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Comprehensive Analysis of Millets in India: Area, Production, Cost of Production and Export Statistics

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Abstract

Millets, recognized for their nutritional richness and adaptability to diverse environmental conditions, have regained global attention due to their sustainable agricultural practices and nutritional benefits. This paper explores the historical significance, global and Indian production trends, cost dynamics, export patterns, and governmental initiatives driving millet cultivation in India. By analyzing statistical data and research findings, the study underscores millets' potential to enhance food security, mitigate environmental impact, and foster socio-economic development.

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Trend Analysis, etc.

Introduction

Millets are a diverse group of small-grained cereals known for their nutritional benefits and ability to grow in challenging conditions. These grains, often referred to as "nutritional powerhouses," are particularly well-suited for marginal or low-fertility soils. The term "millet" is believed to derive from the French word "mille," meaning "thousand," highlighting the large number of seeds found in even a small quantity.[1] Millets can be broadly classified into two main categories: Major Millets and Minor Millets. Major Millets include Sorghum (*Sorghum bicolor* (L.)) and Pearl millet (*Pennisetum glaucum* (L.)), while Minor Millets encompass Kodo millet (*Paspalum scrobiculatum* (L.)), Finger millet (*Eleusine coracana* (L.) Gaertn.), Barnyard millet (*Echinochloa* spp.), Foxtail millet (*Setaria italica* (L.) Beauv.), Proso millet (*Panicum miliaceum* (L.)), and Little millet (*Panicum sumatrense* Roth ex. Roem. and Schult.).

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The majority of millets are planted during the kharif season, typically from May to June, and reach maturity between September and October. These crops often yield well during the rabi season, spanning from October to March, as well as the summer season from January to April.[2]

Millets, one of the oldest staples in human history, faced reduced importance and cultivation due to the widespread shift towards growing rice and wheat driven by urbanization and industrialization. Nevertheless, in modern times, millets have resurfaced as essential crops with substantial agricultural and nutritional significance on a global level. The nutritional values of various millets, as reported[2] are presented in Table 1.

Table 1: Nutritional Composition of Millets

Millet	Carbo-hydrates (g)	Protein (g)	Fat (g)	Dietary fibre (g)	Ca (mg)	P (mg)	Mg (mg)	Zn (mg)	Fe (mg)
Sorghum	67.7	9.9	1.73	10.2	27.6	274	133	1.9	3.9
Pearl Millet	61.8	10.9	5.43	11.5	27.4	289	124	2.7	6.4
Finger Millet	66.8	7.2	1.92	11.2	36.4	210	146	2.5	4.6

The durability and nutritional advantages of millets have propelled them into the spotlight as essential grains for both human consumption and animal feed. Millet production in India has experienced a significant increase in recent years. This growth can be attributed to several factors, including a growing consumer preference for millets and government initiatives aimed at promoting their consumption as a nutritious dietary choice. This article attempts to present a statistical analysis of millet cultivation in India, highlighting its capacity to contribute to sustainable agriculture, nutritional security, and socio-economic advancement.

Methodology

The study employs a comprehensive methodological approach to assess the area, production, cost dynamics, and export patterns of millet cultivation in India. Data collection relied on secondary sources, including FAOSTAT, government publications, and reports from the Indian Institute of Millet Research (IIMR), covering the period from 1961 to 2023, with particular focus on post-Green Revolution shifts. Quantitative data such as production volumes, cultivation area, yield per hectare, and export figures were compiled, with additional cost data from 2017-2018 to 2022-2023 to analyze financial trends. Descriptive statistical techniques were used for trend analysis, including line graphs and pie charts to visualize changes over time and comparative analysis to highlight India's position globally. Seasonal patterns of millet cultivation were examined across kharif, rabi, and summer seasons to capture annual production influences. Cost of production analysis involved evaluating both variable and fixed input costs, focusing on A2+FL metrics and cost trends over recent years, identifying inflation and input price fluctuations as key contributors. A comparative assessment was conducted to determine cost changes across major millet types (Jowar, Bajra, and Ragi). Export data from 2003 to 2020 was analyzed to identify patterns and major international markets, visualized using bar charts and line graphs. The policy evaluation component assessed government initiatives promoting millet cultivation, including the International Year of Millets 2023 and related subsidies and incentives, using policy literature and program reports to gauge their impact on cultivation trends and production output. This integrated approach, combining statistical analysis, historical comparisons, and policy evaluation, provides a thorough understanding of millet cultivation's current status and future potential in India.

Trend of Millets in the World and in India

The World Scenario

Millets have a long history of use as staple grains and for brewing in regions such as Asia, Africa, and Europe. Africa and Asia [figure 1], in particular, play a dominant role in global millet production.[3]

Millets, including pearl millet and other minor varieties, are cultivated in 93 countries around the world, where they hold significant importance in global agriculture. Production statistics for pearl millet and these other minor millets are recorded across these 93 countries.[4]

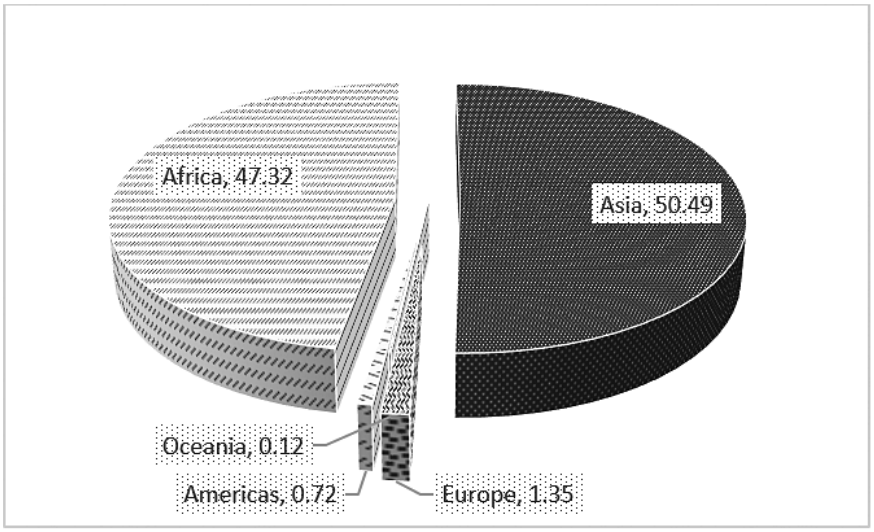

Fig. 1: Country wise distribution of millets in World (FAOSTAT 2022)

Proso millet, one of the earliest grains consumed by humans, is thought to have been domesticated in both Asia and Africa during the Neolithic period, approximately 7,000 years ago. From there, it spread globally and became a staple food in many cultures.[2] Sorghum (*Sorghum bicolor* (L.) Moench) emerges as the most extensively cultivated crop, covering an area of 42.1 million hectares across 105 countries. Sorghum ranks as the fifth-largest cereal crop worldwide, serving as a staple food for populations in various parts of the world, particularly in developing regions of Africa and South Asia.[5] In a 2015 study, Parthasarathy and Basavaraj[6] explored the global status and potential of millet utilization, emphasizing the importance of sorghum and millets as key cereals for food and nutrition security in developing countries. Collectively, these grains account for 10% of Asia's coarse grain production.

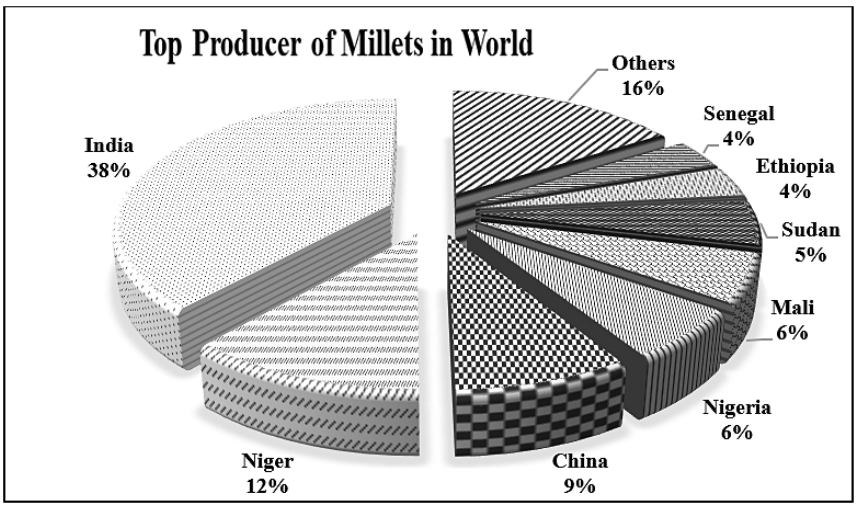

Fig 2: (a) Top producer of millets in world (%) (FAOSTAT, 2022)

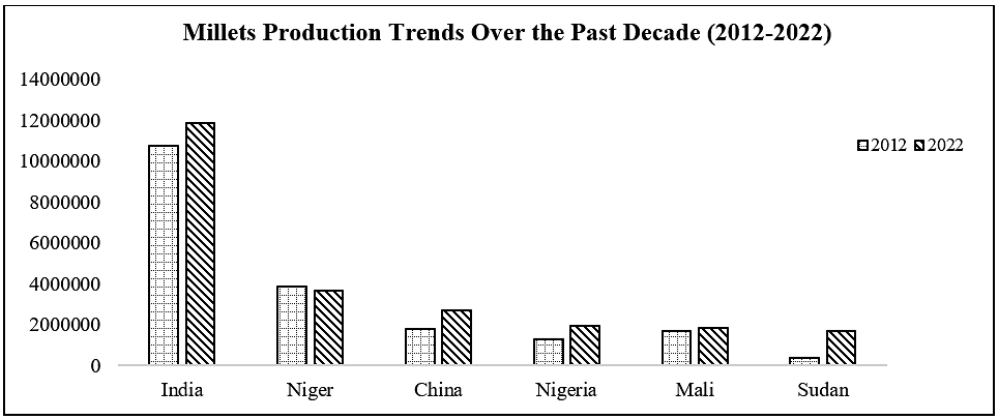

Fig 2: (b) Millets production trends over the past decade (FAOSTAT, 2022)

India leads in millet cultivation, followed by Niger, China, Nigeria, and Mali (Fig 2). While Niger witnessed a decline in millet production from 2012 to 2022, India, China, Nigeria, Mali, and Sudan experienced an upward trend. However, in terms of productivity (100g/ha), the top three countries globally are Azerbaijan (154,816), Mexico (151,000), and Turkey (33,914), with India's productivity at 13,960 (100g/ha).[7]

The list of top ten countries in terms of area under millet includes India, Niger, Sudan, Mali, Nigeria, Chad, Senegal, China, Burkina Faso, and Ethiopia. Based on estimates, the global area dedicated to millet cultivation experienced a decrease of 31.2% between 1961 and 2022, as indicated in FAOSTAT 2023 data (Fig 3). In Asia, there is a significant reduction in cultivated area (148%).[8] This decline could be attributed to limited concentrated efforts in crop improvement, a shift toward more lucrative cash crops, inadequate government policies, and reduced farm profitability. Over the past decades, the consistent decrease in the worldwide cultivated area allocated to millets has categorized them as minor or underutilized grains.

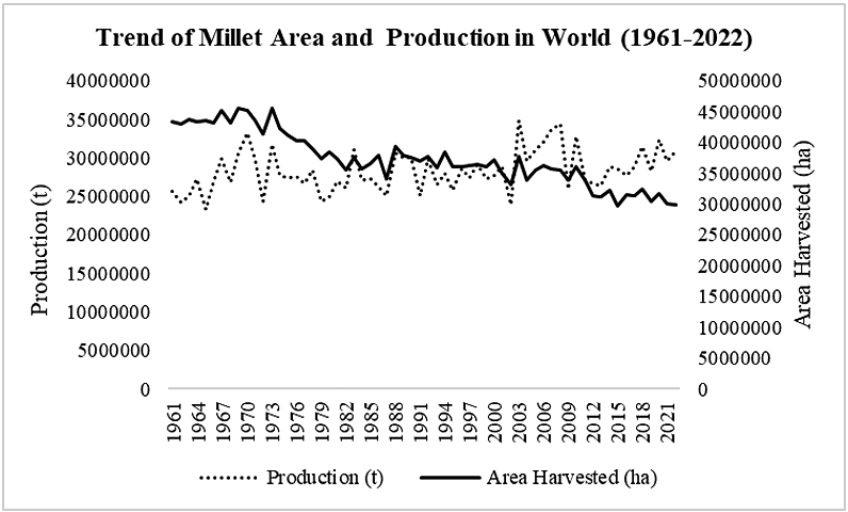

Fig 3: World Scenario of Millets Cultivation

The Indian Scenario

Millets have been integral to Indian cuisine and diets since ancient times. Proso millet was introduced to India at an early stage and quickly became widely cultivated across the country. Referred to as Cheenaka, Kakakangu, Kangu, and aNu in Sanskrit,

archaeological evidence of proso millet cultivation dates back to the first half of the second millennium BC, with crop remains discovered in Gujarat. Ancient Indian texts, such as the Yajurveda, mention various types of millets, including foxtail millet (Priyangava), barnyard millet (Aanava), and black finger millet (Shyaamaka). This suggests that these grains were commonly consumed in India even before the Indian Bronze Age. India leads in millet production, followed by Niger and China. While millets are major food crops in developed countries, they hold significant dietary importance in many developing nations. In 2022, millet cultivation in India covered a total area of 8,488,150 hectares, resulting in a production of 11,849,190 tonnes.[9] India also ranks among the top five millet exporters worldwide. In recent years, millet production in India has seen a consistent upward trend. Indian farmers are increasingly choosing millet as a drought-resistant crop. Additionally, the Indian government has been actively promoting millet production as part of its National Food Security Mission. Consequently, it is anticipated that millet production in India will continue to expand in the foreseeable future.

The primary millets cultivated in India include pearl millet (bajra), sorghum (jowar), finger millet (ragi), foxtail millet, and little millet (Fig 4). Across the country, numerous millet sourcing points are strategically positioned. The primary millet-producing states in India are Rajasthan, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, and Telangana (Fig 5). Together, these ten states account for roughly 98% of India's total millet production. The accompanying pie chart illustrates the millet production distribution across different Indian states for the year 2023-24, using the second advance estimates. Rajasthan leads significantly, contributing 32% of the total production, likely due to its favourable climatic conditions and extensive cultivation area dedicated to millets. Uttar Pradesh follows with 18%. Other notable contributors include Maharashtra and Karnataka, each accounting for 11% of the production, while the remaining states contribute smaller shares.

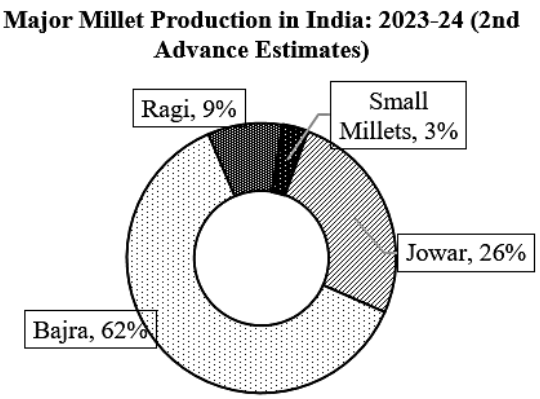

Fig: 4 Major millets production in India (APEDA[9])

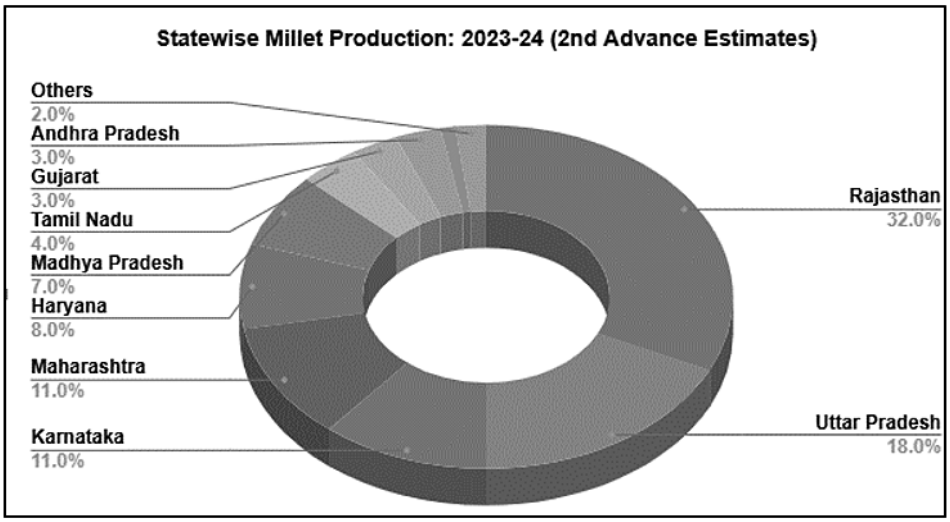

Fig 5: State wise millets production in India

The following pie charts under Fig 6 depicts the major producing states of the India contributing to the production of the three major millets and the minor millets. Maharashtra is the leading producer of Jowar in India contributing 34.8% of the total production in 2023-24 followed by Karnataka, Rajasthan, Uttar Pradesh and Andhra Pradesh

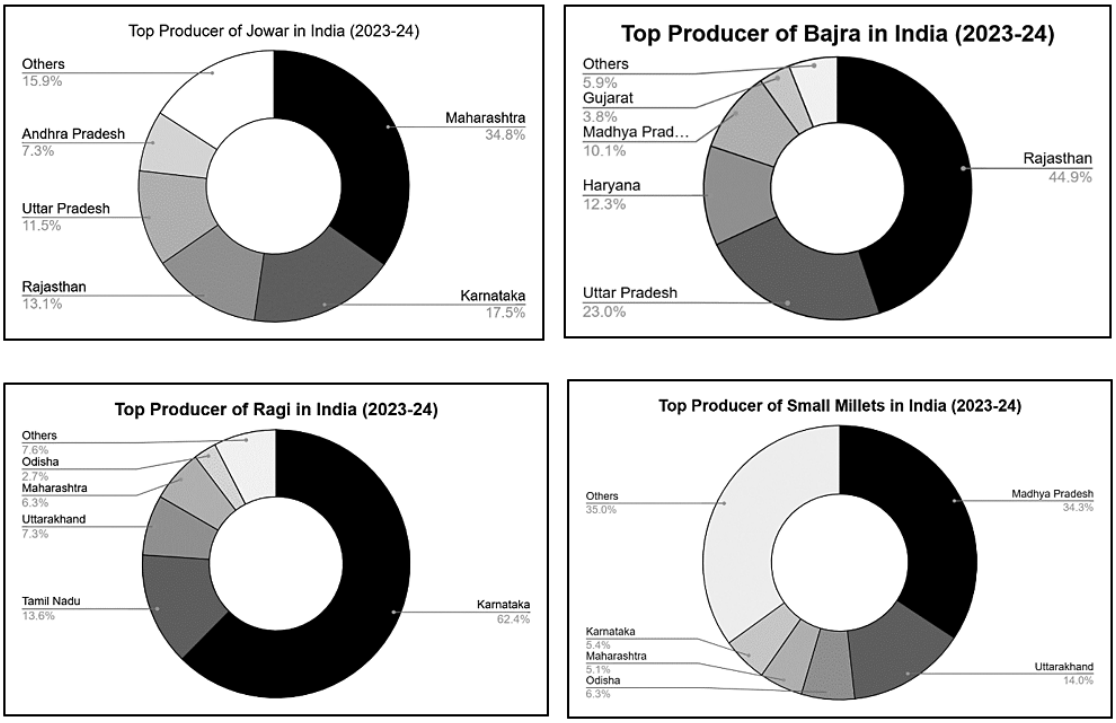

Fig 6: Top Producer of Millets in India (2023-24)

Rajasthan is the leading producer of Bajra in India contributing 44.9% of the total production in 2023-24 followed by Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat. Karnataka is the leading producer of Ragi in India contributing 62.4% of the total production in 2023-24 followed by Tamil Nadu, Uttarakhand, Maharashtra and Odisha. For Minor Millets, Madhya Pradesh and Uttarakhand contributes 34.26% and 13.98% of the total production in 2023-24 respectively. The area planted with small millets is decreasing yearly, and this trend needs to be stopped by involving all stakeholders. Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Chhattisgarh, and Gujarat etc. has experienced the area decline. The area is being diverted to more profitable crops like cotton, maize, soybean and rice. Improving productivity is the key to enhance competitive ability in the marginal agro-ecologies together with enhancing demand, especially among the urban elite for arresting the further decline. In addition to policy initiatives that demand immediate attention, some crop improvement and management strategies for sustaining small millets cultivation.[10]

The line graph depicted in Figure 7 shows the trend in the area under millets, production of millets and its productivity taken in a quinquennial interval pre and post green revolution period in India. It is visible that there has been a significant reduction in the area under millet crops and its production because of the expansion in area under prime cereal crops like rice and wheat and conversion of area under millet cultivation to that of rice and wheat. However, there has been a significant increase in productivity which can be attribute to better cultivation practices, improved plant nutrients and development of high yielding varieties. The same can be depicted in the Figures under 8 for the three major millets viz. Jowar (*Sorghum bicolor*), Bajra (*Pennisetum glaucum*) and Ragi (*Eleusine coracana*).

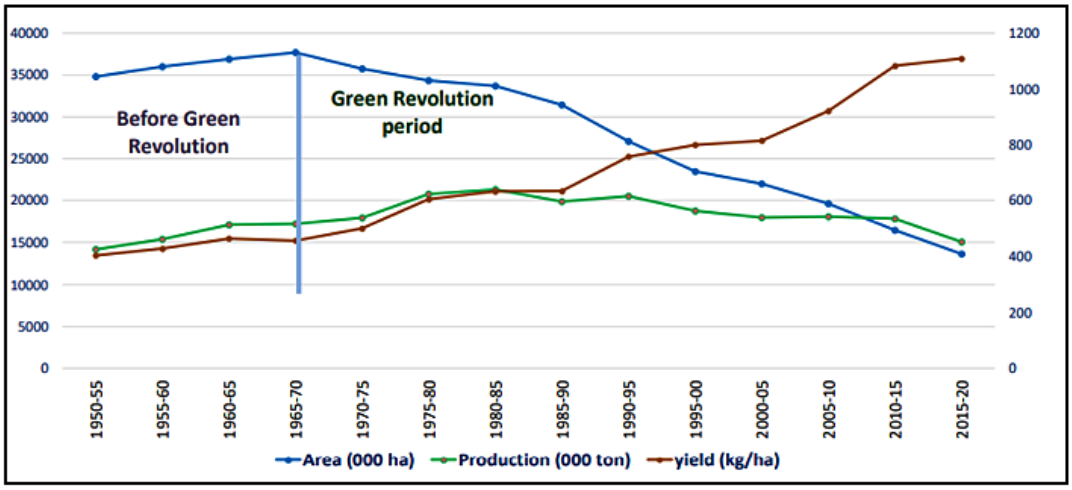

Fig 7: Quinquennial mean, area, production & yield of Millets in India

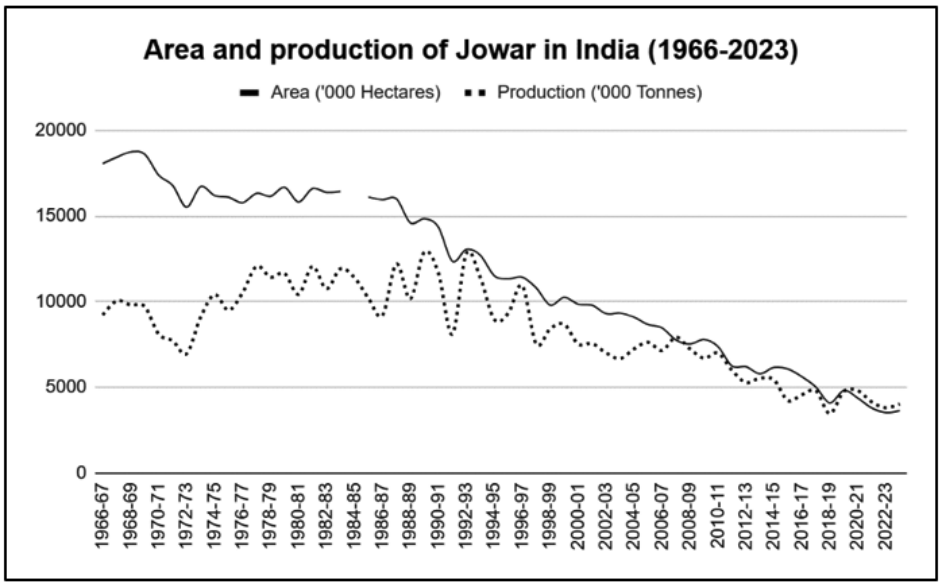

Fig 7.1: Trend in area and production of Jowar in India

Figure 7.1 illustrates a consistent decline in both the area under cultivation and the production of Jowar in India from 1966 to 2023. The area decreased from around 18,000 to below 5,000 thousand hectares, while production dropped from approximately 12,000 to around 3,400 thousand tonnes. This decline can be attributed to factors such as shifts to more profitable crops, changes in dietary patterns, and possibly adverse climatic conditions.

The figure 7.2 shows the trends in the area and production of Bajra in India from 1966 to 2023. The area under cultivation fluctuated but generally remained between 6,000 to 9,000 thousand hectares after 1995-96, while production varied more significantly, with peaks around 2003-2005 and 2010-2011. These fluctuations can be due to variable rainfall patterns, changing agricultural practices, and policy interventions affecting crop yield and area.

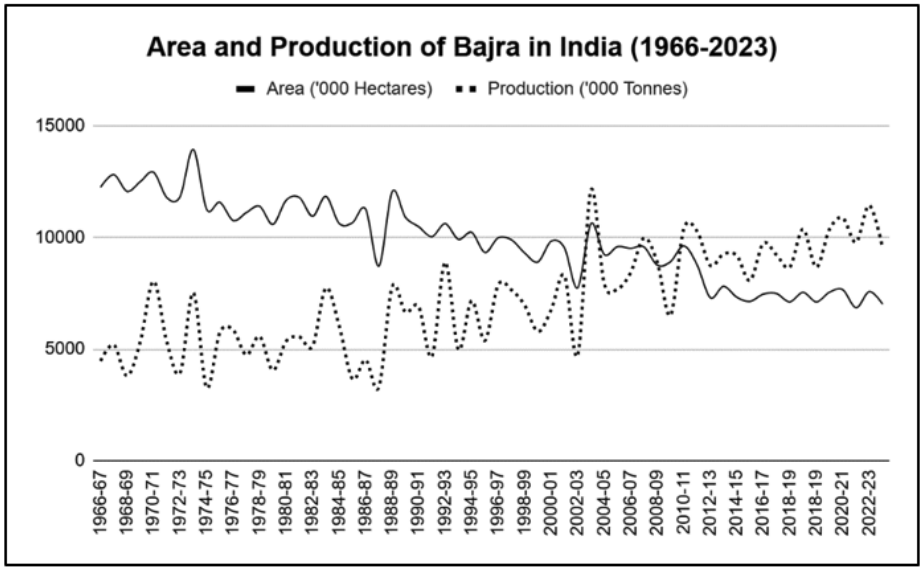

Fig 7.2: Trend in area and production of Bajra in India

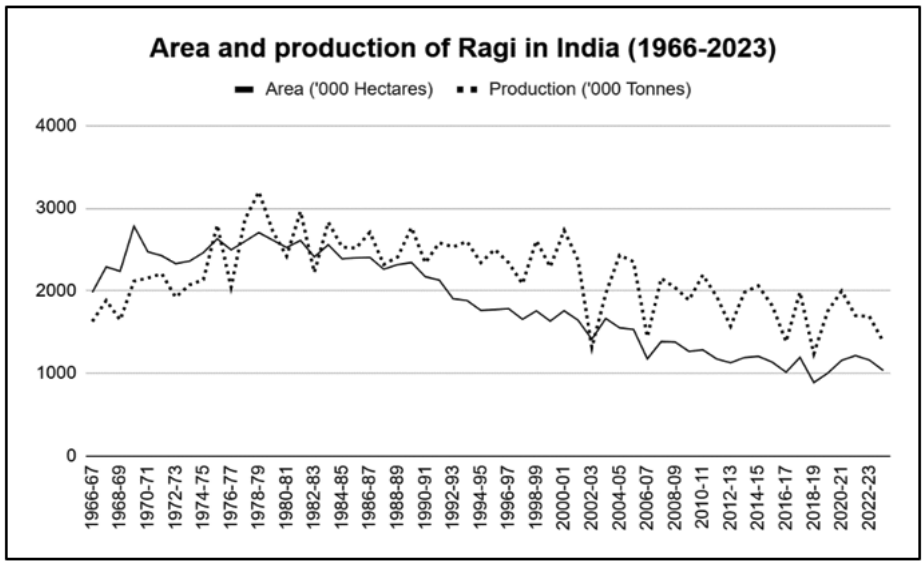

Fig 7.3: Trend in area and production of Ragi in India

Figure 7.3 depicts the trends in both the area under cultivation and the production of Ragi in India from 1966 to 2023. The area under cultivation shows a consistent decline from around 2,700 to approximately 890 thousand hectares, while production also decreases from around 3,200 to 1,200 thousand tonnes. This downward trend can be attributed to reduced demand, competition from other crops, and possibly changing climate conditions affecting yield. Additionally, shifts in agricultural policies and farming practices may have influenced the decline in Ragi cultivation.

Cost of Production of Millets in India

Studying the cost of production is crucial as it directly impacts the economic viability and sustainability of agricultural practices. For farmers, understanding these costs aids in making informed decisions about resource allocation, input usage, and crop selection, ensuring profitability. For policymakers,

accurate cost data is essential for setting fair market prices, determining subsidies, and supporting the agricultural sector.

The cost of production of millets in India has been increasing over the years due to various economic, environmental, and policy-related factors. The projected cost of production (A2+FL) for three main types of millets—Jowar, Bajra, and Ragi—from 2017-2018 to 2022-2023 is presented in figure 8

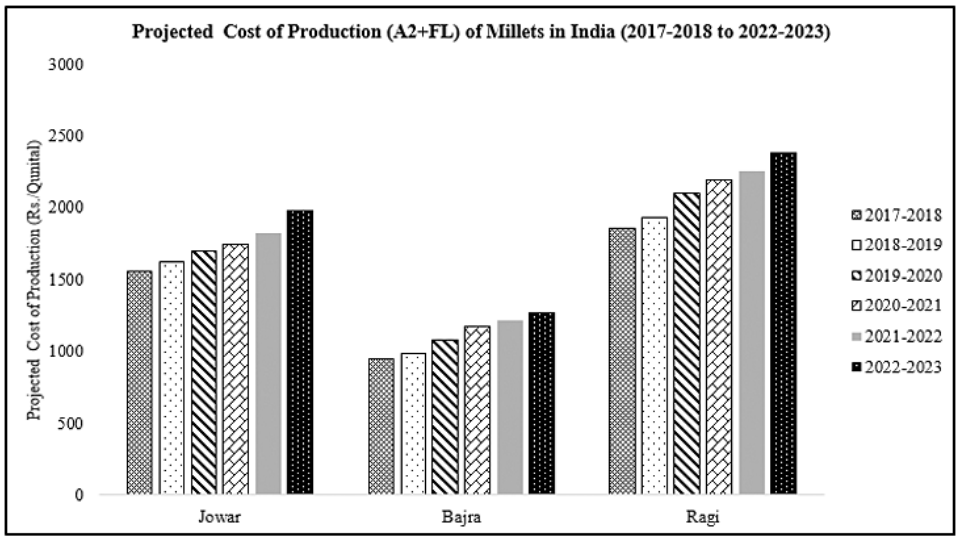

Fig 8: Projected Cost of Production (A2+FL) of Millets in India (2017-18 to 2022-23)

The production cost of Jowar has consistently risen from approximately 1,556 Rs./quintal in 2017-2018 to about 1,977 Rs./quintal in 2022-2023. Similarly, the cost of producing Bajra has steadily increased from around 949 Rs./quintal in 2017-2018 to about 1,268 Rs./quintal in 2022-2023. The production cost of Ragi has also seen an upward trend, rising from around 1,861 Rs./quintal in 2017-2018 to over 2,385 Rs./quintal in 2022-2023. This increase can be attributed to general price inflation, which elevates the costs of inputs like seeds, fertilizers, and labour.

Export of Millets

Millets, being highly nutritious grains, have gained attention both domestically and internationally due to their health benefits and resilience to adverse environmental conditions. Millet exports are a significant contributor to agricultural income in India. The provided export data covers a period of 17 years, from 2003 to 2020, and was obtained from the Millet Statistics compiled by the Indian Council of Agricultural Research (ICAR) and the Indian Institute of Millet Research (IIMR).

Millet Statistics website (https://www.milletstats.com) to explore the export patterns of millets from India to other countries. The insights gleaned from this analysis are graphically presented in Figure 9, revealing substantial variations within the dataset. Sorghum emerges as the predominant millet variety exported, with peak export volumes recorded in the year 2012-13. In contrast, the export of finger millet remains notably lower compared to sorghum throughout the analyzed period.

The enhancement of millet exports from India can be achieved through a combination of government support, trade agreements, market diversification, value addition, and sustainability initiatives. With collaborative efforts from all involved parties, millet exports can be propelled on an upward trajectory. This would not only foster the overall development of the agricultural sector but also bolster India's position in the global millet market.

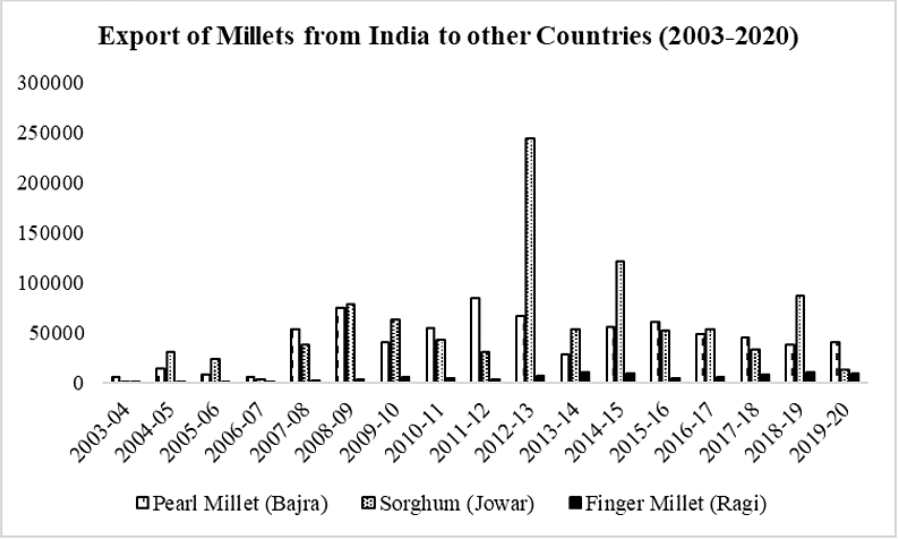

Fig 9: Export of millets from India to other countries

Millets and Food Security

With the global population on the rise, the demand for food is expected to increase accordingly. Currently, cereals contribute to nearly 50% of all calories consumed worldwide.[11] Rice, wheat, and maize have become dominant staple cereals in many regions, but their cultivation requires substantial water resources. Given challenges such as expanding dry areas and declining groundwater levels, the prospects for expanding production of these primary staple crops are limited.[12,13] Research by the National Rainfed Area Authority (NRRA) indicates that even if the full irrigation potential is achieved, about half of the net sown area would continue to depend on rainfed agriculture.[14] These challenges underscore the need to explore alternatives to traditional staple crops. Millets offer a promising solution to these challenges. They thrive in diverse environments, from arid and semi-arid regions to mountainous terrain, owing to their remarkable adaptability to varying climatic conditions.[15] Millets are an essential food source for many small-scale farmers in arid and warmer regions of developing countries, particularly in Africa and Asia. These grains are particularly important for those living in poverty.[16] These nutritious grains are rich in vitamins, minerals, essential fatty acids, phytochemicals, and antioxidants, which can help address a range of health issues stemming from nutrient deficiencies. Cultivating millets can help maintain productivity in drylands and secure future food and nutritional needs.[17] Sorghum and millets are well-suited to regions with limited water availability, thriving even in semi-arid and arid areas due to their resilience to both biotic and abiotic stresses. Additionally, millets yield well in low-quality soils with minimal additional inputs, making them a viable option for sustainable agriculture.[11]

India, China, several regions in Africa (including Western, Middle, and Southern), and parts of South America face potential repercussions from soil degradation, water scarcity, and climate change.[18] These countries may encounter substantial challenges in maintaining crop production and ensuring food security, potentially lacking the capacity to adequately address these issues. As a result, there is a risk of widespread impoverishment, with farmers unable to cultivate crops due to water shortages, ultimately affecting the economic stability of these nations. Yet, initiating proactive measures in the initial phases can mitigate these adverse consequences. This could foster an environment conducive to food security, ensuring the well-being and stability of forthcoming generations. Certainly, swiftly transitioning agricultural methods and dietary habits to include millets among the current populace is essential. Such a transition would enable the projected global population to adopt a healthy lifestyle, supported by abundant water resources.[18]

Minor cereal crops such as millets and sorghum exhibit lower carbon footprints compared to wheat, rice, and maize, rendering them promising candidates for reducing the overall carbon footprint.19 This aspect stands out as a primary rationale behind the potential of millets to contribute significantly to carbon footprint reduction globally.[20]

Government Initiatives Driving Millet Cultivation in India

The Indian government has implemented various initiatives to encourage the cultivation and consumption of millets. These efforts encompass initiatives aimed at raising awareness about the nutritional advantages of millets, providing technical support to farmers, and offering incentives to boost both production and processing.

International Year of Millets 2023

In 2021, the Indian government proposed that the United Nations declare 2023 as the International Year of Millets (IYOM). With the support of 72 other countries, this proposal was approved by the United Nations General Assembly. The goal of the IYOM is to increase awareness of the benefits of millets and promote their consumption and value-added products worldwide. This initiative offers a valuable opportunity to

- Strengthen food security through the increased use of millets.
- Expand global millet production.
- Improve the efficiency of millet processing, transportation, storage, and consumption.
- Promote sustainable and high-quality millet production through collaboration with stakeholders.

Additionally, there is a crucial need for increased investment in research and development to enhance the productivity and competitiveness of the millet industry. Overall, while the trajectory of millet production in India shows promise, there remains substantial groundwork required to fully harness the potential of this significant crop.

Conclusion

This study aims to offer a thorough overview of millet cultivation trends both globally and in India. Despite India's historical consumption and recognition of the importance of millets, there has been a noticeable decline in their cultivation area and subsequent production. This decline underscores the urgent need to expand the cultivation of millets due to their numerous benefits. Raising awareness about the nutritional and overall benefits of millets is essential for increasing demand for these crops. This heightened demand can drive an expansion in both cultivation area and production of millets. Importantly, millet cultivation is resource-efficient compared to other cereal crops, leading to significant reductions in fertilizer and water usage.

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Conflicts of Interest

The authors do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions

- **Bharti, Rahul Banerjee and Pankaj Das:** conceived the conceptualization, investigation, formal analysis, data curation, and writing original draft.
- **Samir Burman, Ankita and Sarita Devi:** performed supervision and edited the manuscript. All of the authors have read and agreed to the published version of the manuscript.

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