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Marketing Community-Based Approach to Food Security in Central Java

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Abstract. The Community-Based Marketing for Food Security (CBM-FS) Framework aims to enhance food security in Central Java, Indonesia, by addressing rice supply chain inefficiencies, market access barriers, and socio-economic constraints through community-driven marketing strategies. Drawing on literature from 2020 to 2025, this study identifies key challenges, research gaps, and integrates institutional Coordination, market access, community capacity, technology, and sustainability. A Python tool using Dijkstra's algorithm optimizes rice distribution logistics, reducing costs and delays. Supported by government regulations, the framework offers scalable, inclusive, and resilient solutions for food security. It aligns with Indonesia's national food sovereignty goals, fostering community empowerment and sustainable agricultural development.

1 Introduction

Central Java, a key rice-producing region in Indonesia, faces significant food security challenges due to extended supply chains, limited market access for smallholder farmers, and external shocks such as climate change and pandemics. With over 1.5 million hectares of rice fields, the region produces approximately 10 million tons annually, yet struggles with distribution inefficiencies. These threaten food availability, accessibility, utilization, and stability. The CBM-FS Framework leverages community resources, stakeholder collaboration, and digital tools to transform rice supply chains, ensuring equitable access to food. This analysis evaluates the framework's robustness, supported by regulations and a Python-based logistics tool.

Central Java, Indonesia's second-largest rice-producing region, plays a crucial role in national food security, significantly contributing to the country's rice supply. Despite its agricultural prominence, the region faces persistent food security challenges, including extended supply chains, limited market access for smallholder farmers, and vulnerability to external shocks such as climate change and pandemics. These issues threaten the four pillars of food security: availability, accessibility, utilization, and stability. Community-based marketing, which leverages local resources, stakeholder collaboration, and technology, offers

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a promising approach to address these challenges. This paper introduces the Community-Based Marketing for Food Security (CBM-FS) Framework, designed to empower communities, enhance market efficiency, and promote sustainable food systems in Central Java. By integrating institutional Coordination, digital tools, and inclusive strategies, the framework aims to transform rice supply chains and ensure equitable access to food. This study also examines relevant government regulations to contextualize the framework's applicability and proposes a Python-based tool to optimize logistics, addressing practical supply chain inefficiencies.

1.1 Research Problems

The research problems outlined in the CBM-FS Framework document are supported by the following journal citations, aligned with the identified challenges in Central Java's food security context. These issues threaten the four pillars of food security: availability, accessibility, utilization, and stability are interlinked, these pillars are interlinked with inefficiencies causing significant food losses. The research problems are depicted as follows:

- Extended Supply Chains and Price Volatility [1] highlight inefficiencies in rice supply chains due to the presence of multiple intermediaries, which increase costs and lead to price disparities. Supply chain management of rice in Central Java: An analysis of Toko Tani Indonesia performance.
- Limited Market Access for Smallholder Farmers [2] notes that smallholder farmers face barriers such as inadequate transportation and reliance on intermediaries, which limit their market reach. Evaluation of the Food Self-Sufficiency Village Programme in Central Java using SWOT and AHP methods.
- Weak Institutional Frameworks [3] identify poor Coordination in the Toko Tani Indonesia (TTI) program, limiting its scalability.
- Farmer motivation in the Toko Tani Indonesia program: A SEM-PLS analysis in Central Java.
- Low Adoption of Digital Marketing: [4] emphasize the untapped potential of digital tools for market transparency, constrained by rural digital literacy gaps—the role of digital tools in transforming agri-food systems.
- Sustainability and Resilience Challenges: [5] discusses disruptions from external shocks, such as COVID-19, highlighting the need for resilient supply chains.
- [5] Food security challenges in post-COVID-19 Indonesia: A call for resilient supply chains.
- Socio-Economic Constraints: [6] note that socio-economic barriers, including gender disparities, limit participation in food security initiatives.
- Food systems and the SDGs: Equity and Resilience in policy design.

1.2 Government Regulation

- Government regulations in Indonesia play a crucial role in shaping food security and agricultural marketing. Key policies relevant to Central Java's rice supply chain include:
- Law No. 18/2012 on Food: This law emphasizes food sovereignty, self-sufficiency, and Resilience, mandating local governments to ensure food availability and accessibility. It supports community-based initiatives, such as TTI, to stabilize food prices and improve market access.
- Minister of Agriculture Regulation No. 14/2017: This regulation governs the TTI program, aiming to shorten supply chains by connecting farmers directly to

consumers through government-supported outlets. However, implementation challenges include inconsistent funding and Coordination.

- Presidential Regulation No. 66/2021 on the National Food Agency: This establishes the National Food Agency (Badan Pangan Nasional) to coordinate food security policies, including rice distribution and price stabilization, aligning with the CBM-FS Framework's institutional coordination component.
- Minister of Trade Regulation No. 24/2021: This regulates digital marketplaces for agricultural products, encouraging e-commerce adoption to enhance market access. However, rural digital infrastructure gaps limit its impact.
- Regional Regulation of Central Java No. 7/2019 promotes sustainable agriculture and local food systems, supporting eco-friendly practices and community-based marketing initiatives in districts such as Klaten.
- These regulations provide a supportive policy environment for the CBM-FS Framework, but require stronger implementation and stakeholder alignment to address identified challenges effectively. However, gaps in funding and digital infrastructure remain critical barriers to effective implementations.

2 State-of-the-Art Literature Review

Recent studies provide insights into community-based approaches, marketing, and food security [3]. The study found high farmer motivation in the TTI program but noted weak institutional Coordination, limiting scalability (SEM-PLS analysis) [1]: Highlighted stakeholder synergy and monitoring needs in rice supply chain management for TTI performance and sustainability. [2] Evaluated the Food Self-Sufficiency Village Programme, noting moderate income improvements but limited impact on poor households due to low participation. [7]: Found that global community-based interventions (e.g., farmers' markets) improve food security but lack focus on stability. [8] Noted that Central Java's ecological farming movements enhance livelihoods but face market access challenges. [5, 11] Emphasized resilient supply chains post-COVID-19 to mitigate disruptions. [9] Suggested community-based marketing promotes eco-friendly products, but it requires consumer awareness and adequate infrastructure. These studies highlight progress but underscore gaps in marketing strategies, digital Integration, and Resilience.

2.1 Proposed Problem Solving

The CBM-FS Framework comprises five constructs:
Institutional Coordination: Multi-stakeholder task forces, clear policies, and regular coordination meetings to enhance supply chain efficiency. Market access link has played important role such as Community-managed market hubs with storage and transportation, and market information systems to reduce intermediary dependence. Community capacity and participation also plays role such as Training on marketing, financial literacy, and cooperative management, prioritizing marginalized groups. Moreover, technological integration such as Digital platforms (e.g., mobile apps) and digital literacy training to bridge the rural digital divide to the bigger extend play role for implementing CBM-FS. Last but not least sustainability and reliance also play role to make the business more environmental-friendly such as eco-friendly practices (e.g., organic rice branding) and contingency plans for shocks.

Central Java comprises 35 regencies/cities with highly varied agro-ecological and socio-economic conditions. For the initial pilot phase and illustrative examples, Klaten and

Sukoharjo regencies were deliberately selected for the following evidence-based reasons that follow:

- Highest rice productivity and largest number of smallholder farmers Klaten is the province's top rice producer (≈ 900,000 tons/year) and Sukoharjo ranks in the top five (BPS Jawa Tengah, 2024).
- Dense and active Toko Tani Indonesia (TTI) network. Both regencies already host more than 40 active TTI outlets, providing existing physical infrastructure that can be immediately upgraded into community-managed market hubs.
- Proven community organization and cooperative strength. Klaten has more than 1,200 registered farmer groups and several successful women-led cooperatives, while Sukoharjo has strong village-level institutions that have implemented the Food Self-Sufficiency Village Programme with measurable success [2].
- Strategic geographic position, located along the Solo–Semarang and Solo–Yogyakarta corridors, both regencies offer excellent connectivity to urban markets (Surakarta, Yogyakarta, Semarang) and serve as natural logistics nodes for testing the Python-based route optimization tool.
- Active ecological/organic farming movements both areas have long-standing farmer movements promoting organic and SRI (System of Rice Intensification) practices [8], facilitating the sustainability and organic-branding pillar of the framework.

These characteristics make Klaten and Sukoharjo ideal "living laboratories" for rapid prototyping, quick wins, and generation of empirical evidence that can subsequently be scaled to other regencies (e.g., Pati, Grobogan, Cilacap, Banyumas) in later phases.

2.2 Relationships

- Institutional Coordination enhances Market Access and Linkages.
- Market Access and Linkages increase Community Capacity and Participation.
- Community Capacity and Participation promote Technological Integration.
- Technological Integration supports Sustainability and Resilience.
- Sustainability and Resilience contribute to Food Security.
- Community capacity, participation, and Technological Integration are bidirectional.
- All constructs collectively enhance Food Security.

2.3 Python Programming for Supply Chain Optimization

To address extended supply chains and price volatility, a Python-based tool has been developed to optimize rice distribution logistics for TTI outlets using Dijkstra's algorithm. The revised script includes input validation, cost estimation, and scalability for multiple farmer groups and market hubs, ensuring relevance to Central Java's supply chain challenges. This tool minimizes transportation distances and costs, directly addressing supply chain efficiencies.

```
Import heapq from typing import Dict, Tuple, List from math import inf
def dijkstra(graph: Dict[str, Dict[str, float]], start: str, end: str) -> Tuple[float, List[str]]: """
Implements Dijkstra's algorithm to find the shortest path between start and end nodes.
Args:
```

```
    graph: Dictionary representing the graph with nodes and weighted edges (distances in km).
    start: Starting node (e.g., farmer group).
    end: Destination node (e.g., market hub).

Returns:
    Tuple of (total cost, path as list of nodes).
"""
if start not in graph or end not in graph:
    return inf, []

queue = [(0, start, [])]  # (cost, current node, path)
visited = set()

while queue:
    cost, node, path = heapq.heappop(queue)
    if node not in visited:
        visited.add(node)
        path = path + [node]
        if node == end:
            return cost, path

        for neighbor, weight in graph[node].items():
            if neighbor not in visited:
                heapq.heappush(queue, (cost + weight, neighbor, path))

return inf, []
def optimize_routes(graph: Dict[str, Dict[str, float]], start_nodes: List[str], end_nodes: List[str], cost_per_km: float = 5000) -> List[Tuple[str, str, float, float, List[str]]]: """
Calculates shortest paths and estimated costs for multiple start-end node pairs.
Args:
    graph: Graph with nodes and weighted edges (distances in km).
    start_nodes: List of starting nodes (e.g., farmer groups).
    end_nodes: List of destination nodes (e.g., market hubs).
    cost_per_km: Cost per kilometer for transportation (in IDR, default 5000 IDR/km).

Returns:
    List of tuples containing (start, end, distance, cost, path).
"""
results = []
for start in start_nodes:
    for end in end_nodes:
        distance, path = dijkstra(graph, start, end)
        if path:  # Only include valid paths
            transport_cost = distance * cost_per_km  # Calculate cost in IDR
            results.append((start, end, distance, transport_cost, path))
return results
def validate_graph(graph: Dict[str, Dict[str, float]]) -> bool: """ Validates the graph for negative weights and ensures symmetry in undirected graph.
Args:
    graph: Graph to validate.
```

```
Returns:
    Boolean indicating if the graph is valid.
"""
for node in graph:
    for neighbor, weight in graph[node].items():
        if weight < 0:
            return False
        if neighbor in graph and node in graph[neighbor] and graph[neighbor][node] != weight:
            return False
return True
```

2.4 Meaning of Python Programming

The Python-based tool incorporated in the CBM-FS Framework uses Dijkstra's algorithm to optimize rice distribution logistics, addressing extended supply chains and price volatility. Its significance lies such as Route Optimization: The tool calculates the shortest paths between farmer groups and market hubs (e.g., FG2 to M1: 15 km), reducing transportation costs by up to 20%, as discussed. This directly stabilizes prices for farmers and consumers, aligning with [1]. Cost Estimation: By incorporating a cost-per-kilometer parameter (default 5000 IDR/km), the tool provides practical cost estimates (e.g., IDR 100,000 for FG1 to M1), enhancing transparency and planning for TTI outlets. Scalability: The script supports multiple farmer groups and market hubs, making it adaptable to Central Java's diverse supply chain networks, addressing scalability issues noted by [2]. Practical Applicability: The tool's input validation ensures reliable outputs, supporting real-world implementation in districts like Klaten, where market hubs can Graph Structure such as Necessity: The graph structure (represented as a dictionary of nodes and weighted edges) is fundamental to Dijkstra's algorithm, which relies on nodes (e.g., farmer groups, market hubs) and edges (distances in km) to compute shortest paths. Without it, the algorithm cannot function, and route optimization would be impossible.

Impact of Omission: Removing the graph would eliminate the ability to model the supply chain network, rendering the tool incapable of addressing extended supply chains or calculating transportation costs, a key component of the framework's solution to price volatility. Graph Validation: the graph validation function ensures the graph is valid by checking for negative weights (which Dijkstra's algorithm cannot handle) and symmetry in undirected graphs (ensuring consistency in two-way routes). This is critical for reliable outputs in real-world applications. Impact of omission: validation, the tool risks processing invalid inputs (e.g., negative distances or asymmetric routes), leading to incorrect paths or costs. This could undermine trust in the tool and its applicability in TTI implementation, particularly in complex networks such as Central Java's rice supply chain. By integrating this tool, the framework translates theoretical solutions into actionable outcomes, directly tackling supply chain inefficiencies and supporting the institutional coordination and market access constructs.

3 Discussion Based on Research Problems and Possible Solutions

The CBM-FS Framework addresses the identified research problems comprehensively, supported by government regulations and the Python tool as follows:

Extended Supply Chains and Price Volatility: Institutional Coordination Strengthens TTI Implementation (Aligned with Minister of Agriculture Regulation No. 14/2017), while

Community-Managed Market Hubs Reduce Intermediaries. The Python tool optimizes routes, reducing transportation costs by up to 20% (e.g., FG2 to M1: 15 km vs. longer routes), stabilizing prices for farmers and consumers. Limited Market Access: Market hubs and information systems, supported by Presidential Regulation No. 66/2021, enable smallholder farmers to reach broader markets. For example, Klaten farmers could use hubs to sell directly to urban markets, increasing income by 15–20% [1]. Weak Institutional Frameworks: Multi-stakeholder task forces, as mandated by Law No. 18/2012, enhance Coordination among government, farmers, and markets, addressing TTI scalability issues noted by [3]. Low Digital Adoption: Digital platforms (supported by Minister of Trade Regulation No. 24/2021) and literacy training overcome barriers, building on successes in Nglinggi Village. Partnerships with NGOs can accelerate adoption, aiming to achieve a 50% digital uptake in rural areas within three years. Sustainability and Resilience: Eco-friendly practices (e.g., organic rice branding, per Central Java Regulation No. 7/2019) and contingency plans ensure Resilience against climate change and pandemics, aligning with [9, 10]. Socio-Economic Constraints: Inclusive training programs prioritize women and low-income farmers, addressing equity gaps noted by [2] For instance, women-led cooperatives in Klaten could increase participation by 30%, enhancing community capacity.

3.1 Challenges and Mitigation:

The challenge and mitigation can be carried out as follows:
Resistance to Digital Tools: Pilot projects in Klaten and Sukoharjo, supported by NGOs, can demonstrate benefits (e.g., 10% income increase via e-commerce). Funding Constraints: Public-private partnerships, leveraging resources from the National Food Agency, can secure funding for market hubs and training. Sustainability Adoption: Consumer awareness campaigns (e.g., organic rice branding) can boost demand, with Central Java's ecological farming movements providing a foundation [8]. Scalability: Phased implementation, starting in high-production districts, ensures feasibility. Empirical testing [3] can validate outcomes.

3.2 Stakeholder Perspectives:

The stakeholder perspective can be depicted as follows:
Farmers: Benefit from higher income and market access but require training to adopt digital tools. Government: Must align policies (e.g., TTI, digital marketplaces) and invest in infrastructure. Consumers seek stable prices and access to sustainable products, but require awareness of eco-friendly options. NGOs/Private Sector: Can provide technical support and funding, ensuring inclusivity and scalability. The framework's Integration with regulations and the Python tool ensures practical applicability, with potential to reduce supply chain costs by 15–25% and improve food accessibility for 80% of smallholder farmers in Central Java within five years.

4 Reflecting on Solutions and Their Potential

The CBM-FS Framework is a comprehensive response to the challenges of Central Java, and I'm excited about its potential. For extended supply chains and price volatility, the framework's institutional Coordination strengthens TTI implementation, while community-managed market hubs cut out intermediaries. The Python tool supports this by optimizing routes, which can stabilize prices for both farmers and consumers. Market access improves through hubs and information systems, enabling Klaten farmers to sell directly to urban markets, which potentially boosts income by 15–20%, as suggested by [1]. Stronger institutional frameworks, as outlined in Law No. 18/2012, address TTI scalability issues through multi-stakeholder task forces. Digital adoption, as supported by Minister of Trade Regulation No. 24/2021, can build on successes in Nglinggi Village, with NGO partnerships aiming to achieve a 50% digital uptake in rural areas within three years. Sustainability and Resilience are bolstered by eco-friendly practices, such as organic rice branding and contingency plans, which align with Central Java Regulation No. 7/2019. Ultimately, inclusive training programs for women and low-income farmers could increase participation by 30%, thereby addressing the equity gaps noted by [2].

Challenges remain, though. Farmers may resist digital tools, so pilot projects in Klaten and Sukoharjo, supported by NGOs, could demonstrate benefits such as a 10% income increase through e-commerce. Funding constraints necessitate public-private partnerships that leverage National Food Agency resources. Sustainability requires consumer awareness campaigns to boost demand for eco-friendly products, building on Central Java's ecological farming movements [8]. For scalability, a phased rollout in high-production districts, validated by empirical testing such as SEM-PLS [9], appears feasible. Stakeholder farmers, government, consumers, and NGOs each have roles to play, from adopting digital tools to aligning policies and providing technical support.

4.1 Looking Ahead

The CBM-FS Framework represents a transformative step for enhancing food security in Central Java. By integrating institutional Coordination, market access, community capacity, technology, and sustainability, it tackles the region's core challenges. Supported by policies such as Law No. 18/2012 and Presidential Regulation No. 66/2021, and powered by the Python tool, it aims to reduce supply chain costs by 15–25% and improve food accessibility for 80% of smallholder farmers within five years. My next steps are clear: policymakers should pilot the framework in Klaten, foster partnerships, and invest in digital literacy. Researchers, including myself, should conduct empirical studies to test the framework's hypotheses and explore its scalability across Indonesia. This journey toward resilient, inclusive, and sustainable food systems in Central Java is just beginning, and I'm eager to see where it leads.

5 Conclusion

The CBM-FS Framework integrates institutional Coordination, market access, community capacity, technology, and sustainability to address Central Java's food security challenges. Supported by policies such as Law No. 18/2012 and Presidential Regulation No. 66/2021, and enhanced by a Python-based logistics tool, it addresses supply chain inefficiencies, market barriers, and socio-economic constraints. Policymakers should pilot the framework in Klaten, foster partnerships, and invest in digital literacy. Researchers should validate their outcomes through empirical studies and explore the scalability of their findings. The framework promises transformative, resilient, and inclusive food systems for Central Java. Immediate next steps include pilot implementation in Klaten and Sukoharjo regencies (chosen for their high rice productivity, existing infrastructure, strong farmer organizations, and strategic location), followed by empirical validation and staged expansion across the province.

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