Indonesia's Readiness to Implement Agriculture Data Analytic – Based Smart Village

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Abstract

Indonesia strengthens village development to accelerate the achievement of the Sustainable Development Goals (SDGs) targets. The Ministry of Villages, Development of Disadvantaged Regions and Transmigration (Kemendes PDTT) publishes the Village SDGs and the concept of a smart village to achieve these goals. To find out Indonesia's readiness in implementing smart villages, it is necessary to conduct a situation analysis. Because agriculture is the main activity in the village, this study focuses on smart village analysis based on Agriculture Data Analytic (ADA). This study aims to analyze Indonesia's readiness in ADA-based smart village development. We used the 2019 Village Potential Data. The methods conducted by descriptive analysis methods, multiple regression analysis and clustering. Indonesia is well prepared if it is seen from the level of participation of villagers in the management of ICT, agribusiness, transportation and renewable energy. The level of participation of villagers varies greatly depending on the character of the province. The results of multiple regression analysis show that the sources of regional budget revenue (APBD), Village Original Revenue (PAD) and self-subsistent (Swadaya) funds have a significant effect on ICT managers in the village through the poor and most residents. APBD, PAD and Swadaya also have a significant effect on agribusiness managers in the village through the poor, the private sector and the business community in the village. Other sources of funds have a significant effect on the management of renewable energy in the village. The APBD and other sources only have a significant effect on transportation managers in the village, through most of the residents. Clustering using a Self Organizing Map (SOM) on 62.847 data and 25 variables related to ICT, agribusiness, transportation and renewable energy activities, was able to map 5 levels of potential smart villages, namely: very potential, potential, quite potential, less potential and not potential.

Keywords:
Agriculture data analytic, Clustering, Renewable energy, SDGs, Smart village

1. Introduction

The achievement target of the SDGs that has been agreed upon in 2030 only has nine years left. Indonesia is increasingly implementing programs to achieve SDGs 2030, including strengthening development in rural and underdeveloped areas. Development in Indonesian villages is supported by the issuance of the Village SDGs by the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration (Kemendesa PDTT) in 2020. The focus of village development in Indonesia can contribute to achieving Indonesia's SDGs 2030 by 74%. This is supported by the territorial aspect and the population aspect. Based on the territorial part, rural areas cover 91% of Indonesia's territory. In terms of population, it is supported by 43% of Indonesia's population living in rural areas (Iskandar 2020). Indonesia's rural areas have varying levels of development. One of the indices used to assess development is the Village Development Index (IDM) which includes economic, social, and ecological aspects. In 2021 the Ministry of Villages PDTT will update the Village SDGs-based IDM. This update is more detailed, relying on data collected from the Neighborhood Association (RT), families, and residents. More detailed data aims to reach data based on the By Name By Address (BNBA) principle. This is expected to provide more complete and accurate information in Indonesia's efforts to accelerate development in rural areas.

Many countries have accelerated rural development through the smart village approach (Ramachanra et al. 2015; Holmes et al. 2017; ENRD 2018; Larsen and Estes 2019). The smart village is a citizen initiative program that innovates and transforms through technology to find solutions to problems in the village (Neito and Brosel 2019). Smart villages are unique, following the cultural treasures of the village. Sustainable village programs are generally bottom-up and have strong synergies with various stakeholders, from regulators, the private sector, NGOs, academics, and even the media (Zavratnik 2018; Tosida et al. 2020a). The development of smart village implementation is accelerating along with the widespread use of information and communication technology (ICT). In many smart village programs in several countries, even ICT is the key to the success of smart village programs (Anderson 2019; Groot et al. 2019; Jagustovic et al. 2019; Maja et al. 2020).

Smart villages in Indonesia have also experienced significant developments since 2017. Starting with the smart village of four villages in Yogyakarta, which includes the smart economy village program (Kulonprogro), smart governance (Dlingo Village), smart living with the cyber village program (Patehan village), and smart tourism in Pulosari Village (Santoso et al. 2019). The sustainability of the smart village program only takes place in Kulonprogo, while the smart village program in the other three villages is experiencing technical problems, human resources, and support from residents and stakeholders. Smart village development in Indonesia has full support from the central government through various regulations. Likewise, the development of smart village studies has increased significantly. However, studies related to smart villages in Indonesia are still limited in conceptual terms. There are still few studies of smart villages that review quantitative approaches to produce a map of the potential for smart village development for regional development in Indonesia.

1.1 Objectives

As in other countries, the characteristics of rural life in Indonesia are closely related to agriculture-based life. The main objective of this research is to conduct a situational analysis of the potential of ADA-based smart villages, using a quantitative approach based on descriptive statistics and optimization of clustering based on artificial neural networks (Self Organizing Map – SOM).

2. Literature Review

Smart village research has experienced significant growth following the development of smart city research, so one of the main factors for the success of smart villages is the ICT factor. The massive growth and use of ICT, even in rural areas, is also aimed at achieving the SDGs, and one of the strategies is deployed through the smart governance process (Anderson et al. 2017; Holmes et al. 2017; ENRD 2018; Ramachandra et al. 2015). Even in its current development, the achievement of the SDGs has been directed to be integrated with artificial intelligence (AI) technology (Vinuesa et al. 2019). The indicators for smart villages that are in line with the Industrial Revolution (RI) 4.0 were formulated by Santoso et al. (2019) and refined by Maja et al. 2020, as shown in Table 1. The development of smart village research in Indonesia is still dominated by general concepts and models (Andari and Ella 2021), socio-economic studies, culture, and technology (Santoso et al. 2019), as well as the implementation of information systems and geographic information systems in several village areas in Indonesia (Salim 2013; Afnarius et al. 2020).

Table 1. Smart Village Variables and Indicators related to SDGs Village Development Components

No.	Dimension	Variabel	Indicator (Santoso *et al.* 2019)	Indicator in line IR 4.0 (Maja *et al.* 2020)
1.	Smart Governance	Participation	Participation in policy decision making	
		Transparency	Information disclosure	
		Service social public	Utilization of ICT to provide services to the community	
2.	Smart Economy	Innovation	- Innovation - Transformation ability - Public funds for research development	- Number of businesses using social media platforms for advertising - % of farmers access farming portal - Number of start-ups based on ICT / 10,000 residents for buying and selling - % of the workforce in the ICT sector - % of workers in education and R dan D are domiciled in villages
		Entrepreneur ship	- Image and trademark - Productivity - Flexibility labor market Multi-actor linkage	
3.	Smart Mobility	Traffic		- Availability of the main road that connects the village with the highway - Availability of a railway line to connect the village to the nearest port - % of village budget allocated for roads - % of village budget allocated for rail network infrastructure - The number of residents in the village transporting residents and parcels - Number of citizens tracking taxis using social media platforms
		Public transportation	Local accessibility	
		ICT transportation	Safe, innovative and sustainable transportation system	
4.	Smart Environment	Efficiency energy	Natural conditions Pollution control	- An early warning system is available in the village, and remote access to the weather station - There is a natural disaster emergency plan and % of trained villagers - % of unique local fauna tagged or linked by tracking tools - Available fire indicators and emergency response plans - % of buildings that can withstand harsh weather conditions - % remote controlled air quality measuring device
		Monitoring network and environment	Environmental protection Resource management Sustainable	
5	Smart People	Digital education	- Digital mastery - Openness	- % of elementary school age children attending school - Number of public schools that can be accessed max 30 minutes in the village - Number of computers, laptops, tablets, or digital interactive learning devices in elementary & junior high school /class - Number of education certificates in the fields of Science, Tech., Engineering and Math per 10,000 villagers
		Creativity	- Flexible - Desire to continue learn and develop - Ethnic and social plurality - Participation in life together	

No.	Dimension	Variabel	Indicator (Santoso *et al.* 2019)	Indicator in line IR 4.0 (Maja *et al.* 2020)
6.	Smart Living	Health and security	- Individual security - Residential quality - Health condition - Education facilities	- Predictable and reliable schedule of doctors to visit clinics in the village - Jumlah warga yang peduli dan mendaftar pada jasa e-health - Number of citizens who care and register for e-health services - Does the village have an alert system of water and air quality levels? - % of households with smart prepaid electricity meter in village% - The total land area allocated for development - % of residences equipped with solar heating (provided by the state) - % of sites that have access to clean village water with a centralized smart meter
		Technology access		
7	Smart Tourism	Tourism facility and attraction	Attractions Tourism interaction Smart tourism economy	

One of the techniques used in this research is clustering. Clustering is grouping using unsupervised learning techniques where no learning phase is needed and does not use labeling for each group. Clustering does not attempt to perform classification. Estimate or predict the value of the target variable. However, the clustering algorithm tries to divide the entire data into groups that have similarities (homogeneous), where the similarity in one group will be of maximum value, while the parallel with records in other groups will be of minimal value (Han et al. 2012; Zaki and Meira).

The SOM algorithm is a cluster analysis technique that is very efficient in handling high-dimensional data, reducing data, and visualizing data. The SOM algorithm is also robust in handling noisy or outlier datasets. The SOM network consists of two layers, namely the input layer and the outgoing layer. Each neuron in the input layer is connected to every neuron in the output layer. Each neuron in the output layer represents the class of the given input. During the self-compilation process, the cluster with the weight vector that best matches the input pattern (has the closest distance) will be selected as the winner (Yin 2008). The advantage of using SOM in object grouping is that it can map a high-dimensional input vector into a two-dimensional space. In addition, SOM can classify categorical data and incomplete input data. The SOM algorithm has several shortcomings, including the number of clusters that need to be precisely determined. The researcher must perform manual inspections or use a hierarchical cluster algorithm or partition to get the cluster limit. The Self Organizing Map (SOM) process is carried out by following the following algorithm:

a Input :
1. Neuron on input layer
2. $\boldsymbol{X} = \{\vec{x}_1, \vec{x}2, \vec{x}3, \ldots, \vec{x}\ n\}$; $\vec{x}i \in R^n$

   $\vec{x}i = \langle xi1, xi2, \ldots, xip \rangle$
3. Weight $W = (wij)$; $i = 1,2, \ldots, \boldsymbol{m}$ and $j = 1,2, \ldots, \boldsymbol{p}$ where is the number of variables and is the number of desired clusters.
4. Learning rate (α) value $0 < \alpha\ (0) < 1$
5. Sum of iteration (T)
6. Maximum error (ε)

b. Output : $W = (wij)$; $i = 1,2, \ldots, \boldsymbol{m}$ and $n\ j = 1,2, \ldots, \boldsymbol{p}$ clustered object

3. Methods

The research method is based on the study of the ADA concept, which refers to the framework (Jennex 2009; Deka 2016; Wolfert et al. 2019), as shown in Figures 1 and 2. Based on Figure 1, we limited the research to the diagnostic analytics level. Then we discuss the results of the diagnostic analytics and elaborate through the ADA framework in Figure 2. The detailed research stages are shown in Figure 3.

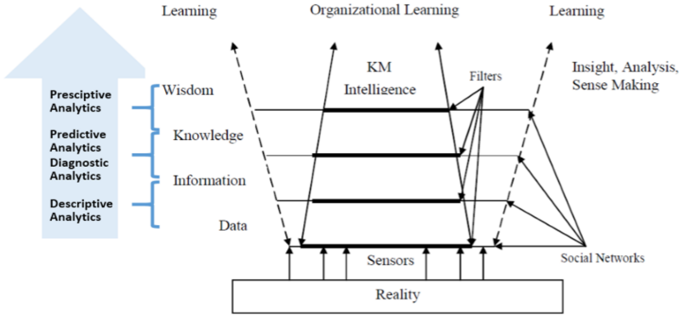

Figure 1. Data analytic concept

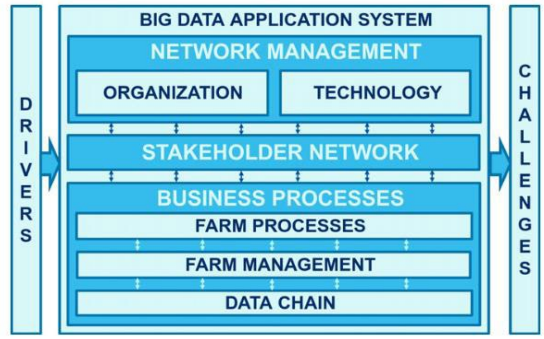

Figure 2. Framework of ADA

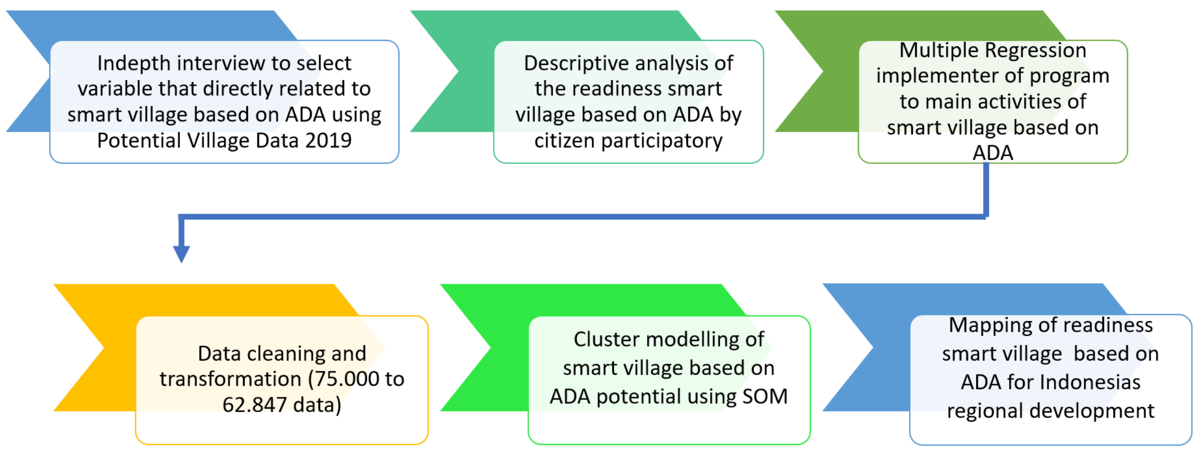

Figure 3. Research method

The research stages consist of six parts, namely:

1) In-depth interviews with three smart village experts, to determine the main activities and variables directly related to the ADA-based smart village concept. Smart village experts include agribusiness experts, social computing experts and village development experts. At this stage of in-depth interviews, we used 2019 village potential data as a reference.
2) Descriptive analysis related to the level of participation of villagers in the main activities. Citizen participation in the main activities of smart village development based on ADA is a basic issue. This is in accordance with the research of Neito & Brosel (2019) which states that the success of a smart village depends on the initiative of the residents, which is supported by the power of innovation and transformation to solve problems that occur in the village. The level of participation of villagers in main activities will be unique depending on the potential of each village (Zavratnik 2018). We aggregate data on citizen participation in the main activities for each province
3) Multiple regression analysis of the main activity actors and the elaboration of village funding sources. According to Santoso et al. (2019) Village funds are the main factor for the success and sustainability of smart villages, therefore multiple regression analysis is carried out in aggregate for the main activity actors and sources of village funds.
4) Cleaning and transformation of village potential data referring to selected variables from interviews with experts. We carried out data cleaning and transformation of 62,847 village potential data in 2019, and according to the reference variables from the interviews
5) ADA-based smart village potential cluster modeling using an artificial neural network (ANN) approach, the SOM algorithm.
6) Mapping of readiness for implementation of smart village based on ADA for regional development in Indonesia.

4. Data Collection

This study used secondary data, namely data on village potential in 2019 in Indonesia produced by Statistic Center Agency (BPS) Indonesia. Because the village potential data has 137 assessment attributes, we use in-depth interviews with three experts to select the attributes that are the main activities for assessing Indonesia's readiness to implement smart villages. Based on the main attributes determined by the results of interviews with experts, we then analyzed using the ADA concept Jennex 2009 approach; Deca 2016; Wolfert et al. 2019).

5. Results and Discussion

5.1. Graphical Results

5.1.1. Indonesia's Village SDGs and ADA-based Smart Village Progresess

Indonesia has a strong commitment to increasing its status to become a developed country. This is according to the vision to be achieved in 2024 and 2045. Indonesia's commitment is also in line with the global development vision that has been agreed upon through the SDGs. One of the follow-ups to this commitment, Indonesia realized it in Presidential Regulation (Perpres) Number 59 of 2017 concerning the SDGs. One alternative to accelerating SDG achievement through development starts from the outskirts and villages, as stated in the third Nawacita point. Village development is believed by (Iskandar 2020) will contribute to the achievement of SDGs by 74%. Territorial and citizenship aspects support this. In the territorial part, Indonesia is dominated by rural areas, while in the citizenship aspect, Indonesia has 43% of the population living in rural areas.

The concept of a smart village to reduce poverty in rural Indonesia is very prospective to be implemented. Initial research has resulted in the basic idea of a smart village in Indonesia (Andari and Ella 2021; Ella and Andari 2018; Sutriadi 2018; Mishbah et al. 2018; Andari and Ella 2021). The implementation of ICT for the initiation of smart villages in several areas has also resulted in a functional ICT model. The ICT model can even improve the performance of village governments to realize the forerunner of smart governance (Salim 2013; Marlintha et al. 2017; Adi and Heripracoyo 2018; Adi et al. 2018; Afinarius et al. 2020). However, these studies are still partial. The research has not comprehensively discussed how to set smart village goals, synergies between citizen and stakeholders, and innovation collaboration towards smart village goals. The main goal of a smart village within the scope of the village SDGs is to reduce poverty in the village. Poverty reduction in rural areas shows a higher rate than in cities, as shown in Figure 4. It shows that the potential for development in rural areas is more substantial. Hence, it is necessary to conduct a more profound study related to the potential characteristics of smart villages based on ADA. The rate of poverty reduction in Indonesia experienced a sloping condition in 2020 and early 2021. This condition is one of the impacts of the COVID-19 pandemic. However, poverty reduction still occurs in villages, albeit at a prolonged rate. The strength of villagers to face poverty and the phenomenon of de-urbanization offers opportunities for creativity for villagers who return from the city due to the termination of work rights. The creativity of the de-urbanization also contributes to increasing the village's economy. The opportunity to improve the village's economy through the creativity of the de-urbanized citizens also contributes to the possibilities for regional development in Indonesia. Therefore, to implement a smart village within the scope of the SDGs, a village needs to know the priorities of regional development, and this can be done through the initial step by analyzing the condition of village community participation in the main activities of a smart village (Neito and Brosel 2019; Holmes et al. 2017).

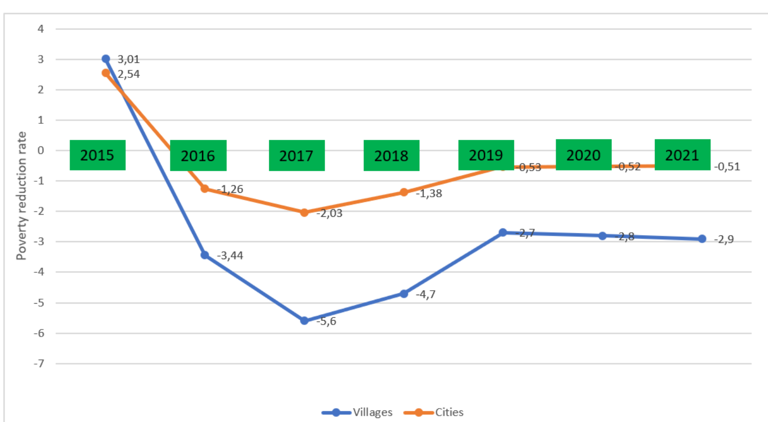

Figure 4. Poverty reduction rate in Indonesia

5.1.2. Results and descriptive analysis of ADA-based smart village readiness in Indonesia

This study focused on the participation of villagers (implementers of programs), which was represented through four main activities as a result of indepth interview with smart village experts, and also related to the concept of an ADA-based smart village within the village SDGs environment (Tosida et al. 2020b). The scope of action in question is implementing ICT management activities, transportation, agricultural and non-agricultural businesses also renewable energy activities. The level of participation of villagers in ICT activities in Indonesia is shown in Figure 5. The involvement of villagers is not limited to the business community, private business actors, but farmers-fishermen, and even the poor participate significantly in several areas. The participation of farmers-fishermen in ICT management, which reached more than 40%, occurred in East Nusa Tenggara, East Kalimantan, North Kalimantan, North Sulawesi, Southeast Sulawesi, West Papua, and Papua. The poor who participate in ICT management significantly (more than 30%) occur in Aceh, South Sumatra, Riau Islands, and Maluku.

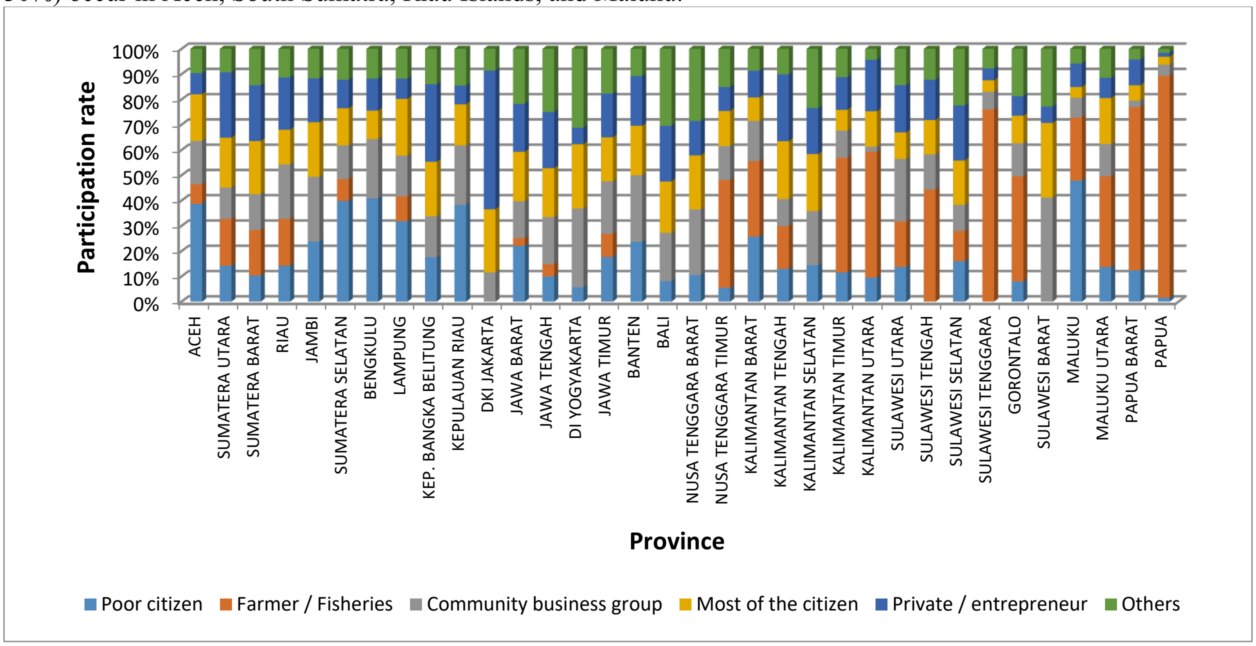

Figure 5. Citizen participatory of ICT management in village as a critical factor of ADA-based smart village

This condition can indicate excellent potential for the development of an ADA-based smart village. The sustainability of ADA-based smart villages needs to be supported by the power of citizen initiatives (Neito and Brosel 2019) in collaboration with various stakeholders within the four-parties scope (academic, business, community, and government) (Tosida et al. 2020b). This collaboration includes planning, design, socialization, implementation, and evaluation activities (Ramachandra et al. 2015; Holmes et al. 2017; Santoso et al. 2019). ICT management activities based on the participation of villagers in each province are very diverse. These activities include the involvement of village youth communities in village SDGs data input, mapping of village areas, and complete data input on the primary needs of villagers through the Drone Participatory Mapping program (Sjaf et al 2021), management of tourist village sites, management of e-fishery and others. The more substantial participation of villagers in ICT activities is reinforced by the results of an ICT survey by the Indonesian Ministry of Communication and Information (Kemenkominfo), showing that in 2018 69,9% of villagers in Indonesia have used social media for buying and selling needs. The potential in Indonesia is in line with the concept developed by Maja et al. (2020) related to smart village development indicators by the industrial revolution 4.0.

The potential of ADA-based smart villages also needs to examine the condition of the level of participation of villagers in agricultural and non-agricultural business activities in the village. Figure 6 shows that conditions in Papua, West Papua, Maluku, Southeast Sulawesi, South Sumatra, and Aceh, the participation of the poor in the management of agricultural and non-agricultural businesses in the village reaches more than 20%. Meanwhile, the involvement of farmers and fishers is evenly distributed in all provinces with a range of 5-27%. This condition is absorbing to study its relationship with the resilience of the poor in facing the declining rate of poverty in the village. This description data analysis is the result of processing from the 2019 Village Potential Data updated. Still, this condition is in line with Figure 4, which shows that the rate of poverty reduction is slowing both in villages and in cities. In ADA-based smart villages, the participation of all levels of society, especially farmers/fishermen who are directly related to ADA, certainly plays an important role. In some examples of prosperous smart villages, farmers and the poor are not able to stand alone. They need to be supported by both the youth and the MSME community (Groot et al. 2019; Santoso et al. 2019; Tosida et al. 2020b). ADA-based smart villages are also supported by telematics MSME clusters in Indonesia (Tosida et al. 2018; Tosida et al. 2020c). Developing the Indonesian telematics MSME cluster that relies on ICT vocational high school (SMK) graduates has generated a lot in the village. The participation of private entrepreneurs in the management of agricultural and non-agricultural businesses in the village has a more robust pattern than the business community's participation. This happens almost evenly in all provinces except in Papua, which is less supported by private participation. This condition can concern the government to encourage the private sector in developing villages through various incentives.

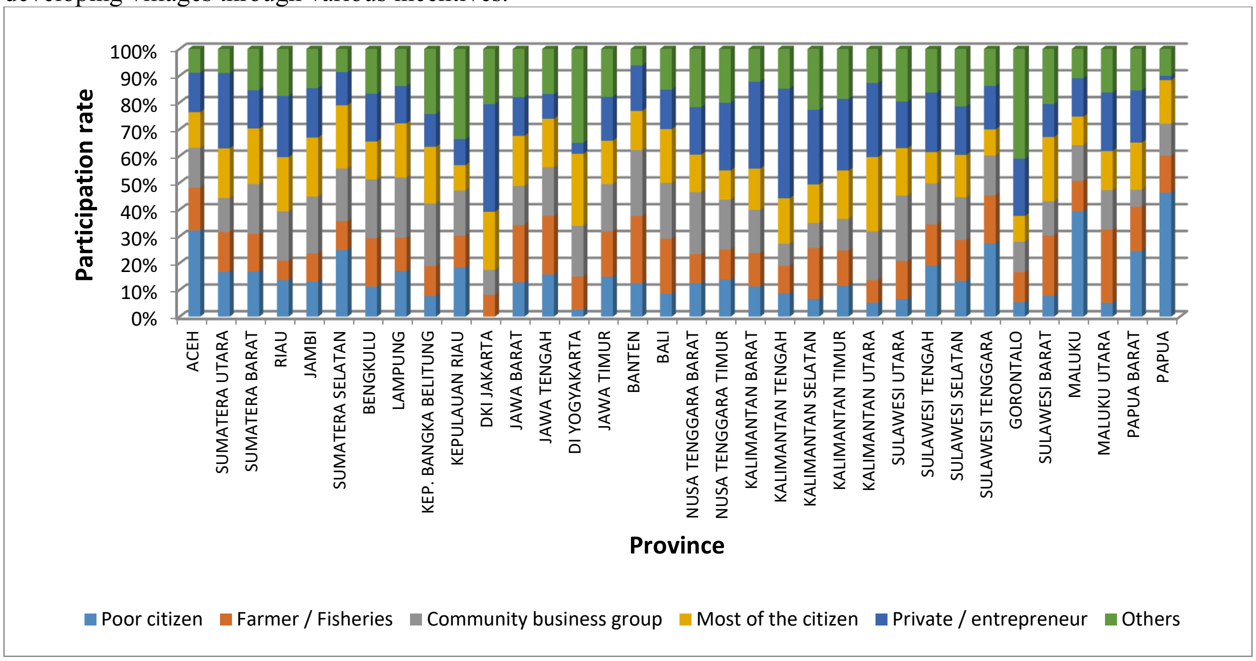

Figure 6. Citizen participatory of agricultural and non-agricultural business in village as a key factor of ADA-based smart village

The potential for regional development through ADA-based smart villages is also carried out through a descriptive analysis of village residents' participation in transportation management activities in the village, as shown in Figure 7. Villagers' participation in transportation management is essential in developing ADA-based smart villages, especially in fulfilling the requirements for smart mobility indicators (Santoso et al. 2019; Maja et al. 2020). Figure 7 shows that the participation of the poor who contributed significantly (more than 20%) to ADA-based smart village development occurred in Aceh, South Sumatra, Bengkulu, Lampung, East Java, Banten, Bali, and North Sulawesi. Farmer-fisherman participation in village transportation management shows significant variations. Farmer-fisherman significant involvement (more than 30%) occurs in Papua, North Maluku, Maluku, Southeast Sulawesi, and Bali. Transportation management is crucial for the distribution of village products and the fulfillment of village logistics. The strength of the participation of the poor and farmer-fishermen can be used as a reference for increasing empowerment in the development of ADA-based smart villages. Still, it takes the strength of encouragement from the government and the business or private community to optimize. Mainly when referring to the smart village indicator, which is in line with the 4.0 industrial revolution, it implies that transportation is a necessary facility for meeting the main needs of villagers, including food, clothing, and housing. The basic requirements of villagers related to education and health are the focus of achieving SDGs Desa point 9 in Indonesia (Iskandar 2020). Therefore this description can be a reference for regional governments to prioritize infrastructure development that supports the empowerment of the poor and farmer-fishermen. in the village (Santoso et al. 2019; Ramachandra et al. 2015; ENRD 2018).

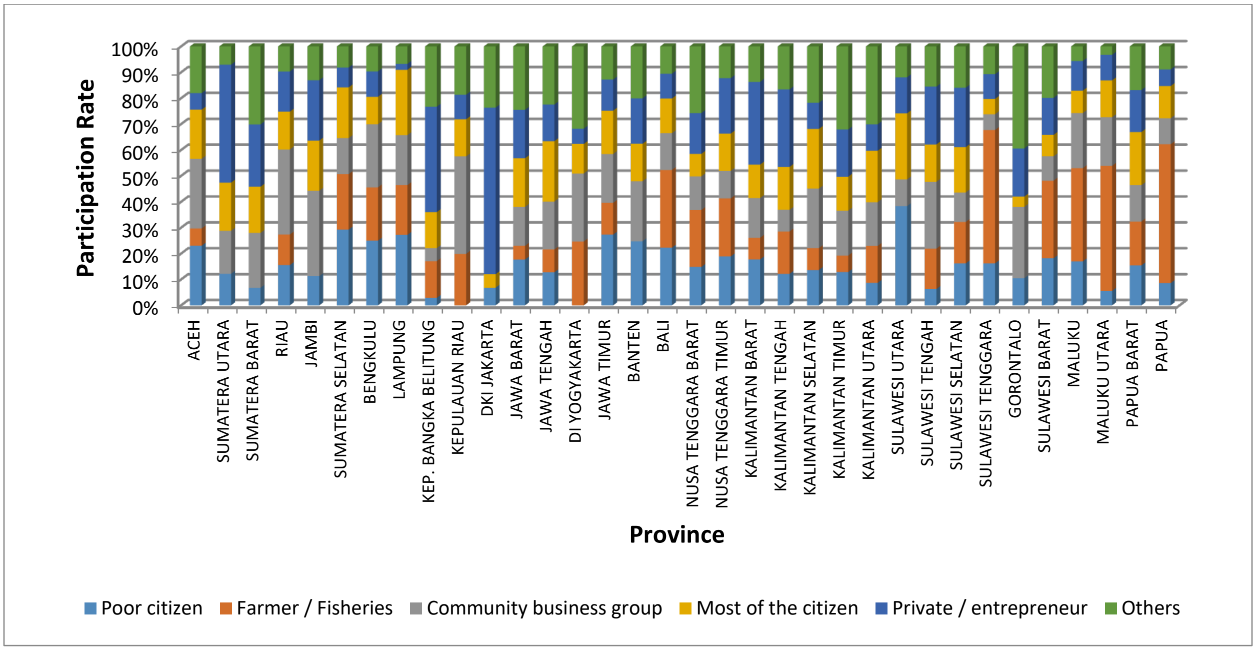

Figure 7. Citizen participatory of transportation management activities in village as a critical factor of ADA-based smart village

Regional development in Indonesia through the development of ADA-based smart villages is also carried out through a descriptive analysis of the participation of villagers if there are renewable energy management activities, as shown in Figure 8. Although most provinces in Indonesia still show the strength of business groups that play an essential role in renewable energy activities, in some provinces, farmers-fishermen and poor people also contribute to this activity with varying levels of contribution (ranging from 10%-80%). Significant contributions (more than 30%) of the poor participating in renewable energy activities occurred in West Sumatra, Riau, Banten, and Maluku. Strengthening the empowerment of the poor in the management of renewable energy can be optimized through an incentive program for planting bio-energy sources. However, this program has not succeeded in synergizing the role of four parties in integrated renewable energy management. Farmer-fishermen who contributed significantly to the management of renewable energy in the village showed higher power to reach more than 60% of the villagers in the Riau Islands, Bali, and North Maluku. The target for achieving renewable energy in Indonesia in 2025 is 23% and will increase to 31% in 2050 (Medco Power Indonesia, 2021). This is related to point 7 of Village SDGs target related to clean and renewable energy villages (Iskandar 2020), particularly the achievement of 99.7% village electrification efforts by 2025. The strategy carried out is to expand distribution networks and build renewable energy power plants and hybrid generators for very remote villages, by optimizing the potential of renewable energy sources in the form of hydropower, geothermal, bioenergy, solar, wind, and marine energy. The indicator for achieving renewable energy villages is that in 2030 household electricity consumption in the village is at least 1,200 kWh, households in the village use gas or wood waste for cooking, and the use of renewable energy mix in the village.

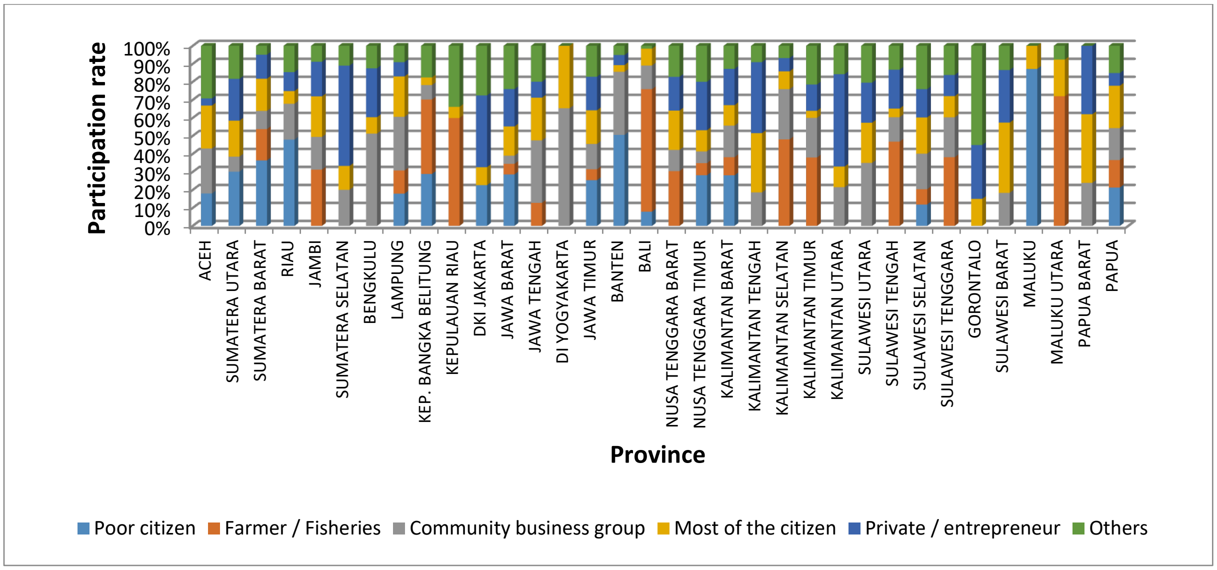

Figure 8. Citizen participatory of renewable energy management activities in village as a critical factor of ADA-based smart village

5.2. Numerical Results

5.2.1. Multiple regression results and analysis for ADA-based smart village readiness in Indonesia

A more in-depth study of the participation of villagers in ADA-based smart village development was carried out through multiple regression analysis, as shown in Tables 1 and 2. This study is different from the study of Tosida et al. (2020b), which focuses on the beneficiaries of ICT management activities and agri-non-business in the village.

Table 1. Multiple regression analysis of ICT management implementers, agriculture and non-agriculture business implementers, and sources of funds for the activities in the village

Implementer	ICT management implementers						Agri & Non-agri Busiinessess implementers					
	Poor citizen	Farmer / Fisheries	Enterpr. Commu.	Most Citizen	Privates	Others	Poor citizen	Farmer / Fisheries	Enterpr. Commu.	Most Citizen	Privates	Others
APBD												
Adj. R Square						0,9949						0,9845
Anova Sig. F						0,0000						0,0000
Anova P-value	0,0012	0,8926	0,9038	0,0082	0,0658	0,0042	0,0007	0,5889	0,2240	0,0030	0,0033	0,0036
PAD												
Adj. R Square						0,9631						0,9344
Anova Sig. F						0,0000						0,0000
Anova P-value	0,0150	0,5825	0,0179	0,5089	0,6592	0,0007	0,1458	0,1974	0,0003	0,6506	0,0084	0,4978
Swadaya												
Adj. R Square						0,9434						0,9458
Anova Sig. F						0,0000						0,0000
Anova P-value	0,0472	0,3373	0,6972	0,4034	0,8287	0,3279	0,0755	0,6283	0,0022	0,2107	0,3995	0,5388
Others												
Adj. R Square						0,9699						0,9488
Anova Sig. F						0,0000						0,0000
Anova P-value	0,2817	0,7761	0,7336	0,0443	0,6439	0,2445	0,2418	0,0043	0,0149	0,5061	0,8603	0,9874

Table 2. Multiple regression analysis of renewable energy implementers, transportation activities implementer and sources of funds for the activities in the village

Implementer	Renewable energy implementers						Transportation activities implementer					
	Poor citizen	Farmer / Fisheries	Enterpr. Commu.	Most Citizen	Privates	Others	Poor citizen	Farmer / Fisheries	Enterpr. Commu.	Most Citizen	Privates	Others
APBD												
Adj. R Square						0,9501						0,9703
Anova Sig. F						0,0000						0,0000
Anova P-value	0,0594	0,3847	0,3564	0,0000	0,0682	0,4111	0,6884	0,6610	0,2205	0,0000	0,2916	0,7882
PAD												
Adj. R Square						0,5929						0,8887
Anova Sig. F						0,0000						0,0000
Anova P-value	0,9631	0,6798	0,0686	0,6649	0,9815	0,4762	0,4248	0,7096	0,8475	0,0399	0,1015	0,0744
Swadaya												
Adj. R Square						0,5984						0,6803
Anova Sig. F						0,0000						0,0000
Anova P-value	0,5340	0,2321	0,8232	0,0521	0,2982	0,3607	0,3856	0,5537	0,3830	0,0922	0,7191	0,6714
Others												
Adj. R Square						0,8655						0,8757
Anova Sig. F						0,0000						0,0000
Anova P-value	0,0044	0,7325	0,0907	0,0062	0,8421	0,6425	0,3578	0,7406	0,0421	0,0000	0,4922	0,9608

In this study, a multiple regression analysis was carried out on the implementers of activities associated with the scheme of funding sources in the village. The high value of adjusted R2 (more than 95%) and the significance ANOVA value of F (less than 0.05) in the four main activities indicate that citizen participation is closely related to the source of activity funds. However, the analysis results show different conditions when analyzed in each funding scheme for each activity implementer. The origins of APBD, PAD, and Swadaya funds have a significant influence on ICT management activities in the village which are carried out with the participation of the poor. The APBD also significantly influences implementing ICT activities in the village, which involve most of the villagers and other residents. PAD makes a high contribution to ICT implementers from the business community in the village and others. This condition shows that the potential strength of the ADA-based smart village can be optimal if the focus of funding is to support poverty reduction in the village. One of the strategies is to empower the poor and the business community to be more independent and have resilience and creativity in the face of drastic changes (Ramachandra et al. 2015; Holmes et al. 2017). The source of APBD funds for regional development is still the mainstay. The allocation of funds for villages continues to increase until, in 2020, it reaches 72 trillion rupiahs with a distribution rate of more than 98% (Iskandar 2020). The development of ADA-based smart villages gives promising hope, especially since 2017 Kemenkomifo, in collaboration with the Kemendesa PDTT has launched a digital village program.

In agricultural and non-agricultural business activities in the village, the APBD significantly influences the poor, most villagers, the private sector, and others as implementers of activities. Meanwhile, PAD only has a significant influence on the private sector, and sources of Swadaya funds only significantly influence implementing activities that come from business groups in the village. The potential for developing an ADA-based smart village requires a strong foundation for agricultural business activities in the village. This multiple regression analysis shows that the APBD fully supports community participation in strengthening business in the village. The private sector and business groups can also contribute through PAD and self-help. This condition is following the objectives of one of the programs launched by the Kemendesa PDTT, namely the Village Innovation Incubation Pilot Program – Local Economic Development (PIID-PEL) in 2020.

The participation of villagers as implementers in renewable energy activities has not shown a significant effect on the four schemes of funding sources. Sources of APBD funds only influence implementers who come from villagers in general, and other funds have a real influence on implementers from the poor. Unlike the case with transportation activities, implementers who come from most residents are significantly influenced by sources of APBD, PAD, and other funds. Based on this multiple regression analysis, it can be shown that the source of funds for village development has not been focused on renewable energy management activities following the mandate of the Village SDGs at point 7. Transportation management is a crucial component, mainly to ensure the mobility of residents and the materials produced by villagers' businesses in general. The potential for developing ADA-based smart villages provides opportunities for strengthening the management of renewable energy and transportation activities in villages, through village and rural development agendas. One of the agendas closely related to ADA-based smart villages is strengthening economic transformation through the development of online-based marketing of Village Area Superior Products (Prukades). The Ministry of Communication and Information has released various strategies for accelerating the digital transformation to support this program. This program aims to reach 12,548 villages that will have 4G internet access by 2023. The other programs continue to be carried out through the Communications and Information Technology Accessibility Agency (BAKTI). Another support is to build 9,113 BTS in villages and sub-districts in disadvantaged, frontier, and outermost areas (3T).

In contrast, the remaining 3,435 located in non-3T areas will be all cellular operators' work areas and commitments. In addition to BTS construction, the Ministry of Communications and Informatics has also built internet access services at 11,817 public facility service points. Of which 3,126 points are the location of health service facilities (Kemenkominfo 2020).

5.3. Proposed Improvements

5.3.1. Cluster model of Indonesia's ADA-based smart village potencies

Village development has full support from the Indonesian government with the Village Law Number 6 of 2014, strengthened by Permendesa Number 6 of 2020 concerning priorities for the use of village funds and Permendesa Number 17 of 2020 concerning the strategic plan of the Kemendesa PDTT in 2020-2024. Regional-based national development in the 2020-2024 period aims to reduce socio-economic disparities in Java and outside Java, to increase integration between provinces within one island and between islands in the economic, socio-cultural, and infrastructure sectors. Village development, development of disadvantaged areas, and transmigration are included in the Second National Priority on Developing Regions to Reduce Gaps and Ensure Equity in the Fourth Priority Activities, namely Development of Disadvantaged Regions, Border Areas, Rural and Transmigration Areas.

A study of regional development priorities can be carried out by optimizing the clustering of 2019 village potential data on the primary data related to ADA-based smart villages, which is the development of research (Tosida et al. 2020a; Tosida et al. 2020b). The attributes used are still the same as the previous research, consisting of 25 features, as shown in Table 3, but the village potential data used is an update for 2019. In addition, the development carried out in this paper is the data used not aggregation data per province, but using direct village potential data totaling 62,847 data. The data cleaning process is carried out by filling in the appropriate blank data, transforming numeric data into categorical data. The number of clusters refers to the developing village index (IDM), which consists of 5 clusters, namely: independent, developed, developing, lagging, and very lagging villages following the proposed development of the smart village model (Andari and Ella 2021), which is then translated into 5 clusters of potential ADA-based smart villages, namely: very potential, potential, quite potential, less potential and not potential. The study of regional development priorities can be carried out through cluster optimization of the 2019 village potential data against the primary data related to ADA-based smart villages, as shown in Table 3.

Table 3 Attributes in cluster analysis for ADA-based smart villages in Indonesia

No.	Atribut	No.	Atribut
1.	Cable phone	14.	Renewable energy management
2.	Mobile phone	15.	Fund sources of ren. energy management
3.	Internet Cafes (Warnet)	16.	The implementer of ren. energy management
4.	BTS	17.	Beneficiaries of ren. energy management
5.	Provider	18.	ICT management
6.	Mobile phones signal	19.	Fund sources of ICT management
7.	Internet signal	20.	The implementer of ICT management
8.	Computer / Laptop	21.	Beneficiaries of ICT management
9.	Internet functionality	22.	Agriculture business management
10.	Transportation management	23.	Fund sources of agriculture business management
11.	Fund sources of transportation management	24.	The implementer of agriculture business management
12.	The implementer of transportation management	25.	Beneficiaries of agriculture business management
13.	Benefaciaries of transport. Management		

The results of clusters for 2019 village potential data using SOM are shown in Figure 9, and the percentage of each cluster is shown in Figure 10. This cluster is an improvement from the cluster produced by Tosida et al. (2020b) by making five potential clusters of ADA-based smart villages consisting of an arrangement as shown in Figures 9 and 10, with an davies bouldin index (DBI) 1,38. The details of the percentage of clusters referred to in Figure 10 are cluster 1 (yellow block - very potential), cluster 2 (green block - potential), cluster 3 (magenta block - quite potential), cluster 4 (blue block - less potential), and cluster 5 (red block - not potential). The results of the cluster (Figure 10) show that villages with potential still dominate the condition of villages in Indonesia to become ADA-based smart villages (35%) spread over several provinces on the islands of Sumatra, Java, Bali and Sulawesi. The drawback of this research is that it has not shown in detail the composition and distribution of villages based on the resulting clusters.

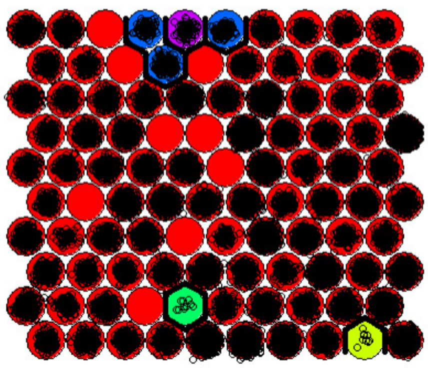

Figure 9. Cluster result

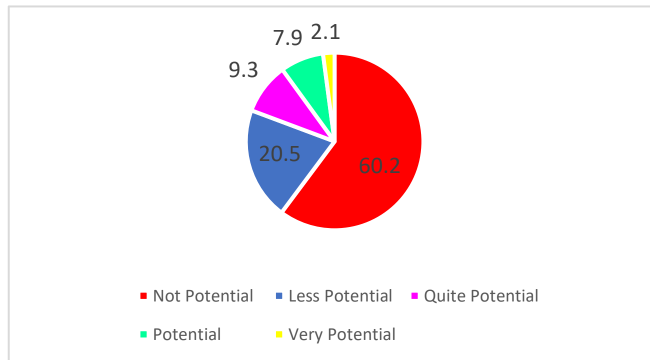

Figure 10. Cluster percentage

Smart village development is closely related to the readiness of village residents to participate. The condition of citizen participation in various activities in the village follows Iskandar (2020), which states that the strategy for achieving Indonesia's SDGs through village SDGs requires BNBA principled user data. However, before mapping the potential of smart villages based on ADA and BNBA, it is necessary to conduct a global study of citizen participation, which is portrayed through implementing the four main activities for the success of ADA-based smart villages associated with sources of funds in the village. The funding variable was chosen because the principal capital for village development is the source of funds. Law No. 6 2014 concerning Villages and Minister of Village Regulation No. 6 2020 concerning the priority of using village funds has spurred development and development in villages, including field development (ICT). Technology and citizen participation are essential variables in the success of the ADA-based smart village program. ICT as a very vital technology is now a fundamental force. Therefore, ICT infrastructure and its management are the chosen variables. In the village potential data, the citizen participation variable is elaborated through the implementing variables of the ICT program, agricultural and non-agricultural businesses, transportation, and renewable energy management. The program implementers in each village have a different composition. This is influenced by community policies and activities and socio-cultural and economic factors in the village community (Dickinson et al. 2012).

5.3. Validation

One of the smart village models in Indonesia was proposed by Ella and Andari (2018) and refined through Andari and Ella (2021), who proposed five stages of smart village development, namely: 1) villages identify and assess current and future conditions; 2) the village assesses local potential; 3) collaborating villages; 4) the village together with other actors formulate strategies and action plans; 5). Villages, together with other actors, implement strategies and action plans. The implementation of ICT for smart village initiation is carried out through information management in Rancasalak Garut Village (Salim 2013), potential maps based on Geographic Information Systems (GIS) in Cinunuk Village (Marlintha et al. 2017) and Kenanga Jaya District (Adi et al. 2017; Adi and Heripracoyo 2018) and GIS in Koto Gadang, West Sumatra (Afnarius et al. 2020). Santoso et al. (2019) examine the social, economic, cultural, and ICT aspects related to developing smart villages in four villages in Yogyakarta. The four smart villages' characteristics represent smart economy, smart governance, smart living, and smart tourism. The potential development of ADA-based smart villages in Indonesia is briefly shown in Figure 10. Details of the potential clusters of ADA-based smart villages can be a reference for regional development through the implementation of digital villages, especially ADA-based smart villages, which refer to the main potential of the village. The cluster results are also consistent with the development of the implementation of digital villages as a driving force for ADA-based smart villages, which have been carried out in various regions, as shown in Figure 11.

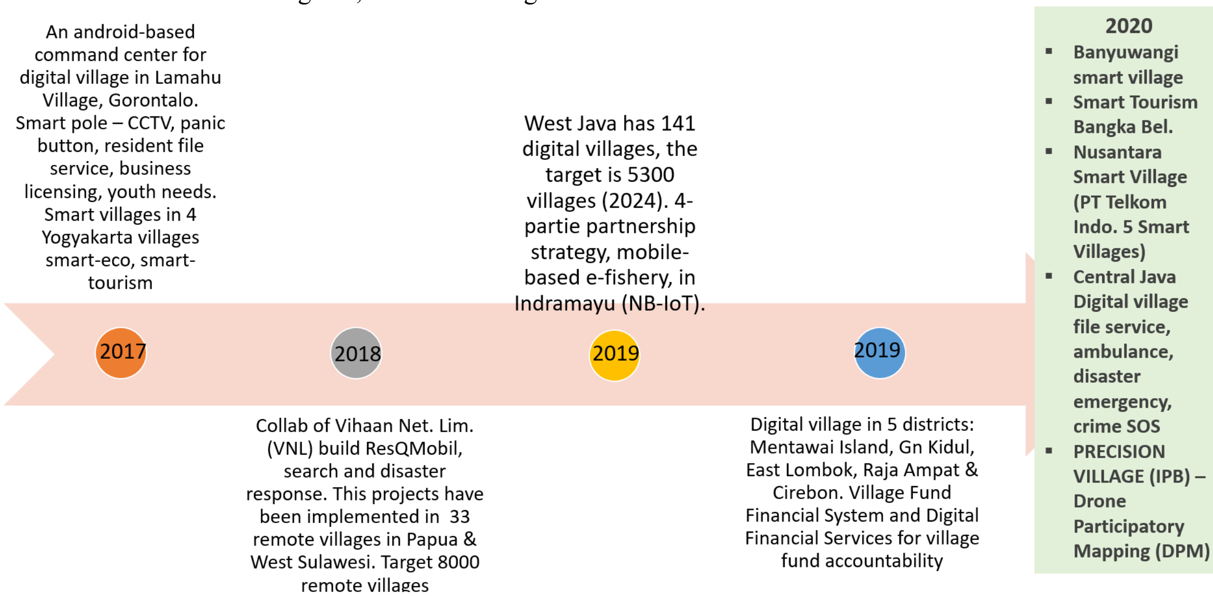

Figure 11. On-going implementation of ADA-based smart village in Indonesia

IPB has initiated the latest breakthrough in smart village development through the Precision Village Data program (Sjaf et al. 2021), which aligns with (Iskandar 2020) related to BNBA. High-precision data with a digital touch must start from the village. Era 4.0 provides the openness and certainty needed to build Indonesia from the village. The old (conventional) approach to collecting data that often create polemics is time to be fixed by utilizing the digital era. For this reason, a new approach is needed that can combine conventional methods with digital techniques based on villager participation. IPB University initiated this new approach under Drone Participatory Mapping (DPM) (Sjaf et al. 2021). DPM is a high-precision village data collection approach that considers the spatial, high-tech, digital, and participatory dimensions. The use of drones (Unmanned Aerial Vehicles) with the involvement of villagers is intended to produce high-resolution images for the benefit of spatial data that has not been owned by the village. With a touch of citizen participation, the spatial data obtained is used to obtain parcel thematic data (demography, education, health, economics, etc.), village maps according to applicable regulations (administration, village boundaries, infrastructure, topography, land use, etc.), village potential data verification, estimates and proxies for land-based village development, village carrying capacity, development infrastructure, and so on.

Moreover, the database obtained from spatial data can be used as a basis for preparing artificial intelligence for the Medium Term Village Development Plan (RPJMDes) and the Village Development Activity Plan (RKPDes). Thus, village planning and development measures have high precision, preventing data and budgets from the village and supra-village levels. The importance of realizing a high-precision village that can end the never-ending data polemic is one of the solutions to accelerate the Village SDGs by 2030.

6. Conclusion

The ADA-based smart village can propose a poverty reduction model in rural areas and accelerate the achievement of village SDGs in Indonesia. The contribution of this study is the production of a map describing the potential ADA-based smart villages in Indonesia based on the participation of villagers in key factors activities that are ICT, agriculture and non-agriculture business, transportation, and renewable energy. The sources of funding APBD, PAD, Swadaya give a very significant contribution to the implementation of ICT management activities, agriculture, and non-agriculture business with an Adjusted R^2 value of more than 0,9. However, different results show that the sources of Swadaya funds and PAD less contribute to implementing renewable energy activities in the village (Adjusted R^2 value is less than 0.6). The results of the SOM-based clustering show that there are five village clusters with five levels of smart village potential. The clustering model has good validity with DBI 1,38, supported by a description of the development of ADA-based smart villages based on the story of ongoing digital village implementation in the territory of Indonesia. A quantitative approach of village potential data in Indonesia that is used to assess the readiness of smart village development has not been widely used. Therefore, this research can be an alternative recommendation for stakeholders in formulating policies related to the acceleration of village development in the context of regional development in Indonesia.

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