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Reframing Agropolitan Infrastructure Priorities through Farmers' Perceptions: An Importance–Performance Analysis of a Strategic Rice-Producing in Babulu

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Abstract

Babulu District is recognized as the primary rice-producing area in North Penajam Paser Regency and serves as a strategic food security buffer for Indonesia's prospective new capital city (IKN). Despite its significant agricultural potential, agropolitan development in the district is constrained by inadequate infrastructure. This study evaluates the importance and performance of 11 agropolitan infrastructure attributes across 18 indicators in Babulu District using the Importance-Performance Analysis (IPA) method. Data were collected through structured questionnaires administered to 62 farmer group respondents drawn from five villages, supplemented by in-depth interviews with key informants. The findings reveal that irrigation channels (gap = 2.93) and water storage reservoirs (gap = 2.40) exhibit the largest importance-performance gaps, followed by farm road networks (gap = 1.79). Furthermore, inter-village comparisons highlight significant spatial disparities, for instance, the performance of farm roads is notably the lowest in Labangka village, severely limiting physical accessibility. Conversely, electricity networks, markets, fertilizer kiosks, and agricultural extension centers demonstrate relatively adequate performance relative to their perceived importance. These results indicate that water management and connectivity infrastructure represent the primary bottlenecks in Babulu's agropolitan system. From a policy standpoint, the findings suggest that infrastructure investment should be sequenced, prioritizing irrigation systems and farm roads before addressing post-harvest facilities, in order to maximize multiplier effects across the agropolitan value chain. The results further indicate that agropolitan infrastructure planning in Babulu should extend beyond the three formally designated priority villages to encompass functionally integrated surrounding areas

Keywords: agropolitan, infrastructure, importance–performance analysis

1. Introduction

The establishment of agropolitan regions has been generally promoted as a means of improving the rural economy by integrating agricultural and agro-industrial sectors. In this regard, infrastructure is considered a critical factor in ensuring the efficiency of production, distribution, and value-adding activities Proper agropolitan infrastructure—irrigation, farm roads, storage facilities, and energy networks—not only needs to be provided to support agricultural production but also to improve regional food security and economic sustainability, generating multiplier effects (Surya et al., 2021; Chakrabarti, 2025; Urugo et al., 2024).

In the context of Indonesia's Nusantara Capital City (IKN) relocation to East Kalimantan, agricultural regions in the surrounding regencies—including North Penajam Paser (Penajam Paser Utara)—have acquired heightened strategic importance as food supply buffers. Babulu District, designated as the primary rice granary of North Penajam Paser Regency with approximately 16,899 hectares of agricultural and plantation land, represents a critical node in the regional food security architecture supporting IKN (Agustian et al., 2025; Jiuhardi et al., 2023). Despite this strategic designation and strong agricultural potential, the initial findings in the field show that the development of agropolitan infrastructure in the Babulu District has not been equally distributed, has weak inter-agency coordination and inadequate investment targeting, a common finding in Indonesia (Handayani, 2021). Several villages continue to experience constraints in basic and supporting infrastructure, such as farm roads, irrigation, storage facilities, and agro-processing units. According to the North Penajam Paser in Number, by 2024 only 22% of the district's irrigation network is in good condition, while approximately 2/3 of roads are classified as damaged. This situation raises a fundamental research problem: to what extent does the existing agropolitan infrastructure in Babulu District meet farmers' needs, and which infrastructure types require priority improvement to support the district's role as a food supply buffer for IKN? This question is particularly relevant given the difficult terrain characteristic of Kalimantan, which amplifies the cost and complexity of infrastructure delivery.

Despite numerous government-led projects, discrepancies between infrastructure development and farmers' actual needs continue to persist. These discrepancies arise from structural, institutional, and political considerations that render policy design remote from the realities of agricultural development. In most developing countries, the governments tend to prioritize in large-scale, capital-intensive projects like centralized irrigation systems and large roads, which are shaped by top-down planning, political expediency, and donor-driven agendas rather than small farmer needs (Bjornlund et al., 2020a; Bjornlund et al., 2020b). Limited farmer participation, fragmented bureaucracies, and urban-centric political economies further decouple rural development. In these conditions, infrastructure development is standardized according to technical templates that disregard agro-ecological and market realities, resulting in irrigation systems that are inappropriate for smallholder farming systems and roads that bypass important agricultural areas (Playán et al., 2018; Lencucha et al, 2020; Van de Zande et al, 2024). These continuing mismatches between the supply of infrastructures and farmers' needs demonstrate the lack of an integrated perception-based evaluation system that could effectively measure the performance of rural infrastructures from a users' perspective.

This study aims to fill this gap by using the Importance-Performance Analysis (IPA) technique to assess the agropolitan infrastructure of Babulu District. IPA is increasingly acknowledged as a strong and practical assessment method for agropolitan infrastructure because it allows for the simultaneous assessment of perceived importance and actual performance, making it easy to prioritize development efforts. Empirical research also shows that IPA is an effective tool in rural and agricultural areas, especially for infrastructure and water resource management, where farmer perceptions are often at odds with government development priorities (Cao et al., 2020; Kanyangale et al., 2025. Through quadrant mapping, IPA distinguishes infrastructure requiring priority investment, maintenance, de-emphasis, or resource reallocation (Esmailpour et al., 2020; Hua & Chen, 2019; Wu et al., 2023). The method has been widely applied in service quality studies and increasingly in agricultural contexts (Santoso et al., 2023; Santoso et al., 2025).

Despite this growing methodological evidence, IPA has not been systematically applied to evaluate the full spectrum of agropolitan infrastructure within a single integrated framework reflecting the interdependence of farm roads, irrigation, water storage, processing facilities, warehouses, electricity, markets, and extension services. While most prior research concerning rural infrastructure mainly focused on individual infrastructure components—such as irrigation systems only (Jayanti & Teuku, 2026; Kanyangale, 2025) or general rural development indicators (Munarso et al., 2024)—the current study adopts an innovative strategy through the use of Importance-Performance Analysis (IPA) within the context of an integrated agropolitan infrastructure system. The importance of integration in the context of infrastructures cannot be overstated because the malfunction of any particular infrastructural component could easily render all other infrastructural elements redundant (Deng et al., 2017; Hanafiah & Nuraini, 2025). In addition, there is always structural friction inherent in agricultural development, specifically between the top-down approach used by the government and the bottom-up nature of farming activities. Governmental policies are typically formulated based on a centralization strategy, with the objective of achieving tangible physical goals and budgetary absorption. Such policies inevitably lead to alienation in the process of policy formulation and decision-making for farmers (Souissi et al., 2024; Amnurdiant et al., 2024). As a result, there is a divergence where the infrastructure built by the state no longer meets the needs of the farmers' everyday life (Sudrajat et al., 2021; Oktarina & Malini, 2021).

Through the provision of answers to these questions, this research seeks to: (1) establish an empirical foundation for the prioritization of agropolitan infrastructure development in the Babulu District, and (2) improve the conceptual foundations of infrastructure performance evaluation in agropolitan regions. The results of this research are expected to inform evidence-based policy decisions on regional agropolitan planning and can be used to contribute to debates on rural infrastructure and food security in emerging agricultural regions.

2. Study Literature

Infrastructure is the central base of agropolitan development, as it facilitates agricultural productivity, market linkage, and rural economic growth. Road infrastructure, both connecting roads and farm roads, has been found to be one of the most effective interventions in agricultural areas. Research evidence reveals that rural roads enhance agricultural production, lower transport costs, and promote non-farm employment and income (Shamdasani, 2021; Chakrabarti, 2025), while also improving the efficiency of agricultural extension services through knowledge transfer (Gebresilasse, 2023). Post-harvest infrastructure is equally important, as storage deficits cause grain losses of 25-30% in developing countries (Kumar & Kalita, 2017), while agro-processing infrastructure can significantly reduce post-harvest losses and improve farm gate income (Urugo et al., 2024), thus establishing that storage and processing infrastructure is a structural base of agropolitan development and not a supplementary facility.

The infrastructure of utility services such as electricity and water is the backbone of almost all agropolitan activities. Rural electrification has been demonstrated to increase agricultural production and earnings through mechanization, cold chain services, and agro-processing, as well as structural transformation (Burlig & Preonas, 2024; Amuakwa-Mensah & Surry, 2022). Irrigation infrastructure also enhances farm productivity, but evidence suggests that the reliability of water is more important than availability (Bravo-Ureta et al., 2020; Gebru et al., 2025). Water storage reservoirs also enhance irrigation infrastructure by stabilizing seasonal fluctuations and ensuring year-round water security (Smith et al., 2023). These results suggest that electricity infrastructure, irrigation channels, and water storage reservoirs should be considered as a system of systems rather than separate infrastructure in the context of agropolitan development.

Market access infrastructure and agricultural support services constitute the institutional and commercial component of agropolitan development. Markets can help reduce transaction costs, ensure price stability, and enhance the bargaining power of farmers (Marion et al., 2024; Donaldson, 2018). In the input service, the lack of physical accessibility to fertilizer kiosks is identified as a significant constraint to the adoption of fertilizer (Benson & Mogues, 2018). Agricultural extension services are knowledge infrastructure, and evidence confirms that access to extension services has a positive effect on crop output, although it is highly dependent on physical accessibility (Danso-Abbeam et al., 2018; Rajkhowa

& Qaim, 2021). These studies together establish that roads, markets, kiosks, and extension services need to be integrated in space to realize the agropolitan synergy.

The Importance–Performance Analysis (IPA) method provides a suitable analytical framework for evaluating such multidimensional infrastructure systems. Originally proposed by Martilla and James (1977), IPA uses a two-dimensional matrix to compare perceived importance and actual performance, enabling the identification of priority attributes for intervention. Its validity and reliability as a decision-support tool have been confirmed in multi-attribute service and infrastructure settings (Azzopardi & Nash, 2013). IPA has been widely applied in environmental management, water infrastructure, and rural development, including river ecosystem services (Hua & Chen, 2019), wetland restoration (Das & Basu, 2020), post-mining community infrastructure in Indonesia (Sutrisno et al., 2023), rural forest management in Taiwan (Chen et al., 2021), and participatory spatial planning (Ravazzoli et al., 2025). Collectively, this literature establishes IPA as a robust and contextually appropriate method for evaluating agropolitan infrastructure in Babulu, given its capacity to integrate stakeholder perceptions with performance gaps and generate evidence-based priorities for infrastructure investment.

3. Methods

3.1. Research Design

This study employs a quantitative descriptive-analytical research design. Quantitative methods are used to measure and compare the importance and performance levels of agropolitan infrastructure attributes, while the analytical dimension is operationalized through the Importance-Performance Analysis (IPA) framework. The study is cross-sectional in nature, with data collected at a single point in time across five villages within Babulu District.

3.2. Study Area

The research site is located in Babulu District, North of Penajam Paser Regency, which is a centre of rice granaries including 16,899 ha for farming areas. Based on the RTRW and RPJMD, the existence of priority villages for agropolitan development covers Gunung Intan, Sebakung Jaya, and Labangka. This current study also involved other villages which had potential in agropolitan areas, such as Rawa Mulia and Gunung Mulia, to enable inter-locality comparison.

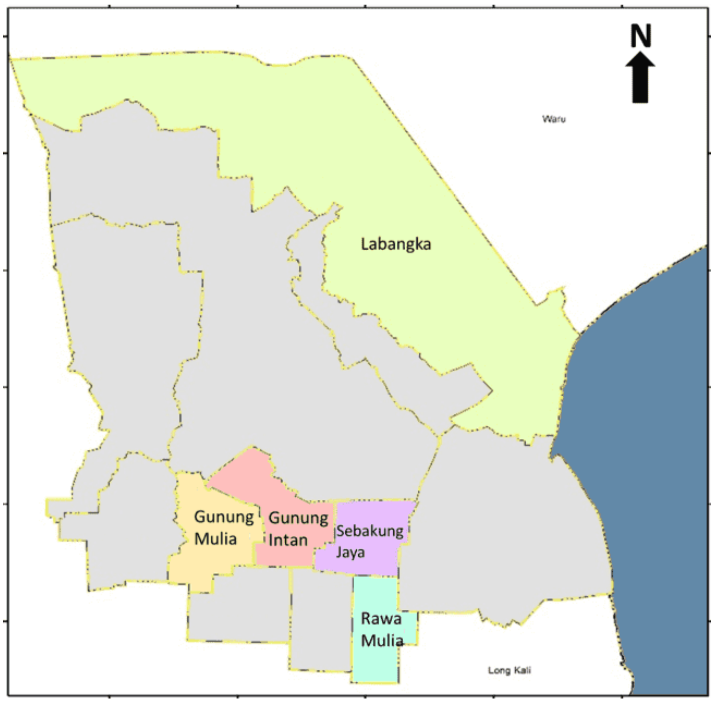

Figure 1. Study Area Map

3.3. Population and Sampling

The total number of farmer groups in Babulu District is 163. The sample size was determined using the Slovin formula.

$$n = \frac{N}{1 + N\,(e)^2} \qquad (1)$$

where N = 163 and the margin of error (e) is 10%, or 0.1, resulting sample size of 62 respondents. Using a 10% margin of error when figuring out how big the sample should be is seen as good enough and makes sense from a methodological point of view. Many studies have used the same level of accuracy in their research. For example, Andres and Hancke (2025) used a 10% error margin in their survey. Similarly, Perez et al. (2021) and Aziz et al. (2026) also used this same level of precision when they collected data from a representative group of people. This study is mainly about describing and exploring things to find general trends instead of getting very exact numbers, so having a 10% error margin is okay. Since the population size is fairly small (N = 163), the difference in accuracy between a smaller margin and a larger one isn't very big. However, using a bigger margin makes the process easier in terms of time, money, and being able to collect data in the field. So, the selected margin offers a good middle ground between reliable statistics and practical limits, and it still makes sure the sample is representative enough for general use.

The sample was evenly distributed among the five villages with the highest number of farmer groups in Babulu District, with 12 respondents from each village. The remaining samples were allocated to Rawa Mulia Village and Labangka Village, which have the highest numbers of farmer groups, resulting in 13 respondents from each of these villages. Moreover, key informant, which was agricultural agency officials, was interviewed.

3.4. Data Collection Instrument

Selection of 11 infrastructure attributes was made according to the following steps. First, systematic literature review was done to find out common attribute categories used in studies with the same theme (Kumar & Kalita, 2017; Danso-Abbeam et al., 2018; Smith et al., 2023; Burlig & Preonas, 2024; Marion et al., 2024; Surya et al., 2021; Handayani, 2021; Santoso et al., 2025). Second, the attributes obtained were compared to infrastructure typologies described in Indonesia's agropolitan development policy guidelines (Peraturan Menteri Pertanian No. 50/2012) and regional development plan guidelines for North Penajam Paser Regency, namely RTRW and RPJMD. Third, the attributes identified at step two were verified by preliminary observations in the field and interviews with agriculture extension officers and district-level officials to make sure they were relevant to conditions in Babulu subdistrict. The 11 infrastructure attributes obtained above encompass all aspects of agropolitan infrastructure, which include transportation (linking road, farm road, loading and unloading facilities), post-harvest facility (storage warehouse, processing factory), utility (electricity, irrigation channel, water storage reservoir), and market support services (market place, fertilizer shop, agriculture extension facility). A total of 18 questions were used to assess the importance and performance of 11 infrastructure attributes. The data were collected using a structured questionnaire with two scales for each attribute:

- Importance: perceived importance of the attribute (Likert scale 1-5), and
- Performance: perceived current condition or service level of the attribute (likert scale 1-5).

Before the actual data collection process, the research objectives were communicated to the village authorities and relevant agricultural institutions. Verbal informed consent was sought from all the research participants. Participants were assured of data anonymity and the freedom to withdraw from the research process. During the data collection process, the researchers were assisted by agricultural extension officers in controlled agricultural environments.

3.5. Data Processing and Analysis

1. The obtained questionnaire data was processed and analyzed by the Importance-Performance Analysis (IPA) method. The mean importance value ($\bar{y}$) and mean performance scores ($\bar{x}$) were calculated for each infrastructure attribute. The gap value for each attribute was computed as (y) – (x), which indicates the difference between the expected value of the farmers and the actual condition of the infrastructure. To provide a comprehensive analysis, this study integrates quantitative IPA results with qualitative insights through an explanatory sequential approach. The quantitative gaps identified in the IPA matrix serve as the baseline, which are subsequently contextualized using in-depth interviews with agricultural agency officials. This qualitative integration helps unpack the institutional, budgetary, and bureaucratic constraints underlying the infrastructural performance gaps perceived by the farmers.
2. To develop the IPA matrix, a cut-off point, denoted as 'C-line,' was identified, where the vertical axis, 'Y-axis,' was set as the overall mean of all importance scores, and the horizontal axis, 'X-axis,' was set as the overall mean of all performance scores. Each infrastructure attribute was then located on the IPA matrix based on its respective mean importance and mean performance values.
3. Based on the location of the attributes in the matrix, the infrastructure attributes were grouped into four quadrants: (I) high importance and low performance (priority for improvement), (II) high importance and high performance (maintenance of performance), (III) low importance and low performance (low priority), and (IV) low importance and high performance (over-allocation of resources).

4. Result and discussion

4.1. Importance - Performance Analysis Quadrants

From the importance scores in the five villages, it is apparent that there is a trend in which irrigation channels ($\bar{Y}$ = 4.88), farm road networks ($\bar{Y}$ = 4.70), electricity networks ($\bar{Y}$ = 4.46), and water storage reservoirs ($\bar{Y}$ = 4.46) have the highest levels of importance. This trend is analytically logical since Babulu District is a rice-growing region in which water and accessibility are the most important factors in rice production. In contrast, agricultural extension centers have the lowest levels of importance (3.41), indicating that farmers in Babulu District do not consider them an important constraint, a result which needs to be subjected to critical evaluation rather than blind acceptance.

Table 1. Importance Level of Infrastructure in the Babulu Agropolitan Area

Types Infrastructure	Village (Farmer Groups)					
	Labangka	Gunung Intan	Gunung Mulia	Sebakung Jaya	Rawa Mulia	Average
Connecting Road Network	4.07	4.08	4.08	4.29	4.5	4.2
Farm Road Network	4.68	4.75	4.92	4.58	4.57	4.7
Loading and Unloading Terminal	3.71	4.08	3.83	3.67	4	3.86
Storage Warehouse	4.79	4	4	4.17	4.43	4.28
Processing Plant	4.79	4.08	4.33	4.29	4.18	4.33
Electricity Network	4.18	4.25	4.46	4.71	4.68	4.46
Irrigation Channels	4.92	4.83	4.92	5	4.71	4.88
Water Storage Reservoir	4.75	4.42	4.63	4.5	4	4.46
Market	4.21	4.29	3.63	3.92	4.21	4.05
Fertilizer Kiosk	4.14	4.25	4	4	4	4.08

Agricultural Extension Center	3	3.25	3.5	3.17	4.14	3.41

A critical observation concerns that a relatively lower importance was accorded to the loading and unloading terminal ($\bar{Y}$ = 3.86) and market ($\bar{Y}$ = 4.05). While these values may not appear alarming individually, they must be contextualized against the substantial body of evidence from across the world regarding the welfare impacts of market connectivity. The relatively lower importance accorded to markets and terminals by Babulu farmers may be a manifestation of a process of adaptive preference formation, where communities may not place sufficient importance on infrastructure, they have not been able to access, rather than a manifestation of structural independence from markets. This is corroborated by the relatively higher importance accorded to farm roads, which functionally act as a prerequisite to market access. Furthermore, this could also imply that the concerns of the farmers are still focused on the upstream production issues, such as access to the fields, so that the downstream issues concerning the infrastructure for their products' marketing and distribution are not yet considered in their decision-making process.

The performance levels of agropolitan infrastructure are presented in Table 2. In general, the performance levels of electricity infrastructure, markets, fertilizer kiosks, and agricultural extension centers are relatively high. On the other hand, irrigation channels, farm road networks, water storage reservoirs, and storage warehouses have low performance levels. This implies that despite the importance of these infrastructures, their performance levels are not adequate to support farmers.

Table 2. Performance Level of Infrastructure in the Babulu Agropolitan Area

Types Infrastructure	**Village (Farmer Groups)**					
	Labangka	**Gunung Intan**	**Gunung Mulia**	**Sebakung Jaya**	**Rawa Mulia**	**Average**
Connecting Road Network	3.9	4.13	4.13	4.04	4.36	4.11
Farm Road Network	2.32	3.13	3.12	3.29	2.68	2.91
Loading and Unloading Terminal	2.86	2.25	3	1.75	2	2.37
Storage Warehouse	2.71	2.83	3.33	2.25	2.21	2.67
Processing Plant	2.93	3.13	3.38	3.38	3	3.16
Electricity Network	4.5	4.5	4.83	4.58	4.54	4.59
Irrigation Channels	1.58	1.92	1.42	2.33	2.5	1.95
Water Storage Reservoir	2	2.08	2	2.25	1.96	2.06
Market	4.82	4.46	3.96	4.13	4.25	4.32
Fertilizer Kiosk	4.36	4.17	4	4.17	4	4.14
Agricultural Extension Center	4.14	4.25	4	4.25	4.36	4.2

The low level of performance in irrigation channels can be linked to the problems that are identified in terms of the capacity of the irrigation channels, damage to the channels, and the unequal distribution of water. In the same way, the low level of performance in farm road networks can be linked to inaccessibility, especially during the rainy season, which will then affect the flow of the agricultural products. This will then result in an increase in production costs and consequently reduce the income of the farmers, thus impacting the performance of the agropolitan system.

The performance scores show a vital structural deficiency in the agropolitan infrastructure system in Babulu District. For instance, the performance of the irrigation channel, which is of paramount importance, scored the least mean at 1.95 out of 5.00. This translates to the widest gap in importance-performance at 2.93. Water storage reservoirs did not fare much better in terms of performance, with a mean of 2.06 and a gap of 2.40. It should be noted that these low satisfaction levels are not just indicative of low satisfaction with the infrastructure services but also reflect a fundamental deficiency in the match between agriculture demand and infrastructure supply. Indeed, the magnitude of the gap in the performance of the irrigation channel in Babulu District confirms the assertion of Smith et al. (2023), which holds that irrigation channels and water reservoirs must be treated as a system. Indeed, the co-occurrence of the two attributes with such low performance in Babulu District suggests a failure in the system.

The farm road network has the third-largest gap ($\bar{Y} = 4.70$; $\bar{X} = 2.91$; gap = 1.79), with performance especially low in the Labangka village ($\bar{X} = 2.32$). This result of deterioration of farm road conditions may leads to a significant increase in transportation costs and a decrease in market prices for small farmers.This result has important implications: in Babulu, the poor performance of farm roads not only impacts transportation but also devalues other infrastructure investments, especially extension service centers and fertilizer kiosks, whose benefits are dependent on physical accessibility. Storage warehouses (gap = 1.61) and processing plants (gap = 1.17) rank next, further emphasizing the post-harvest component of the infrastructure gap. The failure of both the warehouses and the processing facilities in Babulu indicates that there is value leakage in the agricultural value chain from the time of harvest to the time of selling, thus negating the economic basis for the term 'agropolitan'.

After obtaining the average importance and performance values, the C-line was established to create the IPA matrix. The IPA matrix groups each type of infrastructure into four quadrants according to their relative importance and performance levels, as shown in Table 3 and Figure 2.

Table 3. *C-line of Importance-Performance*

No.	Infrastructure	Importance	Performance
1	Connecting Road Network	4.20	4.11
2	Farm Road Network	4.70	2.91
3	Loading and Unloading Terminal	3.86	2.37
4	Storage Warehouse	4.28	2.67
5	Processing Plant	4.33	3.16
6	Electricity Network	4.46	4.59
7	Irrigation Channels	4.88	1.95
8	Water Storage Reservoir	4.46	2.06
9	Market	4.05	4.32
10	Fertilizer Kiosk	4.08	4.14
11	Agricultural Extension Center	3.41	4.20
	Total	46.71	36.48
	C-Line	4.25	3.32

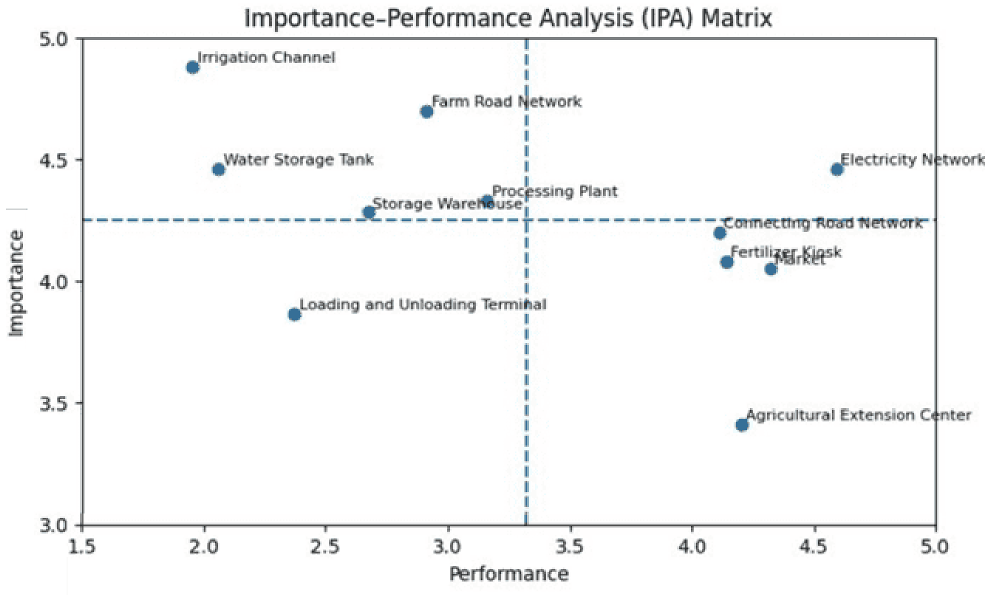

Figure 2. IPA Matrix

Quadrant I: "Focus Effort" comprises the five infrastructure types with the highest level of urgency: irrigation channels, water storage reservoirs, farm road networks, storage warehouses, and processing plants. The empirical robustness of the assignment of these attributes to Quadrant I should be noted but the policy implication of Quadrant I should be qualified. In practice, the five infrastructure types can be seen as part of a single infrastructure complex. In other words, improved accessibility of farm roads will not have a positive impact on agricultural yields in the absence of irrigation channel and water storage reservoir upgrading. Similarly, improved post-harvest handling is impossible without upgrading storage warehouses. Furthermore, improved agro-industrial processing is impossible without upgrading processing plants. In this respect, it can be argued that a sequential investment approach is more appropriate than a simultaneous multi-infrastructure approach.

Quadrant II comprises only the electricity network ($\bar{Y} = 4.46$; $\bar{X} = 4.59$), where performance is higher than importance. The high performance of the electricity service in Babulu can be attributed to the consistent expansion of the national grid due to electrification programs in Kalimantan. However, it is crucial to note that the classification of the Babulu results in Quadrant II is subject to a significant caveat. The quality dimensions of the service—voltage stability, duration of service, and load capacity for agricultural purposes—were not included in the analysis. It is essential to note that Burlig and Preonas (2024) reported that agricultural use of electricity requires a high-quality service with industrial-grade voltage stability rather than household-grade voltage stability. Quadrant III (Low Priority) includes terminals for loading and unloading. These terminals are viewed as less important and of lower performance. While there is still room for improvement, it is not as pressing as the other infrastructure in Quadrant I.

The Quadrant IV (Possible Overkill) category of the agricultural extension center ($\bar{Y} = 3.41$; $\bar{X} = 4.20$) is perhaps the most theoretically interesting result of this study and requires critical scrutiny. The extension centers perform well (fourth highest performance score) but are considered least important by farmers, which is a paradox that may indicate either that the extension services are delivering content that is mismatched with actual farmer needs or that the relevance of extension has been compromised by factors such as low adoption of recommended practices, low extension officer-farmer trust, or the development of informal agricultural information networks. The Babulu data indicate that the extension centers in the district may have reached the level of institutional presence without reaching the level of functional impact, a decoupling between the provision of infrastructure and service quality that may not be captured by the IPA approach, which measures performance in terms of perceived satisfaction rather than impact on yield. This is a basic limitation that must be recognized: high performance scores for extension in this study indicate farmer satisfaction with the delivery of the service, not its productivity effect.

It is therefore clear that an investment sequencing approach should be adopted, in which the priority should be given to irrigation rehabilitation and farm road enhancement, followed by investments in post-harvest infrastructure, for maximizing cumulative benefits in the value chain and enhancing the significance of Babulu as a food supply buffer for the IKN area. Scientifically speaking, this research offers a contribution to the existing stream of research in applied IPA studies in the agriculture and rural development fields, in which the use of IPA can offer insights into a complex combination of agropolitan infrastructures under one unified framework. It is noteworthy, however, that the application of spatial disaggregation at the village level represents a new step compared to traditional IPA uses, offering new insights into the equity issues related to the use of aggregated scores. It can also provide evidence regarding the implementation-planning gap associated with Indonesian regional development. Several limitations can be identified, nonetheless. Firstly, this study relies on the farmers' perception of their infrastructure performance rather than on actual objective measurements. Secondly, the margin of error of ±10% and the cross-sectional design limit the precision and generalizability of the results.

Third, IPA methodology operates on the assumption of independence among attributes, while the infrastructure systems examined are characterized by a high degree of functional interdependence, a drawback that could be overcome in future research using network theory or system dynamics modeling methods. Lastly, the questionnaire failed to differentiate among various indicators of infrastructure functioning, such as availability, reliability, quality, and accessibility, which could lead to the aggregation of various types of infrastructural failures into one performance indicator. Further research should focus on integrating IPA with infrastructure condition assessments, participatory planning, and longitudinal data collection.

4.2. Inter-Village Variation and Spatial Equity

However, a cross-village analysis of the data shows interesting spatial variation in the data that the aggregated IPA scores mask. Labangka village has the lowest performance score for farm roads ($\bar{X}$ = 2.32), while Rawa Mulia and Gunung Intan villages have relatively better performance for irrigation channels ($\bar{X}$ = 2.50 and 1.92, respectively). Sebakung Jaya, one of the three formally designated agropolitan priority villages, assigns the maximum possible importance score to irrigation channels ($\bar{Y}$ = 5.00) but has a performance score of only 2.33, making it the village with the highest irrigation gap in the dataset. This is a paradox because the most strategically located agropolitan village in the dataset has the highest gap in infrastructure performance, suggesting that formal designation does not guarantee prioritized infrastructure delivery in practice. This again brings into question the effectiveness of the current policy implementation mechanism in addressing rural infrastructure service delivery, suggesting a disconnect in the planning documents (RTRW, RPJMD) and the actual budget allocation in the districts—a governance issue that IPA can identify but not solve. These empirical findings strongly corroborate the existing literature regarding spatial connectivity. The severe deterioration of farm roads (gap = 1.79), particularly in Labangka, directly reflects the warnings by Gebresilasse (2023) and Chakrabarti (2025): poor physical connectivity fundamentally devalues other institutional investments. Even if markets and extension centers perform well, their overarching impact is structurally neutralized when farmers cannot physically access them due to compromised farm roads.

The addition of Rawa Mulia and Gunung Mulia, villages that are not formally designated as agropolitan priority areas, also provides a significant methodological finding. Both villages' importance-performance matrices are similar to the three other villages, indicating that the agropolitan infrastructure gap is not limited by administrative boundaries. The implication of this finding is that the agropolitan infrastructure investment strategy for Babulu should not be limited to the three formally designated priority villages, but should instead be focused on a functionally integrated agropolitan territory.

4.3. Reflections on IPA in Infrastructure Evaluation

While the IPA framework is a workable and policy-relevant analytical tool, it is important to transparently acknowledge a number of methodological limitations of this study. First, it is important to note that, in this study, performance is measured in terms of farmer perception and not physical measurements. This is a subjective approach and can result in a score that is influenced by reference points, familiarity, and social desirability bias. To illustrate, it is submitted that the relatively high score for markets and fertilizer kiosks can be partly explained by the relatively low expectations that farmers have. In a critical review of IPA, Azzopardi and Nash (2013) pointed out that perception-based approaches to measuring performance run the risk of collapsing the distinction between objective condition and experienced quality.

Secondly, IPA requires that there be no interdependence between attributes, but the infrastructure systems under investigation in this paper exhibit high levels of functional interdependence. The low performance in irrigation channels, for instance, is expected to negatively impact the level of productivity gains in farm roads, an interdependent relationship that cannot be captured in the IPA quadrant matrix.

Thirdly, this study acknowledges certain limitations. The survey tool does not make any distinction between the different dimensions of infrastructure performance in terms of availability, reliability, quality, and accessibility; thus, the resulting performance score could be an aggregate of different failure mechanisms that require different remedial interventions. Additionally, while the sample is methodologically representative for Babulu District, future research should consider longitudinal assessments and integrate spatial analysis (GIS) with IPA. Such approaches would provide more geographically weighted recommendations and track infrastructure performance across other prospective food buffer zones for the new capital city.

5. Conclusion

- An IPA approach was applied to assess the importances and performances of 11 agropolitan infrastructure elements in the Babulu District of North Penajam Paser Regency based on data collected from 62 farmer groups as respondents distributed over five villages. There are three important lessons to be learned from the results. First, the gaps between importance and performance of irrigation canals and water reservoirs (2.93 and 2.40, respectively) suggest the significance of water supply as the most significant infrastructure obstacle in the agropolitan system of Babulu. Second, farm road networks, storage facilities, and processing plants belong to the high priority quadrant, reflecting the significance of both infrastructure obstacles regarding access and post-harvest infrastructure. Meanwhile, electricity networks, market facilities, fertilizer shops, and agriculture extension facilities perform better than their significance, suggesting that these components are relatively well-served under current conditions.
- Second, the infrastructure gaps are unevenly distributed and are not limited to non-designated villages only. Specifically, Sebakung Jaya, one of the three officially designated villages for the agropolitan development strategy, registered the highest irrigation gap within the entire sample (importance=5.00; performance=2.33). This conclusion contradicts the idea that prioritizing from an administrative perspective means equal distribution in the budget, thus revealing the gap in governance in implementing the spatial planning instruments (RTRW, RPJMD).
- Third, agropolitan infrastructure in Babulu functions as an interdependent system, requiring sequenced investments—starting with irrigation and farm roads, followed by post-harvest facilities—to maximize productivity and strengthen its role for the IKN region. This study advances applied IPA by integrating multi-dimensional infrastructure assessment with village-level spatial analysis, revealing hidden equity issues and contributing to debates on Indonesia's planning-implementation gap.
- Limitations of this study include a margin of error of 10%, along with dependence on perception data and cross-sectionals studies. Survey tools can be refined by distinguishing the availability,

quality or accessibility. Subsequent studies need to consider including objective measures, reducing sampling errors, and using longitudinal and participatory studies methods to improve policy relevance.

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