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The Importance of Millets in Sustainable Farming and Nutrition

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ABSTRACT

Millets-often called "nutri-cereals" are gaining recognition for their potential to address the interconnected challenges of sustainable agriculture, food security, and public health. Traditionally cultivated in arid and semi-arid zones, these ancient grains are highly resilient to climate stress and require minimal inputs, making them ideal for environmentally sustainable farming. Their deep-root systems enhance soil quality, while their low water and nutrient needs make them suitable for water-scarce and resource-constrained regions. In addition to their agronomic advantages, millets offer significant nutritional benefits. Compared to staple cereals like rice and wheat, millets are richer in dietary fiber, essential amino acids, calcium, and iron, and have a lower glycemic index, making them particularly effective in combating micronutrient deficiencies and lifestyle diseases. Furthermore, millet farming sustains the livelihoods of small and marginal farmers, particularly in ecologically vulnerable areas, thereby promoting inclusive rural development. This research adopts a qualitative approach, relying extensively on secondary data collected from credible sources such as the Indian Council of Agricultural Research (ICAR), the Food and Agriculture Organization (FAO), and national policy documents. Descriptive statistics are employed to analyse production trends, yield patterns, water usage, and nutritional composition of millets in comparison to conventional cereals like rice and wheat. Empirical comparisons are made through structured tables and charts, highlighting key indicators such as protein content, iron and calcium levels, water requirement per kilogram of output, and carbon footprint. These comparisons help demonstrate the ecological and nutritional advantages of millets over mainstream cereals. Additionally, market data such as Minimum Support Price (MSP) trends, procurement volumes, and farmer income patterns are examined to evaluate the economic impact of millet cultivation. This evidence-based analysis supports the policy recommendations made in the paper, including improved MSPs, better inclusion in public food programs, and millet promotion campaigns.

Keywords: Millets; Sustainable Agriculture; Climate Adaptation; Nutritional Security; Public Health; Food Policy

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INTRODUCTION

Millets are a group of small-seeded grasses traditionally grown as staple crops in arid and semi-arid regions. In India, they have been integral to dry land agriculture for centuries due to their ability to thrive in challenging environmental conditions. Before the Green Revolution of the 1960s, millet played a significant role in the country's food systems. However, with the subsequent focus on high-yielding varieties of rice and wheat, national agricultural policies shifted, leading to unintended consequences such as heavy dependence on chemical inputs, declining groundwater levels, and reduced crop diversity (Rao & Basavaraj, 2015).

In recent decades, the urban population in India has experienced a significant rise in lifestyle related health problems, drawing renewed attention to the importance of balanced nutrition. Poor dietary habits have emerged as a major underlying factor contributing to both under nutrition and non-communicable diseases (NCDs). Data from the National Family Health Survey (NFHS-5, 2019–21) reveals that 35.5% of children under the age of five are stunted and 32.1% are underweight, pointing to widespread under nutrition and poor early-life dietary intake. Furthermore, micronutrient deficiencies are alarmingly prevalent, with 57% of women aged 15–49 and 25% of men suffering from anemia. In parallel, there has been a marked increase in NCDs such as diabetes, hypertension, and cardiovascular conditions. According to the Indian Council of Medical Research (ICMR, 2020), approximately 77 million adults in India live with diabetes, and over 200 million are at high risk of developing it. The World Health Organization (WHO, 2022) further notes that NCDs now account for 63% of all deaths in India, with cardiovascular diseases alone responsible for 27%, followed by chronic respiratory diseases (11%) and diabetes (3%). This dual burden of malnutrition and lifestyle-related illnesses highlights the urgent need for nutrition-sensitive agricultural and food policies where millets can play a vital role due to their high nutritional value and preventive health benefits. These alarming trends reflect a dual burden of disease, under nutrition among the poor and diet-related lifestyle diseases among the affluent. The increasing consumption of ultra-processed foods, sedentary behavior, and reduced intake of whole grains and fiber-rich foods are major contributing factors (Misra et al., 2011).

This health transition has driven growing demand for functional foods—those that provide health benefits beyond basic nutrition. Millets, with their high fiber, mineral content, and low glycemic index, are being revisited as potential solutions to this complex health crisis (Ruchi et al., 2014). "Functional foods" are those that offer health benefits beyond basic nutrition due to the presence of bioactive compounds. With rising lifestyle-related health issues particularly in urban India there is renewed attention on diet and nutrition. While malnutrition remains prevalent among low-income groups, the affluent are increasingly affected by lifestyle diseases due to the overconsumption of processed foods (Misra et al., 2011).

In this context, millets, especially small and minor varieties are gaining recognition for their nutraceutical value. These grains are rich in phyto chemicals with antioxidant, immunomodulatory, and detoxifying effects, which can help prevent chronic conditions such as cardiovascular disease, diabetes, cancer, and obesity (Rao et al., 2011).

The decline in millet consumption over recent decades is largely due to policy shifts that favoured fine cereals like rice and wheat, combined with increasing incomes and urbanization across Asia. Consequently, millets were increasingly relegated to uses such as animal feed and alcohol production (Rao & Basavaraj, 2015). According to the World Health Statistics (2018), non-communicable diseases (NCDs) accounted for 71% of global deaths in 2016 with cardiovascular diseases contributing 44%, cancers 22%, respiratory diseases 9%, and diabetes 4% (World Health Organization, 2018). A key driver of this trend is the growing consumption of refined cereals, which has replaced the more diverse and wholesome grains like millet (Misra et al., 2011; Ruchi et al., 2014; Gayathri et al., 2016)

Reintegrating millets into modern diets can significantly contribute to restoring dietary diversity and addressing the growing burden of lifestyle-related diseases. However, the importance of millets extends beyond nutrition; they play a critical role in achieving economic resilience, environmental conservation, and sustainable agricultural development. Economically, millet cultivation supports the livelihoods of millions of small and marginal farmers, especially in rainfed and resource-constrained regions. With lower input costs and minimal dependence on chemical fertilizers and irrigation, millets offer higher net returns and reduced risk exposure, thereby enhancing farmer income security. Environmentally, millets are well-suited to dryland ecosystems due to their low water requirement, resistance to pests, and ability to grow on poor soils. Their deep-root systems improve soil structure, reduce erosion, and enhance moisture retention. From a sustainability perspective, millet farming contributes to climate-resilient agriculture by reducing greenhouse gas emissions, conserving biodiversity, and supporting crop diversification. Thus, promoting millet cultivation is not only essential for food and nutritional security but also for fostering a farming system that is ecologically sound, economically viable, and socially inclusive.

REVIEW OF LITERATURE

A growing body of literature emphasizes the potential of millets to contribute meaningfully to sustainable agriculture and nutritional security, especially in resource-constrained environments.

Rao and Basavaraj (2015) highlight how policy shift during the Green Revolution marginalized millet production, despite its inherent advantages in low-input and dryland conditions. Their work stresses the need to reintegrate millets into mainstream farming systems to restore crop diversity and address environmental concerns such as groundwater depletion and soil degradation.

From an environmental sustainability perspective, millets require 70–80% less water than rice and thrive without chemical fertilizers and pesticides (ICAR, 2021). Their deep root systems improve soil structure, enhance water retention and prevent erosion, qualities essential for sustainable land management in arid and semi-arid zones.

Economically, Gayathri et al., (2016) reported that millet cultivation is less input-intensive and more resilient to climate variability, making it well-suited for smallholder farmers. Unlike high-input crops such as paddy and wheat, millets require minimal irrigation, fewer chemical fertilizers, and reduced pest control measures, thereby lowering the overall cost of cultivation. This makes millets an economically viable option for resource-poor farmers, particularly in arid and semi-arid regions.

Low Input Requirements: Millets grow well in poor soils with minimal agronomic support. Their ability to thrive without excessive dependence on fertilizers, pesticides, or irrigation systems significantly reduces production costs. This makes millet farming more accessible and sustainable for marginal and smallholder farmers who often lack access to capital and infrastructure.

Climate Resilience: Millets are drought-tolerant and heat-resistant, enabling them to survive and yield reasonably well under erratic rainfall patterns and rising temperatures. This trait is particularly critical in the face of climate change, which has made traditional agriculture riskier and more unpredictable. Millets act as risk-buffer crops, offering farmers a dependable source of income even in adverse climatic conditions.

Higher Net Returns in Rainfed Areas: Empirical studies show that, in rainfed and dryland regions, millets often outperform water-intensive crops like rice or sugarcane in terms of net profitability. While the gross yields may be lower, the significantly reduced cost of inputs and resilience to crop failure translate to higher and more stable net returns. This economic advantage enhances rural income stability, particularly in regions where crop losses due to water scarcity are common.

Promotes Inclusive Agricultural Development: Since a large proportion of India's farmers are smallholders with limited resources, promoting millet cultivation can contribute to inclusive and equitable agricultural growth. By ensuring better returns with lower risks, millets can uplift rural livelihoods and reduce agrarian distress, especially in ecologically vulnerable regions. Ruchi et al., (2014) highlight that, from a nutritional perspective, millets offer a superior profile compared to refined cereals. Millets are dense in essential nutrients that contribute to better health outcomes, particularly in the context of both under nutrition and the rising burden of non-communicable diseases (NCDs) such as diabetes and cardiovascular conditions.

High Dietary Fiber: Millets are an excellent source of both soluble and insoluble dietary fiber, which aids in digestion, improves bowel regularity, and promotes satiety. This helps in weight management and prevents overeating. Fiber also plays a crucial role in regulating blood sugar levels and lowering cholesterol, reducing the risk of heart disease.

Rich in Calcium and Iron: Unlike refined cereals that lose a significant portion of their mineral content during processing, millets retain high levels of calcium and iron—essential for bone development, muscle function, and preventing anemia. This makes millets especially important in addressing micronutrient deficiencies prevalent in rural and low-income populations.

Essential Amino Acids: Millets contain vital essential amino acids, which are the building blocks of proteins that the human body cannot synthesize on its own. These amino acids support muscle repair, enzyme activity, and overall metabolic function. In populations with limited access to animal protein, millets serve as a crucial plant-based source of quality protein.

Low Glycemic Index (GI): Millets have a low glycemic index, meaning they release glucose into the bloodstream slowly. This helps prevent sharp spikes in blood sugar levels, making them highly suitable for people with diabetes or at risk of developing it. Foods with a low GI also help maintain energy levels and reduce the risk of insulin resistance.

Rao et al., (2011) emphasize that millets are not only valuable as staple grains but also possess significant nutraceutical properties, meaning they offer health benefits beyond basic nutrition. Among these, two key attributes stand out:

Antioxidant Properties: Millets are rich in phenolic compounds, flavonoids, and other bioactive molecules that help neutralize harmful free radicals in the body. These antioxidants protect cells from oxidative stress, which is linked to chronic conditions such as cancer, cardiovascular diseases, and premature aging. Regular consumption of millets can thus enhance cellular health and slow down degenerative processes.

Immunomodulatory Benefits: The bioactive compounds found in millets can also modulate immune responses, either by stimulating or suppressing certain immune functions. This immunomodulatory effect helps in strengthening the body's defense mechanisms, making it more resilient against infections and diseases. It may also play a role in managing inflammatory conditions and autoimmune disorders.

Despite these advantages, literature also identifies barriers such as poor consumer awareness, lack of procurement infrastructure, and weak value chains (Rao & Basavaraj, 2015). These gaps underline the need for coordinated policy efforts to scale up millet adoption.

OBJECTIVES

1. To evaluate the agronomic benefits of millets in sustainable farming systems
2. To assess the nutritional superiority of millets compared to rice and wheat
3. To examine the economic implications of millet cultivation for smallholder farmers
4. To analyse the policy framework and institutional support for millets in India

METHODOLOGY

This research adopts a qualitative approach, relying primarily on the analysis of secondary data. The study draws upon an extensive review of existing literature, policy briefs, and scientific reports issued by respected national and international institutions. Key data related to the nutritional and agronomic characteristics of millets were obtained from the Indian Council of Agricultural Research (ICAR), the National Institute of Nutrition (NIN), the Ministry of Agriculture and Farmers Welfare, and the Food and Agriculture Organization (FAO).

Descriptive statistics and comparative tables were developed to evaluate the differences in nutritional composition and water usage between millet, rice, and wheat. These comparisons serve to emphasize the environmental and health-related benefits of millet when contrasted with more commonly consumed cereals.

Policy analysis was conducted by reviewing relevant government initiatives, including the National Food Security Mission (NFSM), the International Year of Millets 2023 reports, and millet promotion programs implemented at the state level, especially in Karnataka. Scholarly articles, government reports, and developmental publications were referenced to provide a comprehensive context and support the study's conclusions.

An interdisciplinary framework was adopted, integrating insights from environmental science, agricultural economics, and nutrition science. This approach enabled a holistic assessment of the role of millets within sustainable food systems. The results of the study are presented across four thematic dimensions: agronomic, nutritional, economic, and policy.

RESULTS

Agronomic Importance and Environmental Sustainability

- **Adaptability and Climate Resilience:** Millets demonstrate remarkable adaptability to arid and semi-arid climates, requiring approximately 70–80% less water than rice. They thrive in nutrient-poor soils with minimal reliance on synthetic fertilizers and chemical pesticides. Their short maturation period ranging from 70 to 100 days allows for

multiple cropping cycles and reduces exposure to climatic uncertainties, thereby millet farming results in significantly lower greenhouse gas emissions. (ICAR, 2021).

- **Soil Health and Biodiversity:** The deep-rooted structure of millet plants contributes significantly to soil health by reducing erosion, enhancing moisture retention, and improving soil structure. Additionally, millet cultivation fosters agro-biodiversity. Various millet types-such as finger millet, pearl millet, and foxtail millet can be grown together or intercropped with legumes, leading to reduced pest infestation and a decreased dependency on chemical inputs.
- **Lower Carbon Footprint:** Unlike rice cultivation, which is water-intensive and a known emitter of methane due to flooded field conditions, millets are cultivated under dryland systems that emit significantly fewer greenhouse gases. Their minimal input requirements and compatibility with organic practices make millet farming a more environmentally sustainable and climate-smart agricultural strategy. Studies by the Indian Council of Agricultural Research (ICAR, 2021) and the FAO (2021) have confirmed that millet-based cropping systems have a lower environmental footprint compared to rice and wheat due to reduced irrigation, minimal methane emissions, and lower fertilizer dependency.

Economic Benefits for Smallholder Farmers

- **Low Investment with High Resilience:** Millet cultivation is characterized by low input costs and minimal dependence on irrigation infrastructure, making it an economically viable option for small and marginal farmers. These crops are particularly suited to low-resource farming systems, and their yield stability even under adverse climatic conditions contributes to food and income security for rural households. According to a cost-benefit analysis by Rao and Basavaraj (2015), millet production requires 30–40% lower input costs than rice and wheat and yields 20–25% higher net returns per hectare in rainfed areas. The average cost of cultivation per hectare for finger millet is Rs 15,000–Rs 18,000, compared to Rs 25,000–Rs 30,000 for paddy. This economic advantage is particularly significant in semi-arid and resource-constrained zones.
- **Opportunities for Value Addition and Market Expansion:** With the rise in consumer demand for healthy and organic food products, millets are gaining prominence in urban markets. According to a report by the Ministry of Agriculture (2023), the Indian millet-based processed food market is valued at over ₹4,500 crore, with an annual growth rate of approximately 17%. Cities like Bengaluru, Hyderabad, and Delhi have seen a surge in millet-focused start-ups and retail products. Notable examples include:

  - "Slurrp Farm" and "Millet Amma" offering millet-based cookies, dosas,and noodles.
  - Bengaluru's Ragi Café, which features millet-based menus that cater to health-conscious urban consumers.
  - E-commerce platforms like Amazon and Big Basket now offer over 300 millet-branded products ranging from breakfast cereals to energy bars.

  This trend has opened new avenues for Agro-processing industries, including the production of ready-to-eat snacks, millet-based bakery items, and nutritional beverages. Such developments create potential for rural entrepreneurship and strengthen Farmer Producer Organizations (FPOs), thereby enhancing livelihoods and promoting inclusive rural development.

Nutritional Superiority and Public Health

Millets are nutritionally dense grains that offer significant health advantages, especially when compared to widely consumed cereals like rice and wheat. They are particularly beneficial in addressing both macronutrient and micronutrient deficiencies.

- **Protein:** Millets provide a moderate level of protein, which is essential for tissue repair, muscle maintenance, and immune system function.
- **Dietary Fiber:** Their high fiber content improves digestive health, aids in bowel regulation, and helps maintain healthy cholesterol levels.
- **Iron and Calcium:** Millets are a rich source of iron and calcium, critical nutrients for preventing anemia and maintaining bone density, particularly among women and children.
- **Low Glycemic Index (GI):** Due to their low GI, millets are ideal for people managing diabetes or at risk of metabolic disorders, as they help regulate blood sugar levels and reduce insulin spikes. Millets thus serve not only as a sustainable agricultural option but also as a functional food that supports public health, especially in combating non-communicable diseases (NCDs).

Table 1: Comparative Nutritional Values of Millets, Rice and Wheat (Per 100g)

Nutrient	Millets (average)	Rice (white)	Wheat (whole)
Energy (kcal)	320	130	340
Protein (g)	10.49	2.7	13.2
Fiber (g)	8.5	0.4	12.2
Calcium (mg)	344	10	34
Iron (mg)	6.3	0.2	3.9
Glycemic Index	50	72	54

Source: Indian Council of Agricultural Research [ICAR], 2021; National Institute of Nutrition [NIN], 2020

Interpretation and Analysis

The data in Table 1 clearly illustrate the nutritional advantages of millet over rice and wheat. Millets surpass rice in all key nutritional parameters and closely compete with wheat in terms of protein and fiber content. Notably: Calcium and Iron: Millets provide significantly higher levels of calcium and iron compared to both rice and wheat, making them essential for bone strength and anaemia prevention.

Protein and Fiber: While wheat has slightly higher protein and fiber levels than millet, the values for millet are still considerably superior to those in rice. This makes millets beneficial for muscle repair and digestive health.

Glycemic Index: Millets have the lowest glycemic index among the three, making them ideal for individuals managing diabetes or seeking better glycemic control. Overall, the nutritional profile of millets positions them as a wholesome, nutrient-dense grain that supports both sustainable agriculture and improved public health.

Water Use Analysis: Water scarcity remains a pressing challenge in Indian agriculture, especially in semi-arid and rainfed regions. Millets, due to their low water requirements, offer a promising solution to this crisis.

Table 2: Water Requirement of Millets Compared to Rice and Wheat (liters per kg)

Crop	Water Requirement (liters/kg)
Millets	1,200
Rice	3,000
Wheat	1,500

Source: Ministry of Agriculture and Farmers Welfare, 2022

- **Millets: Water-Efficient Grains:** Millets require just 1,200 liters of water to produce one kilogram of grain, approximately 60% less than rice and 20% less than wheat. Their deep root systems enhance soil moisture retention, making them well-suited for rainfed farming systems.
- **Rice: Water-Intensive and Unsustainable:** Rice demands the highest amount of water, around 3,000 liters per kg and is typically cultivated in flooded fields. This leads to severe groundwater depletion and the emission of methane, a potent greenhouse gas. Such practices are increasingly unsustainable, particularly in water-scarce states like Karnataka, Rajasthan, and Telangana.
- **Wheat: Moderately Water-Efficient:** Wheat requires about 1,500 liters per kg less than rice but more than millets. It is commonly grown during the Rabi season, a period that often necessitates extensive irrigation, increasing both energy usage and input costs.

IMPLICATIONS FOR SUSTAINABLE AGRICULTURE

Given that over 50% of India's agricultural land is rainfed and groundwater levels are declining, promoting millet cultivation could significantly alleviate water stress. Their low water footprint makes them ideal for environmentally responsible farming. Furthermore, integrating millets into government food programs such as the Public Distribution System (PDS) and school midday meal schemes can reduce the ecological cost of food production while addressing nutritional deficiencies.

POLICY LANDSCAPE AND INSTITUTIONAL SUPPORT

Government Initiatives

National Year of Millets – 2018: The Government of India declared 2018 as the "National Year of Millets" to promote awareness about the agronomic, nutritious, and ecological benefits of millets. This initiative also facilitated increased research funding and programmatic focus on millet development. It led to:

- Increased R&D funding through ICAR for developing high-yielding and climate-resilient varieties.
- Launch of millet-focused Farmer Producer Organizations (FPOs) in arid zones such as Karnataka, Rajasthan, and Telangana.
- Inclusion of millets in the National Food Security Mission (NFSM) to promote their cultivation in rainfed areas.

International Year of Millets – 2023: In recognition of millets' global importance, the Food and Agriculture Organization (FAO) and the United Nations (UN) declared 2023 as the International Year of Millets. This global platform further emphasized millet's role in sustainable agriculture and food security.

- India organized over 1,000 millet-themed events globally.
- A 25% increase in millet exports (USD 76 million in 2023 vs USD 60 million in 2022 - APEDA).
- National-level branding campaigns like "Shree Anna" to position India as a millet hub.

Integration into Public Food Programs: Several Indian states like Karnataka, Odisha, and Tamil Nadu have started integrating millets into public food programs such as the Public Distribution System (PDS) and school midday meal schemes, enhancing both dietary diversity and rural livelihoods.

- Karnataka's "Shree Anna Yojana", Odisha's "Millet Mission", and Tamil Nadu's Midday Meal Millet Inclusion Program introduced millet-based meals in over 5,000 schools and anganwadis.
- A study by IIM Bangalore (2023) found that children in millet-included programs saw a 20% improvement in iron intake and better attendance.

KEY CHALLENGES

Weak Procurement Infrastructure: Unlike rice and wheat, millets lack a robust procurement and support price mechanism, limiting incentives for farmers to shift or scale up production. Suggested Solution**:** Implement state-specific MSP policies for millets and create procurement centers in arid districts**.**

Low Consumer Awareness and Cultural Acceptance: Despite their health benefits, consumer awareness of millets remains limited, particularly in urban areas. Additionally, modern dietary habits often favor polished grains and processed foods, reducing millet's acceptance.
Suggested Solution**:** Nationwide campaigns via MyGov, FM Radio, and FSSAI with endorsements by nutritionists and influencers, National and International conference with millets fest can effectively create the awareness on millet

Underdeveloped Value Chain: The millet ecosystem suffers from a lack of infrastructure for storage, processing, value addition, and branding. This affects market accessibility and discourages private-sector investment.
Suggested Solution: Invest in cluster-based FPO models, subsidize processing units through NABARD, and partner with agri-tech firms.

RECOMMENDATIONS

To realize the full potential of millets in promoting sustainable agriculture and public health, the following strategic actions are recommended:

- Institutionalize millets in all major food security schemes (PDS, ICDS, Midday Meals) with fixed procurement quotas.
- Announce MSP for major millet varieties and ensure state-level procurement bodies implement decentralized purchase.
- Promote millet start-ups and rural enterprises with interest-free loans and grants for millet processing units.

- Incentivize states through millet cultivation targets and link with climate-resilient agriculture subsidies.
- Launch digital millet market platforms to support farmer-direct urban delivery.
- Include millets in national nutrition education curriculums, food labels, and FSSAI dietary guidelines.
- Organize international and regional millet expos, trade fairs, and millet gastronomy festivals.

CONCLUSION

This study highlights the multi-dimensional importance of millets in addressing critical agricultural, nutritional, and environmental challenges in India. Through empirical comparisons using secondary data, it is evident that millets outperform conventional cereals like rice and wheat in water-use efficiency, climate adaptability, and nutritional density. The findings reveal that millet cultivation enhances farm income stability for small and marginal farmers due to its low input requirements and suitability for dryland conditions. Nutritionally, millets offer superior levels of essential micronutrients, making them vital for combating anaemia, under nutrition, and rising lifestyle diseases. Environmentally, millet farming contributes to sustainable practices by reducing dependency on irrigation, chemical fertilizers, and pesticides. The paper also finds that policy gaps in procurement systems, lack of consumer awareness, and underdeveloped value chains continue to limit millet integration into mainstream markets. Therefore, it recommends targeted interventions such as improved Minimum Support Prices (MSPs), inclusion in public food programs, awareness campaigns, and infrastructure development to promote millet production and consumption. These strategies can collectively pave the way for resilient food systems and inclusive rural development, making millets central to India's pursuit of sustainable agriculture and public health goals.

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