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Millets for Sustainable Food Security: A Review of Global Production, Promotion, and Poverty Alleviation

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Abstract

Millets—nutrient-dense, climate-resilient cereals—are increasingly recognized as critical to addressing hunger and poverty in semi-arid regions of Asia and Africa (Borah.et al.,2026). This review synthesizes secondary data (2012–2025) from FAO, USDA, APEDA, PIB, and Lok Sabha reports analyzing production trends, policy interventions, nutritional benefits, and alignment with Sustainable Development Goals (SDGs 1 and 2) (Maity, 2025). India, contributing ~38% of global output, produced 180.15 lakh tonnes in 2024–25, with Rajasthan leading at 27% (FAO, 2023; USDA Foreign Agricultural Service, 2025; Lok Sabha Secretariat, 2025). Despite strong policy pushes such as the National Food Security Mission, Odisha Millet Mission, and the International Year of Millets (IYoM-2023), processing and marketing gaps persist (NITI Aayog, 2023; PIB, 2025). Nutritionally, millets surpass rice and wheat in protein, fibre, calcium, and iron, making them critical for combating micronutrient deficiencies and non-communicable diseases (Dayakar et al., 2020; Rotela et al., 2021). The study recommends strengthening Farmer Producer Organizations (FPOs), investing in processing infrastructure, and expanding millet integration into food security programs. Future research should focus on yield

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improvement, consumer awareness, and climate resilience modeling to scale millet adoption globally (Yadav et al., 2024).

Keywords: *Millets; Food Security; Sustainable Development Goals; Climate Resilience; Farmer Producer Organizations; Poverty Alleviation; Nutrition*

1. Introduction

Millet is a diverse group of small-seeded grasses classified as cereal crops, cultivated for thousands of years as staple food for humans and fodder for animals, particularly in the semi-arid tropics of Asia and Africa. Unlike rice and wheat, millets thrive in less favourable soils, require minimal water and inputs, and tolerate drought and erratic rainfall. Historically, they formed the backbone of subsistence farming systems in regions marked by climatic variability and resource scarcity (Nagaraja et al., 2024). Today, millets are being rediscovered as "smart foods" that combine nutritional richness with ecological sustainability, offering solutions to pressing challenges of food insecurity, poverty, and climate change (Yadav et al., 2024).

Historical Context

Archaeological evidence suggests millet cultivation dates back over 7,000 years, with artifacts found across Africa and Asia (Clemens et al., 2023). In India, millets were once staple crops, especially in rain-fed regions where rice and wheat cultivation was unreliable. However, the *Green Revolution* of the 1960s and 1970s shifted agricultural priorities toward high-yielding rice and wheat, supported by irrigation and subsidies. This transition reduced millet acreage from 35 million hectares in the 1950s to less than 12 million hectares today (ICRISAT, 2024). Despite this decline, renewed interest in millets has emerged due to their nutritional and ecological advantages, particularly in the context of climate change and food insecurity.

Nutritional Superiority

Millets are nutritionally superior to many conventional cereals. Finger millet (ragi) contains 344 mg of calcium per 100 g, surpassing milk in bone health benefits (Dayakar Rao et al., 2016). Pearl millet (bajra) is rich in iron, vital for populations vulnerable to anaemia (Rotela et al., 2021). Foxtail millet provides methionine, an essential amino acid often lacking in vegetarian diets (Rathore et al., 2016). Beyond micronutrients, millets are high in dietary fiber, antioxidants, and B-vitamins, reducing risks of diabetes, cardiovascular disease, and obesity (Nithiyanantham et al., 2019). Their low glycaemic index (50–70) makes them particularly relevant in India, where diabetes affects over 100 million people (IDF, 2021). Thus, millets are not merely subsistence crops but functional foods with significant public health implications.

Climate Resilience and Sustainability

Millets also offer ecological benefits. They require far less water than rice, tolerate poor soils, and have short growing cycles (60–90 days), making them ideal for smallholders in rain-fed regions (Aggarwal et al., 2024). Their carbon footprint is lower than rice, which emits methane during cultivation (Coulibaly et al., 2019)**.** Millets serve dual purposes as food and fodder, enhancing farm resilience. In an era of climate change, where erratic monsoons and rising temperatures threaten food security, millets provide a sustainable alternative aligned with global calls for climate-smart agriculture).

Policy Revival

India has spearheaded efforts to revive millet cultivation. The United Nations declared 2023 as the International Year of Millets (IYoM), championed by India and supported by 72 countries (FAO, 2023). Domestically, initiatives such as the National Food Security Mission (NFSM**)** on Nutri-Cereals, the Odisha Millet Mission (OMM), and the inclusion of millets in the Public Distribution System (PDS) have revitalized production and consumption (NITI Aayog, 2023). Fiscal backing, including the ₹800 crore PLI scheme for millet-based products and

the ₹2,03,000 crore PM-GKAY allocation, underscores India's commitment to mainstreaming millets in food security programs (PIB, 2025).

Research Gaps

Despite these advances, challenges remain. Processing infrastructure is inadequate, limiting the scalability of millet-based products (Latha, 2019). Consumer awareness is low, with millets often perceived as "poor man's food". Marketing and branding challenges hinder penetration into urban and global markets. Scientific validation of traditional uses and health claims is still evolving, requiring long-term studies (Yadav et al., 2024). Moreover, discrepancies in global definitions—FAO includes sorghum in millet aggregates, while USDA excludes it—complicate cross-country comparisons (USDA FAS, 2025). Addressing these gaps is essential to fully realize millets' potential in eradicating poverty and hunger.

Rationale for the Present Study

This review synthesizes production trends, policy measures, and nutritional data from 2012 to 2025, with a focus on India's leadership in global millet promotion. By integrating socioeconomic, environmental, and health perspectives, the study highlights millets' contributions to the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty) and SDG 2 (Zero Hunger). The findings aim to inform policymakers, researchers, and practitioners about pathways to scale millet adoption, strengthen value chains, and enhance food and nutrition security. In doing so, the study positions millets not only as crops of the past but as grains of the future.

2. Methodology

2.1 Research Design

This study adopts a review-based approach, synthesizing secondary data from authoritative sources to examine millet production, promotion, and their role in poverty and hunger alleviation. Given the global scope of

cultivation and diverse policy interventions, a review design is appropriate to capture both quantitative trends and qualitative insights. Triangulation of data from international organizations, government reports, and peer-reviewed literature ensures reliability and validity (Muskan et al., 2025).

2.2 Data Sources

The review draws upon:

- **FAO/FAOSTAT (2012–2025):** Global production, trade flows, and cross-country comparisons.
- **USDA FAS/IPAD:** Projections of millet output, excluding sorghum (USDA FAS, 2025).
- **APEDA:** Export volumes and values of India's millet trade (APEDA, 2023).
- **Lok Sabha/Rajya Sabha Annexures (2024–25):** State-wise and national production statistics (Lok Sabha Secretariat, 2025).
- **PIB Reports:** Fiscal allocations, policy initiatives, and outcome budgets (PIB, 2025).
- **NITI Aayog:** State-level missions such as the Odisha Millet Mission (NITI Aayog, 2023).
- **ICRISAT:** Nutritional data, child stunting prevention, and climate resilience modeling (ICRISAT, 2024).
- **Peer-reviewed literature (2016–2025):** Insights on nutrition, processing, and policy synergies (Rathore et al., 2016; Nithiyanantham et al., 2019; Rotela et al., 2021; Maity, 2025; Yadav et al., 2024).

2.3 Timeframe

The study covers **2012–2025**, chosen to:

1. Capture the pre-IYoM period (2012–2022).
2. Highlight the International Year of Millets (2023).
3. Extend to **2024–25** to assess India's production rebound and policy impacts.

2.4 Analytical Approach

- **Quantitative:**
    - Compound Annual Growth Rates (CAGR) for global and Indian production.
    - State-wise contributions to identify disparities.
    - Export volumes and values to gauge India's trade role.
- **Qualitative:**
    - Policy evaluation (NFSM, OMM, PLI schemes).
    - Compilation of nutritional studies.
    - Case studies from Odisha, Karnataka, and Rajasthan.

This mixed-methods design captures both numerical production trends and contextual policy/health impacts.

2.5 Limitations of Secondary Data

- **Data discrepancies:** FAO vs. USDA definitions (USDA FAS, 2025).
- **No primary surveys:** Limits insights into consumer adoption barriers.
- **Temporal gaps:** FAO datasets lag by 1–2 years.
- **Regional bias:** India has detailed data; African countries lack disaggregation.

Triangulation and cautious interpretation mitigate these constraints.

3. Nutritional and Health Benefits of Millets

Millets are recognized as **nutri-cereals** due to their dense nutritional profile and functional health properties. Unlike rice and wheat, they provide balanced macro- and micronutrients, making them vital in addressing both malnutrition and rising non-communicable diseases (Yadav et al., 2024).

3.1 Macronutrients

Rich in complex carbohydrates, resistant starch, fibre, and plant proteins, millets lower glycaemic index and improve metabolic health (Rotela et al., 2021). Foxtail millet is notable for methionine, complementing vegetarian diets, while combining millets with legumes enhances protein quality (Rathore et al., 2016; Dayakar et al., 2020).

3.2 Micronutrients

Finger millet provides high calcium (344 mg/100 g), supporting bone health, while pearl millet is rich in iron, combating anaemia (Dayakar et al., 2020; Nithiyanantham et al., 2019). Other varieties supply zinc, magnesium, phosphorus, and B-vitamins, aiding immunity and energy metabolism (Clemens et al., 2023).

3.3 Diabetes Management

With glycaemic indices between 50–70, millets are suitable for diabetes control. Clinical trials show millet diets reduce post-prandial glucose, improve insulin sensitivity, and lower HbA1C (Rotela et al., 2021; Yadav et al., 2024).

3.4 Cardiovascular Health

High fibre and antioxidants reduce cholesterol, oxidative stress, blood pressure, BMI, and triglycerides, lowering risks of hypertension and coronary disease (Nithiyanantham et al., 2019; Rotela et al., 2021).

3.5 Gluten-Free Properties

Naturally gluten-free, millets are safe for celiac patients and adaptable into flours, breads, noodles, and mixes, expanding their role in gluten-free diets (Rathore et al., 2016; Muskan et al., 2025).

3.6 Antioxidant Potential

Bioactive compounds (phenolics, flavonoids, lignans) combat oxidative stress and inflammation, with emerging evidence of protection against cancer, neurodegenerative diseases, and metabolic syndrome (Nithiyanantham et al., 2019; Maity, 2025).

3.7 Child Nutrition

ICRISAT (2024) estimates millet-based school feeding could prevent 24 million cases of wasting and 12 million stunting globally. Their cost-effectiveness supports inclusion in India's Mid-Day Meal scheme, aligning with SDG 2 (Zero Hunger).

3.8 Urban and Processed Foods

Millets are increasingly used in cereals, cookies, noodles, and mixes, with exports reaching $37 million in 2024–25 (APEDA, 2023).

Processing challenges remain, requiring technology to preserve nutrients (Latha, 2019).

3.9 Integrative Benefits

Beyond nutrition, millets aid detoxification, immunity, energy, and muscle health. Their dual role in preventing undernutrition and managing NCDs underscores their global relevance (Dayakar Rao et al., 2016)

4. Global Production Scenario

4.1 Global Trends

Millet production rose modestly from 88.3 MMT (2012) to 91.5 MMT (2025), reflecting a CAGR of just 0.3% (FAO, 2023). Despite ecological and nutritional advantages, millets remain underutilized compared to rice and wheat. The International Year of Millets (2023) renewed global interest, spurring supportive policies (FAO, 2023; USDA FAS, 2025).

4.2 Regional Distribution

Production is concentrated in Asia and Africa's semi-arid regions. India contributes ~38–40% of global output, Africa ~25–30% (Nigeria, Niger, Mali, Ethiopia), and China ~6% (Lok Sabha Secretariat, 2025; Nagaraja et al., 2024).

4.3 Top 10 Producers Globally (FY 2025-26 Estimates)

Based on FAO and USDA projections, the top ten millet-producing countries in 2025 are given in the table:

Table: 1. Worldwide Top 10 Millet Producers

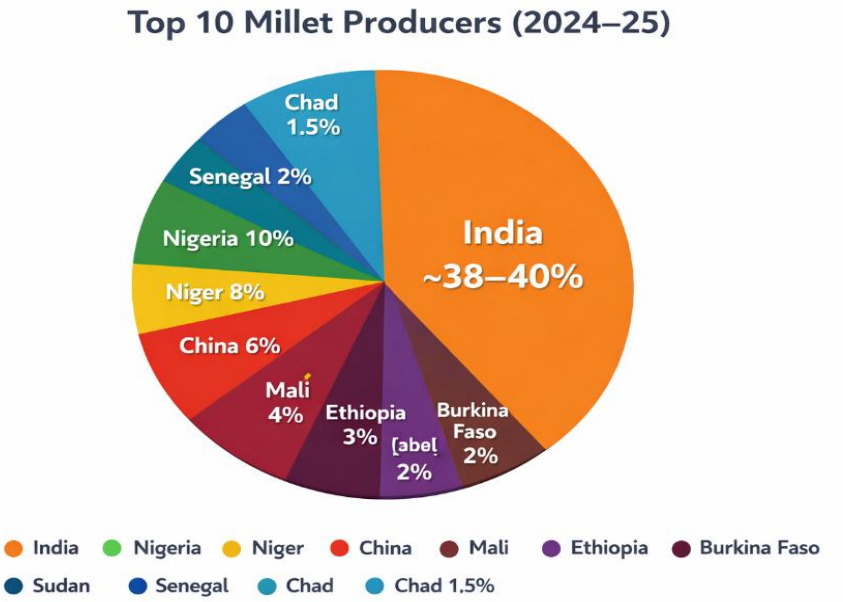
Country	Production in MMT	Percentage
India	18.02	~38–40%
Nigeria	4.8	~10%
Niger	3.5	~8%
China	2.75	~6%
Mali	1.85	~4%

Ethiopia	1.18	~3%
Burkina Faso	0.90	~2%
Sudan	0.75	~2%
Senegal	0.69	~2%
Chad	0.63	~1.5%

Source*: USDA Foreign Agricultural Service, 2025*

Summary: This table shows the top ten countries producing millet in the world in 2025, with India leading the way by producing 18.02 MMT, which represents almost 38-40% of the global production. Nigeria and Niger are next with 10% and 8% respectively, and the African Sahel region is important for supporting millet production. China is the only major Asian producer other than India, contributing about 6%. Smaller percentages, but still substantial, come from other African countries, including Mali, Ethiopia, Burkina Faso, Sudan, Senegal and Chad, which account for 1.5% to 4% of production. This data can also be seen through the figure 1 given herewith.

Figure 1: Percentage distribution of millets



Summary: Together, India, Nigeria and Niger account more than 50% and above-mentioned top 10 countries account for >75% of global output in which India is the top producer with 18.02% of total millet production. (FAO, 2023; USDA FAS, 2025).

4.4 Volatility

Climate shocks caused declines in 2023/24, with India's output down 10% and Niger's down 7%. Recovery in 2024/25 restored India's production to ~18 MMT, stabilizing global supply near 91 MMT (USDA FAS, 2025; Lok Sabha Secretariat, 2025).

4.5 Policy Responses – Africa

Nigeria and Niger expanded extension services and subsidies; Mali tested seed priming and micro-dosing; Ethiopia and Burkina Faso integrated millets into school feeding (Coulibaly et al., 2019; Clemens et al., 2023).

4.6 Policy Responses – Asia

India led with NFSM, OMM, and IYoM-2023 initiatives. China invested in foxtail millet research for urban health markets, while Nepal and

Bangladesh adopted millets in food security programs (Maity, 2025; Yadav et al., 2024).

4.7 Trade and Exports

Millet trade remains limited, but India exported 89,165 MT worth $37 million (2024–25) to markets like Saudi Arabia, UAE, and Nepal (APEDA, 2023). The global millet market, valued at $9 billion (2023), is projected to reach $12 billion by 2025, driven by health-conscious consumers (Muskan et al., 2025).

4.8 Comparative Advantage

Millets require **low water**, are **climate-resilient**, nutritionally superior, and serve dual roles as food and feed, making them ideal for smallholder farmers and sustainable agriculture (Aggarwal et al., 2024).

4.9 Challenges

Persistent barriers include:

- Perception as "poor man's food."
- Processing deficits and lack of modern milling.
- Limited branding and consumer awareness.
- Data discrepancies between FAO and USDA (Latha, 2019).

4.10 Future Outlook

Global production is projected to grow 1–2% annually, with India retaining dominance and Africa expanding through climate-smart practices and school feeding. Improved processing and branding could unlock greater urban and global demand (Yadav et al., 2024; FAO, 2023).

5. India's Production Trends

5.1 Historical Trajectory

The trajectory of millet cultivation in India reflects both resilience and marginalisation. In the 1950s, millets occupied nearly 35 million hectares, producing about 112.7 lakh tonnes annually (ICAR, 2024). By the 1980s, output rose to 200 lakh tonnes, aided by hybrid seeds and cultivation in semi-arid regions (APEDA, 2023). However, the Green Revolution shifted policy focus toward rice and wheat, supported by irrigation,

procurement, and subsidies. As a result, millet acreage declined sharply, falling to ~12 million hectares by 2025 (Lok Sabha Secretariat, 2025). Despite this contraction, yields improved through better varieties and agronomic practices, stabilizing production at ~180 lakh tones in recent years.

5.2 Impact of the Green Revolution

The Green Revolution's emphasis on rice and wheat marginalized millets. Procurement policies, minimum support prices (MSP), and the Public Distribution System (PDS) incentivized farmers to abandon traditional millet cultivation (Muskan et al., 2025). This shift reduced acreage and consumption, contributing to dietary homogenization and rising micronutrient deficiencies, particularly iron and calcium (Nithiyanantham et al., 2019). Moreover, reliance on water-intensive cereals weakened climate resilience, as rice and wheat are more vulnerable to drought and erratic rainfall compared to hardy millets.

5.3 Revival through Policy Interventions

Recognizing these challenges, India launched several initiatives to revive millet cultivation:

- **National Food Security Mission (NFSM, 2018–19):** Declared millets "nutri-cereals" and provided subsidies for seeds and inputs (PIB, 2025).
- **Odisha Millet Mission (OMM, 2017–18):** Built value chains, ensured MSP-linked procurement, and promoted consumption through school meals (NITI Aayog, 2023).
- **International Year of Millets (IYoM, 2023):** Championed by India at the UN, endorsed by 72 countries, raising global awareness (FAO, 2023).
- **Production Linked Incentive (PLI) Scheme (2022–27):** Allocated ₹800 crore to support millet-based processing industries (PIB, 2025).
- **PM-GKAY (2025–26):** Allocated ₹2,03,000 crore to integrate millets into the PDS (Lok Sabha Secretariat, 2025).

Together, these interventions stabilized production at ~180 lakh tones despite declining acreage, demonstrating the effectiveness of policy support.

5.4 State-wise Dynamics

India's state-wise millet production table for 2025–26 based on the available dataset preview. The dataset gives production in lakh tones and is sourced from the Ministry of Agriculture and Farmers Welfare via the Unified Portal for Agricultural Statistics.

Table: 2. State-wise Millet Production Dynamics

State	Total Millet Production (lakh tonnes)	Share in the Percentage
Rajasthan	52.61	40.11%
Uttar Pradesh	22.42	17.10%
Madhya Pradesh	13.13	10.01%
Gujarat	12.54	9.56%
Haryana	9.79	7.46%
Karnataka	9.38	7.15%
Maharashtra	4.95	3.78%
Andhra Pradesh	0.93	0.71%
Tamil Nadu	0.87	0.66%
Odisha	0.55	0.42%

Source: *Dataful- Ministry of Agriculture and Farmers Welfare*

The above table shows that there is a huge difference in the production of millets in various states of India, Rajasthan being the top performer with 52.61 lakh tonnes (about 40.11% of the total millet production in India). Uttar Pradesh and Madhya Pradesh are the next major producers with 17.10% and 10.01% respectively, reflecting the preponderance of the northern and central states in the production of millets.

The mid tier producers like Gujarat, Haryana and Karnataka have a mix of varieties of pearl and finger millet and contribute almost 25% of the country's production. Maharashtra, Andhra Pradesh, Tamil Nadu and Odisha, on the other hand, have smaller shares of less than 4%, but are keen on developing niche varieties and climate resilient millets.

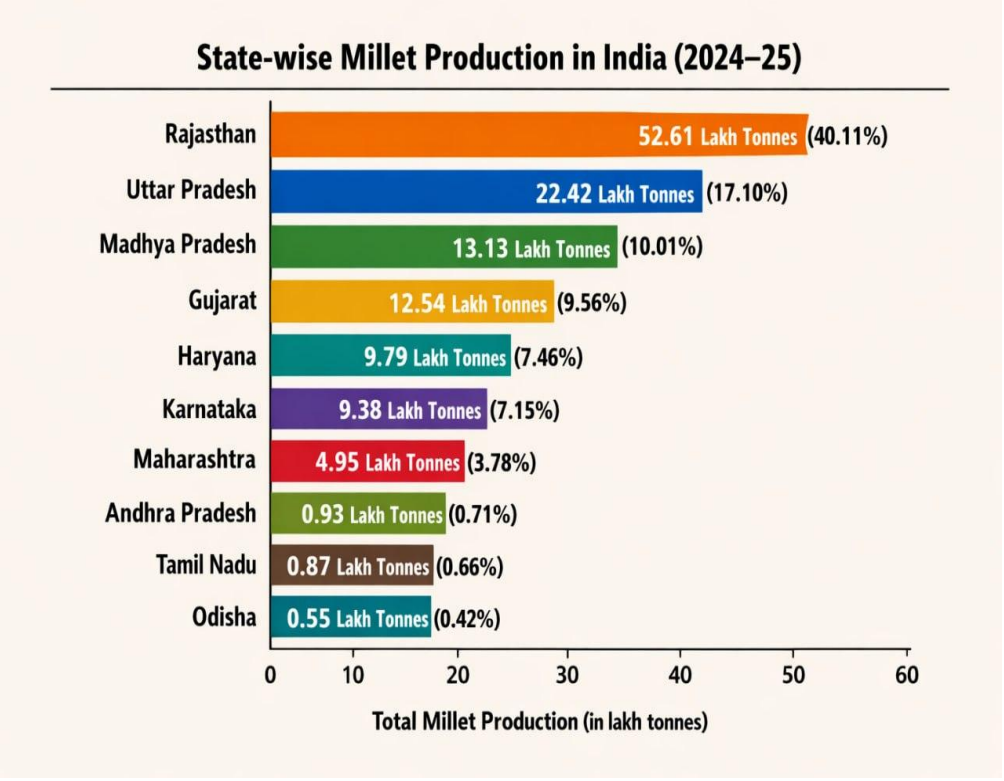


Figure 2: State wise millet production distribution

Summary: All India total millet production: 131.11 lakh tonnes. Together, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Haryana and Karnataka accounts for more than 90% of national production, reflecting agro-climatic suitability and regional specialization. Whereas, Andhra Pradesh, Tamil Nadu and Odisha has small number of millet production.

5.5 Role of Specific Millets

India's agro-ecological diversity supports multiple millet varieties:

- **Pearl millet (bajra):** Rajasthan, Haryana, Gujarat.
- **Finger millet (ragi):** Karnataka, Tamil Nadu.
- **Sorghum (jowar):** Maharashtra, Madhya Pradesh.
- **Small millets (foxtail, barnyard, kodo, little):** Odisha, Chhattisgarh, tribal belts. This diversity underscores cultural preferences and regional adaptation ((Maity, 2025)).

5.6 Acreage Decline vs Yield Stability

Although acreage fell from 35 to 12.2 million hectares, productivity gains from high-yielding varieties, seed priming, and integrated nutrient management-maintained output at ~180 lakh tonnes (ICRISAT, 2024). This demonstrates that yield improvements can offset area reductions, though further gains are needed to meet rising demand.

5.7 Export Potential

India has emerged as a leading exporter, shipping **89,165 MT worth $37 million (2024–25)** to markets such as Saudi Arabia, UAE, and Nepal (APEDA, 2023). Globally, the millet market was valued at **$9 billion in 2023** and is projected to reach **$12 billion by 2025** (Muskan et al., 2025). India's potential is significant, but processing gaps and weak branding limit growth, necessitating investment in value chains.

5.8 Challenges

Despite progress, challenges persist:

- **Processing infrastructure:** Outdated milling and refining technologies.
- **Consumer perception:** Millets still viewed as "poor man's food."
- **Market access:** Weak branding and limited urban penetration.
- **Climate variability:** Production remains vulnerable to monsoon fluctuations (Latha, 2019).

5.9 Future Outlook

India's millet production is projected to grow at **1–2% annually**, supported by policy interventions and rising consumer demand. Rajasthan will remain dominant, but states like Odisha and Chhattisgarh are expected to expand through missions and farmer producer organizations (FPOs). Integration into school meals, PDS, and urban health markets will be crucial for sustaining growth. With improved processing and branding, India can consolidate its role as both a domestic leader and a global exporter (Yadav et al., 2024).

6. Government Promotion Strategies

6.1 National-Level Initiatives

India has emerged as a global leader in millet promotion through a series of national programs. The National Food Security Mission (NFSM, 2018–19) declared millets as "nutri-cereals," recognizing their nutritional and ecological benefits. Subsidies for seeds, inputs, and mechanization, alongside extension services, aimed to expand acreage and productivity while integrating millets into food security schemes (PIB, 2025).

The Rashtriya Krishi Vikas Yojana (RKVY-RAFTAAR) facilitated the creation of Farmer Producer Organizations (FPOs), enabling collective procurement, marketing, and digital MSP payments. These strengthened bargaining power and shortened farm-to-market distances (NITI Aayog, 2023).

A turning point came with the International Year of Millets (IYoM-2023), led by India at the UN and endorsed by 72 countries. The campaign elevated global awareness, branding, and investment in millet products (FAO, 2023). India leveraged this momentum to integrate millets into the Public Distribution System (PDS), ensuring affordable access for 80 crore beneficiaries under the NFSA-2013.

6.2 Fiscal Allocations

Fiscal support has been substantial. The Production Linked Incentive (PLI) Scheme, 2022–27 earmarked ₹800 crores for millet-based

processing industries, including decorticators, flour mills, and fortified food units (PIB, 2025). The Pradhan Mantri Garib Kalyan Anna Yojana (PM-GKAY, 2025–26) allocated ₹2,03,000 crores to integrate millets into nutrition programs for the underprivileged (Lok Sabha Secretariat, 2025). These allocations highlight the government's commitment to mainstreaming millets across rural and urban food systems.

6.3 State-Level Missions

Several states pioneered localized missions tailored to agro-climatic conditions. The Odisha Millet Mission (OMM, 2017–18) revived cultivation, built value chains, and promoted consumption through school meals, engaging over 100,000 households and generating a surplus of 23,500 MT (NITI Aayog, 2023). Karnataka integrated jowar and ragi into the PDS in 2015, setting a precedent for other states (Rathore et al., 2016). Rajasthan, contributing ~27% of national pearl millet output, benefited from NFSM subsidies (Lok Sabha Secretariat, 2025). In rain-fed regions, small millets were promoted for their short cycles and dual food-fodder utility (Nagaraja et al., 2024).

6.4 Role of Farmer Producer Organizations (FPOs)

FPOs remain central to millet promotion. By aggregating smallholders, they reduce transaction costs, enhance bargaining power, and enable digital MSP payments. In Odisha, FPOs shortened farm-to-fork distances, boosting farmer incomes and consumer access (NITI Aayog, 2023). Expanding FPO networks nationwide is vital for scaling millet value chains.

6.5 Integration into Food Security Programs

Millets have been incorporated into multiple food security schemes:

- **PDS:** Affordable household access.
- **Mid-Day Meal Scheme:** Tackling child malnutrition via school meals.
- **ICDS:** Nutritional support for women and children.

These align with **SDG 2 (Zero Hunger)**, strengthening nutrition security for vulnerable groups (ICRISAT, 2024).

6.6 Branding and Export Promotion

India has emphasized branding through the Shree Anna campaign, positioning millets as "superfoods" for health-conscious consumers (Muskan et al., 2025). Exports reached $37 million in 2024–25, with major markets in Saudi Arabia, UAE, and Nepal (APEDA, 2023). Yet perceptions of millets as "poor man's food" persist, requiring sustained marketing to expand global demand.

6.7 Challenges

Key challenges include limited processing infrastructure, low consumer awareness, weak branding, and vulnerability to climate variability. Addressing these requires coordinated efforts across research, policy, and market development (Latha, 2019).

6.8 Future Directions

Future strategies should focus on scaling FPO-led value chains, investing in processing facilities, expanding millet use in school feeding and PDS, strengthening consumer awareness campaigns, and improving export branding. These measures will consolidate India's leadership in millet promotion while advancing sustainable agriculture and food security (Yadav et al., 2024).

7. Millets and Sustainable Development Goals (SDGs)

7.1 Linking Millets to Global Development Agendas

The United Nations Sustainable Development Goals (SDGs) provide a framework for addressing poverty, hunger, sustainability, and equity. Millets, as nutrient-dense and climate-smart crops, directly support SDG 1 (No Poverty) and SDG 2 (Zero Hunger**)**, while also contributing to environmental sustainability, gender equality, and public health. Their role extends beyond food security to encompass economic empowerment, ecological resilience, and inclusive development (Yadav et al., 2024).

7.2 Millets and SDG 1: No Poverty

Millets are low-input crops requiring minimal water, fertilizers, and pesticides, making them ideal for smallholders with limited resources. Their short growth cycles (60–90 days) allow multiple harvests annually, ensuring income stability in arid and semi-arid regions (Katare, 2018; Nagaraja et al., 2024).

Case studies highlight their poverty-alleviation potential. The **Odisha Millet Mission (OMM)** engaged over 100,000 households, ensuring MSP-linked procurement and digital payments, thereby improving farmer incomes (NITI Aayog, 2023). In Africa, subsidies and extension services in Niger and Nigeria strengthened rural livelihoods (Coulibaly et al., 2019). Beyond income, millets reduce healthcare costs by lowering the incidence of non-communicable diseases (NCDs) such as diabetes and cardiovascular disease, improving quality of life for economically disadvantaged communities (Rotela et al., 2021). Thus, millets contribute to both economic and health dimensions of poverty reduction.

7.3 Millets and SDG 2: Zero Hunger

Millets are rich in proteins, fiber, calcium, iron, and zinc, making them effective in combating micronutrient deficiencies prevalent among low-income groups (Dayakar Rao et al., 2016) Their integration into food systems enhances dietary diversity and resilience against climate shocks. Key contributions include:

- **School Feeding Programs:** ICRISAT (2024) estimates millet inclusion could prevent 24 million cases of stunting and 12 million cases of wasting globally.
- **Public Distribution System (PDS):** India's incorporation of millets benefits 80 crore consumers at affordable prices (PIB, 2025).
- **State Initiatives:** Karnataka and Odisha adopted millets in school meals, improving child nutrition (Rathore et al., 2016).

Millets' drought tolerance and soil resilience make them crucial for food security in vulnerable regions such as sub-Saharan Africa and South Asia,

aligning with SDG 2's emphasis on sustainable agriculture (Aggarwal et al., 2024).

7.4 Environmental Sustainability

Millets contribute to **SDG 13 (Climate Action)** and **SDG 15 (Life on Land)** by conserving water, reducing emissions, and restoring degraded soils. Unlike rice, which emits methane during cultivation, millets have a lower carbon footprint (Muskan et al., 2025). Their role in biodiversity enhances ecological resilience and supports sustainable land use (Maity, 2025).

7.5 Gender and Social Inclusion

Millet promotion also advances **SDG 5 (Gender Equality)**. Women, especially in tribal and marginalized communities, play a central role in millet cultivation and processing. Through training, capacity building, and participation in FPOs, initiatives like OMM have empowered women farmers, strengthening their economic and social standing (NITI Aayog, 2023).

7.6 Global Recognition

India's leadership in advocating for the **International Year of Millets (IYoM-2023)** at the UN highlighted their global relevance. The campaign increased awareness, branding, and policy support, catalyzing investments in millet-based products and value chains worldwide (FAO, 2023). This recognition positions millets as key contributors to sustainable food systems and SDG achievement.

7.7 Challenges in Achieving SDG Outcomes

Despite their potential, challenges remain:

- **Consumer Awareness:** Persistent perception of millets as "poor man's food."
- **Processing Infrastructure:** Limited modern milling and refining facilities.

- **Market Access:** Weak branding and low penetration in urban/global markets.
- **Policy Gaps:** Inconsistent support across states and countries (Latha, 2019).

Addressing these barriers is essential to fully leverage millets' contribution to SDGs.

7.8 Future Directions

Future strategies should prioritize:

- Expanding millet use in school feeding and PDS.
- Investing in processing facilities and value chains.
- Rebranding millets as "superfoods" to attract urban consumers.
- Strengthening international partnerships to scale global uptake.

Such measures will not only advance SDG 1 and SDG 2, but also reinforce broader goals of sustainability, gender equality, and climate resilience (Yadav et al., 2024).

8. Key Findings

8.1 India's Dominance in Global Millet Production

India remains the global leader in millet production, contributing nearly 38–40% of total output. In 2024–25, production reached 180.15 lakh tones, a 4.43 lakh tone increase from the previous year (Lok Sabha Secretariat, 2025). Rajasthan alone accounted for ~27% of national output, underscoring its role as the millet hub (APEDA, 2023). This dominance reflects India's diverse agro-climatic zones and strong policy support, positioning the country as both a producer and exporter.

8.2 Policy Interventions Driving Revival

Government initiatives such as the NFSM, Odisha Millet Mission (OMM), and the International Year of Millets (IYoM-2023) have revitalized cultivation. Fiscal allocations, including ₹800 crores under the PLI scheme and ₹2,03,000 crore under PM-GKAY, demonstrate strong political commitment (PIB, 2025). These interventions stabilized

production despite declining acreage, highlighting the effectiveness of policy-driven revival (NITI Aayog, 2023).

8.3 Nutritional and Health Benefits

Millets' nutritional superiority is well established. Finger millet (ragi) provides 344 mg calcium per 100 g, pearl millet (bajra) is rich in iron, and foxtail millet offers methionine (Dayakar et al., 2020; Rathore et al., 2016). Their low glycaemic index (50–70) makes them suitable for diabetes management (Rotela et al., 2021), while fibre and antioxidants reduce cardiovascular risks (Nithiyanantham et al., 2019). These attributes position millets as functional foods capable of addressing undernutrition and NCDs.

8.4 Climate Resilience and Sustainability

Millets thrive in marginal soils, require minimal water, and have short growing cycles, making them ideal for climate-vulnerable regions (Aggarwal et al., 2024). Their carbon footprint is lower than rice, contributing to climate mitigation (Muskan et al., 2025). Their dual role as food and fodder enhances farm resilience, aligning with global calls for climate-smart agriculture.

8.5 Integration into Food Security Programs

India has integrated millets into the PDS, Mid-Day Meal Scheme, and ICDS, ensuring affordable access for millions and addressing child malnutrition and micronutrient deficiencies (ICRISAT, 2024). This demonstrates their potential to advance SDG 2 (Zero Hunger).

8.6 Export Potential and Market Challenges

India exported 89,165 MT worth $37 million in 2024–25, with major markets in Saudi Arabia, UAE, and Nepal (APEDA, 2023). The global millet market, valued at $9 billion in 2023, is projected to reach $12 billion by 2025 (Muskan et al., 2025)). However, weak branding, processing deficits, and consumer perceptions limit export growth.

8.7 Persistent Challenges

Despite progress, challenges persist: limited modern processing infrastructure, low consumer awareness, weak market access, and

vulnerability to climate variability. Addressing these barriers is essential to fully realize millets' potential in eradicating poverty and hunger (Latha, 2019).

9. Study Limitations

9.1 Reliance on Secondary Data

A key limitation of this study is its reliance on secondary sources such as FAO, USDA, APEDA, PIB, and Lok Sabha reports. While authoritative, these datasets are aggregated and may not capture micro-level variations in production, consumption, or farmer perceptions. Differences in compilation methods—for example, FAO versus USDA—lead to discrepancies in global totals (FAO, 2023; USDA FAS, 2025). Without primary surveys, local realities such as household consumption patterns or adoption barriers remain underexplored.

9.2 Data Discrepancies and Definitions

Definitions of millets vary across institutions. FAO includes sorghum in some aggregates, whereas USDA excludes it, producing divergent estimates (USDA FAS, 2025). In India, state-level figures often differ between Lok Sabha annexures and Ministry of Agriculture report due to reporting methodologies (Lok Sabha Secretariat, 2025). Such inconsistencies complicate comparative analysis and obscure production trends.

9.3 Lack of Consumer Perception Studies

The absence of primary consumer research limits understanding of adoption barriers. Millets are often perceived as "poor man's food," restricting urban acceptance (Muskan et al., 2025). Without surveys or focus groups, consumer attitudes, willingness to pay, and branding challenges cannot be fully assessed, narrowing the scope for targeted marketing strategies.

9.4 Limited Longitudinal Health Studies

Although nutritional benefits are well documented, evidence on long-term health impacts is scarce. Most studies are short-term clinical trials

or epidemiological analyses (Rotela et al., 2021; Nithiyanantham et al., 2019). Longitudinal research is needed to validate claims regarding prevention of chronic diseases such as diabetes, cardiovascular conditions, and neurodegenerative disorders.

9.5 Regional Bias in Data Availability

Data availability is skewed toward India, which dominates global production and has robust reporting systems. In contrast, African countries such as Niger, Nigeria, and Mali often lack disaggregated statistics, limiting comprehensive regional analysis (Coulibaly et al., 2019). This bias risks overemphasizing India's role while underrepresenting Africa's contribution.

9.6 Temporal Gaps

FAO and USDA datasets often lag by one to two years, requiring reliance on projections for recent periods (FAO, 2023). This introduces uncertainty, particularly during climate shocks or policy changes. For example, the 2023/24 drought-related decline was reported differently across sources, complicating interpretation (USDA FAS, 2025).

9.7 Scope of the Review

Finally, the review focuses primarily on production, promotion, and nutritional benefits. While critical, dimensions such as trade policies, international cooperation, and consumer behavior in developed countries were not examined in depth. A broader scope would provide a more holistic understanding of millets' role in global food systems.

10. Discussion

10.1 Synthesis of Literature

Recent scholarship consistently emphasizes the nutritional and ecological importance of millets. Rathore et al. (2016) documented processing innovations that made millet-based porridges and staples competitive with rice and wheat, while Nithiyanantham et al. (2019) highlighted their antioxidant properties. Rotela et al. (2021) linked millet consumption to reduced risks of diabetes and cardiovascular disease, and

Yadav et al. (2024) estimated that millet inclusion in school meals could prevent millions of cases of child stunting. Collectively, these studies underscore millets' dual role as functional foods and climate-smart crops.

Nonetheless, gaps remain. Latha (2019) identified persistent challenges in processing, marketing, and consumer awareness, while (Muskan et al., 2025) noted commercialization difficulties in rural–urban markets. Srikanth (2023) examined India–China policy synergies but stressed infrastructural bottlenecks. Thus, while nutritional and ecological benefits are well established, systemic interventions in value chains, consumer education, and policy harmonization are essential for scaling millet adoption.

10.2 Policy Effectiveness

India's millet revival demonstrates the impact of targeted policy interventions. Despite declining acreage, production stabilized at ~180 lakh tones due to subsidies under NFSM, value chain development through OMM, and global awareness generated by IYoM-2023 (Lok Sabha Secretariat, 2025). Fiscal commitments, including allocations under PM-GKAY and the PLI scheme, reflect strong political will (PIB, 2025).

Effectiveness, however, varies regionally. Rajasthan's success in pearl millet stems from agro-climatic suitability, while Odisha's achievements highlight the value of localized missions (NITI Aayog, 2023). Karnataka's integration of millets into the PDS is a notable innovation, but other states lag behind. This unevenness suggests the need for differentiated, context-specific approaches.

10.3 Nutritional and Health Implications

Millets' nutritional superiority positions them as vital tools against undernutrition and NCDs. Finger millet's calcium, pearl millet's iron, and foxtail millet's methionine address micronutrient deficiencies (Dayakar et al., 2020; Rathore et al., 2016). Their low glycemic index supports diabetes management, while fiber and antioxidants reduce cardiovascular risks (Rotela et al., 2021; Nithiyanantham et al., 2019). Integrating millets into

school meals and PDS can simultaneously combat malnutrition and NCDs, advancing SDG 2 (Zero Hunger).

Yet, most evidence derives from short-term trials. Longitudinal studies are needed to confirm long-term health impacts and strengthen policy recommendations (Rotela et al., 2021). Future research should prioritize dietary interventions and chronic disease prevention.

10.4 Climate Resilience and Sustainability

Millets thrive in drought-prone, degraded soils and withstand erratic rainfall, making them suitable for climate-sensitive regions (Aggarwal et al., 2024). Their short growth cycles and low carbon footprint, compared to methane-emitting rice, enhance sustainability (Muskan et al., 2025). These attributes align with SDG 13 (Climate Action) and SDG 15 (Life on Land).

Nonetheless, production remains vulnerable to climate extremes. The 2023/24 drought in India and the Sahel highlighted the need for resilient agronomic practices such as seed priming and micro-dosing (Coulibaly et al., 2019). Scaling these innovations is critical for stabilizing production.

10.5 Market and Export Potential

India's exports, valued at $37 million in 2024–25, reflect rising global demand (APEDA, 2023). The global millet market, projected to reach $12 billion by 2025, offers significant opportunities (Muskan et al., 2025). Urban health trends and sustainability narratives position millets as "superfoods."

However, challenges persist. Processing deficits limit scalability, while weak branding and entrenched perceptions of millets as "poor man's food" hinder urban and premium market adoption (Latha, 2019). Addressing these requires investment in infrastructure, branding campaigns, and consumer education.

10.6 Gender and Social Inclusion

Millet promotion also advances SDG 5 (Gender Equality). Women, particularly in tribal and marginalized communities, play central roles in cultivation and processing. Programs like OMM have empowered women

through training and FPO membership, enhancing both economic and social outcomes (NITI Aayog, 2023). Strengthening women's participation in value chains can further drive inclusive development.

10.7 Future Research Directions

Future studies should focus on:

- Long-term health impacts of millet diets.
- Consumer perception surveys on attitudes, willingness to pay, and branding.
- Climate resilience modeling under extreme scenarios.
- Value chain analysis to identify bottlenecks in processing and marketing.
- Gender studies on women's roles in millet promotion and household nutrition.

These directions will expand the evidence base and inform more robust policy interventions.

10.8 Global Implications

India's leadership in millet promotion offers a model for other millet-dependent nations. African countries can adapt India's strategies in policy support, value chain development, and consumer awareness. International partnerships through FAO and ICRISAT can scale millet adoption globally, advancing SDGs 1 and 2. The recognition of millets during IYoM-2023 underscores their transformative potential for sustainable food systems worldwide (FAO, 2023).

11. Conclusion

11.1 Summary of Findings

This review demonstrates that millets hold unique potential to address the twin challenges of poverty and hunger while contributing to climate resilience and public health. India, producing nearly 40% of global output, has emerged as the leader in millet promotion through strong policy

frameworks such as NFSM, OMM, and IYoM-2023. Nutritionally, millets are rich in protein, fibre, calcium, and iron, making them critical for combating micronutrient deficiencies and non-communicable diseases (Dayakar et al., 2020; Rotela et al., 2021). Their minimal input requirements and short production cycles align with sustainable agriculture goals (Aggarwal et al., 2024).

11.2 Policy Implications

India's policy interventions provide a blueprint for other millet-producing nations. NFSM subsidies, OMM's value chain development, and fiscal allocations under PM-GKAY and PLI schemes have stabilized production despite declining acreage (PIB, 2025; NITI Aayog, 2023). Integrating millets into the PDS and school feeding programs has improved nutrition security, advancing SDG 2 (Zero Hunger). A three-pronged approach—fiscal support, institutional frameworks, and consumer awareness campaigns—is essential for mainstreaming millets globally.

11.3 Recommendations

Key recommendations include:

- **Strengthen FPOs:** Aggregate smallholders for collective procurement and better market access (NITI Aayog, 2023).
- **Invest in Processing Infrastructure:** Modernize milling, refining, and packaging facilities (Latha, 2019).
- **Expand Food Security Integration:** Scale millet inclusion in PDS, Mid-Day Meal, and ICDS programs (ICRISAT, 2024).
- **Consumer Awareness Campaigns:** Rebrand millets as "superfoods" to overcome negative perceptions (Muskan et al., 2025).
- **Enhance Export Branding:** Position India as a global supplier of millet products (APEDA, 2023).
- **Climate Resilience Practices:** Scale agronomic innovations such as seed priming and micro-dosing (Coulibaly et al., 2019).

- **Empower Women Farmers:** Expand training and participation in value chains, aligning with gender equality goals (NITI Aayog, 2023).

11.4 Future Directions and Global Significance

Future research should focus on long-term health studies, consumer perception surveys, climate resilience modeling, and gender-focused value chain analysis. International collaborations through FAO and ICRISAT can harmonize policies and scale millet adoption globally (FAO, 2023). The declaration of 2023 as the International Year of Millets underscored their global significance. India's leadership offers a model for African nations, which rely heavily on millets for food security.

11.5 Concluding Remarks

Millets are not relics of the past but grains of the future. Their nutritional richness, climate resilience, and socio-economic value make them indispensable for sustainable development. India's experience shows how policies, investments, and awareness campaigns can transform food systems, empower smallholders, and improve public health. As the world confronts climate change, malnutrition, and rising NCDs, millets provide a sustainable, inclusive, and resilient pathway forward.

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