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Indonesia’s Food Infrastructure Readiness for Achieving the Global Zero Hunger Agenda

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Abstract

Indonesia's commitment to the United Nations' Zero Hunger agenda necessitates a robust and equitable food infrastructure system. This study assesses the country's readiness across physical, institutional, and technological domains. Utilizing qualitative document analysis and a systems-theoretical lens, the research reveals that Indonesia’s food logistics infrastructure remains uneven, with rural and eastern regions lacking adequate support. Institutional fragmentation, centralized planning, and weak inter-agency coordination continue to hinder progress. The study introduces an integrative infrastructure readiness framework that evaluates capacity in terms of accessibility, resilience, and inclusivity. Recommendations include enhancing coordination through empowered national agencies, integrating digital logistics platforms, and promoting public-private partnerships. The findings provide a strategic model for aligning Indonesia’s infrastructure with the Zero Hunger goal by 2030. This research contributes both theoretically and practically by bridging the current gap in food systems literature through a holistic, readiness-based approach.

Keywords

food security; infrastructure readiness; zero hunger; governance

INTRODUCTION

Addressing food insecurity is central to global development, particularly under the United Nations’ Sustainable Development Goal 2 (Zero Hunger), which emphasizes the eradication of hunger and the promotion of sustainable agriculture. As one of the largest agrarian nations, Indonesia faces complex challenges in securing equitable food distribution and access amidst rapid urbanization, climate change, and economic inequality (FAO, 2015). The concept of food infrastructure readiness refers to a country’s capacity—across logistics, governance, technology, and human resources—to sustain food availability and accessibility under normal and crisis conditions (Fan, Pandya-Lorch, & Yosef, 2014). While Indonesia has made notable progress in agricultural output, national food infrastructure remains vulnerable to disruptions and

inefficiencies that threaten the continuity and equity of food supply (World Bank, 2016).

Institutional frameworks in Indonesia have long grappled with fragmented policy implementation and overlapping jurisdictional mandates between central and regional agencies (Haryani, 2016, p. 89). Inadequate cold chain systems, limited rural transportation networks, and underdeveloped food storage capacities exacerbate post-harvest losses and hinder efficient food distribution (Sumaryanto & Syam, 2015, p. 147). These structural bottlenecks disproportionately affect marginalized communities in eastern Indonesia, undermining efforts to fulfill food sovereignty and resilience. Studies emphasize the need for an integrated approach that harmonizes infrastructure development with socio-economic planning and environmental sustainability (Todaro & Smith, 2015, p. 223). Thus, understanding the interplay between infrastructure readiness and hunger alleviation is essential for achieving SDG 2.

Theoretical contributions to food security often draw from the capability approach, systems theory, and resilience frameworks. The capability approach underscores individuals' freedom to access adequate nutrition, while systems theory emphasizes the interconnectivity of infrastructure components in supporting food systems (Sen, 1999, p. 74; von Braun & Birner, 2017). Meanwhile, the resilience lens addresses the ability of food infrastructure to absorb shocks from environmental, economic, or political crises (Barrett, 2010). Empirical studies highlight that infrastructure readiness is not only a matter of physical assets but also of institutional efficiency, community engagement, and technological integration (Pingali, 2015). These frameworks collectively provide an analytical foundation for evaluating Indonesia's preparedness in embracing the Zero Hunger agenda.

Existing research has extensively discussed agricultural productivity, food subsidy policies, and rural development, but few have examined national food infrastructure as a comprehensive system directly linked to SDG 2 targets (Nasution, 2016, p. 63; Zaks et al., 2016). Most literature isolates physical infrastructure or food policies without integrating governance, innovation, and logistical coherence. This disconnection results in fragmented interventions and limited scalability of food security solutions. Furthermore, spatial disparities between western and eastern regions in Indonesia highlight the urgency of evaluating readiness at both national and sub-national levels. Hence, there is a critical need to address the research gap by adopting a systems-based approach to analyze infrastructure readiness comprehensively.

This study aims to investigate Indonesia's national food infrastructure readiness in supporting the Zero Hunger agenda. Specifically, the study seeks to answer the following research questions: (1) How adequate are Indonesia's food infrastructure systems in ensuring equitable access to food? (2) What are the main institutional and

logistical challenges hindering food infrastructure development? (3) How can Indonesia improve its infrastructure readiness to support the Zero Hunger target by 2030? By addressing these questions, the study contributes to theoretical discourses on food system resilience and offers practical recommendations for policy integration and infrastructure reform. The findings are expected to inform stakeholders involved in sustainable development, food governance, and socio-economic policy implementation.

LITERATURE REVIEW

Food infrastructure, as a critical component of national development, encompasses physical systems, institutional frameworks, and policy mechanisms that ensure the production, storage, transportation, and distribution of food. Scholarly work on food systems increasingly highlights the role of infrastructure readiness in achieving sustainable food security (Barrett, 2010). The integration of logistics, agricultural innovation, and governance capacity is fundamental to establishing a resilient food system. According to Fan, Pandya-Lorch, and Yosef (2014), infrastructure investment—especially in rural roads, cold chains, and irrigation—has a direct impact on agricultural productivity and market accessibility. In the Indonesian context, Sumaryanto and Syam (2015, p. 153) argue that food insecurity is often aggravated not by production shortfalls but by inefficiencies in infrastructure and distribution networks. International frameworks, such as those proposed by the World Bank (2016), recommend that food infrastructure be approached through a systems perspective, emphasizing coherence between national strategies and local implementation.

Several concepts help position this study within the broader food security discourse. The capability approach, developed by Sen (1999, p. 71), focuses on individuals' real freedoms to achieve well-being, including access to sufficient and nutritious food. This theoretical foundation is complemented by systems theory, which interprets national food security as a dynamic interaction of interconnected components—policy, logistics, governance, and community behavior (von Braun & Birner, 2017). Studies also examine how institutional effectiveness, particularly in managing decentralized responsibilities, affects infrastructure outcomes. For instance, Nasution (2016, p. 67) found that inter-ministerial conflicts and overlapping mandates hinder the delivery of food programs. Furthermore, empirical research by Pingali (2015) underscores the significance of aligning infrastructural development with social inclusivity and technological innovation. Despite these contributions, most literature remains siloed, examining single aspects of infrastructure without capturing the systemic readiness necessary for the Zero Hunger agenda. This study seeks to fill that gap by synthesizing cross-sectoral insights and evaluating readiness holistically.

Theoretical Framework

Understanding national food infrastructure readiness requires a multidimensional theoretical approach, combining the capability approach, systems theory, and resilience theory. Each contributes a unique lens through which infrastructure can be evaluated in relation to hunger alleviation. The capability approach, introduced by Sen (1999, p. 71), frames food access as a basic human capability essential to individual well-being. This perspective moves beyond income-based assessments to consider the real freedoms individuals possess to obtain adequate nutrition. Applied to infrastructure, it suggests that readiness must ensure that all individuals—not just those in economically viable regions—can access food, regardless of geographic, economic, or social disparities (Todaro & Smith, 2015, p. 229).

Systems theory offers another critical foundation, emphasizing the interconnectivity and coordination required for effective infrastructure operation. According to von Braun and Birner (2017), food systems are composed of interdependent elements—agricultural production, logistics, governance, and consumer behavior—that function as a cohesive unit. Disruptions in one component (e.g., poor rural transport) can undermine the system's overall effectiveness. Applying systems theory to Indonesia's food infrastructure highlights the need for vertical and horizontal policy integration across ministries and regions (Fan, Pandya-Lorch, & Yosef, 2014). In this way, systems theory underscores the structural complexity involved in achieving the Zero Hunger target.

Resilience theory further supports the analysis by focusing on how infrastructure systems respond to shocks—natural disasters, economic crises, or pandemics. Barrett (2010) defines resilience in food systems as the capacity to absorb disturbances without compromising long-term sustainability. This framework is especially relevant for Indonesia, a country prone to floods, earthquakes, and price volatility. Building resilience into food infrastructure entails not only physical reinforcement but also institutional agility and data-based monitoring systems (World Bank, 2016). Research by Pingali (2015) suggests that resilient systems must integrate local knowledge and technological adaptation to thrive in diverse environments.

To operationalize these frameworks, the study integrates the infrastructure readiness model, which assesses preparedness across four key domains: physical assets, institutional coherence, technological integration, and socio-economic accessibility. This model draws upon existing readiness frameworks from development economics and international logistics (Haryani, 2016, p. 91; Nasution, 2016, p. 69). By merging these theoretical strands, the study establishes an analytical foundation capable of interrogating how well Indonesia's infrastructure is positioned to achieve equitable

food access and long-term security. The combined framework enables a holistic assessment that captures the nuances of policy, practice, and regional disparity.

Previous Research

Early foundational research on food security infrastructure emphasized physical access and distribution systems. Zaki (2010) investigated how rural road development influenced food distribution in eastern Indonesia, finding that isolated areas suffered from delayed deliveries and increased spoilage, which contributed to regional food insecurity. His work underscored the need for improved transportation networks as a prerequisite for equitable food access. In a comparative study, Barrett (2010) analyzed food system resilience in developing countries and identified that food supply chains remained highly vulnerable to external shocks due to inadequate contingency planning and infrastructure deficits. Barrett's model offered insights applicable to countries like Indonesia, where climatic and economic disruptions frequently affect food systems.

In 2011, Siregar explored the decentralization of food policy in Indonesia and found that misalignment between central and regional agencies caused inefficiencies in food procurement and distribution. Siregar's analysis revealed gaps in institutional coordination, recommending integrated governance mechanisms to synchronize policy implementation (Siregar, 2011, p. 117). In a cross-country study, Fan, Pandya-Lorch, and Yosef (2014) introduced a readiness model that examined infrastructure development through technological adoption, stakeholder coordination, and social inclusion. Their work contributed a valuable evaluative tool applicable in the Indonesian context, particularly regarding localized disparities in food system capacity.

Sumaryanto and Syam (2015, p. 154) expanded upon domestic logistics by evaluating the role of cold chain technology in reducing post-harvest losses. Their findings highlighted the lack of investment in perishable goods storage and identified specific regions where losses exceeded 30% annually. Similarly, Nasution (2016, p. 71) critiqued national food governance by identifying overlapping roles among ministries, poor regulatory enforcement, and insufficient local data systems. His study emphasized the need for evidence-based policymaking supported by digital infrastructure and reliable monitoring. Zaks et al. (2016) addressed environmental sustainability in food systems and proposed that infrastructure development should align with ecological constraints, especially in countries with high biodiversity like Indonesia. Their framework suggests integrating environmental indicators into infrastructure planning.

Although each study contributes valuable insights, there remains a clear research gap concerning a holistic analysis of infrastructure readiness across institutional,

technological, and logistical dimensions. Previous research often isolates either the physical or governance aspects, without integrating them into a systems-based evaluation. Moreover, few studies assess infrastructure readiness through the lens of the Zero Hunger SDG, limiting their policy relevance in the global development agenda. This study addresses this gap by synthesizing fragmented perspectives into a unified framework and directly aligning the analysis with SDG 2 goals. The following research questions therefore guide this study: How adequate are Indonesia's food infrastructure systems in ensuring equitable access to food? What are the institutional and logistical barriers to infrastructure development? How can Indonesia enhance its infrastructure readiness to meet the Zero Hunger target by 2030?

RESEARCH METHODS

This study adopts a qualitative research design that relies on conceptual textual data to evaluate Indonesia's food infrastructure readiness in supporting the global Zero Hunger agenda. The type of data utilized includes policy documents, journal articles, official reports, and books that focus on food security systems, infrastructure development, and institutional capacity. This qualitative data is suitable for capturing complex interactions among logistical networks, governance mechanisms, and socio-economic dynamics (Maxwell, 2013, p. 102). Unlike quantitative data, which emphasizes measurable outcomes, qualitative data allows for an in-depth exploration of contextual factors influencing food system functionality (Creswell, 2013, p. 93). This method provides nuanced insights into structural challenges and opportunities within Indonesia's food infrastructure landscape.

The sources of data comprise international publications, Indonesian government reports, peer-reviewed journal articles, and thematic literature reviews. For example, materials from the World Bank, UN FAO, BPS–Statistics Indonesia, and Indonesian Ministry of Agriculture are incorporated to ensure the data reflects institutional practices and empirical realities. Additionally, books by prominent development economists such as Sen (1999, p. 73) and Todaro & Smith (2015, p. 231) are used to frame the theoretical and empirical dimensions of infrastructure readiness. These sources offer both normative frameworks and evaluative criteria, ensuring that the data is valid, reliable, and grounded in existing scholarship (Yin, 2011, p. 132).

The data collection technique employed is document analysis, which involves systematically reviewing, coding, and interpreting textual information from the selected sources. This method is appropriate for examining complex constructs such as infrastructure readiness, which requires a multi-layered understanding of institutions, policies, and physical systems (Bowen, 2009). Document analysis facilitates triangulation across various data types—legal frameworks, empirical case studies,

statistical reports—thus enhancing the credibility and depth of the research findings (Creswell, 2013, p. 101). By collecting data across different levels—international, national, and regional—the study ensures a comprehensive analysis that reflects structural variations in food infrastructure across Indonesia.

The data analysis technique used is thematic analysis, a qualitative approach that identifies, analyzes, and interprets patterns (themes) within the data (Braun & Clarke, 2006). Themes are developed inductively from the data, guided by the theoretical framework. For example, themes such as "institutional fragmentation," "technological integration," and "spatial inequality" are derived from recurring issues found in policy evaluations and academic discourse. The thematic analysis allows for a coherent synthesis of diverse data sources and supports the development of a systems-based model of infrastructure readiness (Yin, 2011, p. 142). This analytical approach facilitates an understanding of how various factors interact to either support or hinder the achievement of SDG 2 in Indonesia.

Conclusion drawing is achieved through synthesis, wherein the themes are interpreted in relation to the research questions and theoretical models discussed earlier. This step involves making logical inferences based on the interplay between empirical findings and conceptual frameworks (Maxwell, 2013, p. 108). The conclusion process also considers the broader policy implications of the findings, such as how improved inter-agency coordination or investment in logistics infrastructure can accelerate progress toward Zero Hunger. These conclusions are not generalized beyond the case of Indonesia but are positioned within a broader discourse on sustainable development, thereby contributing both locally and globally to the ongoing challenge of food security.

RESULTS AND DISCUSSION

The findings of this study underscore the importance of a systems-based and integrative approach in assessing national food infrastructure readiness for achieving the Zero Hunger goal. Drawing from the theoretical frameworks of capability, systems, and resilience, the analysis demonstrates that Indonesia's infrastructure readiness cannot be understood solely through physical development metrics but must also include institutional alignment, governance effectiveness, and technological integration (Sen, 1999, p. 75; Barrett, 2010).

When compared with global best practices, Indonesia reveals a pattern of fragmented institutional mandates and unequal resource allocation across regions, especially between western and eastern provinces (World Bank, 2016). This confirms earlier

findings by Siregar (2011, p. 118), who noted the detrimental impact of policy incoherence on national food program outcomes.

Moreover, the results reaffirm the critical role of inter-agency coordination in determining infrastructure outcomes. Nasution (2016, p. 69) found that Indonesia's food policy remains highly centralized despite the formal process of decentralization. This inconsistency contributes to inefficiencies in local implementation, particularly in rural and remote areas. The general narrative of findings also introduces new insights by integrating socio-political contexts, such as political will and budgeting constraints, which are seldom addressed in prior infrastructure studies. By exploring how budgetary limitations and bureaucratic inertia influence the pace of infrastructure development, this study contributes to a broader understanding of institutional barriers in food systems.

The dialogue between this research and previous literature also highlights the limited scalability of localized pilot programs. While some districts have successfully implemented community-based cold storage and transportation systems, these successes often fail to expand due to the absence of a national scaling strategy (Sumaryanto & Syam, 2015, p. 155). Furthermore, environmental vulnerability exacerbates food infrastructure fragility in Indonesia. Zaks et al. (2016) pointed out the need for infrastructure planning to align with ecological constraints—a recommendation that remains largely unimplemented in current Indonesian food policy. These findings suggest that resilience thinking must move beyond theoretical discourse and be institutionalized within food infrastructure planning.

By addressing the research gap through a unified readiness model, this study offers an original contribution that extends beyond the fragmented approaches seen in prior research. It integrates physical, institutional, technological, and socio-economic domains into a single analytical framework. This model provides not only a diagnostic tool but also a strategic planning guide that can be used by policymakers and development agencies to enhance food system performance. In synthesizing findings across empirical and theoretical domains, the research establishes a comprehensive understanding of how Indonesia can align its infrastructure with the Zero Hunger agenda.

1. Infrastructure Adequacy and Equitable Food Access

This section addresses the first research question: how adequate are Indonesia's food infrastructure systems in ensuring equitable access to food? The study reveals that despite extensive agricultural development programs, the infrastructure supporting food distribution remains highly uneven, particularly

in rural and eastern Indonesia. Infrastructure adequacy is not only a matter of physical availability but also of accessibility and functionality across all socio-economic strata.

According to the World Bank (2016), inadequate rural roads and transport facilities significantly limit access to markets, thereby increasing post-harvest losses and reducing the profitability of smallholder farming. These limitations directly contradict the capability approach, which emphasizes the freedom of all individuals to access sufficient and nutritious food (Sen, 1999, p. 76).

The physical distribution of logistics infrastructure—such as cold storage, warehousing, and farm-to-market roads—remains heavily concentrated in Java and Sumatra, while provinces in eastern Indonesia continue to experience logistical isolation (Sumaryanto & Syam, 2015, p. 154). This spatial disparity is exacerbated by underinvestment and limited political prioritization for peripheral areas.

In these regions, food often becomes scarce and prices volatile, undermining national food security targets. As highlighted by Zaki (2010), access to infrastructure is directly correlated with household-level food security. The study supports these findings by revealing that logistic inequities are among the most persistent barriers to equitable food access in Indonesia.

The role of digital and technological infrastructure also emerges as a critical determinant of food access. Despite the rise of e-commerce and agri-tech platforms, adoption remains limited in rural settings due to weak internet penetration and lack of digital literacy. This technological divide hampers farmers' ability to engage with broader markets or benefit from real-time information systems (Fan, Pandya-Lorch, & Yosef, 2014).

As Barrett (2010) noted, infrastructure must encompass more than roads and storage—it must also include digital systems that enable smart agriculture and responsive supply chains. In Indonesia’s case, the insufficient technological integration further limits the ability of infrastructure systems to enhance food access for the most vulnerable populations.

From a governance standpoint, the centralization of planning and budgeting decisions restricts local governments from tailoring infrastructure development to their unique geographic and demographic needs. Although decentralization has been promoted since the early 2000s, its impact on infrastructure distribution remains limited due to unclear authority divisions and constrained fiscal capacities at the local level (Siregar, 2011, p. 120).

This governance gap restricts equitable planning and results in the repetition of generalized programs that fail to address local food access challenges. A systems theory approach suggests that without effective coordination among administrative levels, the infrastructure system cannot function as an integrated whole (von Braun & Birner, 2017).

The study also identifies gender and social inclusion issues within food infrastructure planning. Infrastructure projects often overlook the mobility and access constraints faced by women and marginalized groups, particularly in remote villages. For instance, storage facilities are rarely located near women-led cooperatives or community centers, reducing their usability by female farmers.

These insights align with findings from Pingali (2015), who argues that inclusive infrastructure design is critical to ensuring long-term food security. Therefore, equitable infrastructure access must also consider social dimensions, not merely geographic distribution.

Furthermore, data limitations pose a challenge to accurately assessing and planning food infrastructure. The national food logistics system suffers from incomplete databases and outdated inventory tracking, which undermines efficiency and responsiveness.

Nasution (2016, p. 73) emphasized that poor data management leads to misallocation of resources and duplication of infrastructure development in some areas while neglecting others. A resilient and equitable infrastructure system must be underpinned by reliable data and real-time monitoring, enabling more responsive and targeted interventions.

Finally, the study identifies promising initiatives in some provinces where community-based food hubs and localized cold chains have improved access to perishable goods. However, these projects are often donor-driven and lack integration into the national infrastructure plan, making them unsustainable in the long term (Zaks et al., 2016).

Their success demonstrates that decentralized, community-oriented models can enhance infrastructure adequacy if appropriately scaled. Hence, national strategies must incorporate such localized models to ensure that food infrastructure truly supports equitable access across Indonesia.

2. Institutional and Logistical Challenges in Food Infrastructure Development

This section addresses the second research question: what are the main institutional and logistical challenges hindering food infrastructure development in Indonesia? The findings show that institutional fragmentation remains the most persistent barrier to coordinated infrastructure planning and implementation. Various ministries—including Agriculture, Public Works, Transportation, and Trade—operate in silos, often issuing overlapping regulations and competing mandates.

This bureaucratic disunity leads to inefficiencies, policy contradictions, and duplication of efforts (Nasution, 2016, p. 70). Siregar (2011, p. 118) noted that the decentralization process, rather than empowering local governments, introduced ambiguity in role division and fiscal authority, further weakening institutional synergy in infrastructure development.

A critical challenge is the underutilization of inter-ministerial coordination platforms, such as the National Food Agency. Although such bodies are mandated to harmonize policies, they lack enforcement power and strategic alignment across sectors. The absence of integrated planning tools and shared databases undermines strategic foresight and results in ad-hoc project implementation (World Bank, 2016).

From a systems theory perspective, the lack of systemic interconnectivity between institutions means that infrastructure is not planned or operated as a cohesive system (von Braun & Birner, 2017). Consequently, food logistics chains suffer from broken links, resulting in high transport costs, inefficient storage, and product wastage.

Budgetary constraints and rigid fiscal planning also hinder timely infrastructure upgrades. While infrastructure projects are often prioritized in national budgets, food-related components—such as post-harvest storage or cold chain systems—receive disproportionately low allocations. Moreover, local governments face limited fiscal autonomy, with most development funding funneled through central government grants that come with strict guidelines (Haryani, 2016, p. 91).

This structure limits regional flexibility and responsiveness to emerging food distribution challenges. Sen's capability approach reminds us that institutional design must empower local actors to respond to community-specific food needs, which is currently constrained by Indonesia's top-down fiscal architecture (Sen, 1999, p. 74).

Logistically, Indonesia's geography presents a significant barrier. As an archipelagic nation with over 17,000 islands, transportation and distribution pose unique challenges. Inter-island food shipments often face delays due to limited port infrastructure, inadequate vessel availability, and poor weather contingency systems (Sumaryanto & Syam, 2015, p. 155).

These logistical limitations contribute to substantial food loss, especially for perishable goods like fish, fruits, and vegetables. Barrett (2010) emphasized that resilient logistics systems must incorporate contingency planning and redundancy, yet Indonesia's current network lacks both. In many cases, perishable food items are either lost in transit or sold at inflated prices in remote regions, widening the inequality in food access.

The weak integration of digital technologies in logistics is another major constraint. While smart agriculture and supply chain platforms are being developed in pilot regions, national logistics systems continue to rely on manual data entry and outdated tracking tools. This results in poor inventory visibility and inefficiencies in resource allocation (Pingali, 2015). Digitalization is essential not only for logistical optimization but also for transparent monitoring and evaluation. The absence of real-time data makes it difficult to anticipate shortages, track shipment delays, or assess infrastructure usage, ultimately reducing the system's overall efficiency.

Additionally, there is a skills gap among public sector professionals involved in infrastructure planning. Most local agencies lack trained personnel in integrated logistics, smart infrastructure design, and data-driven policy analysis. Professional development programs are scarce and fragmented, contributing to inconsistent quality across infrastructure projects (Fan, Pandya-Lorch, & Yosef, 2014).

This capacity gap prevents local governments from innovating or adopting best practices from other regions, reinforcing a status quo of infrastructure mediocrity. Investment in human capital, particularly in logistics and planning, is thus essential for long-term food infrastructure enhancement.

Finally, corruption and political patronage often distort infrastructure priorities. Infrastructure projects are sometimes allocated not based on needs assessments or strategic importance but on political calculations and rent-seeking behaviors. This dynamic undermines accountability, fosters public distrust, and results in infrastructure that fails to serve food security goals (Zaki, 2010).

Transparent procurement systems and performance-based budgeting are therefore necessary to align infrastructure development with national Zero Hunger objectives. Without addressing these institutional and logistical dysfunctions, infrastructure readiness will remain uneven and inadequate, stalling Indonesia's progress toward SDG 2.

3. Strategic Improvements for Achieving Infrastructure Readiness by 2030

This section addresses the third research question: how can Indonesia improve its infrastructure readiness to support the Zero Hunger target by 2030? Based on the analysis, a key strategic improvement involves strengthening inter-agency coordination through the establishment of a centralized but collaborative planning authority. This body must hold the mandate to align food-related infrastructure projects across ministries and enforce cross-sectoral planning standards.

According to Fan, Pandya-Lorch, and Yosef (2014), central coordination combined with localized implementation enhances infrastructure coherence and maximizes resource efficiency. The National Food Agency, if empowered with executive authority and a clear mandate, could serve this function by integrating physical, digital, and policy infrastructure across all levels of government.

Another strategic recommendation lies in adopting an infrastructure readiness framework that measures key performance indicators (KPIs) such as coverage, functionality, resilience, and inclusion. This framework, adapted from global best practices, would enable policymakers to evaluate and prioritize infrastructure gaps in a structured and data-driven manner (World Bank, 2016).

Incorporating readiness metrics into national development plans would ensure that projects are aligned with both food security and resilience goals. Such a framework must also be sensitive to regional disparities and emphasize infrastructure development in neglected eastern provinces, where food insecurity is most acute (Nasution, 2016, p. 72).

A third improvement strategy involves accelerating public-private partnerships (PPPs) for critical logistics systems such as cold chains, warehousing, and intermodal transport. Government alone cannot meet the massive financial and technological demands of food infrastructure development. Pingali (2015)

stressed the importance of leveraging private sector innovation and investment to modernize agricultural logistics.

Incentivizing private involvement through tax breaks, risk guarantees, and transparent regulations could attract sustainable investments, particularly in high-risk or low-income regions. This approach also aligns with the systems theory, which calls for synergy between public and private components to ensure system-wide effectiveness (von Braun & Birner, 2017).

Digital transformation of logistics and supply chains must also be prioritized. Developing a national agri-logistics platform with real-time tracking, geospatial analysis, and predictive analytics could improve efficiency, reduce losses, and ensure timely food delivery. Such systems are currently being piloted in select regions but need scaling through federal support and digital infrastructure investment (Sumaryanto & Syam, 2015, p. 157).

Furthermore, digital literacy programs are essential to ensure that farmers and small-scale distributors can actively engage with these systems. As Barrett (2010) suggests, technology must be both accessible and contextually adaptable to serve the broader goal of equitable food security.

Institutional reform must also target the empowerment of local governments, particularly in infrastructure planning and budgeting. The current fiscal structure severely limits regional initiative and adaptation. Reforming intergovernmental fiscal transfers to include performance-based grants for infrastructure outcomes could incentivize local innovation and accountability (Haryani, 2016, p. 94).

Sen's capability approach reminds us that empowering institutions closest to the people ensures that infrastructure development is relevant, inclusive, and sustainable (Sen, 1999, p. 78). Building local capacity in logistics management, data science, and participatory planning will strengthen implementation and long-term maintenance of infrastructure projects.

Moreover, integrating food infrastructure planning with environmental sustainability goals is essential. As Zaks et al. (2016) argued, infrastructure development must be aligned with ecological boundaries to avoid long-term degradation. Green logistics—such as solar-powered cold chains, climate-resilient transport corridors, and eco-friendly packaging—should be promoted through regulatory incentives and public procurement guidelines.

Environmental impact assessments must be standard practice in all food-related infrastructure projects. This alignment will ensure that progress toward

Zero Hunger does not compromise other SDGs, especially those related to climate action and biodiversity.

Finally, Indonesia must commit to a national roadmap for infrastructure readiness that includes milestones, funding commitments, and stakeholder roles. Such a roadmap would create policy certainty and attract both domestic and international investment. It would also serve as a public accountability tool, aligning annual budgets and regional development plans with the broader Zero Hunger objective.

This roadmap must be informed by data and grounded in participatory consultation with farmers, communities, and civil society organizations. Only through such an inclusive and strategic approach can Indonesia fully align its infrastructure systems with the vision of SDG 2 by the year 2030.

This study has comprehensively evaluated Indonesia's national food infrastructure readiness in relation to the global Zero Hunger agenda. The first research question examined the adequacy of Indonesia's infrastructure in ensuring equitable food access. Findings revealed pronounced disparities in physical, digital, and social infrastructure between urban and rural areas, with eastern Indonesia facing critical logistical isolation. These insights confirm that infrastructure adequacy is not merely a question of physical presence but of systemic accessibility, functionality, and inclusiveness.

The second research question explored the institutional and logistical challenges hindering infrastructure development. Key obstacles included fragmented governance, centralized fiscal control, weak coordination between ministries, and lack of digital integration. These institutional inefficiencies reduce policy responsiveness and hinder localized infrastructure planning. The results illustrate how systems theory and the capability approach are crucial for identifying institutional misalignments that undermine food security initiatives.

In response to the third research question, the study proposed strategic improvements, including the adoption of a national infrastructure readiness framework, empowerment of local governments, and integration of public-private partnerships. These proposals are directly aligned with global best practices and informed by the resilience and systems-based theoretical frameworks. Furthermore, digital transformation and environmentally sustainable infrastructure planning emerged as pivotal areas for reform.

The novelty of this research lies in its integrative readiness model, which consolidates four critical dimensions: physical infrastructure, institutional coherence, technological

systems, and socio-economic inclusion. This framework bridges a persistent gap in existing literature that often treats infrastructure in siloed terms. The model refines current theoretical perspectives by operationalizing infrastructure readiness within the context of SDG 2, enabling direct policy applicability.

Theoretical implications of this research include an expansion of the capability approach to encompass infrastructure planning as a tool for enabling basic human freedoms. The study also contributes to systems theory by demonstrating how national food systems function—or fail—as interdependent networks of physical and institutional components. Practically, the findings can inform Indonesia's strategic policy design, particularly within the Ministry of Agriculture, Bappenas, and local government agencies. The readiness framework can also guide donor agencies and NGOs in assessing and supporting food infrastructure projects in alignment with Zero Hunger goals.

CONCLUSION

This study has provided a comprehensive assessment of Indonesia's national food infrastructure readiness in supporting the global Zero Hunger agenda. Through the lens of capability, systems, and resilience theories, it was found that infrastructure adequacy is uneven and that existing logistical networks, particularly in eastern Indonesia, remain underdeveloped. Institutional fragmentation and centralized fiscal control further constrain the effective delivery and coordination of infrastructure projects. While technological innovations and community-based models offer potential, these are often isolated and lack integration into national planning frameworks.

The findings confirm that a systems-based approach to food infrastructure is essential to achieving SDG 2. Institutional coherence, technological adoption, and socio-economic inclusion must function in tandem to ensure equitable food access. The research contributes a novel integrative readiness model that can serve as both an analytical and policy tool, enabling more targeted, accountable, and sustainable infrastructure planning.

Based on the findings, this study recommends the development of a national infrastructure readiness roadmap, empowerment of local governments with performance-based budgets, and increased investment in digital and sustainable logistics systems. These recommendations are not only relevant to Indonesia but may also inform similar efforts in other developing countries. Future research should explore the application of this model in comparative contexts and examine its operationalization at sub-national levels.

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