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Spatial Analysis of Socio-Economic Vulnerability in COVID-19 Handling: Strategies for the Development of Smart Society and Smart Economy

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Abstract: Sleman Regency has always had an increasing and highest rate of COVID-19 cases in the Special Region of Yogyakarta, Indonesia. One of the implementations of a smart city in some cities and regencies is an appropriate strategy in handling the COVID-19 pandemic. This study aims to analyze the level of socio-economic vulnerability during the COVID-19 pandemic, compile a village typology based on the level of vulnerability, and explore the strategies of smart society and smart economy in handling COVID-19. This study used a mixed method with a sequential explanatory design. The results show that the high level of socio-economic vulnerability can be found in urban areas, while the low and moderate ones dominate in rural areas or the northern region of Sleman Regency. The pattern of socio-economic vulnerability levels is clustered, resulting in eight village typologies. The COVID-19 handling through a smart society and smart economy does not spatially consider aspects of socio-economic vulnerability, but implicitly adjusts the needs and problems of the community. Strategies for managing socio-economic vulnerabilities during the COVID-19 pandemic in the implementation of smart society and smart economy are bringing services closer to the community, shifting services to digital, increasing application features, and increasing community capacity through training.

Keywords: spatial analysis; socio-economic; vulnerabilities; COVID-19; smart society; smart economy

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1. Introduction

Socio-economic conditions and the population of Sleman Regency indicate a high potential risk of COVID-19 transmission. In terms of disaster risk reduction, COVID-19 is considered a threat, while the vulnerability category is associated with physical or mental limitations, for example, people of unproductive age and congenital diseases as well as people with financial limitations suffering from a socio-economic crisis [1]. These elements of vulnerability can interact with others and show different spatial scales and even have a correlation between regions. This shows that each area may need different risk management depending on the regional conditions and needs. Local government efforts in integrating disaster management with regional development planning require relevant data to understand the economic, social, health, education, and cultural environment in the context of identifying disaster vulnerability. Thus, knowledge development is needed by stakeholders, including government at all levels from national to local, community, private, and volunteers [2].

Vulnerability is a measure of the future damage effects of a hazard [3]. Based on this definition, vulnerability has a dynamic nature which means that it is related to space and

time; if a hazard is a phenomenon or condition that is difficult to change, the community's vulnerability will be more likely to change. The components of vulnerability to a threat cover adaptive capacity, sensitivity, and exposure [4]. Adaptive capacity is the potential possessed by the region, system, and society to face change. Sensitivity determines the extent to which the system will be susceptible to external conditions. Meanwhile, exposure is related to phenomena that can pose a danger as it poses a risk to the surrounding environment.

During the COVID-19 pandemic, the use of information and communication technology is increasing due to physical restrictions [5]. Mitigation efforts are carried out by limiting community mobility, such as through the Work-From-Home (WFH) policy. This policy needs to be applied especially in the areas with high exposure and sensitivity. The working from home policy reduces crowds in urban areas and affects regional movement patterns [6]. However, it needs to be supported by the availability of Internet access and an adequate understanding of ICT.

Understanding the concept of smart cities is needed to answer to limited resources in carrying out emergency responses. This is done to meet needs and solve problems, so it requires a special mechanism. The implementation of smart cities in various cities can help deal with COVID-19, because the role of technology will encourage transparency and maximize public safety in the health sector [7]. The smart city concept can anticipate and handle every problem that is present, not only utilizing technology but also requiring full understanding from the community and the government [8]. Based on this explanation, it can be seen that the concept of a smart city is not only about technology but also the use of innovations that can solve a problem in an area effectively and efficiently.

The COVID-19 pandemic, which is inseparable from the role of ICT, is in line with the smart city concept in which the use of technology can assist regions in meeting the needs of the community in terms of education, economy, and health services. Sleman Regency is one of the regions in the Special Region of Yogyakarta that has implemented the smart city concept since 2017 or in the first phase guided by the Ministry of Communication and Information. The implementation of a smart city by involving many sectors has the potential to increase the strength of Sleman Regency in dealing with the COVID-19 pandemic; for example, the recovery rate of sufferers is the highest in this province. This supports disaster management for handling COVID-19 because it is one of the problems faced by the government and requires integrated efforts of private companies, organizations, and communities [9].

There are six dimensions of the smart city concept applied by Sleman Regency and some of the dimensions closely related to socio-economic vulnerability is the dimensions of smart society and smart economy. The smart society dimension aims to give every individual the right to access to education supported by digital learning facilities. This dimension explains community protection by reducing disaster risk for the community which can then increase individual safety. Smart society covers community (community development), learning (education system development), and security (guaranteed community safety and security) [10].

Smart economy is a dimension that can create an economic system built by the appropriate industrial ecosystem to improve people's welfare and prepare an easy and convenient transaction facility. The smart economy consists of factors affecting economic competitiveness by utilizing innovation. Therefore, economic productivity increases and provides employment opportunities and market integration. Implementation of the smart economy in Indonesia applies ICT in e-commerce and uses a virtual space for Small and Medium Enterprises (SMEs) activities [11]. Thus, it can increase welfare and promote local products [11]. The dimensions of smart society and economy have an inverse direction with socio-economic vulnerability as it leads to efforts to increase adaptation and community capacity.

Aspects of concern (priority) in handling the COVID-19 pandemic are health and the economy, as an effort to reduce risks. This is contained in the smart society and smart

economy, which has a direction that is inversely proportional to socio-economic vulnerability or leads to efforts to increase community adaptation and capacity. Vulnerability analysis can be carried out to reduce disaster risk, so that capacity and social capital can be increased. This is in line with the concept of smart society and smart economy because both dimensions are related to the development of a society that is smart, innovative, creative, productive, and able to take advantage of existing potential and technology, thus supporting the success of a smart city in an area.

Spatial analysis can help to identify patterns to carry out spatial and regional analysis that has been widely carried out in various fields, one of which is in dealing with health problems. Based on the characteristics of COVID-19, it is necessary to conduct spatial analysis for epidemiology. Spatial analysis can to answer the tendency of the disease to occur and analyze visible patterns [12]. Currently, every region in Indonesia has conducted a spatial analysis to determine the distribution of the spread of COVID-19. One of them is Sleman Regency, which has created a COVID-19 (covidtracer.slemankab.go.id) information dashboard for public transparency regarding the development of cases so that the public can monitor. Spatial pattern analysis will assist researchers in analyzing geographical phenomena, namely the level of distribution of COVID-19 sufferers and the distribution of socio-economic vulnerability levels. Spatial statistics will be used as a tool to analyze spatial patterns to compare the patterns of objects in each area. Based on this, with the condition of Sleman Regency as an area that has the highest number of COVID-19 cases in the Special Region of Yogyakarta and the potential for smart city implementation that has been implemented since 2020, it would be more appropriate to map the distribution patterns of COVID-19 sufferers and the level of vulnerability, so that it can be known which areas have a concentrated distribution to make it easier for local governments to handle.

Based on the condition of Sleman Regency, spatial analysis is needed to map socio-economic threats and vulnerabilities during the COVID-19 pandemic as well as the appropriate handling strategies. The appropriate handling of the COVID-19 pandemic is affected by regional readiness such as socio-economic factors and population development [13]. Spatial analysis is carried out to consider areas with higher risks to be prioritized and prepared for disaster risk reduction. Efforts to develop a smart society and smart economy can be a form of risk reduction that covers programs and strategies for handling socio-economic vulnerabilities during the COVID-19 pandemic so that the accuracy of strategies for target groups, the synergy between stakeholders, and the correlation between regions can be observed. Therefore, this study has three objectives, namely, to analyze the level of socio-economic vulnerability, to compile village typologies based on the spatial pattern of socio-economic vulnerability, and to explore the strategies of smart society and smart economy in managing socio-economic vulnerabilities during the COVID-19 pandemic.

2. Materials and Methods

This study used a mixed method (quantitative and qualitative) with a sequential explanatory design. A mixed methos used two or more methods with different approaches, such as qualitative and quantitative approaches to obtain data to answer the problems [14]. The data used for quantitative analysis are secondary data obtained from several documents and government agencies. Data from quantitative and qualitative approaches use a connecting combination that connects the results of the first approach, namely quantitative, and the next approach, namely qualitative [15].

The quantitative approach was carried out for the first and second objectives, namely, to analyze the level of socio-economic vulnerability and to compile village typologies based on the spatial pattern of socio-economic vulnerability. In the early stages after secondary data collection, researchers sorted out the data and conducted the best classification test. The best classification test can group data that were originally ratio-scaled into ordinals based on their level. The second stage is a Spearman rank correlation test using IBM Statistics 23 software to assist researchers in determining intervariable dependence,

namely COVID-19 patients who are confirmed in each village as bound variables and indicators of socio-economic vulnerability (population density, incoming migration, people with disabilities, malnutrition, under-five population, non-productive age population, poor households, residents with jobs in the informal sector, health facilities, health workers, and residents with the last education above high school) as a free variable. The third stage is vulnerability analysis which begins with the process of scoring each variable that has a statistical relationship value. After providing a score (rating), spatial analysis is carried out with overlay using ArcMap 10.3 software (ESRI company, Redlands, CA, USA). The overlapping process in question is to sum the scores of each variable grouped based on vulnerability aspects, namely exposure, sensitivity, and adaptive capacity. The fourth stage is spatial autocorrelation analysis with the concept of contiguity edges corners in ArcGIS software, resulting in Moran index values and LISA spatial autocorrelation. The proposed spatial hypothesis with Moran's index autocorrelation can be seen below:
Hypothesis 0 (H0): $I = 0$, *means that there is no autocorrelation between locations.*
Hypothesis 1 (H1): $I > 0$, *means that there is a positive spatial autocorrelation.*
Hypothesis 1 (H1): $I < 0$, *means that there is a negative spatial autocorrelation.*

H0 is rejected if the value of $|Z(I)| > Z(\alpha/2)$ or $|Z(I)| < -Z(\alpha/2)$, meaning that there is a spatial autocorrelation. Spatial autocorrelation is a part of spatial analysis focusing on exploring patterns and attributes in regional studies using a certain model [16]. Spatial autocorrelation is positive if the observation locations are close and the values of the related variables form a pattern. Meanwhile, spatial autocorrelation can be negative if the observation locations are close but the values of the variables tend to be different [17]. The results of spatial autocorrelation testing will help in analyzing spatial correlations between villages and compiling village typologies based on the level of socio-economic vulnerability.

Moreover, the qualitative approach was used for the third objective, namely to explore the strategy of the smart society and smart economy dimensions in managing socio-economic vulnerabilities during the COVID-19 pandemic using exploratory descriptive analysis. The results of quantitative processing become the material for data collection which is carried out purposively. The results of the village typology based on the level of vulnerability can be material for in-depth interviews to further explore and expand information. When quantitative and qualitative data were obtained, the two data groups were reanalyzed by combining similar data, comparing the two data and descriptive-exploratory approaches, so that the two datasets complemented each other. Qualitative data analysis in the third objective was carried out in an exploratory descriptive manner which began with the national policy of handling COVID-19 and then lowered by the Sleman Regency Government into several legal products of the handling program. The implementation of these legal products is manifested in the handling of the economy (social assistance) and health to a report made by the Regional Finance and Assets Agency (BKAD). The data were combined with the results of the revised data of the 2020 Sleman Smart City Masterplan from the Communication and Informatics Service (Diskominfo). After the program data were collected, the researcher selected programs that intersected from the two sources and then grouped them based on the dimensions of smart society and smart economy which played a role in recovery from the impact of COVID-19.

The approach to this study explores information related to problems and handling strategies that occur. After an in-depth interview, the researcher conducted a data transcript and credibility testing. Credibility testing in this study used source triangulation. This was done to see the data obtained from several informants to be described and categorized to get conclusions from the information.

3. Results

3.1. Socio-Economic Vulnerability during the COVID-19 Pandemic

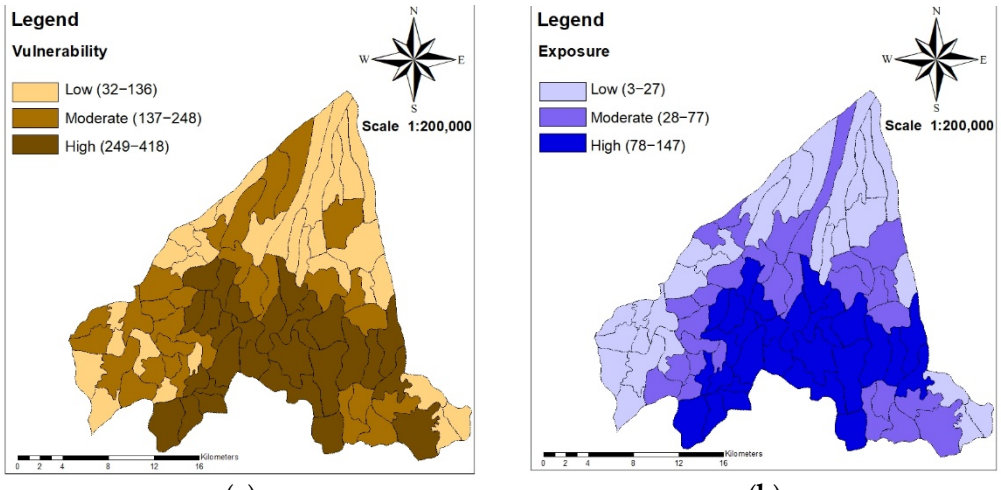
3.1.1. Rank Spearman Correlation Test

The results of the test show that almost all independent variables, namely population density, immigration, people with disabilities, people with malnutrition, under-five children population, non-productive age population, poor households, residents with jobs in the informal sector, health facilities, health workers, and people with the high school education, and higher, have a relationship with the dependent variable of the number of con-firmed COVID-19 cases. However, one variable does not have a relationship, namely the disability variable. The correlation coefficient value shows that almost all variables have a fairly strong to very strong relationship level as the obtained value is higher than 0.5. However, the disability variable has a value of 0.071 which has a very low interpretation, so it is closer to the absence of a relationship. In some studies, people with disabilities are considered vulnerable to COVID-19 as they find it difficult to recover due to the limitations of their condition [18].

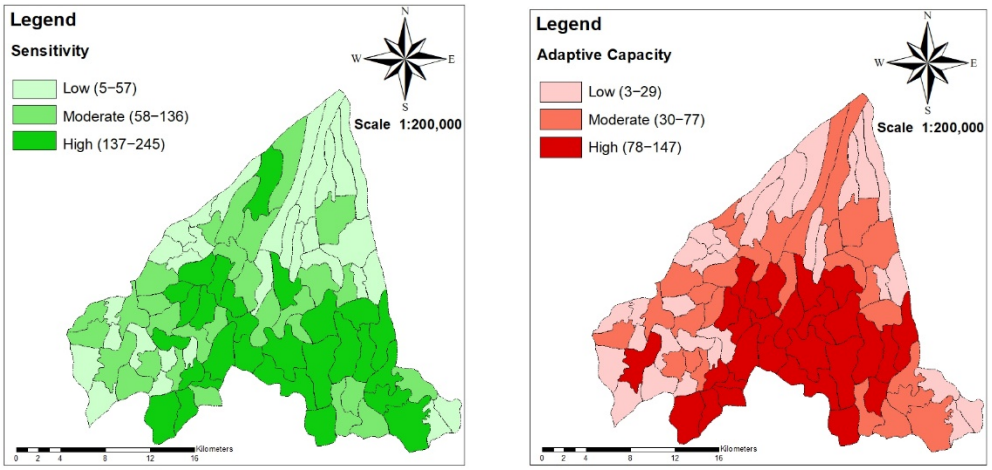
The value of the correlation coefficient shows positive values, meaning that the dependent and independent variables have the same direction. If the number of confirmed COVID-19 cases in a certain village is higher, then, it will be followed by an indicator of higher socio-economic vulnerability. The correlation coefficient value close to 1 indicates a very strong level of relationship [19]. The number of population variables and education levels higher than senior high school is the most correlated due to obtaining a value of 0.817. Education is one indicator of poverty, so if the population in certain areas has a low education level, it will affect their social vulnerability [20]

3.1.2. Mapping of Socio-Economic Vulnerability during the COVID-19 Pandemic

Figure 1 shows the socio-economic vulnerability map obtained from the overlapping process of exposure, sensitivity, and adaptive capacity maps. The results show that villages in urban areas have a high level of exposure, sensitivity, and adaptive capacity, but the vulnerability value will also be high as the role of the exposure and sensitivity components are stronger than the adaptive capacity components in building socio-economic vulnerability in Sleman Regency. If the map of sensitivity, exposure, adaptive capacity, and socio-economic vulnerability is pasted, it shows that some villages have a low level of adaptive capacity with a high level of exposure or sensitivity. The high level of vulnerability occurs due to higher sensitivity than adaptive capacity [21]. Some of the villages are Wonokerto, Margoluwih, and Tirtoadi villages. Even though they are outside the urban areas, the increasing threat of the COVID-19 pandemic makes people's conditions more vulnerable.



(**a**) (**b**)



(**c**) (**d**)

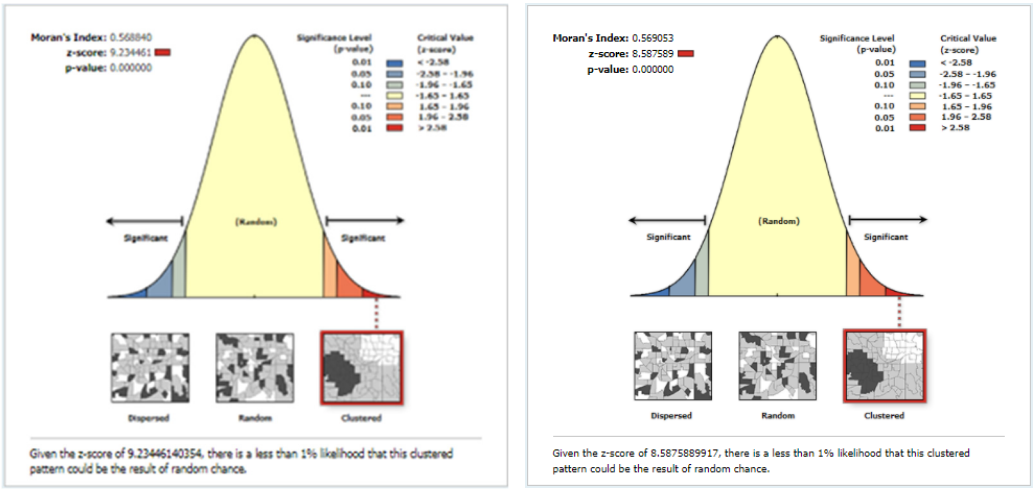
Figure 1. Socio-economic vulnerability map in 2020: (**a**) Vulnerability map; (**b**) exposure map; (**c**) sensitivity map; (**d**) adaptive capacity map (Source: Results of secondary data processing, 2020).

3.2. Village Typology Based on Spatial Patterns of Socio-Economic Vulnerability

3.2.1. Spatial Patterns of COVID-19 Cases and Socio-Economic Vulnerability during the COVID-19 Pandemic

Moran's index (I) value shows a positive autocorrelation. Figure 2 shows the results of the spatial autocorrelation analysis of confirmed COVID-19 cases and the level of socio-economic vulnerability in Sleman Regency in 2020. The results of the autocorrelation of COVID-19 cases show that the z-score or z-count is 9.23, so z-count > z-table, meaning that H0 is rejected. This indicates that there is a spatial autocorrelation between villages. Meanwhile, the results of the spatial autocorrelation of socio-economic vulnerability show that the z-score or z-count is 8.587, so z count > z table, meaning that H0 is rejected which indicates there is a spatial autocorrelation between villages.

p-value can also answer the hypothesis in that if the *p*-value is lower than α, then H0 is rejected. The results show that the *p*-value is 0 < 0.01, so H0 is rejected. This indicates that there is a spatial autocorrelation between villages in Sleman Regency. Moran's index value is 0.568 which means that there is a positive spatial autocorrelation of confirmed COVID-19 cases in 2020 in this regency. Then, for vulnerability, Moran's value of 0.569 is close to +1. It means that there is a positive spatial autocorrelation on socio-economic vulnerability during the COVID-19 pandemic in 2020 in this regency. Positive autocorrelation indicates a clustered pattern which means that adjacent areas or villages have the same characteristics of socio-economic vulnerability.



(**a**) (**b**)

Figure 2. Results of ArcGIS Moran's I spatial autocorrelation: (**a**) Confirmed COVID-19 cases; (**b**) socio-economic vulnerability (Source: Results of secondary data processing, 2020).

The use of Moran's index only represents the global spatial autocorrelation and does not provide information on certain areas. Therefore, Local Spatial Autocorrelation (LISA) testing is required. LISA values showing a significant autocorrelation with a 99% confidence level ($\alpha = 1\%$) were found in 16 villages with positive spatial autocorrelation values as the index shows positive results. These villages are Hargobinangun, Glagaharjo, Kepuharjo, Umbulharjo, Wukirsari, Argomulyo, Sariharjo, Sinduharjo, Minomartani, Condongcatur, Sinduadi, Maguwoharjo, Caturtunggal, Gayamharjo, Wukirharjo, and Sendangtirto villages. The positive autocorrelation value indicates a clustered pattern. Some villages have positive values, such as Condongcatur, Maguwoharjo, and Caturtunggal villages.

A higher value indicates a stronger positive autocorrelation. Thus, those villages have a strong interaction ability with other regions. Villages with a high level of local autocorrelation need more attention as high interactions can increase exposure. Although the adaptive capacity conditions in villages that have a positive autocorrelation are high, they can change over time.

3.2.2. Village Typology

The arrangement of the village typology used the results of the analysis of the socio-economic vulnerability level map and the grouping between villages presented with Moran's scatterplot. Thus, the relationship of the observed values in a village with the average observation value of neighboring villages can be identified. The results from Moran's scatterplot will assist in the interpretation of the relationship between standardized observation values and the weighting matrix [22]. Therefore, villages with a certain level of vulnerability and spatial autocorrelation with other areas can be identified. Figure 3 below shows Moran's scatterplot of data on the level of socio-economic vulnerability in Sleman Regency.

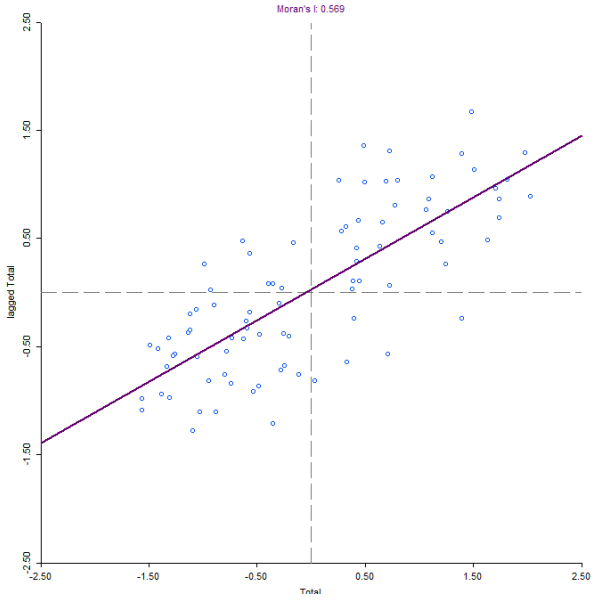


Figure 3. Moran's scatterplot of data on the level of socio-economic vulnerability (Source: Results of secondary data processing, 2020).

Figure 4 shows the results of the village typology based on the level of socio-economic vulnerability and the spatial pattern of Moran's scatterplot. Based on the typology, there are eight village groups: hierarchy I—high, hierarchy I—medium, hierarchy II—moderate, hierarchy II—low, hierarchy III—medium, hierarchy IV—high, and hierarchy IV—moderate. The hierarchy I—high is mostly found in Yogyakarta urban areas which form a clustered pattern. The high level of risk of transmission due to the activities of the surrounding community in these village groups requires a faster and more precise mitigation plan. Although the risk of exposure is high, these villages have a high adaptive capacity so efforts to implement mitigation will be easier. The mitigation covers the implementation of healthy living, health protocols, and socialization related to COVID-19 handling.

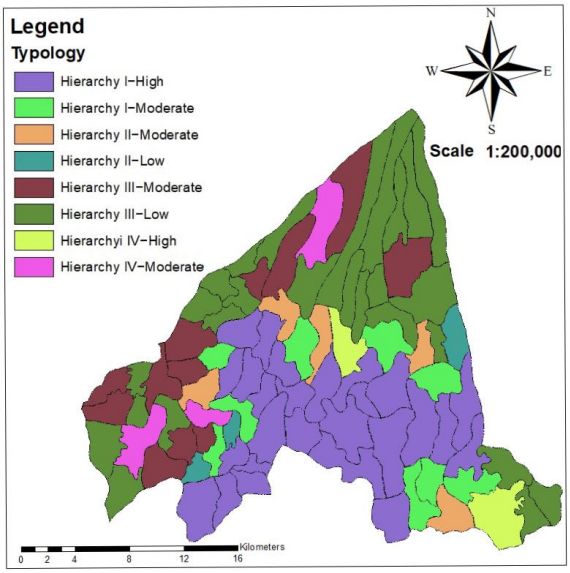


Figure 4. Village typology map based on socio-economic vulnerability level (Source: Results of secondary data processing, 2020).

Based on the village typology map, the village group with hierarchical criteria III—low, is on the north side of Sleman Regency. The characteristics of these villages have low observation values and are surrounded by low observation values. The observation value is the value of the surrounding vulnerability which is included in the low class. Based on the RTRW (Regional Spatial Plan) of Sleman Regency, the northern side of Sleman Regency is dominated by food crop agriculture and horticulture. Village groups in Hierarchy II need attention because they have low observation values, but the surrounding villages have high observation values. As Table 1 shows, those villages are Sidomulyo and Sidomoyo Villages which have moderate levels of exposure but low sensitivity and adaptive capacity. Priority in capacity building is needed for regions with these characteristics as moderate exposure conditions and surrounded by villages with high observation values can increase levels of exposure as they are affected by the surrounding area.

Table 1. Village typology based on socio-economic vulnerability levels and patterns.

Hierarchy	Vulnerability		
	High	**Moderate**	**Low**
Hierarchy I	Minomartani, Tlogoadi, Bokoharjo, Tridadi, Sariharjo, Banyuraden, Caturharjo, Sidoarum, Sinduharjo, Sendangadi, Tirtomartani, Nogotirto, Sinduadi, Ambarketawang, Triharjo, Margomulyo, Tamanmartani, Sumberadi, Maguwoharjo, Caturtunggal, Condongcatur, Balecatur, Trihanggo, Purwomartani, Wedomartani, Sendangtirto	Tegaltirto, Selomartani, Tirtoadi, Pandowoharjo, Margoagung, Sidokarto, Sukoharjo, Kalitirto, Madurejo	
Hierarchy II		Donoharjo, Trimulyo, Margodadi, Widodomartani, Jogotirto	Sidomulyo, Sindumartani, Sidomoyo
Hierarchy III		Girikerto, Margokaton, Sendangagung, Sendangmulyo, Banyurejo, Wukirsari, Sidoagung, Sendangrejo, Bangunkerto, Sumbersari, Sidoluhur, Margorejo	Kepuharjo, Umbulharjo, Wukirharjo, Sendangarum, Glagaharjo, Sendangsari, Sumberrahayu, Sumberrejo, Tambakrejo, Sambirejo, Sumberarum, Hargobinangun, Pakembinangun, Sidorejo, Pondokrejo, Argomulyo, Umbulmartani, Lumbungrejo, Purwobinangun, Bimomartani, Donokerto, Gayamharjo, Mororejo, Candibinangun, Harjobinangun, Merdikorejo
Hierarchy IV	Sumberharjo and Sardonoharjo	Sumberagung, Wonokerto, Margoluwih	

Source: Results of secondary data processing, 2020.

3.3. Strategy for Development of Smart Society and Smart Economy Dimensions in Handling COVID-19

The dimensions of the smart economy and smart society are closely related to efforts to increase community capacity in handling COVID-19. A community-based approach to recovery or reconstruction is more effective in the planning process as the target beneficiaries consider socio-economic vulnerability aspects so that it is in line with the problems and needs of vulnerable communities [23]. The Sleman Communications and Information Office provides ICT infrastructure in increasing community capacity in this regency by

building WiFi in 1212 hamlets as the realization of the vision and mission of the Head of Sleman Regency. Currently, six Wi-Fi networks have been installed in six hamlets in three villages. The hamlets are Gondangan, Kepitu, Karanglo, Cangkringan, Kliwang, and Jaranan which are located in Sardonoharjo, Trimulyo, and Argomulyo villages.

Another strategy implemented by the Sleman Regency Government in addressing socio-economic vulnerabilities is bringing services closer to the community (village level). Moreover, the provision of apps for social and economic activities was also realized through a smart society and smart economy. Table 2 presents the way in which the recovery effort in smart society and smart economy play a role in increasing the adaptive capacity of the community by minimizing the level of sensitivity and exposure so that the community is more capable of surviving the impact of the COVID-19 pandemic. Thus, the manifestations of the programs of these two dimensions tend to be related to adaptive capacity. The form of activities and applications of the smart society dimension cover providing a sense of security (security), forming interaction (community), and learning (learning). Meanwhile, the manifestation of the smart economy is increasing welfare (welfare), building ease of capital and transactions (transaction), and increasing competitiveness (industry).

Table 2. The relationship between socio-economic vulnerability components and the dimensions of smart society and smart economy.

Component of Socio-economic Vulnerability	Smart Society		Smart Economy
	Social Safety Net (JPS)	**Capacity Building and Increasing Access to Job Opportunities**	**Development of Cooperatives, Industry, and MSMEs**
Exposure	• JPS beneficiaries tend to be in areas with a high level of exposure, namely hierarchical typology I—high, only some are in Hierarchy III—low and Hierarchy IV—medium. • JPS plays a role in helping communities affected by the COVID-19 pandemic.	• This program can address the increasing unemployment rate. • Labor-intensive and regular non-institutional training participants are dominated in areas with high vulnerability and exposure, namely Hierarchy I—high, Hierarchy IV—high, and Hierarchy IV—moderate.	• This program responds to the increasing number of MSMEs and the declining turnover of MSMEs in areas with high exposure, namely in Hierarchies I and IV. • Cooperation with Go-Jek and Tiki facilitates public payments in buying MSME products (transactions) and reduces the risk of transmission due to reduced physical activity
Sensitivity	• JPS beneficiaries are dominated by poor households and informal workers. • JPS applicants have technological limitations.	• Groups that are socio-economically vulnerable, and also vulnerable to information. • Involve the village government in considering socio-economic vulnerable communities to be included in the training.	• Based on the mission of the 3rd RPJMD (Mid-term of Regional Development Planning) of Sleman Regency, namely strengthening the people's economic system, accessibility and people's economic capacity, and poverty alleviation. • New MSME actors need assistance because they are social, economic, and technologically vulnerable. • Provision of admin for each village and sub-district for vulnerable MSME actors can help in the registration in Satu Data UMKM apps. • MSME actors with limited capital can be assisted with low-interest loan facilities and BPUM which is a form of the financial ecosystem (transaction) because it provides access to capital for MSMEs.

Adaptive Capacity	• JPS education provides assistance in accessing formal and non-formal education (learning). • JPS Social and health provides access to emergency services for applicants who need protection from the impact of COVID-19 (security). • The JPS development strategy is to improve apps' features so that people can interact directly with admins from the Social Service. It is a form of forum for public participation and to realize efficient interaction (community). • Improvement initiatives by increasing the socialization of apps to Village Social Assistance Personnel (TPD), cadres, and sub-district officials who usually receive complaints directly from the community (community).	• Training activities involve active community participation in solving the problem of scarcity of masks and PPE, people who have lost their jobs, and people who are economically and technologically vulnerable related to the development of interaction (community). • Regular non-institutional training on the production of masks and PPE as well as Internet marketing to form a learning ecosystem. • Labor-intensive activities provide protection from economic impacts as they provide temporary income for affected communities (security).	• MSMEs get a higher level and young entrepreneurs' guidance in an effort to realize community welfare (welfare) by upholding community economic empowerment and employment. • Sleman Mart, virtual exhibitions, and business meeting activities can be an effort to create a competitive industry (industry). • Business meetings and virtual exhibitions are also the implementations of competitive network development.

Source: Results of in-depth interview data processing, 2020.

4. Discussion

Community behavior and social factors are factors related to the transmission of COVID-19 [24]. Therefore, it is necessary to identify the correlation between socio-economic indicators and the number of COVID-19 cases to have proper handling for each region. Connectivity analysis shows variables that have statistical significance. The nature of the COVID-19 pandemic, which can be correlated with all people, and all socio-economic sectors, rich and poor, all age groups, poses a real threat [25]. Therefore, the COVID-19 pandemic can be directly related to the community as the increasing community activity will have the potential for crowds and make it easier for transmission through droplets.

One of the variables included in the exposure aspect with a strong correlation is migration. It means that if an area or village has a high migration rate, it has the potential to have a high number of COVID-19 cases. Migration can increase the rate of COVID-19 [26]. It indicates that areas with high migration rates and COVID-19 cases will be more vulnerable as the migrating population is feared not to be able to adapt well to the destination or carry the virus. Variables of population aged under five and non-productive are included in the sensitivity aspect, which has a strong correlation with the number of COVID-19 cases. Non-productive age is a vulnerable category for COVID-19 as the immune system tends to decrease [27]. The variable of the population under five has a strong correlation with the number of COVID-19 cases which means that regions or villages with high COVID-19 cases also have a high population in children under five. The recovery rate for COVID-19 of children under five in Indonesia is 2.3% with a mortality rate of 0.9% [28].

Based on the map analysis, the level of socio-economic vulnerability during the COVID-19 pandemic forms a compact structure for high levels of vulnerability. Handling at each level of the vulnerability requires different types of handling and priorities. A high level of vulnerability can be a top priority for mitigating the social and economic impacts of the COVID-19 pandemic. Therefore, it is necessary to provide services and the role of the government to increase adaptive capacity. However, areas with low levels of adaptive capacity and high sensitivity or exposure need to get attention too as the increasing number of COVID-19 cases is dynamic and all individuals have the level of risk of transmission.

The socio-economic vulnerability in Sleman Regency needs to be considered to reduce the impact of the COVID-19 pandemic. Regional health and management issues should be linked to the concept of vulnerability that considers aspects of exposure, sensitivity, and adaptive capacity [29]. Vulnerabilities are aspects that can be managed rather than threats that are just triggering [30]. The socio-economic vulnerability map shows that the high level of vulnerability in the Sleman Regency is balanced with a high level of adaptive capacity. Thus, the community's ability to face the threat of the COVID-19 pandemic is better when compared to areas that have high vulnerability and low levels of adaptive capacity. General efforts made by the government are isolation, quarantine, physical distancing, and controlling the rate of community mobility [31].

Figure 2 shows a graph of Moran's index value with a positive autocorrelation. Thus, the socio-economic vulnerability in Sleman Regency has a clustered pattern. It means the surrounding areas have the same characteristics of socio-economic vulnerability. As presented in Figure 1, the level of socio-economic vulnerability in Sleman Regency tends to cluster and the highest value is near the Yogyakarta urban areas. Meanwhile, low vulnerability values tend to cluster on the northern side of Sleman Regency.

Villages that are grouped with similar characteristics at the level of socio-economic vulnerability need attention as they have interactions between regions that cause certain tendencies. As explained in the First Law of Geography, spatial effects are things that are closely related so that they have a relationship compared to those that are far apart [32]. It creates interactions between regions that will influence each other. Figure 4 shows that there is a high interaction, which can be considered in handling COVID-19. The orientation of policy strategies for handling COVID-19 requires spatially socio-economic vulnerability consideration to reduce the impact of the COVID-19 pandemic.

Spatial vulnerability management will prepare the region so that the government and society can face the threat of COVID-19. However, the socio-economic vulnerability can change dynamically as the social, economic, and population conditions of the community can be influenced by external and internal conditions. It is also supported by the nature of COVID-19 which can infect every individual without certain conditions so that every individual has the same opportunity to get infected. Although the analysis of socio-economic vulnerability during the COVID-19 pandemic in 2020 tends to be in Sleman Regency which is included in the Yogyakarta urban areas, handling and strengthening community capacity are also needed in the outside area.

The results show that LISA can estimate the distribution pattern of villages with clustered and adjacent vulnerability levels, so villages with clustered patterns can be identified well. Villages that do not show significant values are dominated by low levels of vulnerability. It shows that there is high activity in villages with positive autocorrelation so that they are interdependent between clustered villages. Hargobinangun and Wukirsari villages are located far from urban areas but have positive and significant autocorrelation values. These villages have the same low level of vulnerability and are close to a low level of vulnerability as the level of exposure and sensitivity in these areas is low.

The vulnerability values in the clustered village have similarities so that they can be the focus in handling COVID-19, which is adjusted to the existing vulnerability aspects. The pattern of community activities and daily life is highly influenced by the COVID-19 pandemic [33]. Areas with a high population close to shopping centers, commercial centers, and offices, are characterized by high community activity [34]. This is related to the value of the village, which has a positive autocorrelation with high sensitivity which needs to be considered. It is because of the high interaction between the area and community that it is unable to withstand threats that require proper handling so that the community can survive and increase its capacity.

Based on the village typology of the level of socio-economic vulnerability, regional interactions based on the level of vulnerability and threat of hazards will form disaster risk [35]. Then, it can be said that villages with high observation values such as those in quadrants I and IV have a greater risk as a strong level of interaction between village areas

causes the same characteristics of vulnerability so that the threat of the COVID-19 pandemic is more likely to disrupt community resilience on this area. However, villages in quadrant II also need to be considered because they have neighbors with high observation values. If this area has increasing interactions with areas that have high observation values, there may be changes in socio-economic vulnerabilities conditions or open risk opportunities from the COVID-19 pandemic. Indicators of vulnerability can change over time and vulnerability is dynamic which can cause areas that originally had low observation values to become high.

Based on the village typology map in Figure 3, the village group with hierarchy III—low, is located on the north side of Sleman Regency which has the characteristics of a rural population with dependence on the agricultural sector. The COVID-19 pandemic tends to have an impact on poverty in urban communities that depend on goods and services from rural areas, while the rural areas supply agricultural, plantation, and fishery commodities, which are more able to survive [36]. Rural communities have high resilience to the COVID-19 pandemic crisis as they rely on the primary production of food commodities as basic human needs [37]. However, this cannot be applied to all regions, because resilience in each region can be influenced by other factors such as access and facilities. The community's resilience is not only in terms of health, but also socially in dealing with the impacts of the COVID-19 pandemic.

The potential strategy that can be applied by policymakers is involving communities in rural areas both in agriculture and non-agriculture in digital economic transactions [38]. This strategy helps in building community connections in urban areas to buy necessities while simultaneously strengthening community capacity by restoring economic activity. It is closely related to the recovery aspect of disaster risk management.

Recovery and reconstruction efforts from the COVID-19 pandemic are not physical recovery or reconstruction of public infrastructure. However, it is an increase in social capital and human resources to be able to deal with the impact of the COVID-19 pandemic. The crisis due to the COVID-19 pandemic has an impact on socio-economically vulnerable groups [39]. Villages in Sleman Regency that are close to the Yogyakarta urban areas are more socio-economically vulnerable than those in the rural areas of the Sleman Regency. COVID-19 mitigation efforts with the ICT concept have been widely applied in Indonesia. Smart mitigation is an effort to integrate the use of technology and information to address disasters in an area within a certain period [40].

The dimensions of the smart economy and smart society are closely related to efforts to increase community capacity in handling COVID-19 as presented in Table 2. Recovery efforts from the dimensions of smart society and smart economy during the COVID-19 pandemic have targets that tend to be in the Hierarchy I and IV. Both typologies also have a high level of sensitivity and exposure. The smart society and smart economy programs consider poor households and residents with informal jobs. Although not spatially considering the vulnerability aspect, in practice it has been implemented in areas that require strengthening social capacity. Recovery efforts which tend to be in the two typologies can increase the community's capacity to survive the impacts of COVID-19.

Meanwhile, the implementation of smart society and the smart economy program is not very visible in villages located in Hierarchies II and III. This is because the COVID-19 pandemic in Sleman Regency tends to affect the service and trade sectors that are outside these hierarchies. Both typologies are classified as low to moderate. However, it is important to note that Hierarchy II has the characteristics of having a high observation value which means that the surrounding villages have high interaction. Thus, if exposure increases, it requires more optimal recovery.

5. Conclusions

Variables from sensitivity, exposure, and adaptive capacity aspects create a high level of socio-economic vulnerability in villages in urban areas. Meanwhile, villages with low to moderate vulnerability levels dominate in the northern side of Sleman Regency. Some

villages have a high level of risk due to low adaptive capacity, but a high level of exposure or sensitivity.

Based on Moran's index value, the spatial pattern of socio-economic vulnerability during the COVID-19 pandemic is 0.569 which indicated that there is a positive spatial autocorrelation between villages with a clustered pattern. However, the LISA value shows that there are only 16 villages with a positive spatial autocorrelation value which indicates a strong interaction. Based on this spatial pattern, there are eight village typologies: Hierarchy I—high, Hierarchy I—medium, Hierarchy II—moderate, Hierarchy II—low, Hierarchy III—medium, Hierarchy IV—high, and Hierarchy IV—moderate. Hierarchy I—high covers most villages, namely 26 villages that require more intensive handling as they have high observation value and are surrounded by villages with high vulnerability observation values.

The handling of COVID-19 in Sleman Regency through the dimensions of smart society and smart economy, including in recovery efforts in disaster risk management has not considered socio-economic vulnerability spatially, but in its indirect implementation has targeted areas in Hierarchy I—high. The smart society and smart economy have a direct role in dealing with COVID-19, for example, the Social Safety Net (JPS), capacity building, and increasing access to job vacancies, as well as the development of cooperatives, industry, and MSMEs. The strategy to address socio-economic vulnerabilities during the COVID-19 pandemic is bringing services closer to the community, switching services to digital, improving app features by considering community needs and ease of access, and capacity building for vulnerable groups through training.

Based on the results obtained, aspects of socio-economic vulnerability need to be considered based on regions in disaster risk management of the COVID-19 pandemic so that the handling carried out is more effective and efficient. Stakeholders and communities from each level of the region must always be involved in building a level of community trust and realizing mitigation, preparedness, emergency response and recovery strategies from the COVID-19 pandemic. In addition, there is a need for coordination between regional apparatus organizations in discussing the sustainability of programs from smart societies and smart economies that have a direct role in handling COVID-19.

This study still has limitations, so it is recommended that further researchers can add other indicators of socio-economic vulnerability that are suspected to have a significant relationship with the variables of confirmed COVID-19 sufferers and can test the influence on the distribution of COVID-19 patients spatially to obtain more accurate analysis results. In addition, more advanced research can also be carried out by exploring more deeply other innovations from smart societies and smart economies that are increasingly developing following the needs and handling of COVID-19 in Sleman Regency.

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