

Development of a Strategy for Independent Village Development Based on IDM Predictions Using Linear Regression: A Study of Bi'ih Village, South Kalimantan

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Abstract

Village development in Indonesia still faces inequality due to uneven utilization of technology, resulting in many villages lagging behind economically despite their strong social and environmental potential. This study aims to predict the status of the Village Development Index (IDM) of Bi'ih Village in 2025 and formulate development strategies toward an independent village through the integration of information technology and local wisdom. The method used is linear regression analysis of IDM data from 2017 to 2024, followed by a gap analysis comparing the achievements of Bi'ih Village with those of 11 self-reliant villages in Karang Intan Subdistrict. The prediction results show that the IDM value of Bi'ih Village in 2025 will be 0.7744, placing it in the Advanced category, 0.0411 points below the Independent threshold (>0.8155). The Social Resilience Index (IKS = 0.8782) and Environmental Resilience Index (IKL = 0.8388) have exceeded the Independent threshold, while the Economic Resilience Index (IKE) remains low at 0.6061. The main constraints include limited access to digital markets, manual financial record-keeping, and low digital literacy among village entrepreneurs. The novelty of this research lies in the formulation of a development strategy based on the integration of ICT and local wisdom, with a focus on strengthening digital BUMDes, implementing integrated financial systems, developing upstream-downstream partnerships, and branding local products. This approach demonstrates that digitalization rooted in local wisdom can enhance economic productivity, strengthen resilience, and support sustainable progress toward independent-village status.

Keywords : BUMDes Digital, Digital Transformation, IDM, Linear Regression, Local Wisdom

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1. INTRODUCTION

The transformation of villages in Indonesia over the past five years has moved towards smart villages, namely the strengthening of basic services, the local economy, and environmental resilience, accelerated through the use of information technology, while remaining rooted in local wisdom [1], [2]. This concept is in line with the Village Development Index (IDM) framework, which assesses village independence from three dimensions, namely social (Social Resilience Index (IKS)), economic (Economic Resilience Index (IKE)), and environmental (Environmental Resilience Index (IKL)). A village is categorized as Independent if it has an IDM value above $\pm 0,8155$ [3]. The integration of advances in information technology and local wisdom is important, because village development that relies solely on one aspect is often unsustainable [4], [5].

Recent research confirms that ICT plays a decisive role in the success of smart villages by expanding market access (village e-commerce), improving the efficiency of administrative services, and strengthening citizen participation through open data and service applications [6], [7], [8]. At the same time, digital interventions that go against local values such as mutual cooperation, deliberation, and

customary institutions tend to fail to be sustainable. On the other hand, when ICT is framed by local wisdom, its impact on socio-economic resilience increases [4], [5].

In recent years, the concept of Smart Village or Digital Village has been increasingly recognized as an important strategy in achieving sustainable and inclusive rural transformation in Indonesia [9]. The digitization of villages has been proven to improve the efficiency of administrative services, empower village MSMEs through digital marketing, and expand access to information [10]. However, digitalization that is not aligned with local values such as mutual cooperation and deliberation has the potential to fail in the long term, while approaches that combine ICT with local wisdom demonstrate greater social and economic resilience [11]. Recent studies show that access to modern ICT infrastructure strengthens the resilience of villages, while supporting the implementation of smart villages based on local wisdom and the alignment of Village Funds with the SDGs agenda [12], [13]. The remaining gap is the lack of empirical studies evaluating how village development strategies can synergize the three dimensions of social, economic, and environmental resilience based on data and local wisdom. This study aims to fill this gap by formulating a self-reliant village development strategy that is quantitatively informed and deeply rooted in local values.

The Karang Intan subdistrict in Banjar Regency, South Kalimantan, is a prime example, with 11 villages achieving self-sufficient status by 2024. These villages have successfully integrated technological innovation with local wisdom, including through ecological initiatives such as the Climate Village Program (Proklim), eco-tourism development, participatory governance, and the optimization of agricultural and plantation potential. For example, Kiram Village has developed nature tourism and a bamboo mosque as its iconic features, while also actively participating in climate adaptation [14]. This success shows that combining ICT for services and markets with local wisdom for institutional and collective behavior is an effective path toward village independence.

In this study, researchers used a linear regression algorithm to predict the position of Bi'ih Village in the 2025 IDM classification, whether it will be included in the Independent category or remain at a lower level, based on IDM data from 2017–2024 covering the three main dimensions: IKS, IKE, and IKL. Linear regression was chosen because of its transparency, ease of interpretation, and low computational complexity, making it well-suited for modeling relationships in village development data [15], [16]. This method has been effectively applied in assessing the impact of socio-economic and environmental factors on village development indices in Indonesia, demonstrating its reliability in policy-oriented research [16], [17]. Furthermore, prior studies on the effectiveness of village funds in West Java have shown that regression models are robust in capturing causal relationships between government funding and IDM outcomes, further validating its suitability for this study [17]. The prediction results will serve as the basis for formulating a Self-Reliant Village Development Strategy through the integration of information technology and local wisdom, adapted from best practices in 11 Self-Reliant villages in Karang Intan Sub-district, with the aim of sustainably enhancing the social, economic, and environmental resilience of Bi'ih Village.

2. METHOD

This research methodology is designed to address the main objective, which is to predict the status of the Village Development Index (IDM) for Bi'ih Village in 2025 and formulate development strategies toward self-reliant villages through the integration of information technology and local wisdom. The approach used combines quantitative and qualitative analysis. Quantitative analysis is conducted using linear regression algorithms to project IDM values based on historical data, while qualitative analysis is used in the formulation of development strategies through comparisons with 11 self-reliant villages in Karang Intan Subdistrict. The research stages are presented in Figure 1.

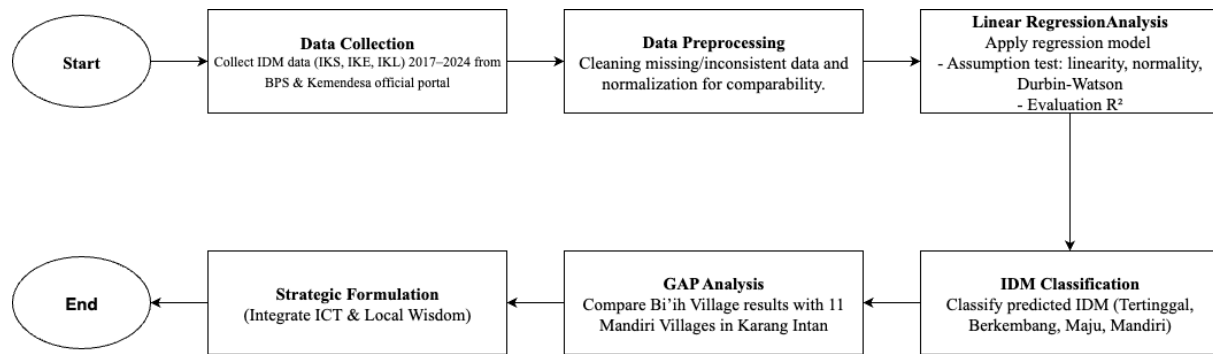


Figure 1. Research Methodology Flow Diagram

2.1. Data Collection

The first stage is the collection of data, which forms the main basis of this study. Researchers used the official Village Development Index (IDM) dataset for villages in South Kalimantan Province for the period 2017–2024, which consists of three main assessment components, namely the Social Resilience Index (IKS), the Economic Resilience Index (IKE), and the Environmental Resilience Index (IKL). The data was obtained from the official portal of the South Kalimantan Province Community and Village Empowerment Agency at https://dinaspmmd.kalselprov.go.id/indeks_desa/index.html, which contains complete information on the index values and status of each village for each year. The use of this official data source aims to ensure the validity, accuracy, and reliability of the analyzed data, as well as to minimize bias that may arise from the use of unverified secondary data. The following is Figure 2, which shows the location where the data for this study was collected.

 HOME DATA DOWNLOAD											
2016 2017 2019 2020 2021 2022 2023 2024											
INDEKS DESA MEMBANGUN (IDM) TAHUN 2024											
Show 25 entries										Search: 630306	
NO	KODE KAB	NAMA KABUPATEN	KODE KEC	NAMA KECAMATAN	KODE DESA	NAMA DESA	IKS	IKE	IKL	NILAI IDM	STATUS IDM
409	6303	BANJAR	630306	KARANG INTAN	6303062001	KIRAM	0,8629	0,7500	0,9333	0,8487	MANDIRI
410	6303	BANJAR	630306	KARANG INTAN	6303062002	MANDIANGIN BARAT	0,8229	0,7000	0,9333	0,8187	MANDIRI
411	6303	BANJAR	630306	KARANG INTAN	6303062003	KARANG INTAN	0,8400	0,7500	1,0000	0,8633	MANDIRI
412	6303	BANJAR	630306	KARANG INTAN	6303062004	PANDAK DAUN	0,8286	0,6833	1,0000	0,8373	MANDIRI
413	6303	BANJAR	630306	KARANG INTAN	6303062005	JINGAH HABANG ULU	0,8343	0,5167	0,8667	0,7392	MAJU
414	6303	BANJAR	630306	KARANG INTAN	6303062006	MALI MALI	0,7886	0,5333	0,8667	0,7295	MAJU
415	6303	BANJAR	630306	KARANG INTAN	6303062007	LOK TANGGA	0,8114	0,5667	0,9333	0,7705	MAJU
416	6303	BANJAR	630306	KARANG INTAN	6303062008	LIHUNG	0,7429	0,5500	0,8667	0,7198	MAJU
417	6303	BANJAR	630306	KARANG INTAN	6303062009	BIIH	0,8171	0,5667	1,0000	0,7946	MAJU

Figure 2. Dataset retrieval dashboard [14]

2.2. Data Preprocessing (Cleaning & Normalization)

After the data has been collected, the next stage is data preprocessing, which includes two important steps: data cleaning and normalization. Data cleaning is carried out by checking for missing values, duplicate records, or input errors such as inconsistent number formats. If missing data is found, the researcher checks the official source and corrects the value or deletes the invalid data row. After that, normalization is performed to standardize the data scale on the three indices (IKS, IKE, IKL) so

that they have the same range and do not cause bias in the analysis process. This step also includes converting date formats to numerical form, adjusting decimal points, and verifying data to ensure consistency with the IDM assessment standards set by the Ministry of Village, Development, and Transmigration.

2.3. Linear Regression Analysis (Predict IDM 2025)

The third stage is the application of a linear regression algorithm to predict the IDM value of Bi'ih Village in 2025. This method was chosen because it is capable of modeling the linear relationship between the time variable (year) and the IDM value based on historical data from 2017 to 2024. This process involves creating a regression equation as described in Equation 1 below.

$$IDM_t = \alpha + \beta t + \varepsilon_t \quad (1)$$

α is a constant, β is the slope coefficient that indicates the trend of change, and ε is an error term. Before the model is used, classical assumption tests such as residual normality and autocorrelation are conducted to ensure the reliability of the prediction results. The IDM 2025 prediction values generated will serve as an initial reference in determining the future status of Bi'ih Village.

Before determining the main method, the researchers compared several prediction algorithms, namely Random Forest, Gradient Boosting, and Linear Regression. Initial test results showed that Linear Regression provided superior performance, as indicated by lower prediction error values and simpler model interpretation. Therefore, this study focused on the use of linear regression.

Before the model was used, a series of classical assumption tests were conducted to ensure validity. Linearity was tested by looking at the data distribution on a scatter plot showing a straight line pattern, as the basis of model assumption testing prior to Equation 2. Residual normality was tested using Shapiro–Wilk, where the null hypothesis states that the residuals are normally distributed. The Shapiro–Wilk statistical formula:

$$W = \frac{(\sum_{i=1}^n a_i x_{(i)})^2}{\sum_{i=1}^n (x_i - \bar{x})^2} \quad (2)$$

Description:

$x_{(i)}$ = sorted data
 $\bar{x}$ = sample mean
 a_i = constant

Significance value (p-value) > 0,05 shows normally distributed residuals. The autocorrelation test uses the Durbin–Watson (DW) statistic with the formula:

$$DW = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2} \quad (3)$$

Description:

e_t = residual in period t

A DW value close to 2 indicates no autocorrelation. The test results show that all three assumptions are met, so the model is suitable for use.

The IDM 2025 prediction values generated will serve as an initial reference in determining the future status of Bi'ih Village, while the model accuracy is evaluated using Equation 4 and 5. To evaluate

the quality of the model, the Coefficient of Determination (R^2) and Root Mean Square Error (RMSE) were used. The evaluation formula is as follows:

$$R^2 = 1 - \left(\frac{SSE}{SST} \right) \quad (4)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (Y_i - \hat{Y}_i)^2}{n}} \quad (5)$$

Description:

SSE = sum of squared errors

SST = total variation of data

Y_i = total variation of data

$\hat{Y}_i$ = predicted value

The evaluation results show an R^2 value of 0.93, which means that 93% of the variation in IDM values can be explained by the model, and a low RMSE, which indicates that the difference between the actual and predicted values is relatively small.

The Linear regression was chosen because of its transparency, ease of interpretation, and low computational complexity, making it well-suited for modeling relationships in village development data [15], [16]. This method has been effectively applied in assessing the impact of socio-economic and environmental factors on village development indices in Indonesia, demonstrating its reliability in policy-oriented research [16]. Furthermore, prior studies on the effectiveness of village funds in West Java have shown that regression models are robust in capturing causal relationships between government funding and IDM outcomes, further validating its suitability for this study [17].

Thus, linear regression is not only superior in terms of accuracy, but also fulfills statistical assumptions, has theoretical justification, and a high level of interpretation, making it a suitable primary method for this study.

2.4. IDM Classification (Tertinggal, Berkembang, Maju, Mandiri)

Based on the results of linear regression predictions, the 2025 IDM value for Bi'ih Village will be compared with the official IDM classification criteria issued by the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration. These categories are: Underdeveloped ($IDM \leq 0.4916$), Developing ($0.4916 < IDM \leq 0.5995$), Advanced ($0.5995 < IDM \leq 0.8155$), and Self-reliant ($IDM > 0.8155$). This stage is important for quantitatively determining the position of Bi'ih Village, whether it is approaching the Independent status or still at the Advanced or Developing level. This classification also helps identify the achievement gap between the IDM value of Bi'ih Village and the Independent threshold.

2.5. Gap Analysis (Compare with 11 Mandiri Villages)

At this stage, a gap analysis was conducted by comparing the achievements of Bi'ih Village in each component of IKS, IKE, and IKL with 11 villages that have achieved independent status in Karang Intan Subdistrict. This comparison not only includes the average values of each index but also identifies the key factors possessed by self-reliant villages, such as the Climate Village Program (Proklm), the success of village-owned enterprises (BUMDes) in managing productive businesses, the use of information technology for tourism promotion, and the effectiveness of participatory village governance. From this analysis, researchers can identify which indicators are still lagging behind and which programs have proven effective in improving the IDM value.

2.6. Strategic Formulation (Integrate ICT & Local Wisdom)

The final stage is the formulation of an Independent Village Development Strategy that integrates Information and Communication Technology (ICT) with local wisdom. This strategy includes innovation in village-based public services, the use of digital platforms for marketing local products, the implementation of a transparent village information system, and the strengthening of community capacity through digital training. Meanwhile, local wisdom is integrated through the revitalization of cooperative values, strengthening traditional institutions, and adapting technology to align with local culture. This strategy is designed not only to simultaneously enhance the values of IKS, IKE, and IKL but also to ensure the sustainability of village development in line with the characteristics of the local community [18], [19].

3. RESULT

This section explains the results of the research process that has been carried out, starting from data processing, analysis of findings, to interpretation of results in accordance with the research objectives. The presentation of results focuses on the achievement of key indicators, projections for the achievement of the Village Development Index (IDM) in 2025, and the identification of factors that influence the development of Bi'ih Village towards independent status. All findings are presented systematically to provide a clear picture of the current conditions and the direction of the village's development in the future.

3.1. IDM Prediction Results for Bi'ih Village in 2025

The prediction of the Indeks Desa Membangun (IDM) value for Bi'ih Village in 2025 was carried out using a linear regression approach, based on historical IDM data from 2017 to 2024. This method was chosen to identify the trend of development progress and to estimate the village's future status by analyzing changes in its key components IKS, IKE, and IKL over time. The resulting model provides both a numerical projection and an analytical foundation for determining targeted development strategies. The following figure shows the results of the linear regression analysis conducted in this study.

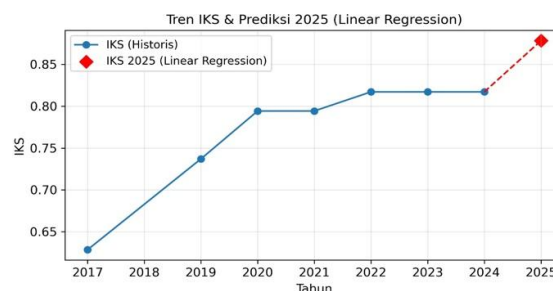


Figure 3. IKS Trends in Bi'ih Village in 2025

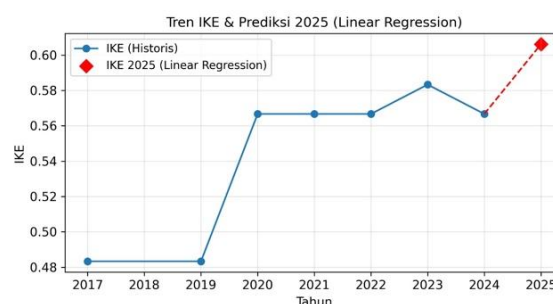


Figure 4. IKE Trends in Bi'ih Village in 2025

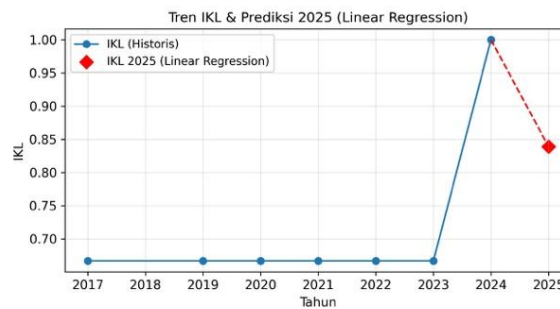


Figure 5. IKL Trend in Bi'ih Village in 2025

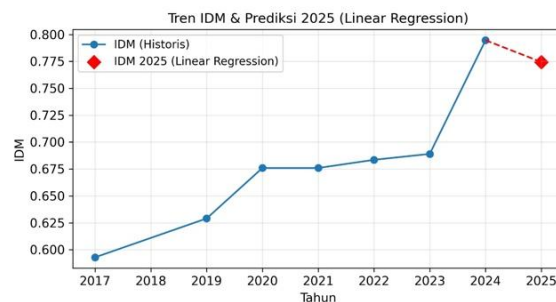


Figure 6. IDM Trend for Bi'ih Village in 2025

Table 1. IDM prediction using linear regression

Tahun	IKS	IKE	IKL	IDM
2025	0.8782	0.6061	0.8388	0.7744

Based on Table 1, the results of linear regression analysis of the Village Development Index (IDM) data for Bi'ih Village for the period 2017–2024 show that the projected IDM value for 2025 is 0.7744. This value is the result of combining the three main components: the Social Resilience Index (IKS) at 0.8782, the Economic Resilience Index (IKE) at 0.6061, and the Environmental Resilience Index (IKL) at 0.8388. From these results, it is evident that the social and environmental dimensions are already at a high level, while the economic dimension remains the lowest aspect and requires further attention.

3.2. Classification of Bi'ih Village Status

Based on the predicted value of the Village Development Index (IDM) for 2025 of 0.7744, Bi'ih Village is classified as an Advanced Village. This classification is based on the assessment thresholds set by the Ministry of Village, Regional Development, and Transmigration, where villages with an IDM value between >0.5995 and ≤ 0.8155 fall into the Advanced category. This predicted value shows a consistent increase compared to previous years' IDM values, but it is still 0.0411 points below the minimum threshold for the Independent category, which is 0.8155. The following is Table 2 IDM [3].

Table 2. IDM Classification Range

Categories	IDM score
Lagging behind (<i>Tertinggal</i>)	≤ 0.4916
Developing (<i>Berkembang</i>)	$> 0.4916 - 0.5995$
Advanced (<i>Maju</i>)	$> 0.5995 - 0.8155$
Independent (<i>Mandiri</i>)	> 0.8155

If examined based on its components, the IKS of Bi'ih Village in 2025 is projected at 0.8782 and the IKL at 0.8388, both of which have exceeded the *Mandiri* threshold. In contrast, the IKE remains at 0.6061, even below the *Maju* category threshold (>0.5995). This condition indicates that the main barrier for Bi'ih Village to advance to *Mandiri* status lies in the low achievement in the economic dimension.

At the national level, this position places Bi'ih Village in the upper-middle tier of the village development map, with strengths in social and environmental aspects but significant challenges in the economic sector. Therefore, priority programs should be directed toward strengthening productive economic activities, such as optimizing the Village-Owned Enterprise (BUMDes), enhancing community entrepreneurship capacity, developing tourism sectors based on local potential, and integrating information technology to expand market reach. With the right and measurable interventions, the 0.0411 point gap can be closed, enabling Bi'ih Village to potentially achieve *Mandiri* status within 1–2 years.

3.3. Gap Analysis Results

Based on the calculations, the IKS value for Bi'ih Village in 2025 is projected to be 0.8782, higher than the average IKS of 11 independent villages in Karang Intan Subdistrict, which is around 0.82. This indicates that Bi'ih Village has relatively equal or even slightly superior strength in social aspects, such as community participation, access to education, health, and basic administrative services.

In terms of the IKL, Bi'ih Village recorded a score of 0.8388, slightly below the average of 0.91 for *Mandiri* villages. Although the difference is not significant, improvements in environmental management, disaster preparedness, and natural resource conservation are still needed to match the achievements of other *Mandiri* villages.

The most striking difference can be seen in the IKE, where Bi'ih Village only achieved 0.6061, far below the average for *Mandiri* villages, which ranges from 0.70 to 0.73. This gap reflects the weak contribution of the economic sector to Bi'ih Village's IDM, which is likely influenced by low diversification of productive businesses, limited use of information technology for marketing, and restricted access to capital and business partnership networks.

This analysis indicates that strategies to accelerate progress toward self-reliance should focus on improving the IKE through interventions that directly target the development of local businesses, the optimization of Village-Owned Enterprises (BUMDes), and the enhancement of community entrepreneurship skills.

3.4. Mapping the Success Factors of Independent Villages

The Karang Intan subdistrict in Banjar Regency, South Kalimantan, has 11 villages with Independent status in 2024 that can be used as benchmarks. Each village has a key area of focus that serves as the primary driver for improving the IKS, IKE, and IKL. Table 3 presents a mapping of the 11 self-reliant villages and the key areas they are developing.

Table 3 shows that environmental and tourism factors are key strengths in several *Mandiri* villages, such as Kiram and Padang Panjang, which have successfully utilized the Kampung Iklim (Proklim) program and tourism potential to improve IKS and IKL. Agriculture and plantations are also the backbone of the economy in many villages, with business diversification and productive land management. Additionally, strong village institutions, such as the active Village-Owned Enterprise (BUMDes) in Mandikapau Timur, have made a tangible contribution to improving the Village Economic Index (IKE).

Table 3. Mapping of 11 Independent Villages

No	Name of Village	Field of Excellence	Description
1	Kiram	Environment & Tourism	022 Proklam Nominees, Kiram Park, Bamboo Mosque, waterfall ecotourism
2	Mandiangan Barat	Nature Tourism	Gunung Mawar Tourism, Gebrak Tourism Program
3	Karang Intan	Agriculture & Administration	Subdistrict center, agricultural product distribution
4	Pandak Daun	Wetland Agriculture	Potential of rice and swamp fisheries
5	Sungai Alang	Agriculture & Horticulture	Highland vegetable and fruit production
6	Sungai Asam	Agriculture & Forestry	Producer of cinnamon, rubber, and forest support
7	Mandikapau Timur	Institutional & Agriculture	Active village-owned enterprises, savings and loan businesses, and farmer kiosks
8	Awang Bangkal Barat	Plantations & Animal Husbandry	Smallholder oil palm, cattle
9	Padang Panjang	Environment (Proklam Lestari & Pembina))	Other village development, environmental management
10	Sungai Landas	Agriculture & Fisheries	Rice, horticulture, fish ponds
11	Mandikapau Barat	Agriculture & Food Barns	Sentra bibit dan lumbung pangan desa

4. DISCUSSIONS

This section discusses the interpretation of research results by linking the findings obtained in Bi'ih Village with previous theories, concepts, and research. The analysis focuses on identifying factors that influence the achievement of the Village Development Index (IDM), comparisons with villages with Independent status in Karang Intan Subdistrict, and strategic implications that can be drawn.

4.1. Interpretation of IDM Conditions in Bi'ih Village

When analyzed based on its constituent components, the Social Resilience Index (IKS) for Bi'ih Village in 2025 is projected to be 0.8782, and the Environmental Resilience Index (IKL) is projected to be 0.8388, both of which have exceeded the Self-Reliance threshold (>0.8155). However, the Economic Resilience Index (IKE) remains at 0.6061, even below the threshold for the Advanced category (>0.5995). This situation indicates that the main obstacle to Bi'ih Village's status upgrade to Self-Reliant lies in the low achievement in the economic dimension. A similar situation was found in previous research studies [20], [21] which emphasizes that even villages with high local economic potential will find it difficult to improve their status without digital transformation in product marketing and village business management. Research of [22], [23] also shows that the success of economic growth is closely related to the integration of information technology to expand markets and distribution efficiency.

4.2. Factors Hindering and Promoting IKE Improvement

Field analysis shows several factors hindering the improvement of IKE in Bi'ih Village, including: limited access to digital markets, manual financial record keeping, lack of information integration between village business units, and low digital literacy among MSME and BUMDes actors. Study of [24] emphasizes that such obstacles are common in villages that have not yet adopted integrated information systems. In contrast, the driving factors in Bi'ih Village include high social participation,

relatively adequate basic infrastructure, and outstanding potential such as durian farming and high-value local processed products. Research [25], [26] emphasizes that utilizing local potential as a basis for digital business development can increase village income and accelerate the achievement of development targets.

4.3. Comparison with Previous Research

Based on previous literature, studies in Pongkok Village [24] and Lobuk Village [22] which proves that the integration of information technology with local strengths can increase the economic productivity of villages. The difference is that in Bi'ih Village, the social and environmental dimensions are already relatively strong, so the focus of the strategy is directed at strengthening the economic dimension, which is still lagging behind. This approach is in line with the findings of [20] which emphasizes the role of the village digital community as a driving force for marketing and business management, as well as [23] which highlights the importance of community-based business models for strengthening economic resilience.

In terms of planning, [27] proposing a Balanced Scorecard framework that is aligned with the principles of village development, in which technology is positioned as a tool to strengthen institutional capacity, not as an end goal. This view is in line with research [28] which emphasizes the need to integrate technology with community empowerment strategies. However, low digital literacy, as revealed by [29], becomes a challenge that must be overcome through inclusive and sustainable training.

Several studies also highlight the opportunities for developing villages based on tourism potential as a driver of the local economy [30] shows that tourist villages can optimize the economic, social, and cultural resources of the village, while [31] adding that digitization promotes efficiency and profitability of rural financial institutions such as BUMDes and cooperatives. This strategy is in line with the recommendations [32] which prioritizes the development of a web-based tourism directory and online promotion to strengthen the pillars of smart living and smart economy.

In addition, a participatory approach tailored to local needs has proven crucial to the sustainability of the program [33]. However, challenges such as the unsustainability of strategies [1], and weak evaluation methods [34], and limited adoption of technology despite its long-standing initiation [35] remains an obstacle in many villages. Similar obstacles are found at the national level, where limitations in infrastructure, economic access, human resource quality, and planning data are major barriers to development [36], [37].

In particular, South Kalimantan Province's rich natural resources and strategic geographical location could be a huge asset if managed properly [38]. In this case, literature from previous studies explains that technological integration, institutional strengthening, and community participation are key to accelerating the transformation of villages towards self-sufficient status.

4.4. Quantitative Impact of Smart Village on Economic Resilience

The results of the study indicate that digitization within the framework of smart villages has the potential to increase the Economic Resilience Index (ERI) of villages by 15–20% within a period of 2–3 years. These findings are consistent with previous studies that confirm the close relationship between organizational, environmental, and technological readiness and the competitiveness of the village business ecosystem [1]. Relevant literature also emphasizes that the digitization of the value chain, from production and recording to marketing, is the most significant factor in driving rural economic growth [25], [39], [40]. In addition, recent studies show that the “smartness” of villages, which includes a combination of organizational readiness, environment, and technology, has a strong correlation with innovation and the competitiveness of the village business ecosystem. This has been proven through a model validated in 179 villages in West Java, which provides strong empirical evidence of this

relationshi [41]. This quantitative comparison is in line with the results of the linear regression prediction for Bi'ih Village. With a current IKE score of 0.6061, an increase of around 22–23% is needed for the village to reach the threshold for independent status. International research reinforces the discussion on digitalization, specifically that digitalization through China's rural e-commerce program has been proven to increase rural community income by 12.97% by facilitating digital financial inclusion and promoting entrepreneurship [42]. Thus, the implementation of a digital technology optimization strategy for MSMEs, BUMDes, and the local agricultural sector can be a realistic path for Bi'ih Village to accelerate its transformation into an independent village.

4.5. Ethical and Policy Urgency in Digital Village Transformation

The digital transformation of villages cannot be separated from ethical issues related to how technology is presented, used, and interpreted by the community. The main challenge is not only a matter of access or infrastructure, but also concerns how to respond to cultural and value changes when the social space of villages begins to be mediated by digital platforms [43]. Digital ethics require that technology not be imposed from outside, but rather developed based on the principles of participation and co-design with citizens, so that decisions on digitization reflect the real needs of rural communities [44]. In this case, local wisdom functions as a cultural barrier for mutual cooperation, deliberation, and customary institutions, which can prevent the exclusion or exploitation of traditional knowledge [45]. If not handled wisely, digitization risks marginalizing vulnerable groups and turning local knowledge into a commodity without fair recognition and benefits. Therefore, the integration of digital ethics and local wisdom must be realized through mechanisms that protect communities' rights to data and knowledge, digital literacy assistance tailored to cultural contexts, and transparent accountability systems for benefits [46], [47]. From this perspective, digitization is not only an economic tool, but also a means to strengthen identity, social solidarity, and the sustainability of village cultural values.

In line with this, the momentum for digital transformation in villages is becoming increasingly relevant in terms of policy. BPS PODES 2024 recorded that there are 84,276 villages/subdistricts in Indonesia, making the scale of digitalization implementation national [48]. In this case, Bi'ih Village, as a developing village, has a great opportunity to feel the impact. The allocation of the 2025 Village Fund amounting to Rp71 trillion through PMK 108/2024 provides significant fiscal space for village governments to promote the digitization of public services, strengthen the local business ecosystem, and improve the digital literacy of the community. These three aspects align with the pillars of a smart village and can serve as key strategies for Bi'ih to accelerate its achievement of self-sufficient village status.

However, the potential will only be effective if it is followed by an outcome-based allocation mechanism, not merely budget absorption. For Bi'ih Village, these outcomes can be achieved through increased digital transactions by BUMDes, increased turnover for durian MSMEs and processed food products, and expanded digital inclusion of residents in village administrative services. With the support of an accountable reporting system, every village fund allocation can be directed appropriately to drive an increase in Bi'ih's IKE and simultaneously reduce the gap with other villages. Thus, national policies are not just numbers on paper but can be translated into concrete local strategies for Bi'ih to move toward becoming a digitally-based self-reliant village.

4.6. Independent Village Development Strategy

Based on the results of the 2025 IDM projections, Bi'ih Village shows a IKS of 0.8782 and an IKL of 0.8388, both of which have exceeded the threshold for the Independent category (>0.8155). However, the IKE remains at 0.6061, below the threshold for the Advanced category (>0.5995). This situation indicates that efforts to accelerate Bi'ih Village's status toward Self-Reliant require strategic

interventions focused on strengthening the economic sector without neglecting social and environmental sustainability.

The proposed development strategy is oriented toward integrating information technology with local wisdom, so that digital transformation can strengthen the village's economic capacity while preserving cultural values. This approach is structured into several steps:

- a) Development of Digital BUMDes, strengthening Village-Owned Enterprises (BUMDes) through an online sales platform that markets leading village products, such as durian and its derivatives, garden produce, and local handicrafts. This system is equipped with a product catalog and digital payment methods to expand market access and increase transaction efficiency [49], [50].
- b) Application-based financial systems and real-time digitization of cash records and transactions for MSMEs/BUMDes will improve the accuracy of financial data and simplify the evaluation process. Automatic financial reports can be used as a basis for decision-making and increase public transparency [22].
- c) Upstream-Downstream Business Partnerships: Establishing partnerships with cooperatives, modern retailers, universities, and crop buyers to strengthen the supply chain. Joint marketing schemes will help reduce distribution costs and increase the competitiveness of local products [51].
- d) Targeted Branding and Promotion, increasing product sales through professional packaging design and storytelling based on local history. Promotion is carried out through social media, village events, and integration with national marketplaces to reach a wider range of consumers [20].

This approach is in line with the results of studies showing that village digitization that combines technology and local wisdom can increase product added value, expand marketing networks, and strengthen community trust in village governance [6], [23], [25].

5. CONCLUSION

The prediction results show that in 2025, Bi'ih Village will still be in the *Advanced* category with an IDM value of 0.7744, or about 0.0411 points behind the threshold for the *Independent* category (>0.8155). The IKS (0.8782) and IKL (0.8388) reflect strong community participation, access to basic services, and environmental management, comparable to the average achievements of Self-Reliant villages in Karang Intan Sub-district. However, the IKE, which only reached 0.6061, indicates that economic diversification remains weak, access to broader markets is limited, and there is no integrated financial system in place for village-based businesses.

Economic dimensions are therefore the main obstacle preventing Bi'ih Village from achieving Independent Village status. Several strategic steps can be taken to overcome these obstacles. First, develop high value-added processed agricultural products, especially durian and its derivatives, to increase community income. Second, establish structured business partnerships with cooperatives, modern retailers, universities, and crop buyers to expand marketing networks and strengthen the supply chain. Third, implement a transparent and real-time financial reporting system for Village-Owned Enterprises (BUMDes) to enhance accountability, efficiency, and public trust. Fourth, strengthen the branding and promotion of village products through engaging local cultural narratives to differentiate Bi'ih Village products from those of other regions. If these strategies are implemented consistently, improvements in economic aspects (IKE) have the potential to close the gap by 0.0411 points. To surpass the Mandiri threshold (0.8155), an increase in IKE of approximately 0.134 points from the current position (0.6061) is required, equivalent to an increase of around 20.3%, thereby enabling the achievement of Independent status.

This study also opens opportunities for future research. This research opens up opportunities to develop Machine Learning (ML) and Artificial Intelligence (AI)-based IDM prediction methods that are more adaptive and accurate in representing the dynamics of village development. In addition, further research can be directed towards strengthening a sustainable independent village framework that is capable of integrating economic growth, social inclusion, and environmental resilience.

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