

Supply Chain Optimization of Bojonegoro Agro-Logistics Hub Through HACCP-Based Hygienic Architectural Design Implementation

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ABSTRACT

This research addresses the design of an Agro-Logistics Hub in Bojonegoro as a strategic solution to agricultural supply chain inefficiencies, price fluctuations, and post-harvest losses resulting from inadequate cold chain facilities. The primary objective of this design is to establish a centralized distribution node and a regional price stabilizer in alignment with the Bojonegoro Regional Medium-Term Development Plan (RPJMD). This study employs a qualitative methodology, utilizing Multi-Criteria Analysis (MCA) for site selection and comparative studies between PIKJ and Puspa Agro. The architectural approach integrates logistics through cross-docking circulation and Hygienic Architecture based on HACCP standards, ensuring strict zoning and the utilization of food-grade materials. The resulting design features modular facilities equipped with large-scale cold storage, sorting areas, and farmer education centers. The selected site on Jalan Ngambon Ngasem (score: 2.8) was proven to be more efficient in streamlining distribution channels compared to urban alternatives. Furthermore, energy mitigation strategies are implemented through extensive rooftop solar power systems (PLTS) to guarantee power stability for the cold storage units. Ultimately, this infrastructure is envisioned as a key driver for food security and sustainable economic growth in Bojonegoro.

Keywords: *Architectural Design, Agro-Logistics Hub, Supply Chain, Cold Chain, HACCP, Bojonegoro.*

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INTRODUCTION

The whole The agricultural sector is a strategic economic pillar for Bojonegoro Regency, aligning with the Regional Medium-Term Development Plan (RPJMD) vision that prioritizes the strengthening of the non-oil and gas sector. However, this potential is hindered by structural challenges such as long supply chain inefficiencies, which trigger high distribution costs and price fluctuations detrimental to both producers and consumers. The urgency of this research is reinforced by the lack of modern post-harvest infrastructure, particularly cold chain facilities, resulting in significant post-harvest losses for the region's leading horticultural commodities. Therefore, architectural intervention in the form of a

centralized facility serving as a distribution buffer and regional price stabilizer is required. (Perda RTRW Kabupaten Bojonegoro 2020–2040.)

The rationalization of this design is based on the need for an "Agro-Logistics Hub" that integrates grading, temperature-controlled storage, and rapid distribution. Although previous research by Bambang (2018) emphasized the importance of food logistics integration, a research gap remains in the architectural realm specifically combining global Hazard Analysis and Critical Control Points (HACCP) hygiene standards with energy independence principles. The state of the art in this design lies in the synthesis between Green Logistics through the use of rooftop Solar Power Plants (PLTS) and hygienic architecture as an adaptive solution to electrical power constraints and climate conditions in Bojonegoro. The primary goal is to design infrastructure capable of optimizing logistics circulation while maintaining sustainable food safety quality. (Bambang, 2018)

Legally and theoretically, the existence of an Agro Wholesale Market is supported by national regulations such as Law No. 7 of 2014 concerning Trade, which mandates mass trading facilities with organized logistics systems. Furthermore, referring to Law No. 18 of 2012 concerning Food, these facilities must ensure food safety and quality through adequate storage space design. The problem-solving plan in this design focuses on implementing an integrated logistics approach through cross-docking circulation for time efficiency, as well as the use of food-grade materials and strict zoning to meet HACCP standards. (Sarkar & Khan. 2023)

Visually, this design aims to communicate the professionalism and modernization of the agricultural sector through expressive mass forms as regional landmarks. The visual function of the building is not merely aesthetic but represents high hygiene standards and technological advancement. Through clean and repetitive materials such as metal panels or exposed concrete, the building is expected to build trust among large-scale investors and distributors. Thus, this Agro Wholesale Market is projected to be a key infrastructure supporting food security and sustainable economic growth in Bojonegoro Regency. (Bambang, 2018)

METHOD

The design of the Agro Wholesale Market in Bojonegoro uses a qualitative-descriptive approach aiming to analyze non-numerical data in depth to produce appropriate architectural solutions. The scope focuses on the physical design of food logistics infrastructure in Bojonegoro Regency, with the primary object being an Agro-Logistics Hub facility integrating HACCP standards and energy independence. The research location is specifically set on Jalan Ngambon Ngasem, Bojonegoro, chosen through land suitability analysis and accessibility to local agricultural production centers. (Sarkar & Khan. 2023)

Table 1 : Primary Data Data collected directly from the study site.

Data Type	Description
Field Observation	Direct observation of the physical and environmental conditions at the selected site (Diponegoro Street), including sun orientation, wind patterns, vegetation, and traffic flow.
Interviews (Optional)	Gathering information from relevant stakeholders, such as the Department of Agriculture , the Department of Public Works and Spatial Planning (PUPR) of Bojonegoro , or potential market users.

Source: personal analysis,2026

Table 2 : Secondary Data

Data Type	Source
Geographic & Climatic Statistics	Central Bureau of Statistics (BPS) of Bojonegoro Regency and the nearest Meteorological, Climatological, and Geophysical Agency (BMKG) station.
Spatial Regulations	Bojonegoro Regency Regional Regulations (Perda) regarding the Spatial Management Plan (RTRW) or Detailed Spatial Plan (RDTR) to determine Land Use and BCR/FAR/Setback (KDB/KLB/GSB) regulations
	Design theories for Agro Wholesale Markets , cold storage standards, and sustainable architecture references.

Source: personal analysis,2026

The design stages are systematically arranged through three main phases. The pre-design stage includes literature studies, data collection, and site analysis to formulate the spatial program. The design stage covers concept development, zoning, form transformation, and architectural visualization. The post-design stage is an evaluation phase to ensure the design meets specified functional and technical criteria. Primary materials include regional policy documents such as the RPJMD, RTRW Bojonegoro, and BPS agricultural statistics, while tools include 3D modeling software and Multi-Criteria Analysis (MCA) instruments.

Data collection techniques involve a combination of primary and secondary data. Primary data is obtained through field observations to map physical site conditions, sun orientation, wind patterns, and traffic flow. Secondary data is collected through documentation studies of official government reports and literature reviews on Supply Chain Management (SCM) theory and cold storage standards. Additionally, comparative studies were conducted on relevant similar objects to dissect spatial programs and technological effectiveness. (Zhovnirchik et al., 2023)

The operational definitions of variables include three critical aspects: logistics efficiency measured through smooth cross-docking circulation, building hygiene defined through rigid HACCP-standard zoning to prevent cross-contamination, and energy sustainability operationalized through the use of solar panels (PLTS) as an independent power source. To process this data, MCA is used for site selection, providing strategic weighting to physical conditions (40%), accessibility (30%), supporting facilities (20%), and land regulation (10%). (Zhovnrchyk et al., 2023)

Table 3: Location Selection Criteria

NO	Location Selection Criteria	Weight	Alternative N1 (HOS. Cokroaminoto St. - City)	W x S	Alternative N2 (Ngambon Ngasem St. - Agro Center)	W x S
1	Physical and Environmental Conditions	40%	2	0.8	3	1.2
2	Accessibility	30%	2	0.6	3	0.9
3	Availability of Supporting Facilities	20%	3	0.6	2	0.4
4.	Land Use and Regulations	10%	2	0.2	3	0.3
5.	TOTAL	100%	-	2.2	-	2.8

Source: personal analysis,2026

Multi-Criteria Site Analysis Results

This table compares Jl. HOS. Cokroaminoto (N1) and Jl. Ngambon Ngasem (N2) as alternative locations for the Agro Wholesale Market in Bojonegoro, based on the functional logic and spatial planning previously discussed.

Based on the total score of 2.8, the location on Jl. Ngambon Ngasem (N2) is the most suitable site for the Agro Wholesale Market design.

FINDING AND DISCUSSION

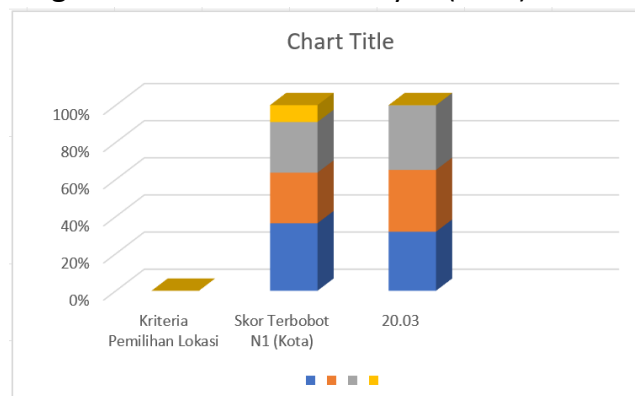
RESEARCH RESULT

Table 1: Results of Site Multi-Criteria Analysis (MCA)

Alternatif Lokasi	Skor Total (B x N)	Keterangan
1 N1 (Jl. HOS. Cokroaminoto)	2,2	Kurang sesuai karena keterbatasan lahan dan potensi kemacetan kota.
2 N2 (Jl. Ngambon Ngasem)	2,8	Tapak Terpilih karena unggul pada kriteria Aksesibilitas dan Kondisi Fisik.

Source: personal analysis, 2026

Figure 1: Multi-Criteria Analysis (MCA) Chart



Research Result: Site Multi-Criteria Analysis (MCA)

The primary finding of this research is the determination of the most optimal site for the Bojonegoro Agro Wholesale Market through a Multi-Criteria Analysis (MCA). The analysis compared two potential locations: **Jl. HOS. Cokroaminoto (N1)** and **Jl. Ngambon Ngasem (N2)** based on strategic weighting.

Based on the total score of 2.8, the site on Jalan Ngambon Ngasem (N2) was selected as the optimal location for the Agro-Logistics Hub design. This finding validates the hypothesis that proximity to agricultural production centers is more effective for regional-scale logistics than urban-centered locations. (Zhovnrchyk et al., 2023)

SITE SELECTION ANALYSIS

Site Selection Alternative 1



Figure 2: Selected Site or Location, and Site Boundaries

Discussion of Findings

A. Supply Chain Optimization through Strategic Accessibility

The selection of the Ngambon Ngasem site directly addresses the core problem of long supply chain inefficiencies.

- **Inbound Logistics Efficiency:** Proximity to farmers significantly reduces transportation costs and minimizes "food loss" (physical damage) of horticultural products during transit.
- **Operational Flow:** The site allows for a **Cross-Docking** system, separating "Dirty Flow" (receiving from farmers) and "Clean Flow" (distribution to secondary markets) without bottlenecks. (Wang et al. 2026)
- **Heavy Vehicle Access:** Unlike urban sites, this location supports 24-hour maneuverability for heavy trucks (tronton/trailers), which is essential for regional distribution.

B. Energy Mitigation and Sustainable Architecture

While local grid power is limited (Score 2 in MCA), the site's physical characteristics provide a major opportunity for energy independence:

- **Rooftop Solar Power (PLTS):** The large horizontal roof area of the warehouse is utilized for massive solar panel installations to power the **Cold Storage** units, ensuring a continuous cold chain. (Vijayakumar et al. 2024)
- **Passive Design:** Buildings are oriented North-South to minimize solar heat gain, reducing the energy load required for refrigeration.

C. Regulatory Compliance and Regional Impact

The analysis of the Regional Spatial Plan (RTRW) confirms that the Ngambon Ngasem site is zoned for **Agricultural Services and Logistics**. This provides legal certainty

for large-scale development and allows for flexible building coverage (KDB) to accommodate wide maneuver areas and modern shed structures. (Perda RTRW Kabupaten Bojonegoro 2020–2040.)

DISCUSSION

Interpretation of Findings

The selection of the site on Jalan Ngambon Ngasem (Score 2.8) is a critical milestone for the project, as it serves as the foundational pillar for optimizing the agricultural supply chain in Bojonegoro. This result is important because it demonstrates that the "Agro-Hub" strategy—placing logistics infrastructure near production centers—is more effective at cutting distribution costs and minimizing food loss compared to traditional urban-centered markets. Furthermore, the integration of HACCP-standard hygienic architecture and rooftop solar power (PLTS) transforms the facility from a mere warehouse into a self-sustaining, modern distribution node that can guarantee food safety and quality regardless of local electricity constraints. (Sarkar, P. R., & Khan, M. K. 2023).

Relationship to Literature

These findings align with and expand upon the research by Bambang (2018), which emphasized the necessity of food logistics integration for regional stability. While previous studies focused primarily on the management aspect of logistics, this design addresses a specific "research gap" in architectural literature by synthesizing Global Hygienic Standards (HACCP) with Green Logistics. Additionally, the implementation of linear cross-docking systems in this project improves upon existing models, such as Puspa Agro, by prioritizing strict zoning and the use of food-grade materials to eliminate cross-contamination risks during the distribution process. (Bambang 2018)

Limitations of the Study

Despite the strategic results, there are certain limitations that may affect the implementation of this design:

- The study relies on Multi-Criteria Analysis (MCA) with specific weightings that are subject to changes in local government policy or regional planning.
- There is a lack of high-resolution technical data regarding the specific refrigeration load for the cold storage, which might require a more detailed mechanical-electrical study.
- The reliance on rooftop PLTS assumes consistent solar radiation and ignores the potential need for significant battery storage costs that were not fully calculated in this architectural phase.

Implications

The results of this design provide several practical and academic implications:

- **Practical Application:** The Bojonegoro Regency Government can utilize this design as a prototype for modern agricultural infrastructure to strengthen regional food security and stabilize market prices.

- **Social Impact:** The inclusion of farmer education and R&D zones within the complex suggests that this facility can serve as a center for community empowerment, helping local farmers improve their grading and packaging standards.
- **Future Research:** Further studies are recommended to focus on the detailed refrigeration specifications and a comprehensive cost-benefit analysis of the energy transition from the PLN grid to 100% solar redundancy (Zhovnirchuk et al., 2023)

CONCLUSION

Based on the design of the Agro-Logistics Hub on Jalan Ngambon Ngasem, Bojonegoro, serves as a strategic solution to overcome supply chain inefficiencies and minimize post-harvest food damage through its proximity to agricultural production centers. This location has proven to be the most ideal as it supports 24-hour truck logistics accessibility, which is crucial for regional food distribution. The integration of technology through rooftop solar power (PLTS) implementation and the application of HACCP-standard hygienic architecture has successfully transformed this facility into a modern food infrastructure prototype that is energy-independent and sustainable, while simultaneously strengthening Bojonegoro's position as a national food barn. (Vijayakumar et al. 2024)

As a developmental step, this research suggests further technical studies regarding the detailed specifications of the cold storage refrigeration system to ensure that energy load calculations align with the planned PLTS capacity. Functionally, the provision of an education or R&D (Research and Development) zone within the complex is highly recommended to improve the quality standards of local farmers' products through grading and packaging training. Finally, it is expected that the Bojonegoro Regency Government can provide policy support in facilitating the technological integration of this project so that it can be realized promptly as a modern and highly competitive food logistics facility. (Vijayakumar et al. 2024)

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