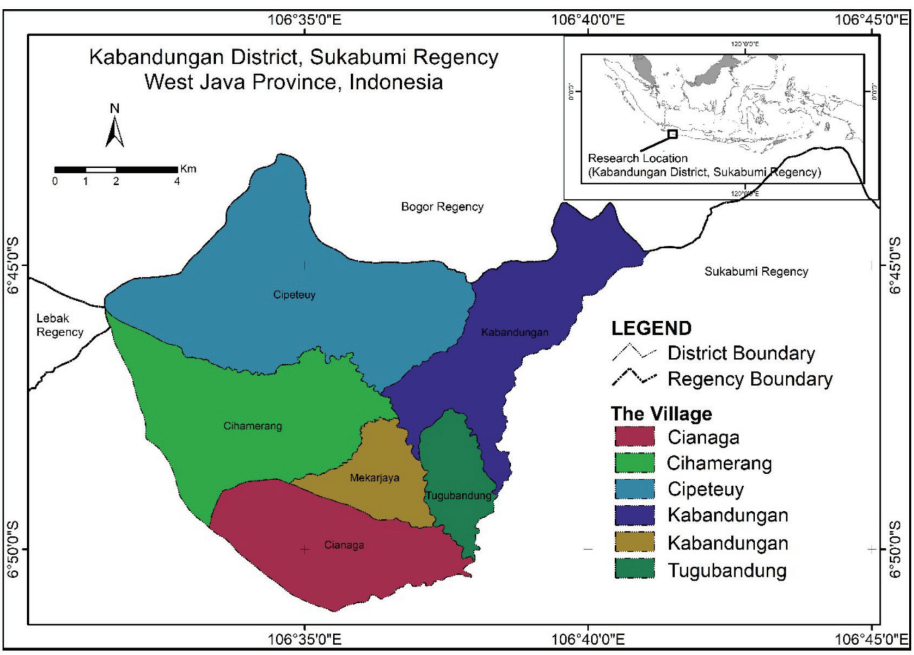

Figure 7: Research location map

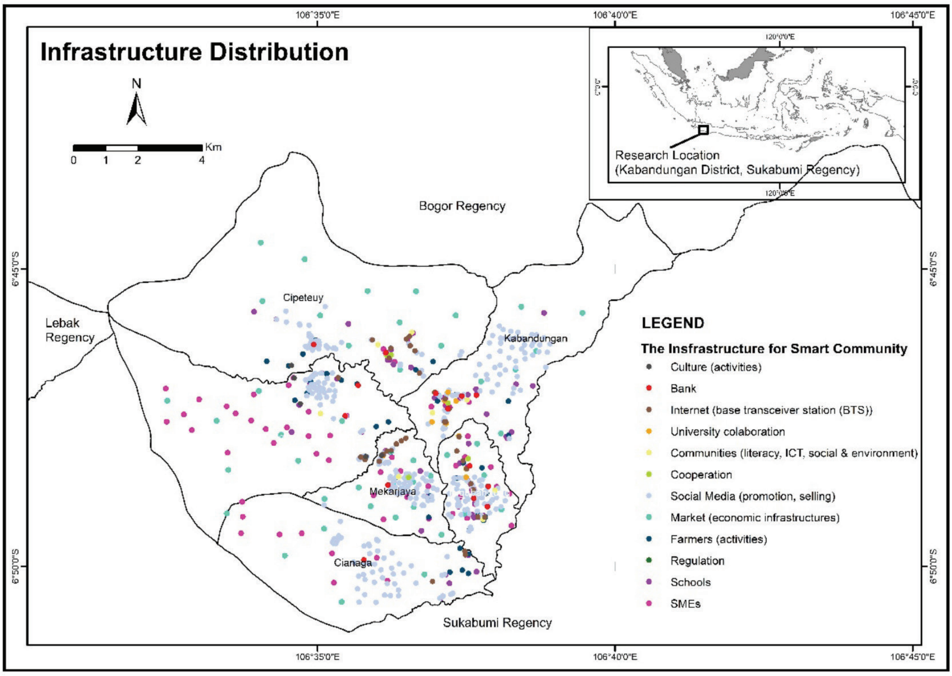

Figure 8: Infrastructure distribution map

projects, especially the smart economy in Kabandungan Sub-district, Sukabumi Regency, West Java Province, Indonesia, refers to (Tosida *et al.,* 2022a), which demonstrates that a village community known as the Kabandungan Youth Community (Kompak) is capable of innovating to build village internet networks independently. To facilitate the management of Internet Service Providers (ISPs), Kompak established a cooperative in Indonesia known as Cooperative Rukun Tetangga-Rukun Warga (RT RW) Net Indonesia. Citizens and young people who are actively empowering their communities and who have been formally inaugurated as a Community Information Community (KIM) by the local administration of the Sukabumi Regency in 2021 make up the cooperative's membership.

Since 2019, Kompak's activities have increased as a result of receiving direction from academics at the Institut Pertanian Bogor (IPB), also known as the Bogor Agriculture Institute and now known as IPB University. This was done in collaboration with the local government of the Sukabumi Regency in order to strengthen the personalities and capabilities of Kompak members. One of Kompak's many accomplishments is the expansion of their firm into the production of hand-built Uninterrupted Power Supplies (UPS), where the power comes from recycled batteries from old cell phones. Kompak has also been successful in enabling women and young people to become internet resellers, which will lead to an improvement in the economy of the surrounding community as a direct result of the growth in the number of ISP enterprises. Village internet coverage, which at first only covered six villages in the Kabandungan Sub-district, has now expanded to additional sub-districts that are located in the area surrounding the Kabandungan Sub-district. (Phahlamohlaka *et al.,* 2014; Sutriadi 2018; Adi & Heripracoyo 2018) It is envisaged that the strengthening of Kompak's capabilities will rise if it is integrated through an infrastructure model for smart communities.

The experts have come to a consensus on the 14 infrastructure factors that are included in Table 1. These variables were acquired from the

Table 1: Variables scores and weights of infrastructure dynamic spatial model of smart community potencies

No	Variables	Score			Weight
		3	2	1	
1	Market (economic infrastructure)	> 10 units	6-10 units	< 6 units	0.05
2	Road length (km), Local 60%; Other road 30%; footpath 10%	> 30.00	>10.00	< 10.00	0.05
3	Schools	> 7 units	5-7 units	< 5 units	0.05
4	Internet [*base transceiver station* (BTS) and *optical distribution point* (ODP)]	> 7, > 90% coverage	3-7, 50-90% coverage	< 3, < 50% coverage	0.10
5	Media sosial – promotion, selling	> 30% sampel	20-30% sampel	< 20% sampel	0.10
6	Irigations / Rivers (km)	< 100	100-250	> 250	0.04
7	Bank	> 3 unit	2-3 unit	< 2 unit	0.05
8	Cooperation	2-3 unit	1-2 unit	0 unit	0.07
9	Farmers (activities and land cover)	land cover = ricefield	Land cover = gardens, fields	Land cover = others	0.10
10	SMEs (activities)	> 20 unit & active	10-20 unit & active	< 10 unit	0.09
11	Communities (literacy, ICT, social & environment)	> 3 unit & active	2-3 unit & active	< 2 unit	0.15
12	Culture (activities)	> 1 unit & active	1 unit & active	< 1 unit	0.05
13	University colaboration (implementatif)	> 1 unit & active	1 unit & active	< 1 unit	0.05
14	Regulation (unit & impact)	> 3 dan impact > 1%	2 dan impact 0.5-1%	1 dan impact < 0.5%	0.05

findings of an SLR elaboration that was related to the ability of smart communities to develop a sustainable smart economy in the setting of a smart village. The outcomes of the process of establishing scores and weights for each selected variable using the Delphi method are also shown in Table 1. This procedure was carried out by five professionals and involved the use of the table. The state of the infrastructure that already exists at the place of the research is taken into account throughout the procedure of calculating scores and weights. After receiving scores and weightings from each expert, the research team engages in discussion with the experts in order to arrive at a consensus regarding the scores and weightings. One represents the overall weight value for all 14 variables. The process of obtaining the classification of the smart economy potential for each town may be summarised in Table 1, which serves as the fundamental standard for the exercise. The process of obtaining the classification of the smart economy potential for each town may be summarised in Table 1, which serves as the fundamental standard for the exercise. Equations 1 through 8 will be used in the subsequent stage of the classification process for the potential of infrastructure-based smart communities.

According to this model, it is possible to expand the benefits to other villages, thereby establishing smart economies or smart villages throughout the West Java region or other parts of Indonesia that possess similar characteristics and resources as this specific area (Sutriadi 2018; Chen *et al.* 2018). The Causal Loop Diagram (CLD) is used to carry out the initial approach to the model. Following this, the Delphi method is used to have five specialists who have been involved in the cooperation model provide weighting and scoring. The results of the weighting are used to classify the potential of smart communities for the smart economy. This classification is accomplished by an overlay process consisting of 14 variables, and it is continued by determining class intervals through the use of frequency distribution techniques. Kernel density clustering was the methodology that was utilised in Mora-Garcia *et al.* (2015) investigation of the potential for smart communities to contribute to the development of a smart economy.

Classification of Spatial-Based Smart Community

Figures 9.1 through 9.5 illustrate the dynamic spatial model of the infrastructure that could be used in smart communities in the future. According to Figure 9, the dynamics of potential smart communities are heavily influenced by community activities, which are the initiators and executors of economic-based digital innovations. This conclusion may be drawn from the fact that potential smart communities can become smart. Interviews conducted on the ground with various stakeholders were used to validate this approach. For instance, the smart community class level was reduced in Cihamerang Village in 2020 despite the fact that it had been a possible class in 2018-2019. This change occurred in the year 2020. The results of the field validation showed that one of the extremely active communities in Cihamerang Village went through a change in management, which led to a decline in the activities that took place in the community. This situation affects the economic downturn that is related to citizens' participation in communal activities.

Model Cluster Potential Smart Community

Clustering the potential of smart communities with the help of a density kernel was used in a more in-depth assessment of the potential of smart communities for the smart economy (Mora-Garcia *et al.* 2015), and the findings are displayed in Figure 10. According to the findings of the survey of potential smart communities, the Tugubandung Village area has greater potential

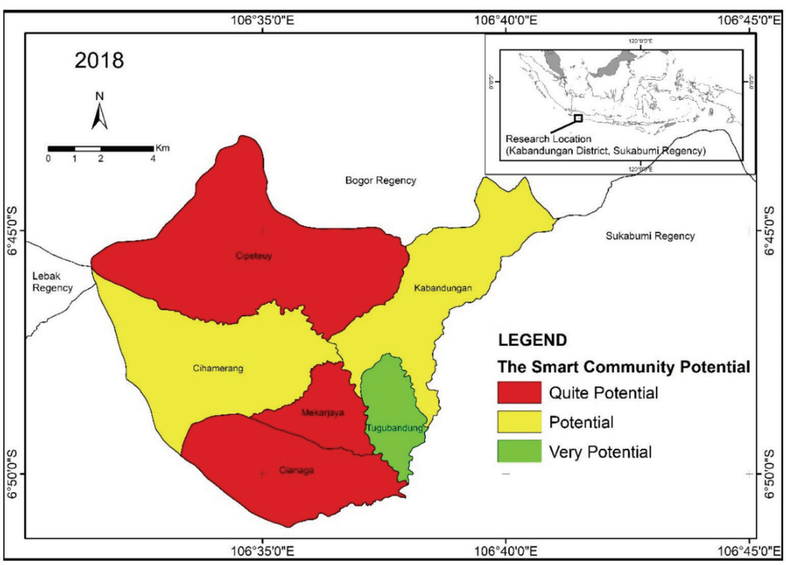

Figure 9.1: Infrastructure dynamic spatial model of *smart community* potencies in 2018

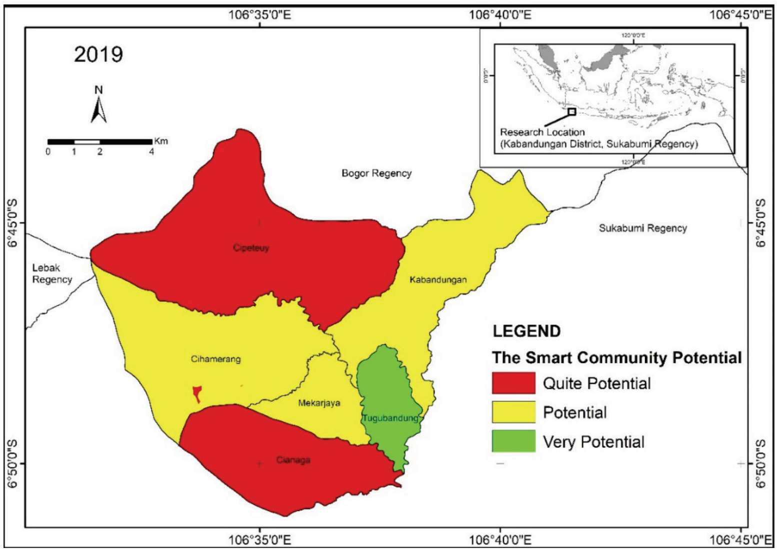

Figure 9.2: Infrastructure dynamic spatial model of *smart community* potencies in 2019

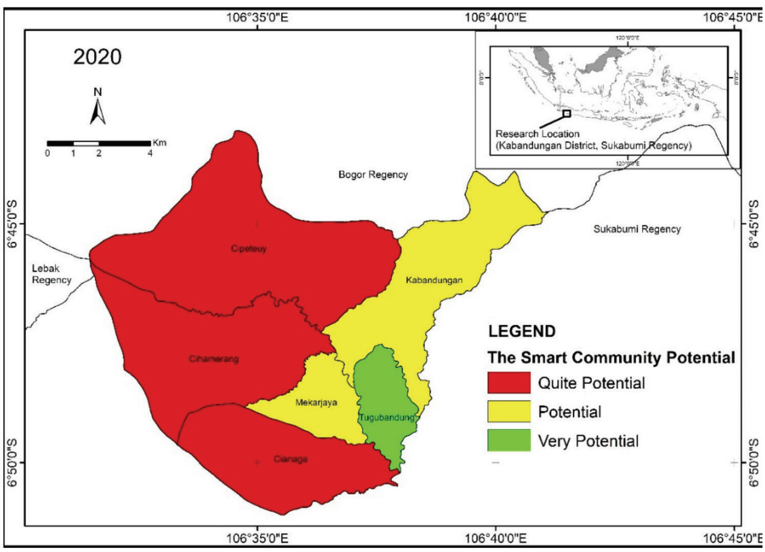

Figure 9.3: Infrastructure dynamic spatial model of *smart community* potencies in 2020

concentrated in the middle of the village area. This potential is spread out equitably. This is in line with the fact that there are community activity centres based on information and communications technology, which are able to innovate while also enhancing the income of local citizens. On the village, internet connection is where Mekarjaya, Kabandungan, and Cipeuteuy might potentially have a position for themselves as smart villages.

It is possible to validate the location of the potential smart community cluster for the smart economy by using the financial values of the villages, as illustrated in Figure 11. The pattern of distribution of smart community clusters corresponds with the pattern of distribution

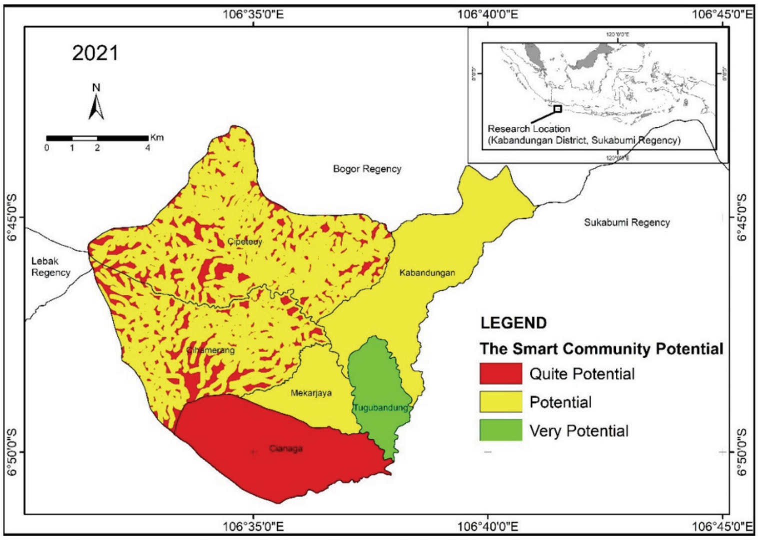

Figure 9.4: Infrastructure dynamic spatial model of *smart community* potencies in 2021

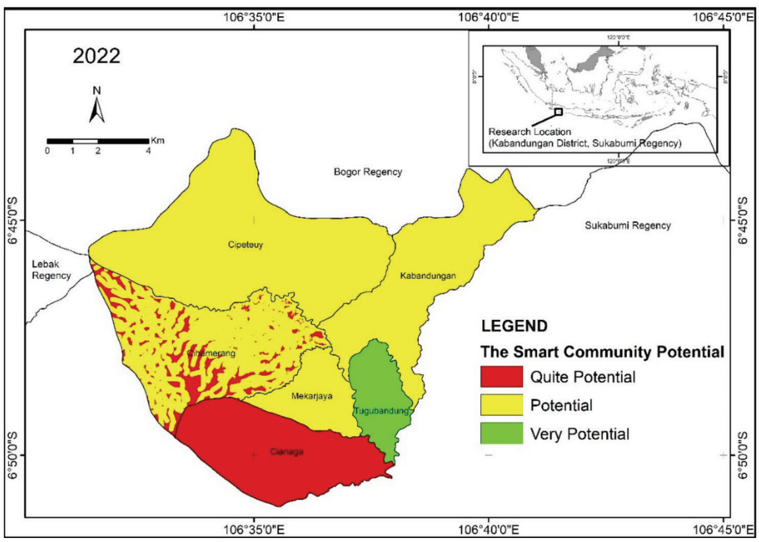

Figure 9.5: Infrastructure dynamic spatial model of *smart community* potencies in 2022

of village internet locations operated by the RT RW Net Cooperative, which is centred in Tugubandung Village. This helps farmer capital and MSEs. In the villages of Cipeuteuy, Mekarjaya, and Kabandungan, there are smart community cluster locations that also show farmer group activities that synergise with the literacy community and contribute to helping market products through social media. This is in accordance with research (Anderson *et al.*, 2017; Beza *et al.,* 2017; Suriandjo *et al.,* 2023). Smart community cluster locations show farmer group activities that synergise with the literacy community and contribute to helping market products through social media. Through the revitalisation of the healthy internet greeting village program, this community is predominately made up of high school students or equivalents who receive training in capacity and character strengthening as a form of

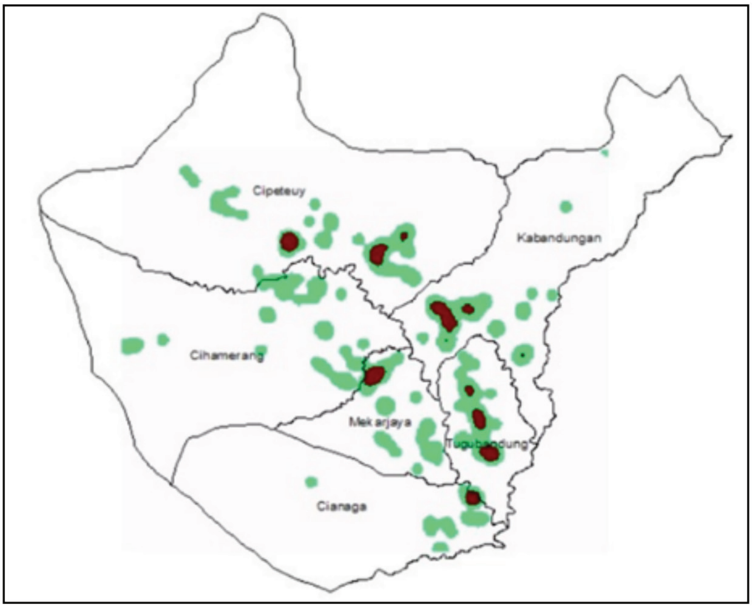

Figure 10: Spatial-based cluster model of smart community potencies

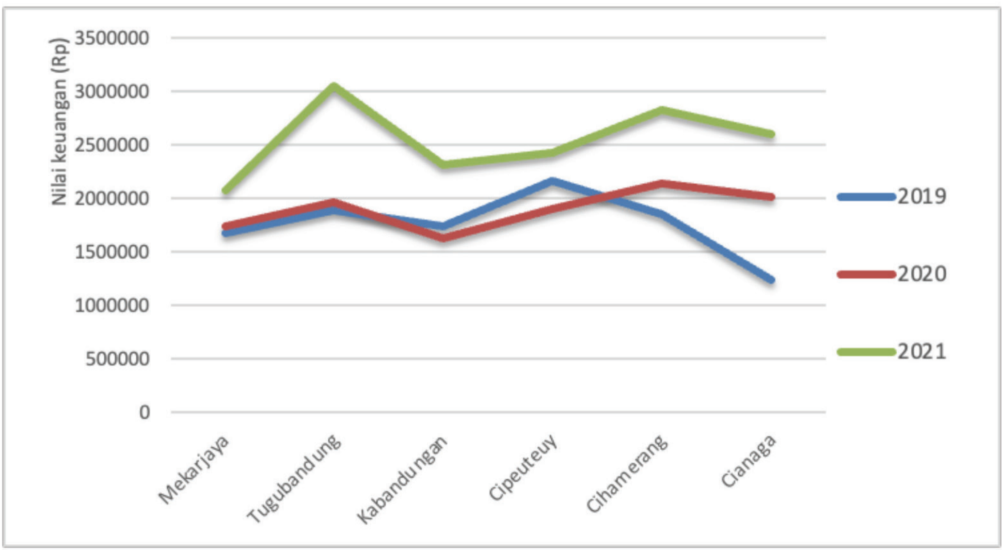

Figure 11: Village's financial value

community collaboration from universities, the Communications and Information Office, and the Ministry of Communication and Information (Tosida *et al.,* 2022a). Other participants include the Communications and Information Office and the Ministry of Communication and Information.

Conclusion

Through the utilisation of dynamic spatial analysis and Causal Loop Diagram (CLD), an effective infrastructure model for the smart community's potential has been developed. The outcome of the infrastructure classification model is the identification of three distinct classes of smart communities, namely, extremely prospective, potential, and less potential. The dynamics of the potential for smart communities are greatly influenced by the activities that take place inside the community of the village. An investigation into greater detail, utilising the prospective smart community clustering concept. The placement of potential smart communities is in close proximity to community activities that are based on digital innovation. These activities can contribute to boosting the economy as well as the literacy of residents. Field surveys and an analysis of the economic dynamics of the village are used to validate the infrastructure model for possible smart communities. The potential of a smart community can forecast, on the basis of the infrastructure model, the village's ability to generate community activities in order to stimulate the attainment of a smart economy. This allows for the potential of a smart community to be utilised.

This research still has deficiencies in terms of predicting the potential level of smart communities in the coming year. Therefore, this research can be continued by predicting the potential level of smart communities through a spatial dynamic simulation approach. This approach can be carried out by adding intervention scenario patterns to the variables of the infrastructure model for the potential of smart communities to build a smart economy.

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Conflict of Interest

All authors declared that they have no conflicts of interest.

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