

FINGER MILLET: A RESILIENT FAMINE CROP FOR MARGINAL FARMING HOUSEHOLDS

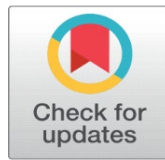
Sadiq, M. S.¹ , Singh, I.P.² , Ahmad, M. M.³ , Adamu, M. Y.⁴

¹ Department of Agricultural Economics and Agribusiness, FUD, Dutse, Nigeria

² Department of Agricultural Economics, SKRAU, Bikaner, India

³ Department of Agricultural Economics and Extension, BUK, Kano, Nigeria

⁴ Department of Crop Protection, MAUTECH, Yola, Nigeria



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Corresponding Author

Sadiq, M. S., sadiqsanusi30@gmail.com

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ABSTRACT

Finger millet (*Eleusine coracana*) is a crucial cereal crop grown predominantly in semi-arid regions of Africa and Asia. It serves as a food security buffer for poor farming households due to its resilience to adverse climatic conditions and minimal input requirements. This paper examines finger millet's nutritional, economic, and agronomic importance, highlights its role in mitigating food insecurity, and discusses its potential in addressing global challenges like climate change and poverty. The review provides a conceptual framework for understanding its socio-economic relevance and concludes with recommendations for improving finger millet production systems through research and policy interventions.

Keywords: Finger Millet, Famine Crop, Food Security, Climate-Resilient Agriculture, Nutritional Super Food, Poor Households

1. INTRODUCTION

Finger millet (*Eleusine coracana*) stands as a testament to the resilience of traditional crops in the face of environmental challenges. Often referred to as "ragi" in India [Kumar et al. \(2023a\)](#) and various local names in Africa, is one of the earliest domesticated cereals, playing a crucial role in the agricultural heritage of humanity. In Nigeria, **finger millet** is commonly referred to as "**Tamba**" in the Hausa language, predominantly spoken in the northern regions. It may also be recognized by other

local names depending on the region and ethnic group, but "Tamba" is the most widely used term. Originating in the Ethiopian highlands, this resilient crop has spread across semi-arid and arid regions of Asia and Africa, adapting to diverse climatic and soil conditions. Its deep-rooted cultural significance is evident in traditional diets, rituals, and farming practices, particularly among smallholder and subsistence farmers [Devi et al. \(2014\)](#), [Patel and Naik \(2020\)](#), [FAO \(2021\)](#).

Domesticated over 4,000 years ago in East Africa, it holds historical significance as a staple food for millions of people across the tropics, particularly in regions prone to erratic rainfall and poor soil fertility [Tesfaye et al. \(2021a\)](#). While global agriculture has largely shifted its focus to high-yielding cereals like wheat, maize, and rice, finger millet continues to serve as a cornerstone of food security in many marginalized communities. Its enduring relevance stems from its unique adaptability, nutritional superiority, and ability to thrive in conditions where other crops fail.

One of the remarkable features of finger millet is its role as a "famine crop." Unlike resource-intensive staples, it requires minimal inputs, such as fertilizers and irrigation, while remaining highly productive in semi-arid and arid regions [Obilana and Manyasa \(2002\)](#), [Nirgude et al. \(2020\)](#). The crop's resilience to pests, diseases, and environmental stresses makes it invaluable in the context of climate variability, particularly as smallholder farmers face increasing threats from drought and soil degradation. Its long shelf life, with grains that can be stored for years without significant loss of quality, further reinforces its role as a critical food reserve during periods of scarcity.

Nutritionally, finger millet is often considered a "super food" due to its dense concentration of macronutrients, micronutrients, and bioactive compounds. It is one of the richest plant-based sources of calcium, essential for bone health, and contains significant levels of iron and magnesium, which are vital for combating anemia and supporting overall metabolic health. Additionally, its high fiber content supports digestive health and helps regulate blood sugar levels, making it an excellent dietary choice for individuals with diabetes or metabolic disorders. In regions with high rates of malnutrition, finger millet has emerged as a critical food crop for vulnerable groups, including children, pregnant women, and the elderly.

From a socio-economic perspective, finger millet provides multiple benefits. Its cultivation supports rural livelihoods by creating employment opportunities across the value chain [Ogunade et al. \(2022a\)](#), from farming and harvesting to processing and marketing. Traditional finger millet-based foods, such as porridge, flatbreads, and beverages, hold cultural significance in many regions and are increasingly gaining traction in urban markets due to growing interest in health-conscious and gluten-free diets. This demand has opened avenues for commercialization, including the production of value-added products like finger millet flour, malted beverages, and ready-to-eat snacks, offering smallholder farmers a pathway to increased income and market integration.

Despite its potential, finger millet remains underutilized and under-researched compared to global staple crops. Its declining cultivation is linked to factors such as labor-intensive farming practices, limited access to improved seed varieties, and insufficient policy support. Additionally, the crop is often viewed as "poor man's food," resulting in a lack of awareness about its nutritional and economic value in urban areas. Addressing these challenges will require coordinated efforts to improve research investment, develop climate-resilient and high-yielding varieties, and enhance value chain integration to connect smallholder farmers with lucrative markets.

This review seeks to underscore the critical role of finger millet in addressing food security and malnutrition while promoting sustainable agricultural systems. By exploring its socio-economic, agronomic, and nutritional dimensions, the review highlights pathways to leverage its potential in combating the dual challenges of climate change and poverty. It aims to provide actionable insights for policymakers, researchers, and stakeholders in agriculture, nutrition, and rural development.

2. THEORETICAL AND CONCEPTUAL FRAMEWORKS

2.1. THEORETICAL FRAMEWORK

The production and utilization of finger millet can be robustly analyzed using **sustainable livelihoods theory** and **resilience theory**, both of which focus on strengthening the ability of communities and systems to cope with environmental, economic, and social challenges.

- **Sustainable Livelihoods Theory:** This theory underscores the importance of creating and maintaining agricultural systems that enhance food security, provide income opportunities, and build adaptive capacity in resource-limited settings. Finger millet exemplifies these principles as it thrives in marginal environments, requires minimal external inputs, and supports both subsistence and commercial farming systems. Its role in sustaining household nutrition and income, even during periods of climatic or economic stress, demonstrates its alignment with sustainable livelihood objectives.
- **Resilience Theory:** Resilience theory explores the capacity of agricultural systems to absorb disturbances, adapt to change, and continue functioning effectively. Finger millet's inherent drought tolerance, pest resistance, and adaptability to degraded soils exemplify its resilience. Its cultivation enhances ecosystem diversity and stability, reducing reliance on monoculture crops that are more vulnerable to climate change. By supporting intercropping systems and contributing to soil fertility, finger millet reinforces the resilience of farming households to climate-induced shocks.

Together, these frameworks provide a foundation for understanding how finger millet can serve as a critical component of sustainable agricultural strategies aimed at addressing food insecurity and promoting socio-economic stability in marginalized regions.

3. CONCEPTUAL FRAMEWORK

A conceptual framework for analyzing finger millet's role in farming systems integrates three interconnected dimensions—**agronomic potential**, **nutritional value**, and **economic role**—which are influenced by overarching factors like climate variability, government policies, and market dynamics. These dimensions form a dynamic feedback loop that shapes the adoption, cultivation, and impact of finger millet.

1) Agronomic Potential

- Finger millet is highly adaptable to arid and semi-arid environments, thriving in poor soils with minimal external inputs such as fertilizers and irrigation. This makes it a reliable crop for farmers in resource-constrained settings.
- Its short growth cycle allows for flexibility in planting and harvesting, making it a viable option in areas with unpredictable rainfall patterns.

- The crop's ability to coexist with other plants in intercropping systems enhances overall farm productivity and resilience, while its genetic diversity presents opportunities for breeding programs to develop improved varieties that are resistant to climate stressors.

2) Nutritional Value

- Finger millet is a powerhouse of nutrients, providing essential macronutrients such as protein and carbohydrates, alongside critical micronutrients like calcium, iron, and magnesium. Its high dietary fiber content supports gut health and helps manage conditions like diabetes and obesity.
- The bioavailability of its nutrients, combined with its gluten-free properties, makes it an essential crop for populations with specific dietary needs, including those suffering from celiac disease.
- Its potential for addressing malnutrition is particularly notable in developing countries, where traditional cereal-based diets often lack sufficient micronutrient content.

3) Economic Role

- Finger millet supports rural economies through job creation in its production, processing, and marketing. Traditional processing techniques such as malting, milling, and fermentation have provided livelihoods for generations, particularly for women in rural communities.
- Increasing demand for gluten-free and health-focused products in urban markets has expanded its commercial potential, offering farmers and entrepreneurs opportunities for higher incomes through value-added products.
- Its ability to be stored for extended periods without significant quality loss adds a layer of economic security, allowing households to manage food and income more effectively during lean seasons.

4) Interlinking Factors

- **Climate Variability:** Changes in temperature and rainfall patterns significantly influence finger millet cultivation. Its resilience to climate stressors positions it as a critical crop for adapting to these challenges.
- **Government Policies:** Policies promoting research on improved finger millet varieties, subsidies for its cultivation, and market access can enhance its adoption and profitability.
- **Market Dynamics:** The presence of robust value chains and access to urban markets can incentivize farmers to cultivate finger millet on a larger scale, ensuring better returns.

4. FEEDBACK LOOP

The interrelation between these dimensions creates a dynamic system:

- Enhanced agronomic potential leads to higher yields, improving household food security and creating surpluses for market sales.
- Better market integration and economic incentives drive investments in cultivation and processing, which in turn enhance the crop's perceived value and encourage its adoption.

- Increased consumption of finger millet improves public health and awareness of its benefits, fostering demand and driving further investments in its value chain.

This conceptual framework highlights the potential of finger millet to act as a transformative crop in addressing the interconnected challenges of malnutrition, climate change, and rural poverty. By leveraging its unique agronomic, nutritional, and economic attributes, stakeholders can unlock its full potential to contribute to sustainable agricultural systems and resilient livelihoods.

Step-by-Step Development of the Conceptual Framework for Finger Millet's Role in Farming Systems

A conceptual framework is a structured representation of the key elements, relationships, and dynamics influencing the subject of study. For finger millet, the framework integrates **Agronomic Potential**, **Nutritional Value**, and **Economic Role**, influenced by external factors like climate variability, government policies, and market dynamics. Here's how the framework is built step-by-step:

1) Identify the Core Dimensions

The first step is to determine the primary aspects that define finger millet's significance. These are:

Agronomic Potential

- Resilience to harsh environmental conditions (e.g., drought tolerance, low fertility soils).
- Compatibility with low-input farming systems.
- Contribution to sustainable farming practices (e.g., intercropping, soil conservation).

Nutritional Value

- High nutrient content (calcium, iron, dietary fiber, etc.).
- Suitability for addressing malnutrition and specific dietary needs (e.g., gluten-free diets).
- Functional health benefits, including its role in managing diabetes and improving gut health.

Economic Role

- Opportunities for employment and income through production, processing, and value addition.
- Increasing demand for millet-based products in health-conscious and gluten-free markets.
- Long storage life offering economic security during lean seasons.

2) Define the Interrelationships among Dimensions

The three dimensions are interconnected, forming a dynamic feedback loop:

Agronomic Potential ↔ Nutritional Value:

- Agronomic resilience supports consistent production, ensuring a stable supply of nutrient-rich food.
- Nutritional benefits incentivize farmers to cultivate finger millet, maintaining its relevance in farming systems.

Agronomic Potential ↔ Economic Role:

- Finger millet's ability to grow in resource-poor environments ensures its cultivation, even in marginal lands, contributing to local economies.

- Economic incentives (e.g., value addition) encourage farmers to adopt improved agronomic practices.

Nutritional Value ↔ Economic Role:

- High nutritional value drives demand in urban and health-conscious markets, creating economic opportunities for farmers.
- Increased economic returns motivate households to integrate finger millet into their diets, promoting better nutrition.

3) Identify Influencing Factors

Key external factors affect the dimensions and their interrelationships:

- **Climate Variability:** Affects agronomic performance and influences the role of finger millet as a climate-resilient crop.
- **Government Policies:** Drive research, market development, and farmer support for finger millet cultivation.
- **Market Dynamics:** Influence demand for millet-based products, impacting farmers' incomes and the crop's adoption.

4) Develop the Feedback Loop

The framework emphasizes the dynamic nature of finger millet's role in farming systems, where the outcomes of one dimension feed back into the others:

- Improved **Agronomic Potential** enhances yields and quality, supporting better **Economic Role** outcomes through market opportunities.
- Higher **Economic Role** outcomes motivate adoption of finger millet, reinforcing its **Agronomic Potential** and increasing access to **Nutritional Value**.
- Increased awareness of **Nutritional Value** generates market demand, leading to investments that improve both **Agronomic Potential** and the **Economic Role** of the crop.

5) Visualize the Framework

Below is a visual structure of the framework:

Figure 1

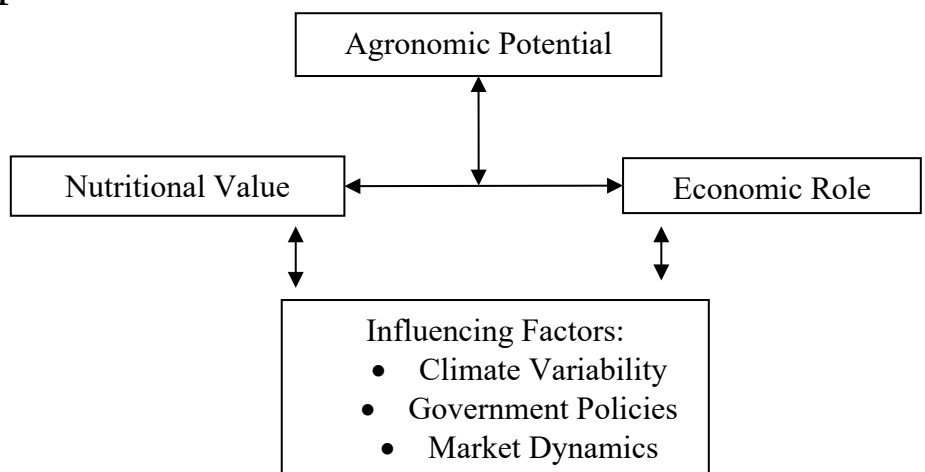


Figure 1 Conceptual framework

6) Explain the Dynamic Feedback

This framework shows that:

- Finger millet's agronomic resilience enables consistent production under challenging conditions.
- Its nutritional benefits drive market demand and public health initiatives.
- Economic opportunities through processing and marketing incentivize better farming practices and improve livelihoods.

7) Address Policy Implications

The framework suggests that:

- Investment in research can improve agronomic potential and develop high-yielding, climate-resilient varieties.
- Market development can boost demand and enhance economic returns for farmers.
- Public health campaigns can promote awareness of finger millet's nutritional value, increasing its adoption.

This structured framework can guide decision-making for stakeholders, including policymakers, researchers, and agricultural planners, to maximize finger millet's potential.

5. RESEARCH METHODOLOGY

The current study systematically analyzed the data sourced from journals, conference proceedings, monographs, edited books etc in arriving at its results and discussion. Extensively, the literature was explored so as to get insightful information for proper and valid inferences.

6. RESULTS AND DISCUSSION

Nutritional Significance

Finger millet's nutritional profile has garnered attention for its potential to address malnutrition and improve dietary health. In addition to its macronutrient composition (7-10% protein, 1.5% fat, and 65-75% carbohydrates), the crop is a rich source of essential amino acids, including tryptophan, methionine, and cysteine [Kumar et al. \(2023a\)](#). These amino acids are crucial for muscle repair, immunity, and metabolic functions, particularly in regions where diets are predominantly cereal-based and lack protein diversity.

The crop is also packed with phytochemicals, including polyphenols and flavonoids, which have antioxidant and anti-inflammatory properties [Kumar et al. \(2023b\)](#). These compounds contribute to the prevention of chronic conditions such as cardiovascular diseases, diabetes, and cancer. Finger millet's high calcium content (344 mg per 100 g) surpasses that of most cereals, supporting bone development and reducing the risk of osteoporosis. Iron and magnesium levels make it effective in combating anemia and promoting energy metabolism.

In traditional diets, finger millet is often used to prepare porridge, infant weaning foods, and fermented beverages, particularly in India and Africa. Recent innovations include its incorporation into nutraceuticals, health snacks, and gluten-free bakery products, highlighting its versatility. Its low glycemic index makes it suitable for managing blood sugar levels, further cementing its status as a functional food for diabetes care.

Agronomic Benefits

Finger millet stands out for its agronomic versatility and resilience. Its adaptability to harsh environments, including semi-arid and arid regions, makes it a valuable crop for regions prone to climate variability [Upadhyaya et al. \(2014\)](#). In addition to thriving in low-fertility soils, the crop demonstrates resistance to common pests and diseases, reducing the need for chemical inputs and lowering production costs for farmers.

The crop's deep root system enhances its drought tolerance, enabling it to extract water from deeper soil layers during prolonged dry spells. Its cultivation as a "catch crop" due to its short growing season (90-120 days) allows farmers to harvest even when rainfall is insufficient. Furthermore, finger millet contributes to soil health by preventing erosion and maintaining soil organic matter. It is often intercropped with legumes, providing a symbiotic system that enhances nitrogen availability in the soil.

Genetic diversity within finger millet presents opportunities for breeding programs aimed at improving yields, resistance to biotic and abiotic stresses, and nutritional quality. As a climate-resilient crop, finger millet aligns with sustainable agricultural practices, offering a reliable option for addressing the challenges posed by global warming and soil degradation.

Economic Importance

Finger millet has significant economic implications, particularly for smallholder farmers. Beyond its role in food security, the crop supports rural economies through diverse income-generating opportunities. Traditional processing methods, including pounding, grinding, and fermentation, create employment, especially for women, who are often the primary processors and marketers of millet-based products.

In urban and international markets, the demand for finger millet has risen due to growing consumer awareness of its health benefits. Products such as finger millet flour, malted beverages, and ready-to-eat snacks are increasingly popular in health-conscious and gluten-free markets [Ogunade et al. \(2022b\)](#). This shift has opened avenues for value addition, enabling farmers and entrepreneurs to earn higher incomes through innovative products like energy bars, cookies, and breakfast cereals.

The crop's potential for export is also noteworthy, particularly to regions with large populations of gluten-intolerant consumers. However, to capitalize on this demand, there is a need to strengthen supply chains, improve branding, and create farmer cooperatives that can negotiate better prices and access to markets.

Challenges in Cultivation

Despite its numerous advantages, finger millet faces several constraints that hinder its widespread adoption and productivity:

- **Low Yields:** Finger millet yields remain lower compared to other cereals, such as wheat, maize, and rice. The average yield of 1-1.5 tons per hectare lags behind due to limited research on high-yielding and disease-resistant varieties.
- **Labor-Intensive Practices:** Traditional cultivation and processing methods are labor-intensive, discouraging farmers from scaling up production.
- **Limited Research and Development:** There is inadequate investment in breeding programs, agronomic practices, and post-harvest technologies, leading to stagnant productivity.

- **Market and Value Chain Gaps:** Farmers often face limited access to markets and infrastructure for processing and storage, resulting in post-harvest losses and reduced profitability.
- **Perception Issues:** In many regions, finger millet is viewed as a "poor man's crop," reducing its appeal among urban consumers and policymakers.

Addressing these challenges will require coordinated efforts to invest in research, promote mechanization, and develop infrastructure to support processing, storage, and market integration.

Addressing Climate Change and Food Security

Finger millet is uniquely positioned to play a critical role in mitigating the impacts of climate change on agriculture and food security. Its low water and fertilizer requirements make it an ideal crop for regions facing water scarcity and resource constraints. By promoting its cultivation, farming systems can reduce dependency on high-input crops like maize and rice, which are more vulnerable to climate-induced stresses [Tesfaye et al. \(2021b\)](#).

The crop's role in diversifying cropping systems is particularly significant for improving farm resilience. Intercropping finger millet with legumes not only enhances soil fertility but also reduces the risks associated with monoculture farming. Additionally, its ability to thrive in degraded soils offers a pathway for reclaiming marginal lands, thus expanding arable land use.

As global temperatures rise, finger millet's genetic adaptability presents an opportunity for breeding climate-smart varieties that can withstand heat stress, erratic rainfall, and emerging pests. Policies that promote finger millet cultivation as part of climate adaptation strategies can enhance food security and reduce vulnerability among farming communities in semi-arid regions.

Finger millet's contribution to food security is amplified by its potential to address "hidden hunger"-micronutrient deficiencies that affect millions worldwide. By integrating finger millet into school feeding programs, public health campaigns, and food aid initiatives, governments and organizations can leverage its nutritional benefits to improve health outcomes in vulnerable populations.

7. CONCLUSION AND RECOMMENDATIONS

Conclusion

Finger millet is a resilient crop with immense potential to improve food security, nutrition, and economic stability among marginalized farming communities. Its ability to thrive in resource-poor environments positions it as a critical component of climate-resilient agriculture.

Recommendations

- **Research and development:** Invest in breeding programs to develop high-yielding and disease-resistant varieties.
- **Extension services:** Enhance farmer awareness about agronomic practices and nutritional benefits.
- **Market development:** Strengthen value chains through processing technologies and access to markets.
- **Policy support:** Include finger millet in public procurement schemes and subsidize its production inputs.
- **Integration into food systems:** Promote finger millet as part of school feeding programs and health interventions to combat malnutrition.

CONFLICT OF INTERESTS

None.

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