Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

Interactive Visualization of Food Security Trends in North Aceh with a Business Intelligence Dashboard

Lidya Rosnita[1*], Muhammad Ikhwani[2], Hafizh Al Kautsar Aidilof[3], Muhammad Muaz Munauwar[4]
[1,3]Informatic Engineering Universitas Malikussaleh, Indonesia, [2]Information System Universitas Malikussaleh, Indonesia, [4]Agroecotechnology Universitas Malikussaleh, Indonesia
[1]lidyarosnita@unimal.ac.id, [2]muhammad.ikhwani@unimal.ac.id, [3]hafizh@unimal.ac.id, [4]muaz.munauwar@unimal.ac.id

open access

***Corresponding Author**

Article History:
Submitted: 04-11-2025
Accepted: 12-11-2025
Published: 21-11-2025

Keywords:
business intelligence; dashboard; data visualization; decision making; north aceh.

ABSTRACT

Food security in North Aceh Regency faces multifaceted challenges, including production fluctuations, price instability, and fragmented monitoring data across various institutions. These issues often hinder timely decision-making and the formulation of effective policies. Therefore, this study aims to develop a comprehensive Business Intelligence (BI) dashboard that can interactively visualize food security trends in North Aceh to support data-driven and evidence-based decision-making. The research methodology involves integrating data from multiple sources such as the Central Bureau of Statistics (BPS) and the Department of Agriculture using the ETL (Extract, Transform, Load) process to ensure consistency and accuracy. A data warehouse was then designed to store and manage the consolidated datasets efficiently, followed by the development of an interactive visual dashboard as the main analytical tool. The resulting dashboard is capable of visualizing six key parameters of food security through thematic maps, trend graphs, and comparative charts that allow users to observe temporal and spatial patterns. Advanced interactive features such as filtering, drill-down analysis, and cross-filtering provide users with the flexibility to independently explore data from different perspectives. The analysis demonstrates that the BI dashboard effectively integrates fragmented datasets, simplifies complex information, and enhances analytical capabilities for stakeholders. Overall, the findings indicate that implementing an interactive BI dashboard is a strategic and innovative solution to transform food security monitoring in North Aceh into a more proactive, integrated, and adaptive governance system, thereby strengthening regional resilience and policy responsiveness.

INTRODUCTION

Food security is a crucial element in sustainable national development. According to Law Number 18 of 2012 on Food, food security is defined as a condition in which food is sufficiently available for households, reflected in the availability of food in adequate quantities and quality, that is safe, evenly distributed, and affordable. Food security not only concerns agricultural production but also encompasses aspects of distribution, accessibility, supply stability, and community consumption patterns.

Amid global challenges such as the COVID-19 pandemic, climate change, and geopolitical uncertainties affecting global supply chains, the issue of food security has become increasingly critical and requires systematic handling. The pandemic has revealed the vulnerability of food systems to sudden disruptions, leading to distribution interruptions, price increases of basic commodities, and local food crises (FAO, 2020). Therefore, regional food security, as an integral part of national resilience, must be strengthened—not only in terms of production but also in data monitoring and adaptive, information-based decision-making.

North Aceh Regency is one of the main rice-producing regions in Aceh Province, with great potential to support local food self-sufficiency. However, data and reports from recent years indicate significant fluctuations in food production, especially rice. This situation is caused by several factors, including climate change, land-use conversion, limited production facilities, and suboptimal distribution of agricultural assistance (BPS Aceh Utara, 2022). In addition, the limited adoption of modern agricultural technology and lack of access to real-time information further exacerbate the problem.

One of the main challenges in managing regional food security is the lack of data integration and visualization. Key information such as data on food production, consumption, stock, and distribution remains scattered across various institutions such as BPS, the Department of Agriculture, the Food Security Office, and Bappeda, and is generally presented in conventional, static formats. Such formats hinder rapid analysis and evidence-based policymaking (Suryana, 2021).

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

Business Intelligence (BI) technology offers a strategic and data-driven solution to address the persistent challenges of fragmented data management and limited analytical insight in food security monitoring. BI enables the integration of heterogeneous data sources into a unified analytical environment, transforming raw data into interactive and comprehensible visual representations (Goncalves et al., 2023). Through BI dashboards, policymakers and stakeholders can effectively monitor production and consumption trends, detect early signs of food insecurity, and formulate policies that are more accurate, timely, and evidence-based (Sanabia-Lizarraga et al., 2024). The implementation of BI tools—such as Power BI—has demonstrated significant success in integrating agricultural and economic data into dynamic visualization platforms that enhance decision-making and promote transparency (Hibatulwafi & Asmiyanto, 2024). Consequently, the adoption of BI frameworks in food security systems can substantially improve data accessibility, analytical efficiency, and strategic responsiveness, fostering a more adaptive and sustainable model of regional governance (Hasfita et al., 2025).

This interactive dashboard also has the potential to serve as a tool for public education and transparency. When data is presented openly, visually, and accessibly, the public becomes more aware and involved in monitoring food conditions and can make wiser daily consumption decisions. Therefore, the development of BI dashboards in the context of food security serves not only as a technical tool but also as an effort to strengthen food governance through technology and collaboration.

LITERATURE REVIEW

Food security is a multidimensional issue encompassing aspects of production, distribution, consumption, and the stability of a region's food supply. According to the Food and Agriculture Organization (FAO) definition, food security exists when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs for an active and healthy life." (Termine, 2024) Food security in the literature is commonly classified into four main pillars: availability, access, utilization, and stability (Okpala, Korir & Manning, 2024). Moreover, recent community-service research at Universitas Malikussaleh indicates that local food-security interventions in Aceh must address these four pillars simultaneously to enhance resilience and governance

In the national context, the Law of the Republic of Indonesia No. 18 of 2012 on Food states that food security is a shared responsibility between the government and society. Food security is a crucial issue, especially in agricultural regions such as North Aceh, where fluctuations in rice production and food distribution significantly affect community welfare.

Several factors contribute to food vulnerability, including climate change, land degradation, the conversion of agricultural land to non-agricultural use, and dependence on inefficient distribution systems (Suryana, 2021). These problems are further compounded by the lack of real-time information on food security indicators, sectoral data fragmentation, and limited accessibility for policymakers and the public.

METHOD

Business Intelligence (BI) is broadly understood as a systematic set of processes and technologies for collecting, storing, processing, and presenting information from heterogeneous sources to support more accurate and timely decision-making (Tirno, 2024). BI applications extend well beyond commercial enterprises and have been widely adopted in government and regional development settings to enable evidence-based policymaking and to increase transparency and accountability (Tandilino, 2025). Local implementations also demonstrate BI's practical utility for public services: a recent study using BI to analyse immunization coverage in Lhokseumawe—conducted under Universitas Malikussaleh supervision-showed how dashboard-driven insights can identify geographic gaps and guide targeted interventions (Fitrisya, 2024).

Several recent studies define Business Intelligence (BI) as a system composed of key components such as a centralised data warehouse, data mining and predictive analytics modules, online analytical processing (OLAP) engines, and interactive visualization dashboards (Socius, 2025). In the context of food security, BI facilitates the integration of data from multiple institutions and the presentation of that consolidated information in a format easily understood by stakeholders, thus enabling more comprehensive monitoring and decision-making (Hidayat et al., 2024).

The methodology adopted in this study follows the standard BI development cycle, consisting of Extract, Transform, and Load (ETL) processes**,** data warehouse modeling**,** and dashboard visualization (Anugraeni, 2025). The ETL process was used to integrate data from various institutional sources, ensuring data consistency and quality. Subsequently, a star-schema data warehouse was designed to store and manage multidimensional food-security indicators efficiently. The visualization phase applied visual analytics design principles to develop an interactive dashboard that presents key food-security parameters-including harvested area, production volume, dominant commodities, and sub-district distribution-through thematic maps, trend graphs, and comparative charts, allowing users to explore the data intuitively (Hidayat et al., 2024).

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

RESULT

The main outcome of this study is the development of a data integration framework that successfully consolidates food security information in North Aceh from various fragmented sources. Food production data from the Department of Agriculture, price and consumption data from BPS North Aceh (2022), as well as accessibility and vulnerability data from other relevant institutions, were successfully integrated. This process addresses the classical challenge in regional food governance-data fragmentation that hinders comprehensive analysis (Suryana, 2021).

The critical stage in the ETL (Extract, Transform, Load) process is the data transformation phase, in which data with differing formats, periods, and definitions are harmonized. For example, rice production data typically measured in quintals per hectare were standardized, and sub-district names were aligned with the official reference codes from BPS. The final result is an integrated data warehouse that serves as the foundation for analysis, as illustrated in Figure 1.

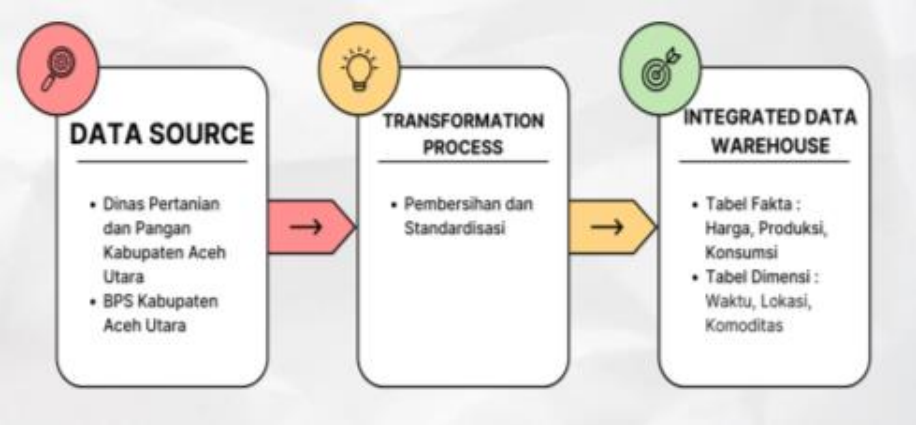

Fig. 1 Data Integration Flowchart from Fragmented Sources to a Unified Data Warehouse

The integration of food security data in North Aceh was carried out through a systematic framework consisting of several key stages. The first stage involved identifying and collecting data from various sources, including internal government sources such as the Department of Agriculture, as well as external sources such as commodity prices in traditional and modern markets and climate data from the Meteorology, Climatology, and Geophysics Agency (BMKG).

The main challenges encountered were the diversity of data formats-ranging from Excel spreadsheets and databases to PDF reports—and potential inconsistencies in definitions or reporting periods. To address these issues, data transformation and cleaning stages were implemented. In this stage, data from all sources were standardized into a uniform format, errors were corrected, missing values were handled, and regional codes (such as sub-district and village codes) were standardized using references from BPS.

The result of this process was a centralized data warehouse or data mart that serves as a “single source of truth” for food security analysis. This systematic integration successfully transformed previously isolated and incomparable data into a structured, cohesive, and analyzable database, providing a strong foundation for subsequent visualization and analytical processes.

Based on the integrated data, an interactive dashboard was designed to visualize seven key food-security parameters-harvested area, district map, distribution of staple-crop harvested areas, distribution of vegetable and fruit harvested areas, average prices, largest sub-districts, and dominant commodities-and the dashboard interface was developed using contemporary visual-analytics and dashboard-design principles to improve comprehension of complex information (Goncalves et al., 2023). Local implementation evidence from Universitas Malikussaleh further demonstrates that BI dashboards tailored to regional agricultural datasets can reveal geographic gaps and price anomalies that support targeted interventions (Fitrisya, 2024). As shown in Figure 4.2, the dashboard presents information in an informative and easily explorable format.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

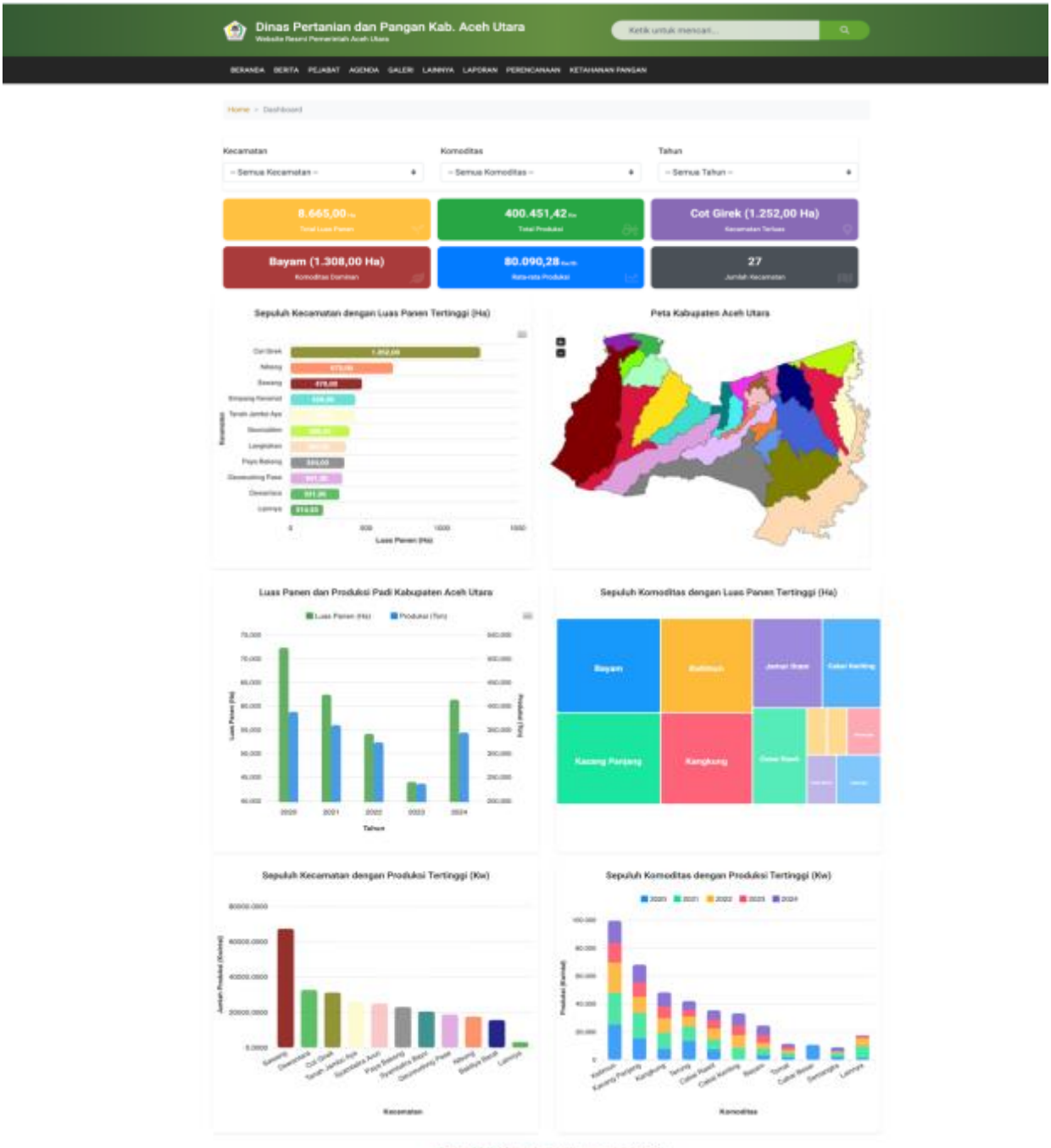

Fig. 2 Business Intelligence Dashboard of the North Aceh Regency Agriculture and Food Service

This figure consists of six main visual components describing agricultural production trends and distribution:

Bar Chart: "Top Ten Subdistricts with the Largest Harvested Areas (Ha)". This chart shows the ten subdistricts with the largest harvested areas in North Aceh. Cot Girek ranks the highest with approximately 1,852 hectares of harvested land, followed by Muara Batu and Seunuddon. The visualization helps identify regions with the greatest agricultural potential, which can serve as focus areas for commodity development and regional planning.

Map of North Aceh Regency: The thematic map displays the administrative boundaries of each subdistrict using different colors. It provides a spatial representation of harvested area or production distribution, allowing users to easily interpret the geographic patterns of agricultural productivity.

Bar Chart: Harvested Area and Rice Production in North Aceh Regency (2020–2024). Shows the relationship between harvested area (hectares) and total rice production (tons). The data indicates fluctuations over time, reflecting variations caused by factors such as weather conditions, policy changes, or agricultural infrastructure.

Treemap: Top Ten Commodities with the Largest Harvested Areas (Ha). Commodities such as spinach, cucumber, water spinach, and chili pepper dominate the visualization. The treemap provides a proportional overview of

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

each commodity's contribution to the total harvested area.

Bar Chart: Top Ten Subdistricts with the Highest Production (Kw). Displays total production volume per subdistrict. Subdistricts with the highest bars represent the largest contributors to the region's food production and food security.

Stacked Bar Chart: Top Ten Commodities with the Highest Production (Kw) per Year (2020–2024). Visualizes the production trends of various commodities over five years. Each color represents a different year, illustrating temporal changes in crop productivity.

The dashboard demonstrates that this systematic integration is a prerequisite for implementing the principles of evidence-based policy. With the availability of a "single source of truth," analyses that were previously impossible-such as linking a decline in production in a particular sub-district with price and accessibility data-can now be performed in real time, providing a solid foundation for policy formulation.

The colored thematic map (Choropleth Map) of North Aceh Regency displays data at the sub-district level, directly visualizing sub-district parameters. The bar chart illustrates the harvested area of the ten largest sub-districts, the harvested area and rice production in North Aceh sub-districts, the ten sub-districts with the highest production, and the ten commodities with the highest harvest production. The treemap chart presents commodities with the largest harvested areas. The interactive filter panel allows users to select the year, sub-district, and commodity to perform drill-down analyses.

DISCUSSION

This study demonstrates that the use of a BI dashboard significantly enhances the effectiveness of decision-making in the food sector of North Aceh, especially in the context of global challenges such as climate change and supply chain disruptions (FAO, 2020). The dashboard facilitates a shift from a reactive to a proactive and data-driven approach. A concrete example is its capability to function as an early warning system. When the dashboard displays a consistent increase in prices in a particular region alongside rising vulnerability indicators, policymakers can immediately respond by planning market operations or targeted social assistance before the situation escalates into a food crisis.

Furthermore, the dashboard serves as a collaborative platform that brings together various stakeholders such as the Department of Agriculture, the Department of Trade, and Bappeda. By referring to the same visual data during coordination meetings, discussions become more focused and objective, fostering the creation of integrated and effective policies. This information transparency also opens opportunities for public participation in monitoring, aligning with the goal of strengthening collaborative food governance as mandated by the Food Law No. 18 of 2012. Thus, the BI dashboard is not merely a visualization tool but also a catalyst for strengthening the entire regional food security ecosystem.

The design of the interactive dashboard focuses on the principles of User-Centered Design (UCD) to ensure informativeness and ease of use. The dashboard interface is arranged with a logical layout, generally following a drill-down pattern where users can start from an overview and navigate toward more specific details. Data visualizations are carefully selected to clearly convey information: thematic maps (choropleth maps) are used to display the geographic distribution of food insecurity across sub-districts, while bar charts compare performance across regions or commodities. Interactivity is a key advantage of this dashboard, allowing users to filter data by time period, commodity type, or specific region. The drill-down capability enables users viewing the North Aceh map to click on a sub-district to see detailed data such as top commodities, harvested areas, production levels, and corresponding years. Tooltips appearing when hovering over graphical elements provide additional information without cluttering the main display. The combination of appropriate visualization and interactivity results in a dashboard that not only presents static data but also serves as an exploratory tool, enabling users to discover insights independently.

The existence of this Business Intelligence (BI) dashboard has significantly improved decision-making effectiveness in North Aceh's food sector by transforming the paradigm from intuition-based (gut-feeling) to data-driven decision-making. First, the dashboard accelerates access to integrated information—program planners no longer need to spend days collecting and merging data from multiple spreadsheets; comprehensive information is available within seconds. Second, the dashboard's visualization and interactivity capabilities assist in identifying patterns, trends, and anomalies that may not be apparent in raw data. Third, the dashboard functions as a powerful communication tool in coordination meetings. All stakeholders can discuss issues using the same data and visualizations, minimizing miscommunication and keeping the focus on solutions. For example, when addressing food insecurity in a village, the dashboard can immediately indicate whether the root cause lies in availability factors, economic access (price), or both. Consequently, decisions—ranging from short-term interventions such as social aid to long-term policies like the development of village food storage systems—become more effective, efficient, and accurate, supported by concrete visual evidence.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

CONCLUSION

Based on the results and discussions of this study, the following conclusions can be drawn:

1. Data Integration Successfully Established Through a Systematic Approach.
   This study successfully designed and implemented a systematic data integration framework to consolidate food security data for North Aceh Regency from various fragmented sources (BPS, Department of Agriculture, etc.). Through the ETL (Extract, Transform, Load) process, previously scattered and unstructured data were transformed into a cohesive and reliable integrated data warehouse. This demonstrates that the BI approach can overcome data silos and create a "single source of truth," which serves as a critical foundation for further analysis.
2. The Developed Interactive Dashboard Effectively Presents Complex Information in an Informative Way.
   The study successfully designed an interactive and informative Business Intelligence dashboard. This dashboard not only displays static data but also visualizes five food security parameters through thematic maps, trend graphs, and comparative charts. Interactive features such as filters, drill-downs, and cross-filtering have proven to empower users to explore data independently, identify patterns, and understand the root causes of food security issues at the sub-district level more quickly and comprehensively.
3. The BI Dashboard Has Significant Potential to Enhance Decision-Making Effectiveness.
   The findings indicate that the BI dashboard holds strategic value in transforming decision-making processes in the food sector from being reactive and intuitive to proactive and data-driven. Its capability as an early warning system and an integrated collaboration platform enables stakeholders to identify potential vulnerabilities, design targeted interventions, and coordinate more effectively. Therefore, this dashboard is not merely a visualization tool but a solution that directly contributes to strengthening regional food security toward greater resilience and sustainability.

ACKNOWLEDGMENT

We would like to express our gratitude to LPPM for providing us with a research grant sourced from PNBP Universitas Malikussaleh in 2025.

REFERENCES

Anshari, S.F., Retno, S. (2023). Penerapan Metode Nine-Step Kimball Dalam Pengolahan Data History Menggunakan Data Warehouse dan Business Intelligence. *Jurnal Ilmu Komputer*. 16(1), 69-79.

Azhar, A., & Sari, R. P. (2021). Analisis Faktor-Faktor yang Mempengaruhi Ketahanan Pangan Rumah Tangga di Kabupaten Aceh Utara. *Jurnal Agrisep*, 22(1), 15-28.

Barrett, C. B. (2010). Measuring Food Insecurity. *Science*, 327(5967), 825–828. https://doi.org/10.1126/science.1182768

Goncalves, C. T., Angelico Gonçalves, M. J., & Campante, M. I. (2023). *Developing Integrated Performance Dashboards Visualisations Using Power BI as a Platform*. Information**,** 14(11), 614.

Fadhil, R., & Nurmala, N. (2020). Pemetaan Daerah Rawan Pangan dengan Metode Fuzzy Logic di Provinsi Aceh. *Jurnal Teknologi dan Sistem Informasi (JTSI)*, 1(2), 1-8.

FAO. (2020). *The State of Food Security and Nutrition in the World 2020*. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/ca9692en

Fitrisya, A. (2024). *Analisis Efektivitas Program Imunisasi Menggunakan Business Intelligence pada Kota Lhokseumawe*. Universitas Malikussaleh Repository.

Hanifah, S., et.al. (2022). Implementasi Business Intelligence dan Prediksi Menggunakan Regresi Linear Pada Data Penjualan dan Breakage di PT XYZ. *Jurnal nasional Teknologi Informasi dan Sistem Informasi*. 8(3), 144-152. https://doi.org/10.25077/TEKNOSI.v8i3.2022.144-152

Hasfita, F., Syukriah, S., Faisal, F., Bakhtiar, B., Asmara, R., Nur Aksa, F., & Jamidi. (2025). *Sosialisasi Pentingnya Pelatihan Para Petani dalam Peningkatan Potensi Ketahanan Pangan di Kecamatan Matang Kuli Kabupaten Aceh Utara*. Jurnal Malikussaleh Mengabdi, 4(1), 240-245. https://doi.org/10.29103/jmm.v4i1.23007

Hibatulwafi, F., & Asmiyanto, T. (2024). *Business Intelligence Implementation for Groceries Commodity Price Data Analytics*. SINTECH Journal, 7(1). https://ejournal.instiki.ac.id/index.php/sintechjournal/article/view/1676

Okpala, E. F., Korir, L., & Manning, L. (2024). Food Acquirability: An Unexplored Component of Food Security? *Foods*, 13(13), 2052. https://doi.org/10.3390/foods13132052

Ramadhani, Y., et.al. (2024). Implementasi Business Intelligence Dalam Analisa Penjualan Mobil Mitshubishi Menggunakan Visualisasi Data. *Adopsi Teknologi dan Sistem Informasi* (ATASI). 3(1), 1-11. https://doi.org/10.30872/atasi.v3i1.435

Sanabia-Lizárraga, K. G., Carballo-Mendívil, B., Arellano-González, A., & Bueno-Solano, A. (2024). *Business Intelligence for Agricultural Foreign Trade: Design and Application of Power BI Dashboard*. Sustainability**,** 16(21), 9576. https://doi.org/10.3390/su16219576

E-ISSN : 2807-9035
Volume 5, **Number** 2, November 2025
https://doi.org/10.47709/brilliance.v5i2.7190

Socius. (2025). *Business Intelligence components: data warehouse – OLAP – data mining – dashboard.* Socius: Jurnal Penelitian Ilmu-Ilmu Sosial, 2(11), 554-558.

Suryana, A. (2021). *Manajemen Ketahanan Pangan: Teori dan Aplikasi*. PT Penerbit IPB Press.

Tandilino, C. (2025). *Big Data and Business Intelligence in the Public Sector: Challenges and Opportunities for Transparency.* Journal of Public Information Management, 6(1), 45–59.

Termine, P. (2024). Ensuring food security: why agency and sustainability matter. Committee on World Food Security (CFS) Insights. Retrieved from https://www.fao.org/family-farming/detail/en/c/1729615/

Tirno, R. R. (2024). *Effect of business intelligence on organizational decision-making and performance.* International Journal of Information Systems, 12(3), 77–89.

Tumini, T., Subekti, E. S. (2023). Implementasi Business Intelligence Untuk Menganalisis Data Proses Manufaktur Menggunakan Google Data Studio. *Jurnal Ilmiah Tekik Informatika dan Komunikasi*. 3(3), 143-151. https://doi.org/10.55606/juitik.v3i3.625

Utara, B. P. S. K. A. (2022). *Aceh Utara dalam Angka 2022*. BPS.

Praza, R., & Nurasih, S. (2020). Analisis Hubungan Pengeluaran Dengan Ketahanan Pengan Rumah Tangga Petani Di Kabupaten Aceh Utara. Jurnal Agrifo. 5(1). 23-34. https://doi.org/10.29103/ag.v5i1.2735

Zulfikar, Z., & Amalia, R. (2021). Pemanfaatan Teknologi Informasi dalam Meningkatkan Pelayanan Publik di Pemerintah Daerah: Studi Kasus di Kabupaten Aceh Utara. *Jurnal Administrasi Publik (JAP)*, 9(2), 110-125.