Business Intelligence for Food Security Decision-Making from Transformed Paddy and Rice Production Data in North Kalimantan

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Abstract

The agribusiness sector in North Kalimantan Province faces challenges of supply chain inefficiencies and limited post-harvest infrastructure, which hinder food security and stability. This study aims to transform historical data on rice and paddy production from the Statistics Indonesia into Business Intelligence tools to support precise decision-making. The method used is a descriptive-quantitative approach, with an action research design. Historical data for the period 2018-2025 is processed and visualized in Looker studio. The main focus of the analysis is the extraction of production variables into technical indicators of efficiency, using yield percentages and geospatial mapping. The study's results show that the system successfully integrates production metrics, with an average actual yield of 59.15%, which is below the national standard of 64.02%. Analysis of the time-series chart shows a decrease in production, especially in Nunukan, which is a producer of Adan rice with premium varieties. Geospatial visualization reveals the region's polarization, where the administrative area is not directly proportional to production volume. The conclusion of this study confirms that the development of this dashboard is effective as a visual audit tool for detecting technical inefficiencies and spatial disparities. The transformation of tabular data into interactive insights enables policymakers to determine more targeted agricultural technology interventions to strengthen regional agribusiness supply chains.

Keyword: *Business Intelligence, Dashboard, Decision Making, Food Security, Yield*

1. INTRODUCTION

The agribusiness and national food security sectors are facing significant structural challenges towards the 2025 sustainable development target. Declines in agricultural infrastructure capacity, land conversion, and inefficiencies in supply chain management are the main obstacles to ensuring the stability of food availability for the community [1], [2]. In regions of Indonesia with extensive and fragmented topographic characteristics such as North Kalimantan (Kalimantan Utara/Kaltara) Province, comprehensive management of macro data on rice and rice plant/paddy production is crucial. A resilient agribusiness system requires precise data integration between production and consumption centers to anticipate availability disparities and price spikes early [3], [4].

In response to the complexity of agribusiness data management, the adoption of digital tools based on Exploratory Data Analysis (EDA) has emerged as a key approach in data science that researchers and policymakers rely on. EDA helps prepare data for more in-depth analysis, revealing insights. EDA helps data-driven decision-making processes [5]. Device usage and Business Intelligence (BI) have been scientifically proven to increase the speed and accuracy of interpreting large-scale national food trends[6]. Across a broader spectrum of technologies, forecasting integration and the Internet of Things (IoT) have also begun to be widely implemented to monitor supply chain movements and predict the availability of strategic commodities [7], [8], [9]. This digital transformation shifts the old paradigm that relies on managerial intuition toward spatial policy grounded in quantitative evidence (evidence-based policy).

Business intelligence tools such as Looker Studio are used for data visualization, converting sales and expenses from tables into interactive graphs that help management make faster decisions. Transforming tabular data into dashboards to visualize it can support decision-making. This is expected to be done by converting raw data into a graphical format to make it easier to understand and manage in business [10]. Dashboards can empower users to create compelling narratives using interactive reports and data visualizations. With the help of Business Intelligence tools, data can be turned into actionable insights for business processes [11].

In the fields of agricultural science and SCM (Supply Chain Management), the efficiency of the agro-industry is not only assessed by how much grain is harvested, but also by the efficiency of post-harvest processing (midstream). Inefficiencies in mill mechanization infrastructure have direct implications for the high yield loss rate (food loss), which can be measured through the percentage of yield [12]. This mapping of post-harvest efficiency conditions demands an accurate geospatial approach. This is supported by research [13], [14], which confirms that spatial analysis is vital for uncovering local-level surplus or deficit statuses that are often overshadowed (biased) by aggregate averages at the provincial scale.

Although various studies have contributed to the development of food systems, most previous studies have fundamental limitations (main limitations). Much research has focused solely on the development of mathematical prediction models [15] or on studying agribusiness macroeconomics, without offering interactive visualization solutions applicable to decision-makers at the regional level. Furthermore, conventional approaches often ignore the urgency of identifying "spatial polarization", which is a real inequality between the volume of rice production and the capabilities of post-harvest technology conversion in the field. The absence of visual audit instruments that can track actual yields in real time causes agricultural technology assistance allocation policies (such as Rice Milling Unto be) to be mis-targeted.

Given these limitations, a gap analysis is required that calls for direct scientific intervention. This research gap raises a new question: How can a minimalist dataset consisting solely of rice and paddy production variables be extracted to produce technical indicators of processing efficiency and mapped to detect spatial disparities? The novelty and uniqueness of this scientific paper lie in transforming limited tabular data (only two volume variables) into a percentage yield formula, which is then visualized in a Business Intelligence tool to audit post-harvest infrastructure across every district/city in North Kalimantan. This research aims to transform historical data on rice and paddy production from the Statistics Indonesia (*Badan Pusat Statistik*/BPS) into Business Intelligence tools to support precise decision-making in order to maintain food security.

2. LITERATURE REVIEW

2.1 Digital Transformation and Business Intelligence

The use of data visualization-based decision aids has become a new standard in food information management [6]. Proves that the exploratory approach using Tableau (BI) is very effective in dissecting national food price data in a multidimensional manner (univariate, bivariate, and multivariate). This aligns with the research [4], which emphasizes that Indonesia's food security challenges require support for the research and development of adaptive food technologies.

2.2 Supply Chain Efficiency and Agribusiness Yield

The yield variable is a crucial indicator of technical efficiency. [12] explained that agribusiness efficiency is often hampered by inadequate processing technology in the *midstream*. Post-harvest losses (*Food Loss*). This is a limiting factor in national food availability. [1] He added that damaged agricultural infrastructure has reduced production capacity, so modernization through logistics and technology infrastructure is a must by 2025.

2.3 Spatial Analysis and Region Polarization

Spatial mapping is crucial for detecting hidden disparities in aggregate data. A study conducted in Tegal region showed that spatial analysis can accurately identify surplus and deficit status at the sub-district level [14]. In line with this, a study highlights fluctuations in food availability across regions in North Hulu Sungai, underscoring the need to balance supply and demand using spatial data [13]. reinforcing this argument by stating that a spatially integrated agribusiness system contributes significantly to national food stability [3].

2.4 Projections and Future Technology Directions

The development of future monitoring systems is already leading to the integration of artificial intelligence. [15] Develop a production-prediction system using multiple linear regression to optimize food security. Time-series historical forecasting has also been used by [7] in North Sumatra and by [8] in Lampung. Lastly, [9]**.** Exposing the great potential of the Internet of Things (IoT) in monitoring the food supply chain in real-time to reduce inefficiencies.

3. METHODOLOGY

3.1 Research Methods

The method in this study uses a Quantitative, deductive approach, with an action research design. This research is designed to bridge the gap between raw data and decision-makers' strategic needs. Action Research as a Form of Intervention, where this research is not just passive observation, but a technical action to solve obstacles in the agribusiness supply chain. The development of the BI dashboard is a digital intervention to address the weaknesses in logistics infrastructure and processing technology. This aligns with the argument [12], which states that strengthening the agribusiness supply chain requires an integrative strategy to maintain distribution stability. The transformation of BPS data into a decision tool is a concrete form of "action" to improve managerial efficiency.

Descriptive Properties for Characteristic Mapping. The purpose of spatial polarization mapping demands a descriptive research design that can detail phenomena without manipulating variables. The use of geospatial visualization is crucial because aggregated data often hides disparities between regions. As evidenced by [14], spatial analysis allows the detection of stock vulnerability and surplus/deficit status that is not visible in the provincial average. Thus, the dashboard's descriptive nature serves as a visual audit instrument for the government.

Quantitative Approach with Data Exploration (EDA). The use of production absolute numbers and yield formulas positions this study within a quantitative framework. This methodology adopts the principles of EDA using modern visualization tools. [6] emphasizing that an exploratory approach using tools such as Tableau (or similar) is very effective for analyzing food prices and production, both univariate and bivariate, to draw data-driven conclusions.

2.2 Stages of Research

This research stage is systematically designed following the Action Research framework, which aims to transform raw data into digital policy intervention instruments. With a measurable flow, this research bridges the gap between tabular historical data and the need for interactive visualization to support precise decision-making. The stages carried out in the research are shown in Figure 1.

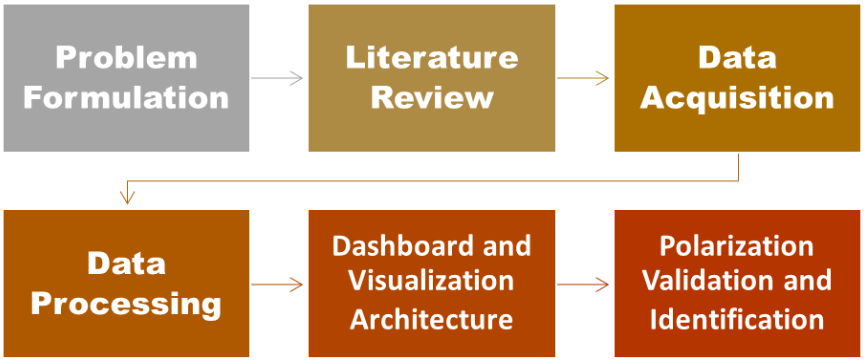


Figure 1. Research Stages

a. Problem Formulation
   This initial stage focuses on identifying structural challenges in agribusiness in North Kalimantan, particularly supply chain management obstacles and the deterioration of agricultural infrastructure. The problem formulation aims to answer how to extract a minimalist dataset (rice and paddy production volume) into a technical indicator of processing efficiency or yield. The main focus is to uncover "spatial polarization", i.e., the inequality between the area and the capabilities of post-harvest conversion technology that have not been seen in aggregate average data.
b. Literature Review
   A literature review was conducted to build a strong theoretical foundation regarding digital transformation and agribusiness efficiency standards. At this stage, an analysis was conducted of previous research on Digital Transformation and Business Intelligence, Supply Chain Efficiency and Agribusiness Yield, and Spatial Analysis and Regional Polarization to gain a comprehensive understanding.
c. Secondary Data Acquisition
   Data is obtained from the BPS, the official data authority. The use of historical data (2018-2025) is critical to establish long-term trend patterns. The challenge of food security towards 2025 requires a robust database to address declining production capacity, which often results from infrastructure degradation [1].
d. Data Processing

A crucial step in this stage is calculating the Yield Percentage. Research references show that milling efficiency (yield) is key in minimizing food loss. The main factor of agribusiness efficiency failure is often rooted in inadequate processing technology [12]. Formula 1 is a way to find a percentage of the redemption.

$$\text{Yield} = \frac{\sum \text{Rice Production}}{\sum \text{Paddy Production}} \times 100\% \tag{1}$$

e. Dashboard and Visualization Architecture
   Visual components such as Scorecards, Bar Charts, Time Series, and Maps are prepared to support multidimensional analysis. The use of Bubble Map and Color Area specifically refers to food distribution mapping techniques to determine whether the area affects production levels.
f. Polarization Validation and Identification
   The final stage is to test whether the dashboard can display spatial polarization. This stage aims to generate strategic insights for investors regarding the optimal location for investing in modern rice milling units (RMUs).

2.3 Tools

For dashboard development, Looker studio from Google is used. The Business Intelligence instrument consists of the following strategic components:

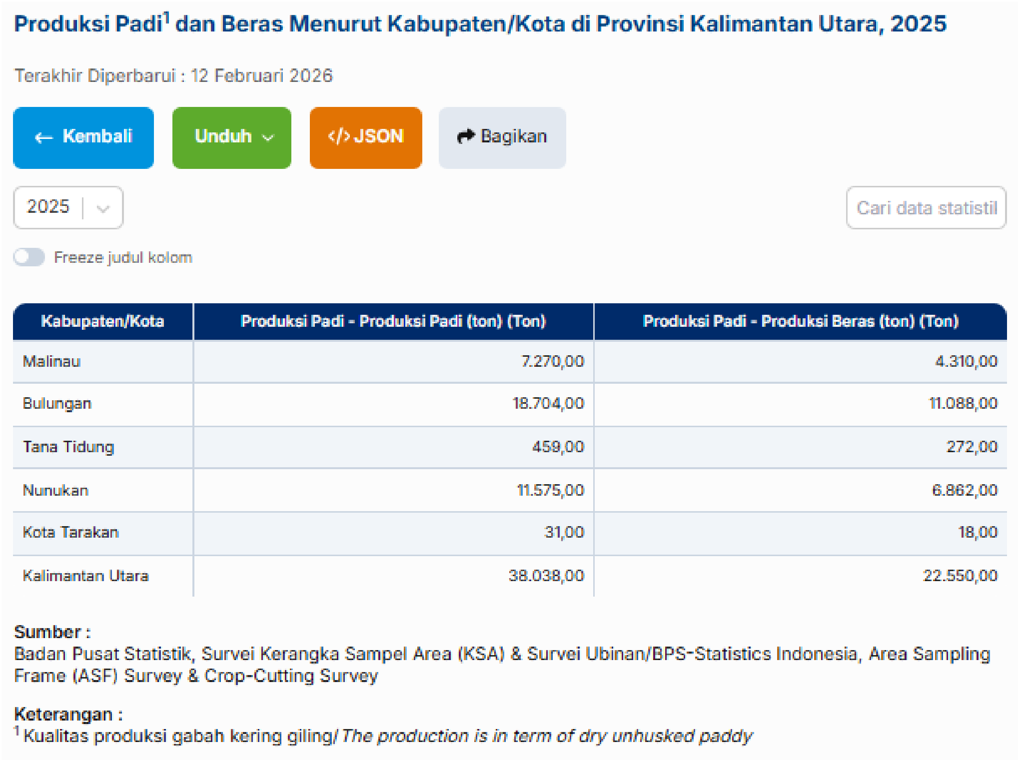
a. Scorecards
   Display three main aggregate metrics, namely Total Rice Production, Average Percentage of Yield, and Total Rice Production as macro performance indicators.
b. Bar Chart (Spatial Efficiency)
   Displays categories by regency/municipality on the X axis of Matrix X, and the Percentage of Yield value on Matrix Y. This component is used to map the polarization of areas categorized as "Efficient" (≥60%) or "Critical".
c. Time Series Chart (Trend Analysis)
   Using year as matrix X, paddy and rice production as matrix Y to monitor multi-year production fluctuations.
d. Spatial Map
   Using bubbles to represent paddy production volumes and color area to show the area of rice-producing areas. The use of this map is crucial in identifying areas with minimal production.

4. RESULTS AND DISCUSSION

This research has successfully developed a BI dashboard based on Looker studio that integrates historical data on rice and paddy production in North Kalimantan Province for the period 2018 to 2025. As a manifestation of the Action Research method, this study has transformed BPS North Kalimantan tabular data into an interactive monitoring system. This dashboard functions as a technology intervention instrument to accelerate strategic decision-making. The success of this development is characterized by the system's ability to automatically present macro metrics through the Scorecards component, which includes Total Rice Production of 264,216 Tons and Rice Production of 152,294 Tons. In addition, this instrument has identified critical efficiency indicators by calculating an actual yield of 59.15%, providing a strong basis for the government to conduct a post-harvest infrastructure audit in each district/city. Using available geospatial visualization, this dashboard also successfully uncovers regional polarization, enabling the precise detection of disparities between areas and production volumes to support evidence-based policies.

4.1 Data Acquisition and Processing

The data obtained from BPS North Kalimantan is processed and stored in an online spreadsheet, which reduces maintenance and costs and facilitates online updates to the dashboard. An example of data obtained from BPS North Kalimantan is shown in Figure 2.



Produksi Padi[1] dan Beras Menurut Kabupaten/Kota di Provinsi Kalimantan Utara, 2025

Terakhir Diperbarui : 12 Februari 2026

← Kembali | Unduh | </> JSON | Bagikan

2025 | Cari data statistil

Freeze judul kolom

Kabupaten/Kota	Produksi Padi - Produksi Padi (ton) (Ton)	Produksi Padi - Produksi Beras (ton) (Ton)
Malinau	7.270,00	4.310,00
Bulungan	18.704,00	11.088,00
Tana Tidung	459,00	272,00
Nunukan	11.575,00	6.862,00
Kota Tarakan	31,00	18,00
Kalimantan Utara	38.038,00	22.550,00

Sumber :
Badan Pusat Statistik, Survei Kerangka Sampel Area (KSA) & Survei Ubinan/BPS-Statistics Indonesia, Area Sampling Frame (ASF) Survey & Crop-Cutting Survey

Keterangan :
[1] Kualitas produksi gabah kering giling/ *The production is in term of dry unhusked paddy*

Figure 2. North Kalimantan BPS Data

The data from Figure 2 must be processed so that the studio looker can read it. The data is formatted as required. The *Tahun* (year) is changed to Type Year with the format DD/MM/YYYY, *Kabupaten/Kota* (Regency/Municipality) to Type of Geography, and *Produksi Padi* (Paddy Production) and *Produksi Beras* (Rice Production) to Numeric Number Type. The results of this data transformation are then stored in an online spreadsheet format to optimize device storage space and facilitate direct, low-cost dashboard updates. This adjustment to the data format is a crucial step to ensure the Business Intelligence instrument accurately recognizes each variable, enabling the system to automatically calculate the production figure and map the geospatial coordinates of the North Kalimantan region with precision. Table 1 is an example of stored data.

Table 1. Kaltara Paddy and Rice Production Data

Tahun	Kabupaten/Kota	Produksi Padi (Tons)	Produksi Beras (Tons)
31/12/2025	Kabupaten Malinau	7270	4310
31/12/2025	Kabupaten Bulungan	18704	11088
31/12/2025	Kabupaten Tana Tidung	459	272
31/12/2025	Kabupaten Nunukan	11575	6862
31/12/2025	Kota Tarakan	31	18
….	….	….	….

31/12/2018	Kabupaten Nunukan	13835.77	8160.1
31/12/2018	Kota Tarakan	52.1	30.73

4.2 Business Intelligence Dashboard Development

Integration of Key Metrics (Scorecards) Based on data processed from 2018 to 2025, the system displays three main indicators in aggregate. Total Rice plant /paddy production (*Produksi Padi*) of 264,216 Tons. Rice Production (*Produksi Beras*) of 152,294 Tons, and Average Actual Yield (*Rendemen*) of 59.15% during this period. The shape of the Scorecard component is shown in Figure 3.

Figure 3. Scorecards

This transformation enables stakeholders to view production performance in real time without manually processing raw data. This is in line with the findings of previous research [6], which states that an exploratory approach through data visualization increases the speed of interpretation of national food trends.

4.3 Analysis of Yield Efficiency and Production Trends

The results of the visualization on the Bar Chart and Time Series Chart provide a descriptive picture of rice processing efficiency across regions. The efficiency identification using Formula (1) shows that the *Persentase Rendemen Aktual* (Percentage of Actual Yield), displayed as bars, averages 59.15%. This value shows that production in Kaltara is still far from the National Standard Conversion Rate of 64.02% [8] [13] [16]. In food security studies, yield is often referred to as the GKG-to-Rice Conversion Rate. Sources say that the national standard conversion rate used is 64.02% [8]. This means that, technically, every 100 tons of rice (Milled Dry Rice/GKG) will produce 64.02 tons of rice. The results of the yield visualization for each region in Kaltara are shown in Figure 4.

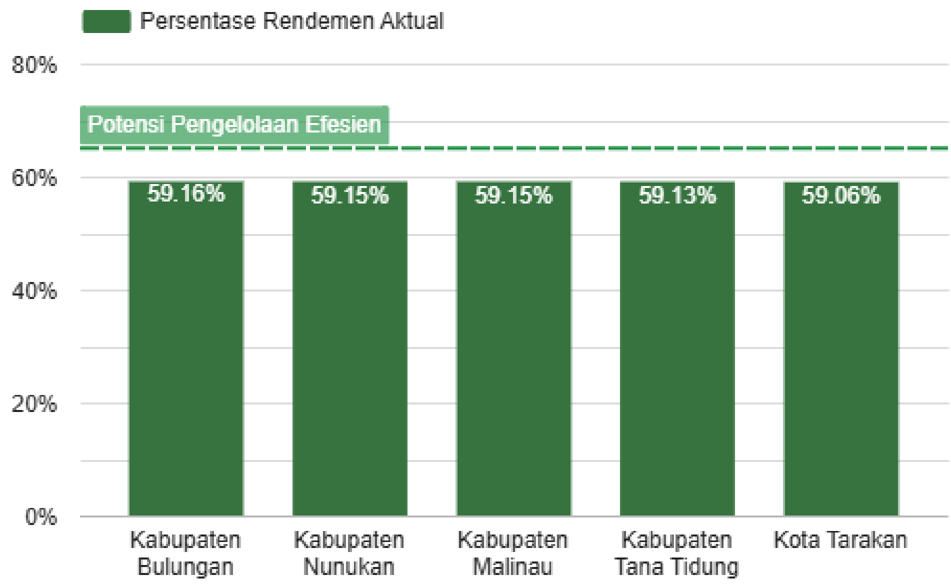


Figure 4. Percentage of Yield

Bulungan region showed the highest percentage of yield at 59.16%, while the city of Tarakan was 59.06%. The low yield in the entire North Kalimantan region as shown in figure 4, where production is below the *Potensi Pengelolaan Efisien* (Efficient Management Potential) line (64.02%), indicates a problem with the supply chain or milling technology. This emphasizes that the limitations of logistics infrastructure and post-harvest processing technology often influence inefficiencies in the agribusiness supply chain [12]. Analysis of the time series shows a decline from 2018 to 2023. Production begins to increase from 2024 to 2025. The production graphs for the period are shown in Figure 5.

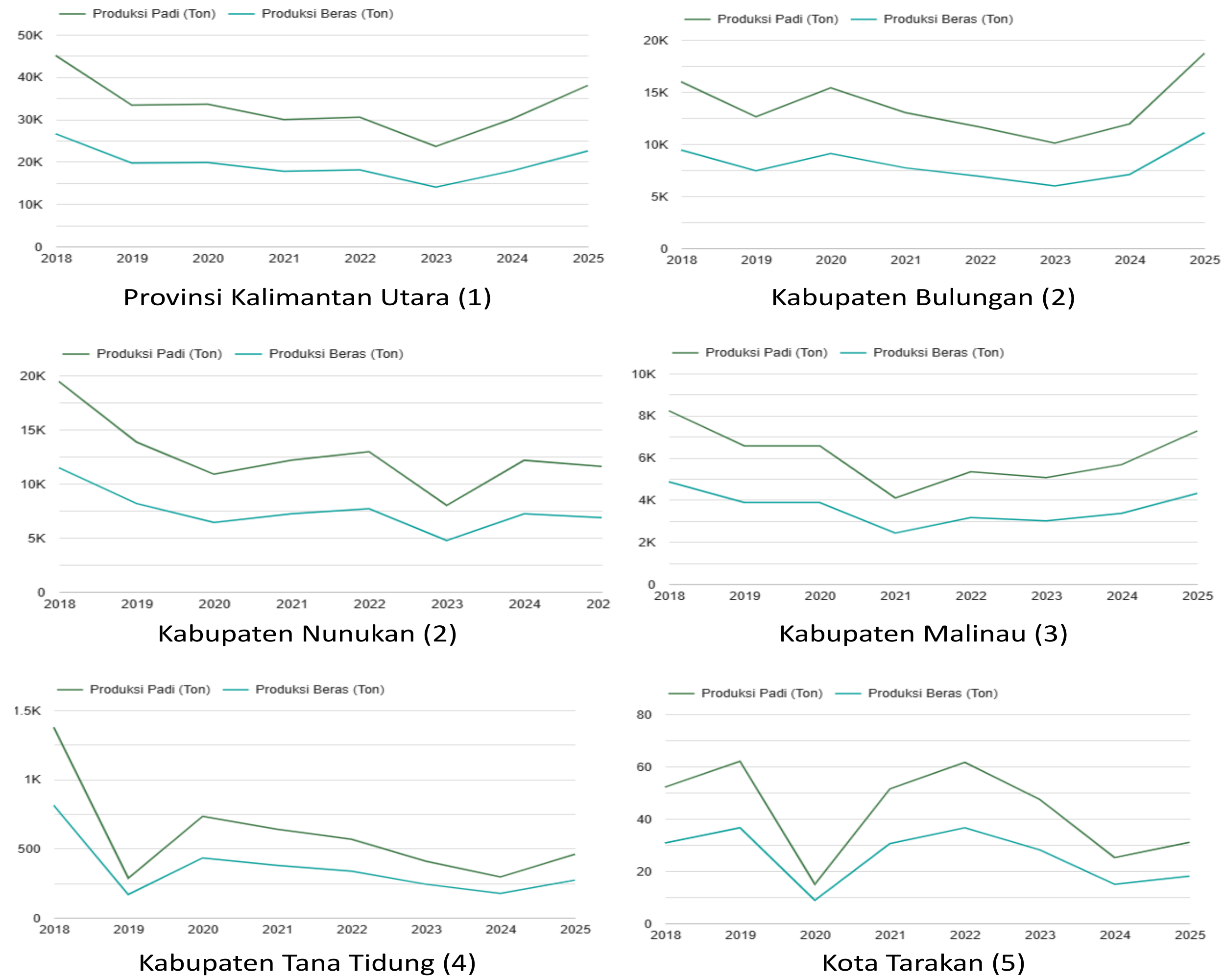


Figure 5. Rice and Paddy Production Graph

In Figure 5, the North Kalimantan event (1) from 2018 to 2025 as a whole show that production that occurred in 2025 showed a greater increase when compared to 2018. Bulungan region (2) is the largest producing area in North Kalimantan, the graph shows that there is an unusually significant downward trend throughout this period and there is a significant increase in 2025. In Nunukan (3) the decline in production continues to occur every year. If left unchecked, this will have an impact on Adan rice production in Nunukan. Adan rice is a local superior rice variety (premium rice quality) that is not only of high economic value but also has high cultural and historical value [17], [18]. The downward trend in Tana Tidung region (5) shows a decrease in the number of decreases every year.

4.4 Spatial Polarization Mapping

The use of Spatial Map with a combo map type (bubble and colors area) has successfully demonstrated the polarization of production across regions in North Kalimantan. Polarization in the map visualization shows that the area of an area is not proportional to the amount of rice it produces. In the map used, the area is divided into three rice production areas based on color (Color Area). Green is the color of maximum rice production, yellow for the intermediate level, and red for areas with minimal rice production.

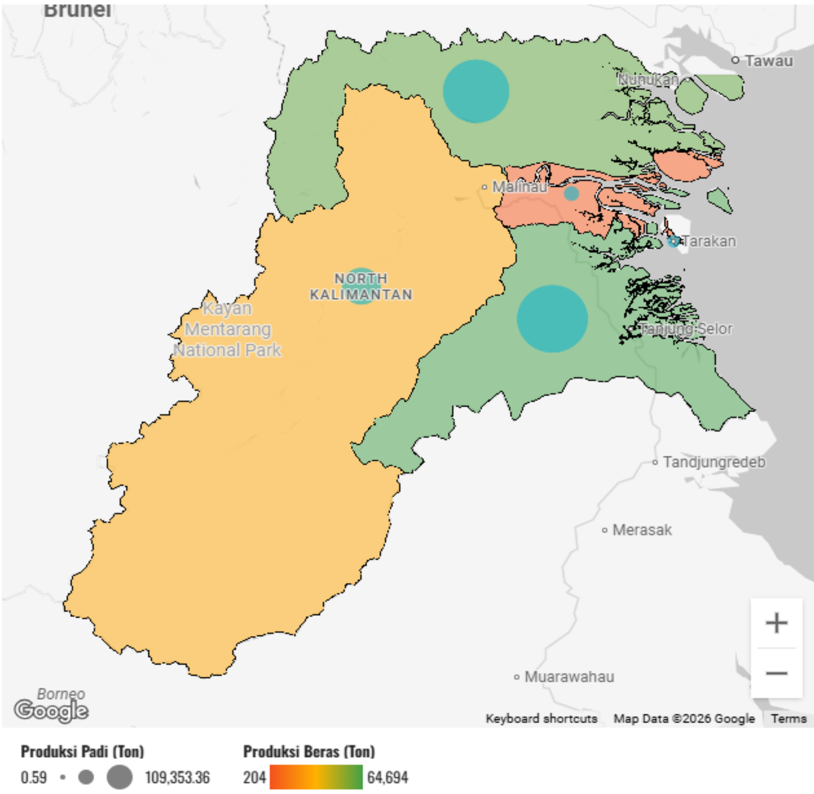


Figure 6. Rice and Paddy Production Map

In Figure 6, the use of bubbles is intended to indicate the amount of rice production; the larger the bubble, the greater the rice production. Bulungan and Nunukan are the largest rice-producing areas. Tarakan and Tana Tidung are the smallest producers. In Figure 6, Malinau is the largest area in terms of production, but this is inversely proportional to the amount of production.

4.5 Supply Chain and Agribusiness

The results showed an average actual yield of 59.15%, a figure that technically indicates post-harvest losses that need to be monitored. This value is far below the National Standard Conversion Rate of 64.02%, indicating significant differences in processing efficiency in converting grain into rice across North Kalimantan. This low yield rate, which ranges from 59.06% to 59.16% at the district/city level, confirms the presence of structural obstacles in the midstream phase of agribusiness, especially related to limitations in logistics infrastructure and the already inadequate rice milling technology (RMUs). These findings prove that transforming BPS data into Business Intelligence tools is not just about visual presentation but also about a visual audit tool to detect inefficiencies masked by aggregate data. With this dashboard, policymakers can make more precise interventions, such as determining the optimal location for investment in modern milling units to reduce food loss. In the end, integrating historical data into this interactive monitoring system is key to implementing evidence-based policies to maintain food availability stability in North Kalimantan. The results of the development of the dashboard as a whole are shown in Figure 7.

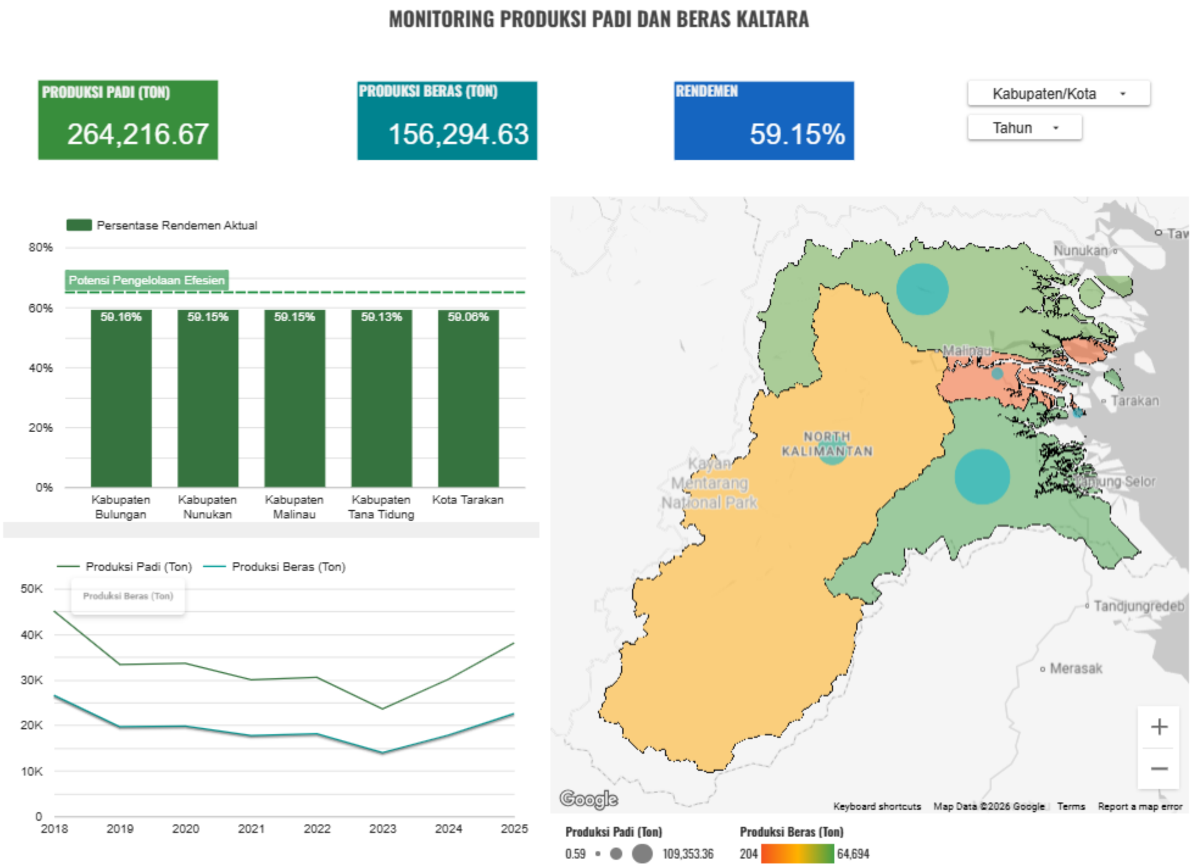


Figure 7. Dashboard Business Intelligence

The main findings reveal that the average actual yield in the region is only 59.15%, well below the national standard of 64.02%, indicating significant inefficiencies in post-harvest processing technology and the extent of food loss. Nunukan region continues to experience decline, which if not addressed, has the potential to lose premium superior varieties that are known for their economic and cultural value. In addition, through geospatial analysis, this study emphatically demonstrates the region's polarization: the land area is not directly proportional to production volume, as seen in the contrast between Malinau, which is large but has lower production than Bulungan and Nunukan.

3. CONCLUSION

This study successfully addressed the challenges of digital transformation by converting the minimalist dataset from BPS North Kalimantan (2018-2025) into an interactive, functional Business Intelligence (BI) tool. Technically, this study demonstrates that limited production volume data can be used to derive critical efficiency indicators, namely the actual yield figure (59.15%), which reveals systemic inefficiencies in post-harvest processing technology, as it is below the National Standard of 64.02%. Furthermore, the use of geospatial visualization successfully proves the hypothesis of the existence of "spatial polarization", where the area is not directly proportional to production capacity, as seen in the phenomenon of Malinau region. Thus, the purpose of the research to provide precise decision support tools has been achieved; this dashboard not only presents data, but functions as a visual audit instrument that can direct policy interventions and agribusiness infrastructure investments more accurately and on target in North Kalimantan

Province. For future research, it is recommended to expand the scope of analysis by integrating additional variables that are more comprehensive of the agribusiness ecosystem and supply chain management. Researchers can then combine data on logistics costs across regions, consumer-level market price fluctuations, climate variables, and land availability in real time. The integration of these more complex variables is expected to improve the monitoring system's predictive capabilities, thereby providing a more comprehensive picture of the food supply chain from upstream to downstream and strengthening national food security.

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