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Repositioning Millets in India's Agro-Ecology: A Sustainable Pathway to Climate-Resilient Agriculture and Rural Livelihoods

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Abstract

Millets, a diverse group of small-seeded cereal grains, are gaining global recognition for their superior nutritional value and climate-resilient properties. Designated as "nutri-cereals," these grains thrive in arid and semi-arid regions, require minimal inputs, and hold immense potential for sustainable agriculture and rural development. This paper evaluates India's renewed millet agenda within its agro-ecological framework, analyzing their role in ensuring food and nutritional security, promoting climate-smart practices, and strengthening rural livelihoods. With the FAO declaring 2023 as the International Year of Millets, India's proactive policy measures and growing consumer awareness present new opportunities to reposition millets in both domestic and global food systems.

Keywords: Millets, Climate Resilience, Food Security, Sustainable Agriculture, Rural Livelihoods

1. Introduction

In the context of global agricultural challenges and the urgency of climate change, millets have emerged as a strategic crop group offering solutions across ecological, nutritional, and economic dimensions. In recognition of their multifaceted value, the Food and Agriculture Organization (FAO) of the United Nations designated 2023 as the *International Year of Millets*. This global observance seeks to revitalize interest in these traditional grains by promoting their cultivation, processing, and consumption worldwide. Millets are hardy, small-seeded grasses with a long history of cultivation, particularly in arid and semi-arid regions, where they have supported food security and rural livelihoods for millennia.

Celebrated for their high nutritional profile—including rich content of proteins, dietary fibre, micronutrients, and antioxidants—millets are also climate-resilient and resource-efficient. They grow in marginal soils, require minimal water and inputs, and serve as dual-purpose crops for food and fodder. These attributes make them particularly relevant for addressing contemporary concerns around food insecurity, environmental degradation, and the vulnerabilities faced by smallholder farmers in developing countries.

India, a leading producer and consumer of millets, has been instrumental in spearheading the global campaign to mainstream millet-based agriculture. National policy frameworks, such as the *National Food Security Mission* and the *National Programme for Nutritional Support to Primary Education*, along with research initiatives by the Indian Council of Agricultural Research (ICAR), underscore India's commitment to reviving millet cultivation. Historically embedded in the country's dietary traditions—especially among rural and tribal populations—

millets are also witnessing a renaissance in urban food systems, where increasing health consciousness and environmental concerns are fueling demand for millet-based products.

This paper examines the repositioning of millets within India's agro-ecological landscape and explores their potential as a sustainable solution to climate-resilient farming and rural economic development. It investigates the nutritive and agronomic advantages of millets, analyzes national trends in millet production and policy, and assesses the opportunities and challenges associated with integrating millets into mainstream agriculture. In doing so, it argues that millets hold transformative potential for reconfiguring India's food systems toward sustainability, equity, and resilience.

1.1 Understanding Millets: A Nutrient-Rich Grain

Millets refer to a diverse group of small-seeded grasses widely cultivated across the globe for their use as cereal crops. These grains, which appear in various colors such as white, green, yellow, and red, are small and round in shape. They are widely recognized for their exceptional nutritional content, often surpassing traditional staples like wheat and rice by three to five times in terms of proteins, essential minerals, and vitamins. Being naturally gluten-free, millets are rich in Vitamin B-complex, calcium, iron, potassium, magnesium, and zinc. Their low glycemic index (GI) makes them especially suitable for individuals with grain allergies or metabolic disorders such as diabetes, supporting better glycemic control and aiding in weight management.

1.2 Benefits of Millet Cultivation in India

Traditionally labeled as "coarse grains," millets are now more accurately described as *nutri-cereals* due to their immense health and environmental value. Often referred to as "miracle grains" or "crops of the future," millets thrive in challenging agro-climatic conditions. Their drought tolerance and minimal input requirements make them ideal for regions with limited water availability and poor soil quality. In India, millets serve a dual purpose: they are used both for direct human consumption and as livestock fodder, thereby enhancing household food security and farm-level economic viability.

Millets also play a vital role in climate change mitigation. Their cultivation emits significantly less carbon compared to crops like paddy, which releases methane, and wheat, which is sensitive to temperature fluctuations. Moreover, millet farming generally avoids the use of synthetic fertilizers, and the grains themselves are naturally resistant to pests and have longer shelf lives. Nutritionally, millets are powerhouses—rich in dietary fibre, vitamins, and essential micronutrients. Specifically, **sorghum (jowar)** contains bioactive compounds such as polyphenols and antioxidants that can help manage obesity, reduce the risk of hypertension, cardiovascular diseases, type 2 diabetes, and certain forms of cancer. The high fibre content also supports digestive health and prevents constipation.

1.3 Significance of Sustainable Agriculture in the Indian Context

Sustainable agriculture plays an essential role in meeting the food demands of an ever-growing population while preserving the natural ecosystem. As India faces mounting pressure on its agricultural systems, adopting environmentally responsible farming practices becomes

imperative. Sustainable agriculture emphasizes the efficient use of natural resources while balancing social equity and economic viability. It not only minimizes the ecological footprint of traditional farming methods but also contributes to improved crop yields and healthier food options for consumers.

A key aspect of sustainable farming is maintaining critical resources like soil fertility, especially in regions with limited access to water and land. Alarmingly, agriculture accounts for approximately 70% of the world's freshwater consumption, with water-intensive crops using about 80% of this share. Over the past century, global freshwater extraction has doubled every three decades. In India, nearly 80% of surface water is directed toward agricultural use—placing a heavy burden on groundwater reserves, especially in states known for cultivating water-guzzling crops such as paddy, sugarcane, and cotton. If current trends continue, the nation may soon confront a severe groundwater crisis with far-reaching implications for food security and rural livelihoods.

Promoting sustainable agricultural techniques can significantly reduce dependency on non-renewable resources, limit the use of chemical inputs, and conserve vital natural capital. Ensuring that farmland remains fertile and productive is crucial to sustaining food supply for a growing population. Hence, adopting eco-friendly and resource-efficient farming practices is vital to India's long-term agricultural resilience.

1.4 Overview of Millet Cultivation

Millets encompass a wide variety of small-seeded cereal grasses cultivated across the globe for human consumption and livestock fodder. While many millet species fall under the botanical tribe *Paniceae*, others belong to different classifications. These grains are especially vital in the dry and semi-arid tropical regions of Asia and Africa—most notably in South India, Mali, Nigeria, and Niger—where they serve as staple crops due to their adaptability and short growth cycles under high temperatures and limited rainfall. Remarkably, around 97% of millet production occurs in developing countries, attesting to their global importance.

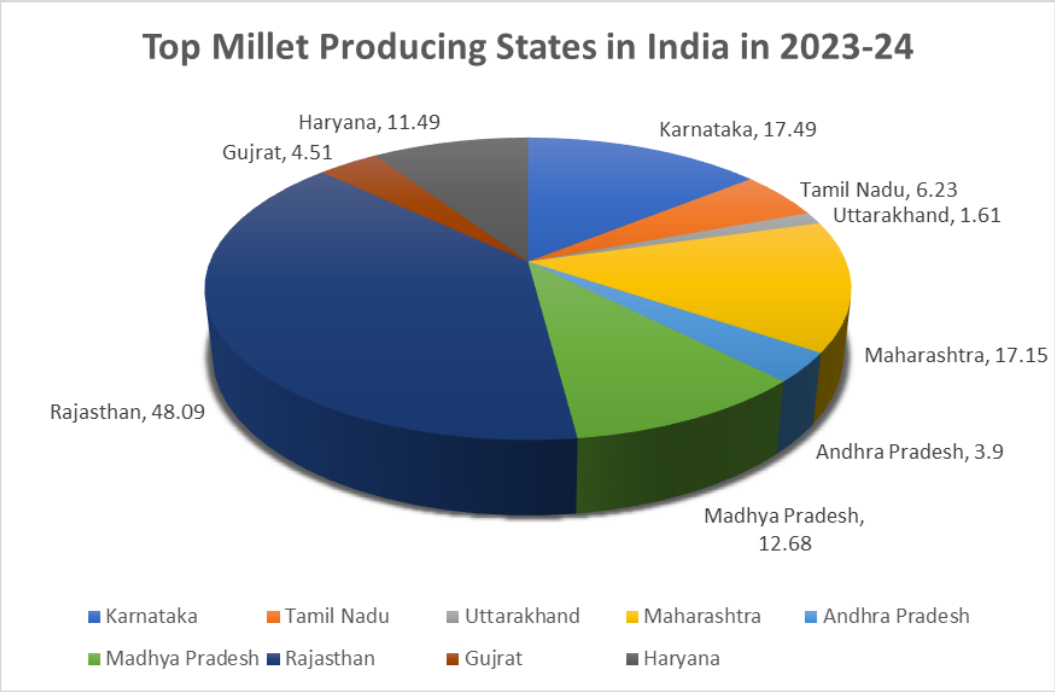
With a legacy that spans over 7,000 years, millets are believed to have played a foundational role in the development of multi-crop farming systems and settled agricultural societies. In India, millets flourish in states receiving low to moderate rainfall (200–800 mm), making them essential to dryland farming systems. As highly nutritious grains, millets offer a blend of food security, climate resilience, and livelihood support. Their versatility also extends to lesser-explored uses such as biofuel production, brewing, and animal feed—earning them the moniker of "smart food" that benefits both people and the planet.

Among Indian states, **Rajasthan** leads millet production and is often referred to as the "Millet Bowl of India." The state's favorable agro-climatic conditions and longstanding millet-growing traditions contribute significantly to the country's overall output, especially of **pearl millet (bajra)**. Other major millet-producing states include:

- **Maharashtra**: Known for cultivating pearl millet, finger millet, and sorghum, with key regions like Marathwada and Vidarbha being prominent contributors.

- **Karnataka**: A leader in finger millet (ragi) production, Karnataka has implemented several initiatives to revive and expand millet cultivation.
- **Tamil Nadu**: With a long-standing cultural association with ragi, Tamil Nadu has focused on revitalizing millet farming through supportive schemes and promotion of millet-based diets.
- **Andhra Pradesh and Telangana**: Both states produce a mix of sorghum, finger millet, and pearl millet, recognizing millets for their nutritional and economic importance.
- **Gujarat**: Particularly active in pearl millet farming, Gujarat's regions such as Kutch, Saurashtra, and North Gujarat contribute notably to the national output.

In addition to these states, millets are also cultivated across Madhya Pradesh, Uttar Pradesh, Odisha, Chhattisgarh, and several others, with variations in crop type and scale based on local climate and preferences. Millet cultivation in India thus holds significant promise—not only for enhancing farmer incomes and dietary health—but also for contributing to a more sustainable, climate-resilient agricultural future.



2. Opportunities and Challenges of Millet Production in India

2.1 Opportunities for Sustainable Growth of Millets

The growing interest in sustainable agriculture and nutrition-sensitive food systems presents multiple avenues for enhancing millet production in India. These opportunities are rooted in both intrinsic crop characteristics and evolving market and policy environments.

Nutritional Advantages and Shifting Dietary Preferences

Millets are inherently rich in dietary fibre, protein, and essential micronutrients, such as iron, calcium, and magnesium. Their gluten-free composition and low glycemic index make them

suitable for individuals with celiac disease, diabetes, and other metabolic conditions. As awareness of diet-related health issues rises, millets are increasingly viewed as ideal grains for promoting public health, particularly in urban and health-conscious populations.

Resilience to Climatic Stress

Millets demonstrate a high degree of resilience under adverse environmental conditions, including drought, poor soils, and heat stress. Unlike water-intensive crops such as rice and wheat, millets require minimal irrigation, making them highly suitable for rainfed agricultural systems and climate-vulnerable regions. Their adaptive traits position them as strategic crops for climate-resilient agriculture.

Expanding Market and Product Diversification

There is growing consumer demand for millet-based products, such as flours, breakfast cereals, snacks, and noodles. The increasing acceptance of millets in urban markets has created opportunities for value addition and agro-processing enterprises. By integrating millets into processed food chains, both farmers and entrepreneurs can enhance income generation and market reach.

Export Potential

India possesses a long tradition of millet cultivation, offering a competitive advantage in global markets. The rising international demand for organic and nutrient-dense grains has opened avenues for millet exports. Strategic export promotion policies and certifications can further enhance India's share in the global millet trade, contributing to rural income and foreign exchange earnings.

Alignment with Sustainable and Low-Input Agriculture

Millet farming aligns well with ecological farming systems. These crops require fewer chemical inputs, have lower carbon footprints, and support soil conservation through deep root systems. As a result, millet cultivation serves as a viable pathway to eco-friendly agriculture, especially within the broader context of agroecology and organic farming movements.

Institutional and Policy Support

The Indian government has recognized the strategic value of millets by incorporating them into key agricultural schemes such as the *National Food Security Mission* (NFSM), *Paramparagat Krishi Vikas Yojana* (PKVY), and through their inclusion in the *Public Distribution System* (PDS). These policy interventions aim to increase production, incentivize farmers, and mainstream millet consumption at both household and institutional levels. The declaration of 2023 as the *International Year of Millets* has further galvanized public and private sector interest in scaling up millet-based systems.

2.2 Challenges Hindering the Expansion of Millet Cultivation

Despite these promising opportunities, several structural and operational barriers continue to impede the wider adoption of millet cultivation in India.

Climate Variability and Weather Dependence

Although millets are known for their resilience, their yields can still be affected by erratic rainfall and temperature anomalies. The increasing unpredictability of climatic conditions under global warming scenarios introduces new uncertainties in millet productivity and cultivation planning.

Pest and Disease Vulnerabilities

Millets are susceptible to a variety of pests and diseases, including bird attacks, insect infestations (e.g., stem borers), and fungal infections such as smut and blast. The lack of readily available and affordable pest management solutions places an additional burden on smallholder farmers.

Inadequate Access to Improved Seed Varieties

The availability of high-yielding, disease-resistant millet seed varieties remains limited. Farmers, particularly in remote regions, often lack access to quality seeds, which restricts productivity gains and curtails the cultivation of less commercialized millet types.

Market Uncertainty and Price Instability

Traditionally categorized as coarse grains, millets have suffered from lower market valuation and limited procurement infrastructure. Price volatility, coupled with weak value chains and procurement incentives, diminishes the economic attractiveness of millet farming, especially when compared to government-supported staples such as rice and wheat.

Low Mechanization and Infrastructure Deficits

Millet farming is predominantly practiced on small-scale or subsistence farms, where the availability of mechanized tools, irrigation systems, and post-harvest infrastructure is minimal. This lack of investment reduces efficiency, storage capacity, and overall competitiveness in the agricultural supply chain.

Weak Awareness and Promotional Efforts

Millets have long remained outside the dominant agricultural discourse, receiving less attention than major cereals. A general lack of awareness among consumers, policymakers, and extension agents regarding the benefits of millets hampers their integration into mainstream food systems. Changing public perception and creating demand require sustained education, advocacy, and institutional commitment.

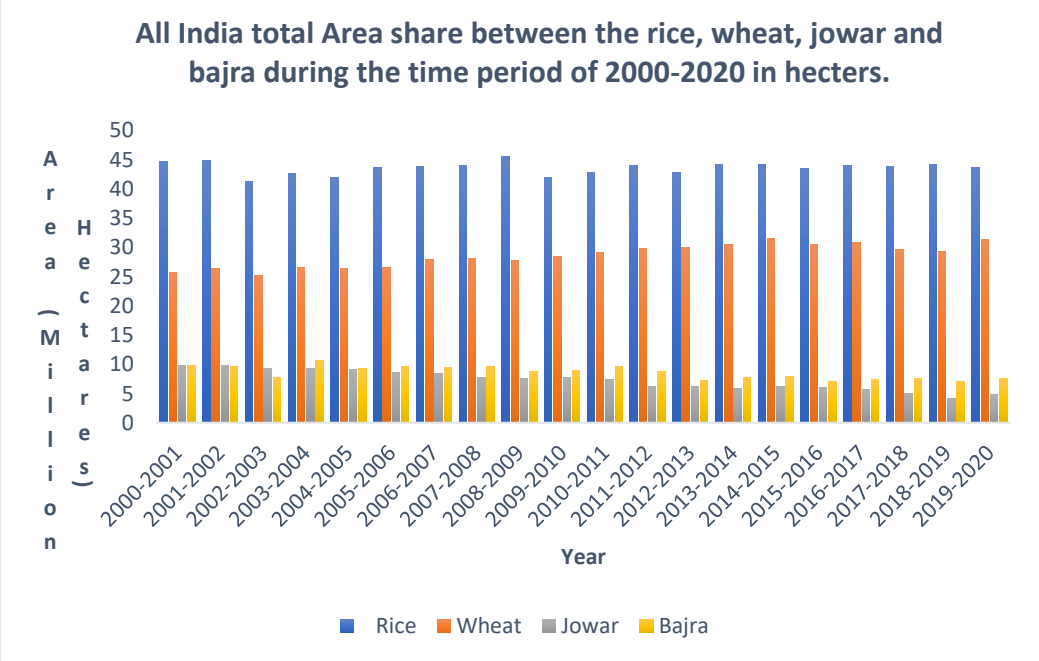
2.3 Policy and Research Imperatives

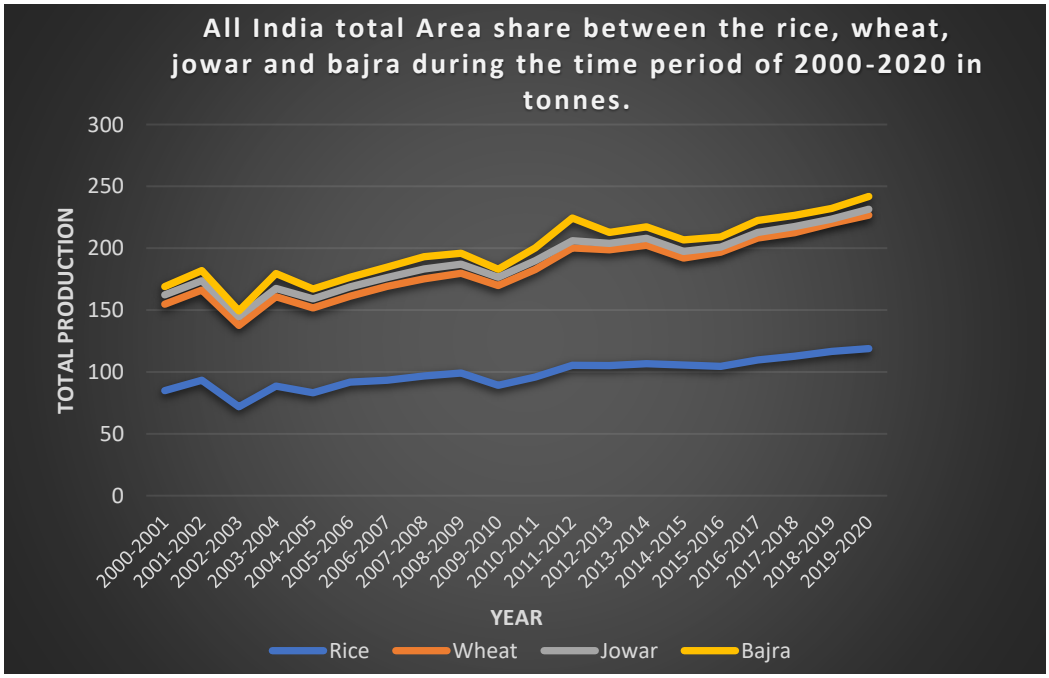
To fully leverage the potential of millets in achieving food security, climate resilience, and sustainable livelihoods, a coordinated and multi-pronged strategy is essential. This includes:

- **Investing in R&D** for improved varieties, pest management, and product innovation.
- **Enhancing market infrastructure**, procurement systems, and value-chain integration.
- **Providing targeted subsidies** and support services to incentivize millet farming.

- **Raising consumer awareness** through public campaigns and school nutrition programs.
- **Strengthening global linkages** to position India as a leader in millet exports.

A strategic approach that integrates scientific innovation, policy support, and grassroots participation can revitalize millet farming as a cornerstone of sustainable agriculture in India.





In Figure 2 and Figure 3 rice, wheat, jowar, and bajra are the four main crops being analyzed. Production of rice and wheat is consistently higher compared to jowar and bajra. Rice and wheat production generally show an increasing trend over the years. Jowar and bajra production appear to fluctuate, with no clear upward or downward trend. The area dedicated to

rice and wheat remains relatively stable, with slight fluctuations. The area dedicated to jowar and bajra shows more significant variations. Rice production has consistently increased from 84.98 million tonnes in 2000-2001 to 118.87 million tonnes in 2019-2020. Wheat production has also steadily increased from 69.68 million tonnes in 2000-2001 to 107.86 million tonnes in 2019-2020. Jowar and bajra show less consistent patterns, but their production generally fluctuates within a certain range. A significant increase in rice and wheat production is observed around 2010-2011.There is a notable drop in jowar production in 2015-2016, followed by a slight recovery. Bajra production remains relatively consistent, with a slight decrease in recent years. The consistent increase in rice and wheat production might be attributed to their importance in the Indian diet and as staple foods. Fluctuations in jowar and bajra production could be influenced by factors such as changing dietary preferences, market demand, and agricultural policy. While the data doesn't provide yield per hectare, the trends in production and area suggest that advancements in farming practices and technology may have contributed to increased yields for rice and wheat. Policy. Policymakers may want to analyze the data further to understand the factors behind the fluctuations in jowar and bajra production and consider measures to stabilize their production.

MINIMUM SUPORT PRICE (MSP) according to crop year:-

Year	Paddy	Jowar	Bajra	Ragi	Wheat
2016-2017	1470	1625	1330	1725	1625
2017-2018	1550	1700	1425	1900	1735
2018-2019	1750	2430	1950	2897	1840
2019-2020	1815	2550	2000	3150	1925
2020-2021	1868	2620	2150	3295	1975
2021-2022	1940	2738	2250	3377	2015
2022-2023	2040	2970	2350	3578	2125

Table1:-MSP in Rupees (per quintal) during the time period of 2016-2023.

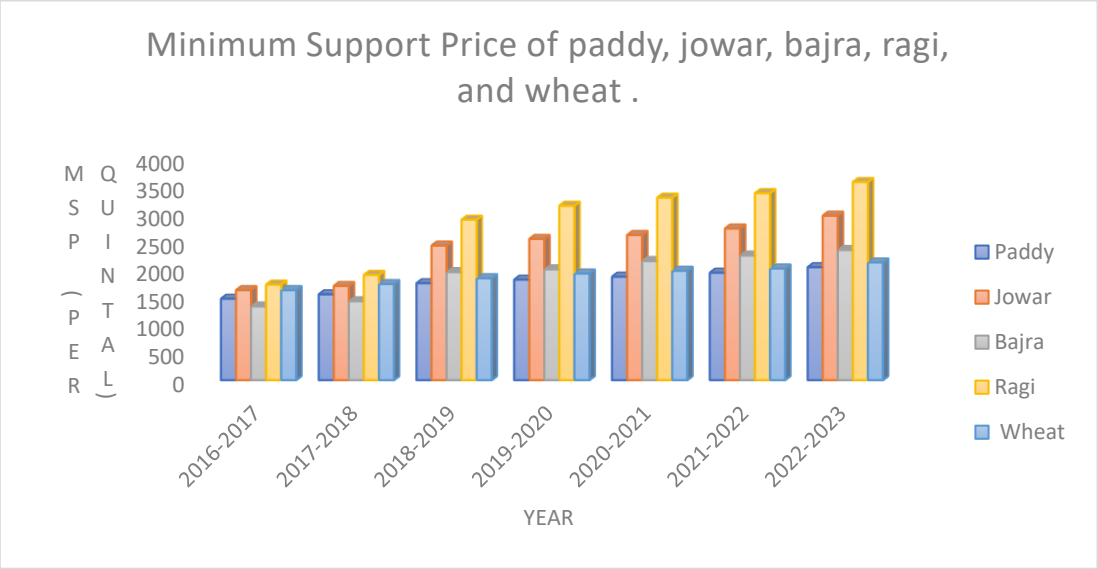


Figure 4

Figure 4 shows the MSP for all crops generally shows an increasing trend over the years. Each crop has its own specific rate of increase. Paddy, wheat, and ragi show relatively steady and consistent increases in MSP over the years. Jowar and bajra have seen more significant increases in MSP, especially in recent years. Ragi's MSP has seen a steady and significant increase over the years, making it a noteworthy crop in terms of price support. The consistent increase in MSP indicates government efforts to provide better price support to farmers and improve their income. The higher increase in MSP for jowar and bajra might encourage farmers to cultivate these crops, potentially leading to shifts in crop preferences. Higher MSPs can contribute to increased income for farmers, but they can also influence cropping patterns and market dynamics. The MSP increase may reflect rising costs of production and inflation in the agricultural sector. Higher MSPs can potentially lead to improved livelihoods for farmers, especially those growing crops with substantial MSP increases. The impact of MSP varies across regions, and its essential to consider regional variations in production costs, market demand, and farmer preferences. The data indicates a focus on increasing MSP for certain crops, which could be driven by factors such as food security, nutritional requirements, and market demand. While higher MSPs can benefit farmers, they should also be evaluated in the context of sustainable agricultural practices and resource management. Increasing MSPs might impact food prices and the overall agricultural supply chain, warranting continuous monitoring.

It is important to note that the MSP is just one aspect of agricultural policy and economic dynamics.The broader context, including production trends, market conditions, government policies, and global factors, should be considered for a comprehensive analysis of the agricultural sector.

3.Conclusion

The revitalization of millet cultivation in India signifies a pivotal shift toward sustainable, nutrition-sensitive, and climate-resilient agriculture. As the country grapples with the twin challenges of environmental degradation and food insecurity, millets offer a strategic solution grounded in ecological prudence and socio-economic inclusivity. Their inherent adaptability to arid and semi-arid agro-climatic zones, minimal input requirements, and superior nutritional profile make them ideal candidates for addressing the vulnerabilities of both smallholder farmers and consumers.

This paper has illustrated the multifaceted benefits of millets—ranging from their role in mitigating climate risks and conserving water resources to improving dietary diversity and supporting rural economies. It has also highlighted the growing market demand, export potential, and the scope for value addition, underscoring millets' viability within both traditional and modern food systems. Equally, the analysis has brought attention to persisting challenges, such as market volatility, limited access to improved seed varieties, and infrastructural deficits, which must be addressed through coordinated policy and institutional efforts.

To unlock the full potential of millets, a paradigm shift is required—one that transcends token promotion and embeds millets at the heart of national agricultural planning, public procurement, and dietary practices. Strengthening research and development, improving

market linkages, investing in post-harvest processing, and enhancing farmer awareness are essential steps in this direction. Furthermore, sustained government commitment and public-private collaboration can ensure that the momentum generated by the International Year of Millets translates into long-term systemic transformation.

In conclusion, repositioning millets within India's agro-ecological landscape is not merely an act of revival; it is a forward-looking strategy to build a more resilient, equitable, and sustainable agricultural future. As climate uncertainties intensify and the quest for nutritional security deepens, millets emerge not only as heritage grains of the past but as critical components of a resilient food system for the future.

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