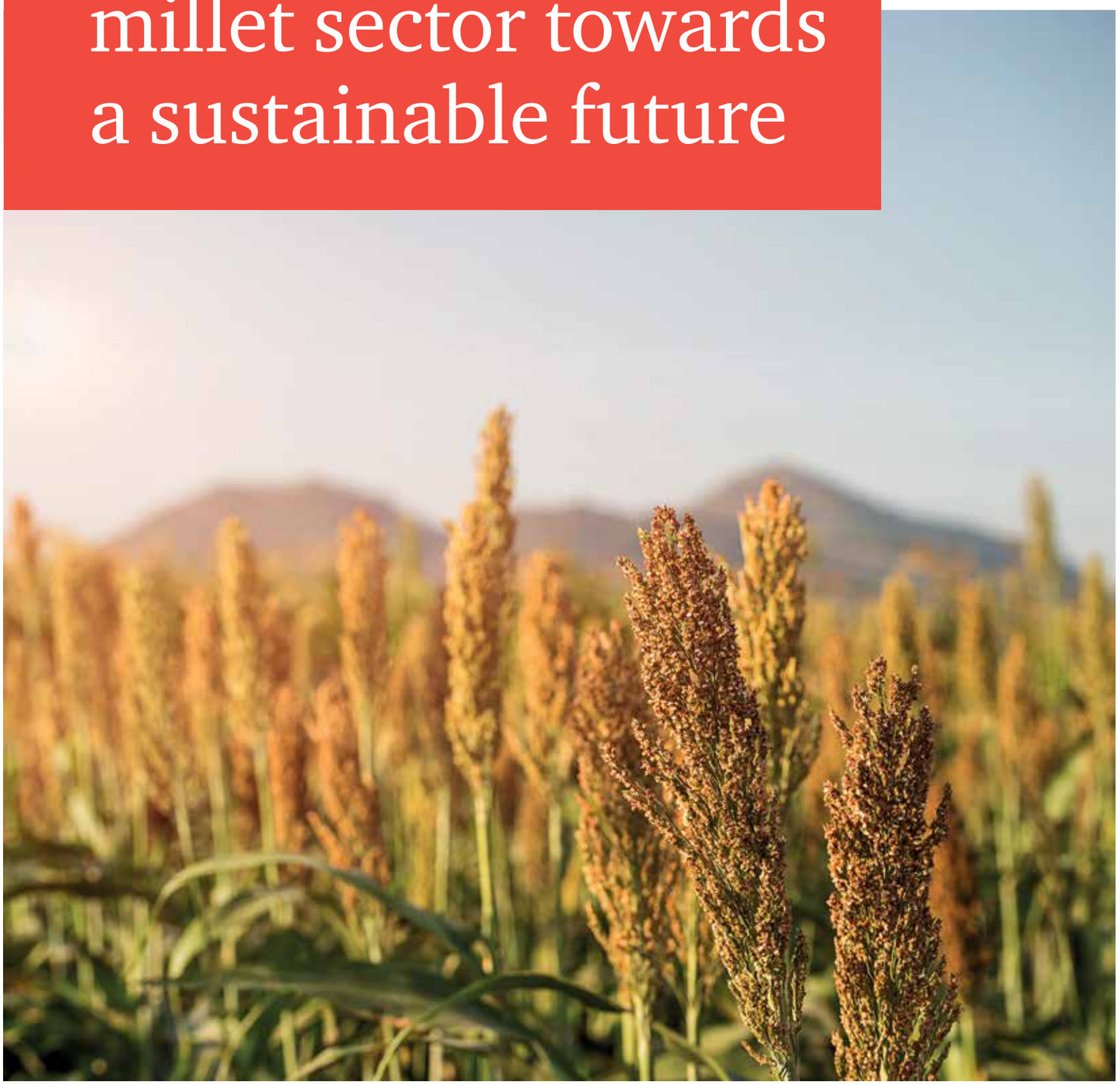
Propelling India's millet sector towards a sustainable future



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संदेश

कृषि हमारी अर्थव्यवस्था में महत्वपूर्ण भूमिका निभाती है और लाखों लोग अपनी आजीविका के लिए इस पर आश्रित हैं। वर्षों से, कृषि ने भारत को सिर्फ खाद्य सुरक्षित ही नहीं बनाया है, बल्कि इसने उत्पादक और निर्यातकों के रूप में कई कृषि उत्पादों के निर्माण में भी मदद की है।

पोषणिक सुरक्षा के महत्व को केंद्रित कर भारत सरकार ने मिलेट्स (श्री अन्न) के प्रोत्साहन के लिए कई कदम उठाए हैं जैसे कि मिलेट्स को 'पौष्टिक अनाज' के रूप में नामांकित करना, 2018, राष्ट्रीय मिलेट्स वर्ष के रूप में घोषित करना और संयुक्त राष्ट्र के माध्यम से वर्ष 2023 को अंतर्राष्ट्रीय मिलेट्स वर्ष के रूप में मनाना। विश्वभर में मिलेट्स को लोकप्रिय करने के लिए कुछ महत्वपूर्ण कदम रहे हैं, इंटरनेशनल मिलेट्स क्षेत्र और उत्पादन में वृद्धि और प्रसंस्करण प्रौद्योगिकी और बुनियादी ढांचा नवीनीकरण और घरेलू और निर्यात बाजारों में विभिन्न श्रेणियों की आवश्यकताओं की पूर्ति आदि।

भारत के लिए मिलेट्स आम आदमी की थाली में अपनी स्थिति फिर से हासिल करे, इसके लिए मिलेट्स को मुख्य धारा में लाने के लिए नेतृत्व करना अनिवार्य है। इस संदर्भ में, मैं FICCI और PwC टीम द्वारा इसे तैयार किए गए नॉलेज पेपर की प्रशंसा करता हूं, जो निश्चित रूप से वैश्विक मिलेट्स परिदृश्य का अध्ययन करने और 'भविष्य के भोजन' को मुख्यधारा में लाने की दिशा में किए जा रहे प्रयासों के रूप में महत्वपूर्ण स्रोत का कार्य करेगा।

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Message

Millets are the oldest cultivated grains in the world and have been an integral part of our diets in India. They are rightly called 'Miracle Crops' or 'Food of the Future' as not only they are rich in nutrients and fibers but also hardy crops that can withstand extreme weather conditions. India is a leading producer as well as consumer of millets with 20% of total world production and 80% of Asia's production. With research support led by Indian Council of Agricultural Research (ICAR) through the Indian Institute of Millets Research (IIMR), India is making significant strides in production and productivity of all major millets i.e., sorghum, pearl millet and finger millet and minor millets i.e., proso millet, little millet, foxtail millet, kodo millet and barnyard millet.

IIMR is primarily engaged in basic and strategic research on millets. It coordinates and facilitates millets research projects at national level through All India Coordinated Research Projects on Millets, Pearl Millet and Small Millets and provides linkages with various national and international agencies. Genetic resource management, crop improvement for increased productivity, genetic enhancement for high biomass per unit time, mitigation of adverse effects of climate change, development of crop production technologies for increased input efficiency, Abiotic and biotic stress management, seed science and technology, and value addition for commercialization are key areas of our current focus. Significant achievements have been made in millets research and some of the highlights are – release of 35 Sorghum Hybrids through AICRP system and around 175 varieties through State Agriculture Universities (SAUs); increase in kharif sorghum productivity by 93% and rabi sorghum productivity by 80% through new crop varieties and improved production technologies; enhanced production and utilization of sorghum in food, feed, fodder and biofuel sectors through sustainable production, protection, processing and seed technologies across cropping systems and agro-ecological zones; up-scaled value addition protocols through pilot studies for use of kharif grain in non-food sector, particularly feed, starch production and potable or industrial alcohol, and sweet-stalked sorghum in the production of syrup and ethanol; development of new DNA markers and practice of marker-assisted selection for evolving new cultivars resistant to drought, shoot fly, and other stresses; improvement in grain and fodder quality using transgenic and marker approaches; incorporation of novel traits in new cultivars through wide hybridization and allele mining; and development of new technologies to prevent contamination of sorghum grains by mycotoxins. Research on transgenic lines resistant to abiotic and biotic stress are in pipeline.

Along with research and development, extension plays a significant role in disseminating right knowledge and information on the importance of millets for cultivators, consumers and climate alike. I congratulate FICCI and PWC team for their timely initiative of creating awareness through this knowledge report, and I am sure this shall also provide a unique opportunity to engage with all stakeholders to promote production, consumption and trade of millets in India.

(Himanshu Pathak)

2nd August, 2023
New Delhi

Message from FICCI

Millets, often referred to as nutri cereals, stand as a beacon of health, nutrition and sustainability. India, a prominent producer and consumer of millets, has risen to the forefront on the global stage by spearheading the IYoM. Millet production in India holds a multifaceted importance encompassing nutrition, environment and economics. Suited to diverse conditions, millets offer essential nutrients, manage diabetes, enhance food security, conserve biodiversity and symbolise cultural heritage. This remarkable initiative is rooted in the realisation that amid the mounting demand for food and the constraints on expanding cultivation areas, millets present a sustainable solution which ensures both food security and enhanced nutrition.

In our pursuit of this noble objective, the Indian Government has undertaken substantial actions – especially during the observance of the IYoM. However, we must recognise that a majority of our farmers are small and marginal. As we march ahead, it is imperative that millets receive conscious attention from all stakeholders to transform them into an attractive and profitable crop for our dedicated millet-growing farmers. To achieve this, the concept of farmer producer organisations (FPOs) must be intensified, functioning as the cornerstone of this transformation. By seamlessly integrating FPOs with forward and backward linkages, we have the potential to revolutionise the agricultural landscape. The time is right for us to empower millet FPOs with knowledge and best agricultural practices, thereby forging a robust supply chain that spans from the farm to the market.

The merits of millets extend beyond economics – they encompass the environmental, nutritional and cultural realms. Millets present a potential crop for the future, heralding benefits for the environment, nutrition and our economy. As we forge ahead, it becomes our responsibility to share this awareness not only within our borders but also across the globe. Therefore, it is high time to build the brand of India in millets, for they hold the potential to reshape our agricultural landscape.

I congratulate the FICCI task force on millets and the PwC team for their remarkable endeavours in developing a knowledge report. This report, undoubtedly, shall provide the compass needed for diverse stakeholders to navigate and chart strategies that will shape the sector's future.

T R Kesavan
Chairman
FICCI National Agriculture Committee and Group President, TAFE

Message from FICCI

Millets, often overshadowed by more familiar grains like wheat and rice, hold profound significance in global agricultural and culinary history. This humble yet resilient cereal, cultivated for millennia across diverse cultures, has silently nourished civilisations, enriched diets and contributed to ecological sustainability. As we dive into the world of millets, we uncover their historical significance, nutritional prowess and their pivotal role in addressing contemporary global challenges like food security, quality nutrition and climate change. In 2023, this led to receiving support from 72 countries in the United Nations General Assembly to celebrate the IYoM. The Government of India's commitment to put millets 'Shree Anna' on every plate is certainly praiseworthy, and a perfect way to commemorate the International Year of Millets (IYoM).

These century-old grains are now gaining prominence as a smart and sustainable choice of crops which provide food, feed, nutrition and fodder security to the nation. Being nutritionally superior to rice and wheat, high in dietary fibre and low in glycemic index, millets are all set to tackle the nutritional challenges and lifestyle problems at the consumers' end. On the other hand, the low carbon and water footprint, climate-resilient nature and ability to grow in adverse conditions with less inputs make it a favoured crop among farmers. Cultivation of high-yielding short-duration varieties reduces the risk for farmers and safeguards them from suffering due to erratic rainfall. This makes millets the best choice for both consumers and farmers alike.

India proudly holds the mantle as the world's leading millet producer, contributing a remarkable 41%[1] to the total global production and a staggering 80% of Asia's output.[2] This presents a great opportunity for millets to emerge as a crop of choice for the global population. We foresee rising market demand for millets globally due to their health benefits which have generated a renewed interest among consumers. India can indeed emerge as a 'millet bowl' and has the potential to lead the global supply chain. Achieving this vision will require significant efforts to empower smallholder Indian millet farmers with agricultural inputs, technologies and linkages that enable them to increase their yields and incomes.

In a nutshell, enhancing the production of millets through productivity-led growth is of paramount importance. This calls for providing improved, high-yielding seeds to farmers and improving the seed replacement rate of millets. Spreading awareness about good agriculture practices by undertaking frontline demonstrations is vital. Improvement in varieties, breeding for disease resistance, and low rancidity for better shelf life are a few crucial areas for research and development in millets. Stakeholder-driven meticulous planning at the state level will prepare India to build a brand India as the millet bowl of the world.

In the last year, the FICCI Task Force on Millets with a representation of members from each segment of the millet value chain with the vision 'to facilitate impactful partnership to make Indian millets value chain more remunerative to farmers, beneficial to consumers, efficient and globally competitive', has taken several initiatives at the centre and state levels, which align with Government's millet mission and the prime minister's vision of India's responsibilities towards the global good. I congratulate the PwC team for their commitment and hard work in putting together this knowledge report which will certainly be insightful for readers, value chain players and policymakers.

As we embrace millets, we cultivate a healthier future for all – a resilient, sustainable, and nourishing path forward for the generations to come.

Jitendra Joshi
Chairman, FICCI Task Force on Millets
and Director, Seeds sales, South Asia, Corteva Agriscience

1. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1895783#:~:text=As%20per%20FAO%2C%20world%20production,of%20the%20total%20millet%20production
2. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1845652

Message from PwC

Millions of farmers across the world depend on millets for livelihood, food and nutrition, with a majority of these crops tracing their origins back to Asia and Africa.[3] In today's times, when the rate of climate change is becoming unprecedented, immediate measures are important to ensure sustainability. In this scenario, being a hardy, climate-resilient crop, millets come across as the 'silver lining' and a promising source of addressing rising food concerns due to climate change.

Millets present farmers with an opportunity to bring diversification in their cropping systems and de-risk their agri-enterprises. This is demonstrated most prominently in case of weather-related uncertainties when millets offer an assured harvest when other crops don't perform well. However, the time has come to realise the untapped potential of millets, particularly in terms of enhancing farmers' income by strengthening the supply side. Therefore the most opportune time to initiate such efforts is now, when the entire world is celebrating the IYoM, led by the Government of India.

On the demand side, it's time to take steps that enhance acceptability of millets as 'food of choice'. This requires concerted efforts to enhance awareness about millet recipes and conveniences in cooking which can affect millet consumption at a large scale. Secondly, focus on improving processing infrastructure for millets is vital. Such steps will propel the growth of the sector by building integration at the value-chain level and encouraging millet-based entrepreneurship ecosystem in the country. The miracle grain and super food of the future presents a USD 2 billion opportunity for expanding the country's footprint in terms of millet exports and millet-based value-added products.[4] Additionally, policy intervention and contribution of all stakeholders is inevitable to achieve the desired development of millet industry and tapping the market demand.

Millets, being a climate-smart crop, can also contribute significantly towards supporting India in achieving its Sustainable Development Goals. There is a need to bring about a paradigm change in policy measures for the development of an enabling ecosystem to transform the millet economy as a whole. In order to highlight steps to achieve this, this report proposes adopting a four-pronged strategy, 'PAID' – outlining '**p**roduction enhancement', '**a**wareness creation', '**i**nnovation' and '**d**emand generation' – which aims at bringing together the segregated efforts that are being made in India for a more holistic approach towards making Indian millets global for the cultivators, consumers and climate.

Shashi Kant Singh
Partner, Agriculture and Food Sector
PwC India

3. The Story of Millets, 2018, Indian Institute of Millets Research
4. https://apeda.gov.in/milletportal/files/Indian_Superfood_Millet_APEDA_Report.pdf

Executive summary

Millets are a collective group of small-seeded crops, botanically belonging to the 'grass' family. They are one of the earliest staple foods of the world, with origins dating back to the Indus Valley Civilisation.[5] As part of the IYoM celebrating these environmentally friendly and highly nutritious crops, this knowledge paper highlights the role of millets in ushering in economic prosperity and environmental sustainability, along with proposed ways to achieve these goals. The report broadly comprises three sections: knowing our nutri cereals, existing mindsets around millets and mainstreaming millets, and taking 'Shree Anna' to every plate.

Millets are the 'next-gen solution' for cultivators, consumers and the climate. With the effects of climate change becoming increasingly pronounced each year and affecting global agricultural and food production systems, millets offer potential for greater environmental sustainability and economic prosperity.

The World Bank estimates that between 32 and 132 million people can be pushed into poverty by 2030 due to climate change, with Sub-Saharan Africa and South Asia being the most vulnerable regions.[6] In this scenario, millets can serve as 'future crops' for climate resilient agriculture (CSA) due to their ability to withstand high temperatures, grow in water-scarce and resource-poor soils, and their physiological efficiency as C4 plants. Millets are inherently not input-intensive crops, and this gives smallholder farmers the flexibility to invest in their cultivation. In addition to being less input demanding, millets present a better nutritional profile than the major cereals grown globally, namely wheat, rice and maize. They are rich in dietary fibre, proteins, vitamins, and minerals, and have a lower glycaemic index. In today's age, when metabolic syndrome is becoming more prevalent among children and adolescents, millets offer several health benefits by lowering blood glucose and cholesterol levels, improving insulin sensitivity, and preventing inflammation. Also, India being the largest producer of millets and at the forefront of the IYoM celebrations, the export of millets and millet-based value-added products presents a USD 2 billion opportunity for the country.

However, current perceptions and attitudes towards millets are limiting their potential to boost health and nutrition and bring prosperity to producers. Millets have long been treated as a poor man's crop due to their ability to withstand the harshest and driest of weather and soil conditions. When given a choice, however, farmers prefer cultivating fine cereals or other crops over millets as they offer assured prices and markets, and are hence less risky.

To mainstream millets and take the Shree Anna to every plate, we propose a four-pronged strategy – PAID – comprising (a) 'Production enhancement', (b) 'Awareness creation', (c) 'Innovation' and (d) 'Demand generation'.

'Production enhancement' interventions entail crop and varietal improvements, concerted efforts on value-added product development, innovations in production and processing technologies, and holistic policy support for millet promotion. The 'awareness creation' facet in the proposed strategy highlights the importance of mainstreaming millets and prioritising the interests of cultivators, consumers and investors alike. 'Innovation' for increasing the area under millet cultivation along with dedicated product development endeavours would be helpful in increasing consumption. Finally, 'Demand generation' through public-private partnership models and global initiatives would be helpful in the long run.

In order to ensure a holistic and long-term millet growth story, it may be pertinent to extend the focus on millets for at least a decade ('Decade of Millets') rather than a year, in order to make it the 'cereal of the future' and drive the people, planet and prosperity agenda.

5. https://www.dw.com/en/can-indias-push-for-millets-start-a-food-revolution/a-64852003#:~:text=The%20humble%20millet%20is%20believed,great%20Indus%20Valley%20Civilization%20era.
6. https://openknowledge.worldbank.org/entities/publication/a549a5ee-71cd-5ed4-bcf3-3a8cb508b199

Contents

1. Knowing our nutri cereals

Millets are one of the most ancient crops known to humankind and were among the first ones to be domesticated. Archaeological evidence of charred millet grains discovered at Harappan sites and their mentions in the Vedas (religious texts with origins in ancient India) further validate their long history.[7] They have traditionally been a staple food, nourishing millions of farming families across Asia and Africa, with strong cultural values attached. Millets are mainly grown in arid and semi-arid regions of the world as they thrive in such environments, thus demonstrating their ability to withstand higher temperatures and drought-prone conditions. Notably, millets require just 350 mm of water to grow, which is more than 3.5 times less than the water requirement of the paddy crop (i.e., 1,250 mm).[8] Besides being climate resilient, millets also represent next generation crops for ensuring nutritional security and enhancing farm economies.

1.1. Millets as the 'next-gen solution' for cultivators, consumers and the climate

1.1.1. Addressing climate change

Over the past three decades, there has been an alarming increase in the frequency of extreme weather events, as highlighted by the United Nations.[9] Experts unequivocally assert that climate change has played a significant role in intensifying these events. Presently, heatwaves, droughts and floods are becoming more widespread, while the accelerated melting of glaciers and ice sheets is contributing to a rise in sea levels. Moreover, the Arctic Sea has experienced a substantial reduction in ice coverage, and the warming of our oceans has triggered marine heatwaves. These climate-related changes are already impacting people's lives, directly or indirectly affecting food safety. According to the World Bank, climate change may have a significant impact on global poverty by possibly pulling more than 100 million people into poverty by 2030.[10] These statistics underline the urgent need to address climate change and its impact on food security.

Millets as the 'go-to' crop for mitigating climate change effects

~ Can grow in high temperatures (arid and semi-arid environment)
~ Suitable for dryland agriculture

~ Can withstand drought
~ Can be grown in extreme weather conditions and saline soils

~ Can grow in areas receiving less rainfall
~ Are mostly kharif and rainfed crops in India

~ Can grow in areas receiving less rainfall
~ Are mostly kharif and rainfed crops in India

Source: PwC research and analysis

In this context, millets emerge as a crucial solution, having been widely recognised for their ability to address nutritional, agrarian and climate-related challenges. Today, experts from around the world advocate the sustainable production and consumption of these nutri cereals as an effective measure to mitigate the adverse effects of climate change and ensure a secure and healthy food system. As the world becomes increasingly aware of the negative impacts of climate change, millets are gaining attention as future crops. With 70% less water consumption than rice,[11] and a shorter growth cycle compared to wheat millets offer a comprehensive solution to tackle the challenges arising from climate change.[12] The Food and Agriculture Organization (FAO) underscores the unique qualities of millets compared to more commonly

7. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1887847
8. https://krishi.maharashtra.gov.in/Site/Upload/GR/millets-Book.pdf
9. https://news.un.org/en/story/2023/07/1139162
10. https://documents1.worldbank.org/curated/en/706751601388457990/pdf/Revised-Estimates-of-the-Impact-of-Climate-Change-on-Extreme-Poverty-by-2030.pdf
11. https://www.ceew.in/blogs/5-ways-india-can-make-internaltional-year-of-millets-popular-for-sustainable-food-systems
12. https://www.orfonline.org/expert-speak/millet/

known cereals such as wheat, rice and corn. Millets showcase an impressive ability to thrive in drought conditions and non-irrigated areas with minimal rainfall, leading to a significantly lower water footprint. Moreover, millets outshine other crops due to their minimal need for synthetic fertilisers and pesticides. This reduction in chemical dependency empowers farmers to embrace sustainable agricultural practices that are not only better for the environment but also promote long-term ecological balance. Furthermore, the cultivation of millets encourages farmers to diversify their crop rotations, moving away from the repetitive monocropping pattern.

This diversification acts as a natural defence mechanism, effectively reducing issues such as soil depletion and heightened susceptibility to pests, which are commonly associated with monocropping.

Another significant aspect is the abundant carbon content found in millet crop residues – the leftover plant material. When these residues are left on soil or incorporated back into it, they contribute to maintaining and increasing soil carbon levels. This is vital for sustainable farming systems as it enhances soil health and fertility, supporting long-term agricultural sustainability. Beyond their environmental benefits, millets also play a crucial role in enhancing our immune system, thus contributing to a healthy lifestyle.

1.1.2. Addressing hunger and malnutrition

According to a United Nations report, the global impact of hunger has reached alarming levels, with approximately 828 million people affected in 2021.[13] A more recent report released in March 2023 reveals an increase in the number of pregnant and breastfeeding adolescent girls and women experiencing acute malnutrition.[14] In the 12 countries most severely impacted by the global food and nutrition crisis, the figures relating to the affected population have risen from 5.5 million in 2020 to 6.9 million. The impact of hunger on children is equally concerning. Globally, 51 million children under the age of two suffer from stunting, meaning their growth and development are hindered due to malnutrition.[15] In India, according to a report by FAO, there were 224.3 million undernourished people between 2019 and 2021.[16] The country ranked 107 out of 121 on the Global Hunger Index 2022. These statistics underscore the urgent need for interventions to address malnutrition and improve the wellbeing of India's vulnerable populations.

Embracing millets for a healthier future

Although millets were overlooked during the Green Revolution, the Government has reintroduced them into public diets across the country. Noteworthy initiatives such as POSHAN 2.0 emphasise the promotion of dietary diversity and food fortification while also supporting traditional knowledge systems and integrating millets. Across various states, civil society organisations (CSOs) have collaborated with state governments and key institutions, including the Department of Women and Child Development, NITI Aayog and the Food Corporation of India (FCI), to introduce millets into the Integrated Child Development Services (ICDS). This flagship programme aims to reduce malnutrition among children and women of reproductive age. For example, in Karnataka, millets have been successfully incorporated into the Mid-Day Meal (MDM) scheme, especially in tribal areas.[17] In Odisha, the government-led Odisha Millets Mission has implemented a unique multi-stakeholder intervention, introducing millet-based foods into the State Nutrition Programme (SNP) in Keonjhar and Sundargarh districts. As a part of this initiative, ragi laddoos are provided as an additional supplement during morning snacks to 1.5 lakh pre-school children across 6,077 Anganwadi centres.[18] Similarly, in Maharashtra, the Tribal Development Department has collaborated with multiple stakeholders to revive ragi cultivation and consumption in Thane, Palghar and Nashik districts. Furthermore, in the semi-arid regions of Madhya Pradesh, women's federations have taken the lead in processing and supplying kodo millet bars to pre-school children through Anganwadi centres. These collaborative efforts by various stakeholders have significantly contributed to the resurgence of millets in the Indian diet.

13. https://www.fao.org/newsroom/detail/un-report-global-hunger-SOFI-2022-FAO/en
14. https://data.unicef.org/data-for-action/undernourished-and-overlooked-unicef-report-sheds-light-on-global-nutrition-crisis-faced-by-adolescent-girls-and-women/#:~:text=The%20report%20also%20shows%20that,5.5%20million%20to%206.9%20million.
15. https://www.unicef.org/press-releases/malnutrition-mothers-soars-25-cent-crisis-hit-countries-putting-women-and-newborn
16. https://www.thehindu.com/opinion/open-page/road-to-a-malnutrition-free-india/article66308540.ece
17. https://www.downtoearth.org.in/blog/food/millets-should-be-mainstreamed-for-better-nutritional-outcomes-in-children-87780
18. https://thelocavore.in/2023/05/30/ragi-laddoo/#:~:text=Ragi%20Laddoos%20are%20served%20to,Photo%20by%20Odisha%20Millets%20Mission

Broad nutrient profile of Indian millets[19]

Parameter	Unit	Nutrient per 100g									
		Pearl millet	Sorghum	Finger millet	Foxtail millet	Barnyard millet	Kodo millet	Proso millet	Little millet	Wheat	Rice
Energy	kcal	**361**	349	328	331	341	302	309	314	321	356
Protein	g	11.6	10.4	7.3	**12.3**	7.7	8.3	8.3	10.1	10.6	7.9
Carbohydrate	g	65.5	**72.6**	72	60.9	67	69.9	65.9	65.6	64.7	78.2
Dietary fibres	g	1.2	1.2	2.6	**14**	7.6	8.5	9	7.7	11.2	2.8
Calcium	mg	42	42	**344**	31	17	22	27	32	39.4	7.5
Iron	mg	8	8	8.9	3.6	9.3	**9.9**	0.5	1.3	3.9	0.6

Source: http://www.millets.res.in/pub/2018/The_Story_of_Millets.pdf

19. https://www.millets.res.in/pub/2018/The_Story_of_Millets.pdf

From first crops to future crops – highlighting the health benefits of millets

Scientific name and origin	Health benefits
Sorghum (Sorghum bicolor): It is known as the king of millets and originated in north-eastern Africa around 5,000-8,000 years ago. 	• Sorghum, known for its high calcium content, is also a rich source of iron, protein and fibre. • It helps in weight loss and is beneficial for bone formation and heart health.
 Pearl millet (Pennisetum glaucum): It underwent domestication in the northern-central Sahelian Africa region around 4500 BC.	• Pearl millet combats diabetes mellitus, cancer and cardiovascular conditions. • It helps lower blood pressure, and reduces the risk of heart disease and the rate of fat absorption.
Finger millet (Eleusine coracana): It is believed to have emerged during the early Iron Age in the highlands of Eastern Africa. 	• Finger millet combats multiple conditions like blood pressure, heart problems and asthma. • It specifically benefits people with diabetes by supporting slow digestion.
 Little millet (Panicum sumatrense): It is an indigenous grain originating from India, and its cultivation spans across diverse regions.	• Little millet is an excellent source of minerals such as calcium, iron and zinc. • It also offers essential fats that can support weight loss efforts.
Foxtail millet (Setaria italica): It was domesticated in China over 8,000 years ago. It is now cultivated in India and other regions of the world. 	• It facilitates the steady release of glucose without disrupting the body's metabolism. • Regular consumption of foxtail millet has been linked to a reduced prevalence of diabetes.
 Proso millet (Panicum miliaceum): It ranks among the earliest-known human foods, believed to be the first domesticated cereal grain.	• Proso millet is abundant in minerals, polyphenols, vitamins and proteins. • It is traditionally consumed as a recuperative food post pregnancy or during illness.
Barnyard millet (Echinochloa esculenta/frumentacea): It is widely agreed upon that its roots can be traced back to central Asia. 	• Barnyard millet stands out with its low and slowly digestible carbohydrate content. • It reduces blood glucose and lipid levels. It is also beneficial for patients with diabetes.
 Kodo millet (Paspalum scrobicultum): It is believed to have originated in tropical Africa and was domesticated in India 3,000 years ago.	• Kodo millet aids in weight loss, is easily digestible, and is rich in phytochemicals and antioxidants. • It also helps to regularise menstruation in women.

Source: PwC research and analysis

With changing lifestyles, the emergence of metabolic syndrome, encompassing conditions such as diabetes, high blood pressure (hypertension) and obesity, has become a significant global concern. While diabetes affects 422 million people worldwide, hypertension affects an estimated 1.28 billion adults aged 30–79 globally, with a majority residing in low and middle-income countries.[20] Moreover, the global population dealing with obesity stands at 2.3 billion, and this includes both adults and children.[21] India has 254 million people who are obese, 315 million people affected by hypertension and 101 million people diagnosed with diabetes.[22] In this scenario, millets can serve as an affordable solution for addressing multiple lifestyle diseases, given their impressive nutritional profile. Highly nutritious and rich in protein, fibre, Vitamin B, calcium, iron, manganese, magnesium, phosphorus, zinc, potassium, copper and selenium, millets offer several health benefits for people with metabolic syndrome by lowering blood glucose and cholesterol levels, improving insulin sensitivity and preventing inflammation. They also contribute to weight management and support bone health.

Thus, in essence, millets outshine other cereals as a valuable and sustainable food option that not only addresses pressing environmental issues but also offers a wide range of health benefits.

By embracing millets, we can pave the way for a better future for both the planet and its inhabitants.

1.1.3. Increasing farmers' incomes

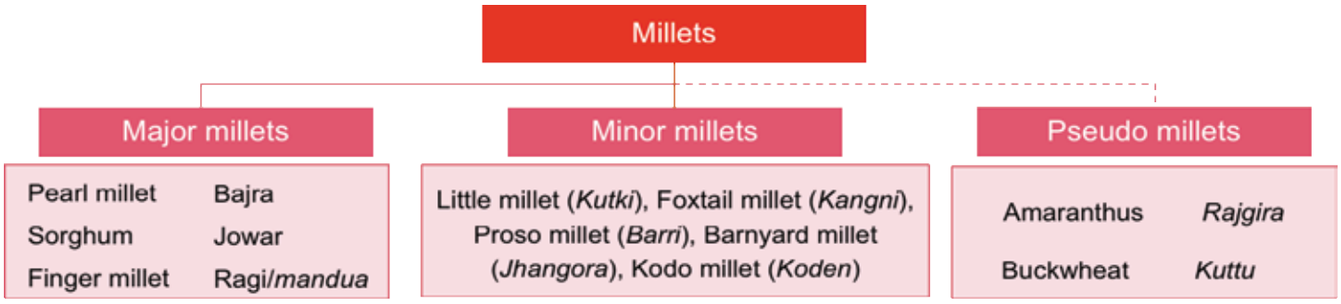
Given India's pioneering role in bringing millets to the forefront as a revolutionary crop and a rising sense of global health consciousness, the export of millets and millets-based value-added products represents a USD 2 billion opportunity that the country can tap into.[23]

Having long been sidelined from the main food basket, millets are now steadily regaining the world's attention – thanks to the Government of India's (GoI's) initiatives, including its proposal to the FAO to celebrate an International Year of Millets (IYoM). The following sections discuss the different varieties of millets and their journey from centres of origin to major producing countries today.

1.2. Millets: A spotlight on their types and origins

Millets derive their name from the Latin word milum which means 'grain'. From a botanical classification point of view, millets belong to the Poaceae (grass) family and are broadly categorised as small-seeded cereal grains. Various types of millets, having different colours, textures, appearances and grain sizes, are cultivated across the world. Based on the size of the grain, millets are classified into major and minor millets. The major millets comprise sorghum (Sorghum bicolor), pearl millet (Pennisetum glaucum) and finger millet (Eleusine coracana), and the minor millets comprise little millet (Panicum sumatrense), foxtail millet (Setaria italica), proso millet (Panicum miliaceum L.), barnyard millet (Echinochloa frumentacea) and kodo millet (Paspalum scrobiculatum). A third category, known as pseudo millets, has a nutritional profile similar to that of millets. Classified on the basis of gran size, it comprises amaranthus (Amaranthus viridis) and buckwheat (Fagopyrum esculentum).

Classification of millets based on grain size

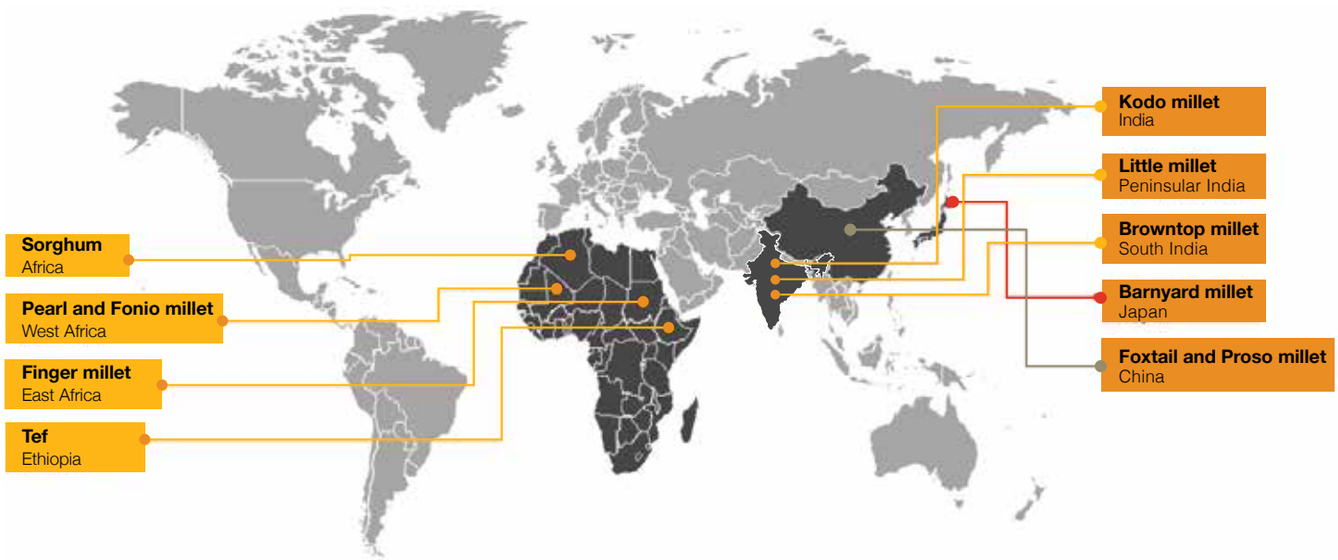


Source: PwC research and analysis

20. https://www.who.int/news-room/fact-sheets/detail/hypertension
21. https://world-heart-federation.org/what-we-do/obesity/
22. https://economictimes.indiatimes.com/news/how-to/why-india-is-seeing-a-rise-in-hypertension-diabetes-cases/articleshow/100881351.cms
23. https://apeda.gov.in/milletportal/files/Indian_Superfood_Millet_APEDA_Report.pdf

As far as regions of origin are concerned, a majority of millets have their origins in Asia and Africa. Sorghum (jowar) originated in Africa, while the roots of pearl millet (bajra) go back to West Africa. Finger millet (ragi) originated in East Africa. Little millet (kutki) is native to Peninsular India. Foxtail millet (kangni) and proso millet (barri) have their roots in China. Barnyard millet (jhangora) is associated with Japan, while kodo millet (koden) is native to India. Apart from these millets, there are other varieties like fonio millet from West Africa, tef from Ethiopia and browntop millet from South India.[24]

An overview of the different types of millets and their respective regions of origin



Source: https://www.millets.res.in/pub/2018/The_Story_of_Millets.pdf

Having originated mainly in two continents, millets journeyed across the rest of the world, becoming an important crop for farmers to fall back on in case of climate uncertainties and an integral part of diets. Today, they are cultivated in more than 130 countries.[25] However, Asia and Africa still remain the major producers and consumers of millets.

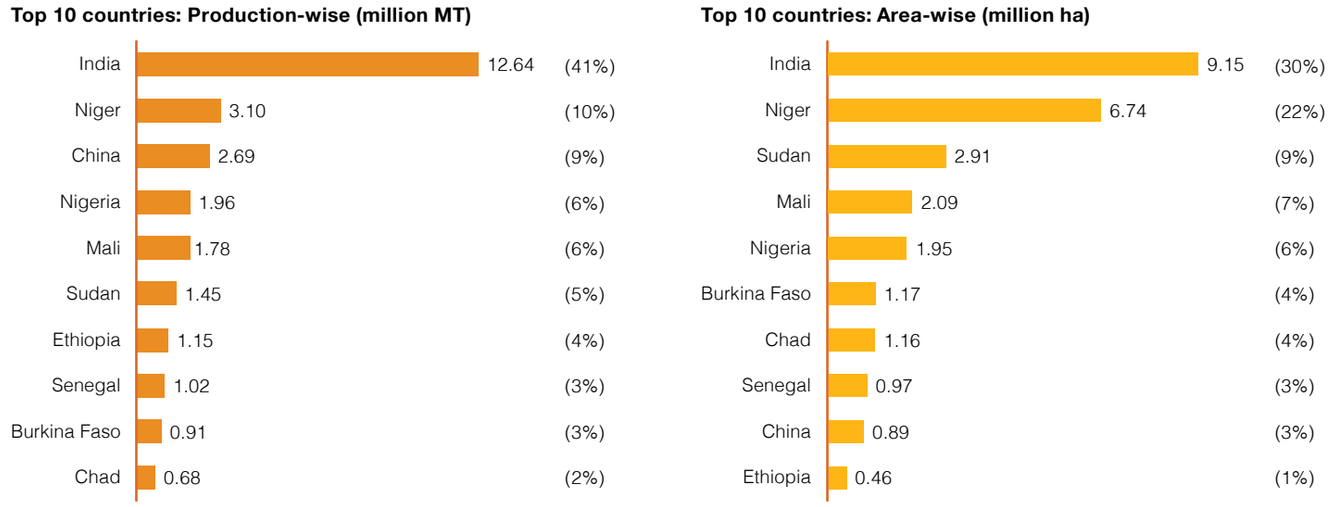
1.3 Understanding global and national production of millets

1.3.1. Global production

Globally, 30.59 million MT of millets is produced on 30.86 million ha of land.[26] The top 10 millet-growing countries account for 89% of the total global area under millet cultivation and produce 90% of the world's supply of millets. Apart from ranking differently, the top 10 countries in terms of both production and area under millet cultivation are the same. With the exception of India and China, the remaining eight countries are all in Africa. With 41% of world's total production and 30% of the total area under cultivation, India leads the way in millet production, followed by Niger and China with 10% and 9% of the total production respectively. On the consumption front, Africa – as a whole continent – is the largest consumer of millets in the world at 40%.[27]

24. https://www.millets.res.in/pub/2018/The_Story_of_Millets.pdf
25. https://www.indiascienceandtechnology.gov.in/listingpage/millets-future-food
26. Basis a five-year average calculation for the years 2019-20 till 2023-24; data sourced from United States Department of Agriculture (USDA)
27. https://www.orfonline.org/expert-speak/millet/

Top 10 countries in terms of millet production and area under millet cultivation



Source: United States Department of Agriculture (USDA)

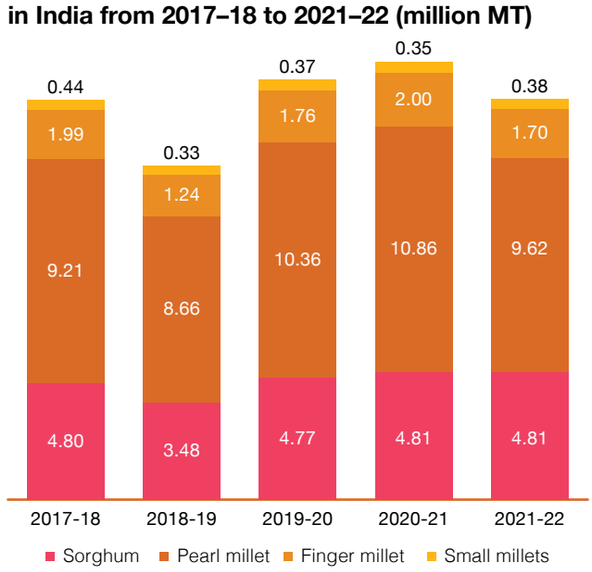
In 2021, the world exported 509.73k MT of millets worth USD 198.66 million. The top exporters of millets were Ukraine (USD 45.71 million), the United States (USD 28.52 million), India (USD 27.42 million), the Russian Federation (USD 17.72 million) and France (USD 14.25 million).[28] In the same year, the world imported 553.71k of millets worth USD 256.86 million, with the top importers being Indonesia (USD 37.86 million), the European Union (USD 28.87 million), Germany (USD 16.55 million), Belgium (USD 13.80 million) and Canada (USD 13.51 million).[29] The global market size of millets is projected to grow at a compound annual growth rate (CAGR) of 4.60% (from 2023–2028) and reach USD 13.80 billion by 2028.[30] As a leading producer of millets, India's share in international trade is forecasted to grow exponentially, representing a USD 2 billion opportunity.[31]

1.3.2. Indian production

India produced an average of 16.39 million MT of millets between 2017–18 and 2021–22, including 9.75 million MT of pearl millet, 4.54 million MT of sorghum, 1.74 million MT of finger millet and 0.37 million MT of minor millets. The average area under millet cultivation in the country has been 13.28 million ha, with 55% under pearl millet, 33% under sorghum, 8% under finger millet and 4% under minor millet cultivation.[32]

The top 10 millet-growing states in 2021–22 were Rajasthan, Maharashtra, Uttar Pradesh, Madhya Pradesh, Gujarat, Haryana, Jharkhand, Karnataka, Tamil Nadu and Andhra Pradesh, which cumulatively have a more than 95% production share.

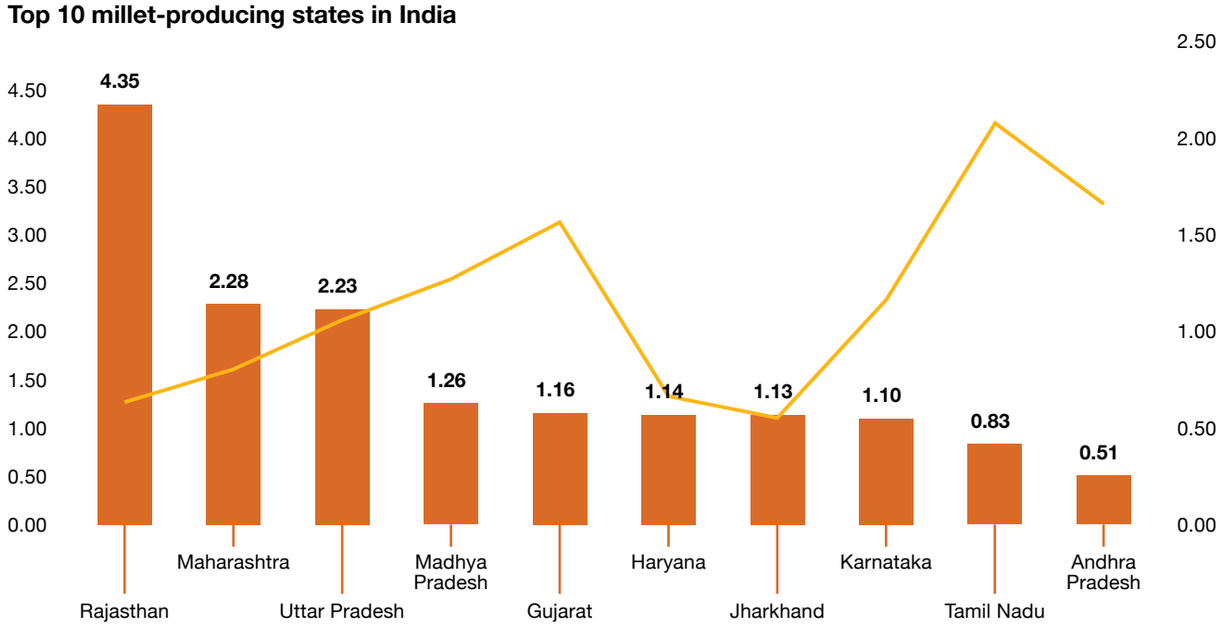
Five-year millet type-wise production trend in India from 2017–18 to 2021–22 (million MT)



Source: https://apeda.gov.in/milletportal/files/Statistics_report.pdf

28. https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2021/tradeflow/Exports/partner/WLD/product/100820
29. https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2021/tradeflow/Imports/partner/WLD/product/100820
30. https://www.mordorintelligence.com/industry-reports/millets-market
31. https://apeda.gov.in/milletportal/files/Indian_Superfood_Millet_APEDA_Report.pdf
32. https://apeda.gov.in/milletportal/files/Statistics_report.pdf

Top 10 millet-producing states in India



Source: https://apeda.gov.in/milletportal/files/Statistics_report.pdf

India stands at the third position globally in terms of export value. In 2021, India exported 91.29k MT of millets to 84 countries. The top 10 export destinations for Indian millets have been the United Arab Emirates (UAE), Nepal, Saudi Arabia, Libya, Oman, Yemen, Tunisia, Egypt, the United Kingdom (UK) and Qatar.

India has always acknowledged the importance of millets, considering them a 'super food' and a prominent way to enhance farmers' incomes, consumer health and the nation's prosperity. The country has taken multiple initiatives to mainstream millets.

India's key initiatives towards mainstreaming millets

2012	Initiative for Nutritional Security through Intensive Millet Promotion (INSIMP)
2013	National Food Security (NFS) Act covers 'coarse grains'
2018	Millets officially declared as nutri cereals
	Millets made part of the National Food Security Mission (NFSM)
	GoI declared the year 2018 as the 'National Year of Millets'
	GoI launched the Sub-mission on Nutri-cereals under NFSM with an outlay of INR 300 crore for 2018–19
	GoI sent a proposal to the FAO of the United Nations for declaring 2023 as the IYoM
2021	The United Nations General Assembly (UNGA) declared 2023 as the IYoM
2022	FAO opening ceremony of IYoM 2023 held in Rome, Italy
	Multiple events, seminars and conferences organised and led by GoI[33]
2023	Global Millets (Shree Anna) Conference, inaugurated by the Prime Minister of India; release of a commemorative coin
	Compendium of Indian millet (Shree Anna) start-ups and book of millet standards launched digitally

33. https://www.nutricereals.dac.gov.in/Officialdocumentscollection.aspx

2. Current perceptions about millets

From being one of the first crops, millets have now been deemed as the 'crops of the future'. Therefore, it is important to understand the current perspectives and limitations around millets and acknowledge the biases and inattention faced by the millets sector. Such assessments will help in eliminating the limitations of the millet value chain and make the industry more profitable.

2.1. Prevailing perspectives

2.1.1. Millets: The poor man's crop

Millets have traditionally been an integral part of the staple diet for over a billion people in arid and semi-arid regions of the world. Despite being culturally and nutritionally significant, especially for the rural populations across Asia and Africa, they have often been deemed as the 'poor man's crop'. This is due to their characteristic feature of being one of the last crops standing in the harshest (up to 50°C) and driest weather conditions, and their ability to grow in areas with low soil fertility (pH ranging from 4.5 to 8, and soil salinity of up to 12 dS/m) with minimal inputs.[34]

Furthermore, as millets are mostly a part of the low external input sustainable agriculture (LEISA), investments in millet production systems in India usually remain lower than those for fine cereals – i.e. paddy and wheat. For example, the cost of paddy cultivation in Tamil Nadu is more than INR 85k per quintal (2020–21) and that for wheat in Andhra Pradesh is approximately INR 60k per quintal. However, the cost of cultivation for millets (especially sorghum and pearl millet) ranges from INR 40–50k per quintal on an average.[35] Despite this, when given a choice, farmers are noticeably more inclined towards growing crops that fetch potentially higher prices in the market, such as fine cereals.

2.1.2. Less acceptance as a preferred food choice

Millets are often an unpopular choice for cereal consumption given their unique and peculiar taste, which discourages most people from consuming them. They are not a food of 'choice' but rather 'chance' (i.e. inaccessibility or non-affordability of food alternatives) or 'compulsion' (e.g. advised for medical purposes). When offered a choice, however, wheat and rice are the most preferred grains for daily consumption, mainly due to their palate-pleasing taste and convenience in cooking. In addition to apprehensions regarding the taste and convenience of cooking millets, millet consumption is affected by the perception that it causes warming effects in the body.[36] Some studies also suggest that excluding millets from regular food preparations and eating habits is related to the lack of knowledge on how to cook them.[37] Although the 'gluten-free' quality of millets is preferable from a health point of view, it hinders with proper flour binding, chapati/roti-making and similar preparations, making fine cereals – especially wheat – a more preferred choice. Moreover, in addition to the lack of traditional knowledge of preparing millet-based recipes due to rapid urbanisation, there is also a lack of awareness on various ways to incorporate millets into different recipes and food preparations, thus limiting their culinary usage in general.

After the Green Revolution, there was a steady decline in millet production and consumption, and a preferred shift towards wheat and rice – partly due to the abundance of finer cereals at affordable prices. Millets saw a reduction of

34. https://www.millets.res.in/pub/2018/The_Story_of_Millets.pdf
35. PwC analysis
36. https://timesofindia.indiatimes.com/city/visakhapatnam/millet-only-diet-not-recommended-docs/articleshow/67762916.cms
37. https://www.frontiersin.org/articles/10.3389/fsufs.2021.680777/full

more than 3 million ha in area under cultivation between 2011 and 2021 and were replaced by crops that had better income generation potential such as wheat, maize, mustard, cotton, chickpea and groundnut. Between 1972 and 2005, Haryana – the epicentre for the Green Revolution – experienced a 50% decrease in area under cultivation and an 85% decrease in consumption of millets in both urban as well as rural areas. The reason for this is primarily attributed to exponentially increased attention on input-intensive wheat and paddy cultivation.[38] Therefore, it is an opportune time to bring about innovations for improving the palatability and acceptability of millets by all age groups, as they have the potential to be used as the 'next-generation food'.[39]

2.2. Existing technologies

2.2.1. Limited use of modern production technology

In most production areas in India, millets are still cultivated using indigenous traditional knowledge (ITK) by smallholder farmers who already lack resources for the adoption of farm mechanisation for millet cultivation. The core reason for this is not the lack of modern millet production technologies but farmers either lacking the awareness or accessibility to those innovations. This affects crop productivity because individual crop yield potential is not fully achieved in farmers' fields as portrayed by the research and extension institutes through frontline demonstrations (FLDs).

An overview of production technologies available for millet farming in India

Seed	Farm machinery	Package of practices (PoP)
State-wise and season-wise HYVs and hybrids released[40] Example: 167 hybrids and 61 varieties of pearl millet released through Indian Council of Agricultural Research (ICAR) All India Coordinated Research Project (AICRP) on pearl millet[41]	Tractor/power tiller drawn six-row planter with fertiliser drill Bullock-drawn three-row planter with fertiliser drill Manually operated pull type three-row planter/manually operated push type single-row vertical plate planter with fertiliser drill Multi-millet thresher and finger millet thresher cum peeler by the ICAR Central Institute of Agricultural Engineering (CIAE)[42]	Standard PoP for all millets grown in India, developed by the Indian Institute of Millets Research (IIMR)[43]

Traditional agricultural practices for millet farming often result in the wastage of resources. For example, the conventional broadcasting method of sowing millets may result in up to 90% wastage of seeds as compared to using the multi-millet seed-cum-fertiliser planter. Conventional on-field post-harvest practices such as threshing involve a lot of labour (beating millet panicles over wooden planks to separate the grains), are time-consuming and mostly carried out by the women of the farming households. Such methods affect the quality of grains in terms of texture damage, making them vulnerable to insect/pest infestation during storage. On the other hand, use of farm machines such as multi-millet thresher saves time and threshes a variety of millets (finger, kodo, little, foxtail, proso and barnyard millet)

38. http://oar.icrisat.org/96/1/HOPE1.pdf
39. https://www.millets.res.in/farmer/Latest_Millet_English_Full_Book_2020.pdf
40. https://www.millets.res.in/farmer/Latest_Millet_English_Full_Book_2020.pdf
41. http://www.aicpmip.res.in/pearl%20millet%20hybrids%20and%20varieties.pdf
42. https://static.vikaspedia.in/mediastorage/document/Millet_Production_Machinery.pdf
43. https://www.millets.res.in/technologies.php

with maximum efficiency – i.e. up to 97%.[44] Time is a major factor when harvesting millets – especially little millet – as the crop falls to the ground and gets damaged if not harvested timely. This calls for developing efficient and affordable machinery for threshing and dehulling, and enabling its availability and accessibility to small farmers.

2.2.2. Availability of primary processing technology with limited access

Farmgate (primary) processing of millets is an important step in their value addition for both household consumption and further processing into secondary, tertiary and quaternary products. Although the major millets are without husk (naked grains), minor millets need to be dehulled as they have an outer husk layer that is inedible. Despite being a powerhouse of nutrition, millets also contain certain anti-nutrients that interfere with the absorption of minerals in our body. For example, sorghum and finger millet contain tannins and polyphenolic compounds that have anti-nutrition properties. Therefore, it is essential to ensure that millets are processed properly in order to eliminate these anti-properties. Common household processing methods that are employed to reduce their negative impacts and make them fit for human consumption include decortication, milling, soaking, malting, germination, fermentation, roasting/popping and cooking. These methods minimise the content of phytates, phenols, tannins and trypsin inhibitors in millets, and improve their digestibility and bioavailability of minerals.[45] Although processing of millets is an important activity, it often proves to be a tedious task due to the small, varying size of these grains owing to the variation in crop varieties, agronomic practices and location-specific weather patterns. Anecdotal experience suggests that 1 kg of little millet takes nearly one hour to process.[46] Thus, manual processing is both time-consuming and labour intensive.

Shorter shelf life of processed products

Another challenge that needs to be addressed is the short shelf life of processed millets. While prepared meals quickly go rancid, millet flour can only be stored for very short durations. For example, pearl millet flour has a short shelf life, ranging from five to ten days.[47] This raises storage concerns and renders processed products more prone to pest infestation. In addition to addressing the elimination of rancidity by standardising processing operations and infrastructure, research is needed for biomolecular interventions – especially for pearl millets.

No 'one-size-fits-all' machinery

There are nine types of millets that are mainly grown in India, all having varying grain sizes and morphological features.[48] Even within one type of millet, variations in size, shape and texture of grains are common. For example, the glumes in sorghum, pearl millet and finger millet get easily detached during harvesting and threshing. However, a few traditional varieties require further mild abrasion in cereal (emery) pearler for their glumes to get detached. Also, while minor millets such as foxtail and proso can be de-husked in a single stage, millets like kodo, barnyard and browntop require multiple stages.[49] Therefore, retrofitting or fabrication is necessary for processing millets. At present, however, most equipment manufacturers offer only a single set of sieves for all pre- and post-hulling operations, limiting the range of use of grader.

44. Pre and post-production mechanization and value addition of millets: ICAR-CIAE Perspective, 2023 (https://pub.isae.in/index.php/aet/article/view/1384/1208)
45. Indian Farming, Volume 73 No. 01, 2023, ICAR (https://www.icar.org.in/sites/default/files/Indian-farming-January-2023.pdf)
46. https://milletadvisor.com/millet-conservation-for-the-future-generation/
47. https://krishi.icar.gov.in/jspui/bitstream/123456789/28925/1/19.%202018_Die%20size_chemical.pdf
48. https://milletadvisor.com/millet-grain-identification/
49. Knowledge paper on millets: The future super food for India, June 2022 (https://www.assocham.org/uploads/files/Report_Millets%202022%20(Print%20Version)%20(1).pdf)

2.2.3. Selective affordability of secondary and tertiary processing technology

The processing machinery currently available in the market is mostly small scale, with capacities of up to two tonnes per hour. Though higher-capacity machinery can be purchased from big players in the market, these require high capital investment (approximately INR 2 crore) and are unviable for micro, small and medium enterprises (MSMEs).[50] Also, most of the primary and secondary processing machines are improvised versions of paddy processing machinery.[51] For example, 40 different machines are required to be retrofitted to develop 50 processed and value-added products from millets.[52] Even then, the grain (head rice) recovery percentage is rather low and ranges between 70–80%[53] – for example, only 40–50 kg of rice is recovered from one quintal of browntop millet grains.[54] As a result, apart from the high initial capital required to set up a millet processing unit (i.e. INR 15–20 lakhs) or the cost of setting up a composite processing infrastructure project, the cost of processing is also significantly high (i.e. INR 10–14/kg of millets).[55]

2.3. Policy perspective

2.3.1. Focus on popular cereals (wheat and rice) since the mid-1960s

From a 'food-deficit' to a 'food-surplus' country, India has come a long way in foodgrain production, with foodgrain stock estimates well ahead of the buffer norm – i.e. more than 1.5 times.[56] All of this was made possible through the introduction of new technologies including HYVs of wheat and paddy that were highly responsive to more inputs. This has been continuously improved over time owing to the vast research and extension network of ICAR. Moreover, this endeavour was well supported by a favourable policy environment such as input subsidies and positive pricing guidelines. Compared to wheat and rice, millets have been subjected to both inadequate investments and received less attention, from both policy and research perspectives. For varietal improvements, the focus has primarily been on major millets and no quality standards and grades have been established for millets so far.

2.3.2. Limited inclusion of millets in the public distribution system (PDS)

Covering more than 800 million people, India's PDS is one of the largest in the world.[57] It is an important channel established under the National Food Security Act (NFSA, 2013) through which the Government provisions food to the identified poor. Of India's population, close to 57% receives monthly rationed foodgrains – mainly wheat and rice – at subsidised prices.[58] The overall combined cost of food subsidy was INR 2.95 lakh crore for Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY) and NFSA in 2021–22.[59] The supply of wheat and rice may have reduced hunger, but the challenge of malnutrition still persists. As per the National Family Health Survey (NFHS-5) 2019–21, 35.5% of children below five years of age are stunted, 32.1% are underweight and 19.3% are wasted.[60] Thus, introducing dietary diversity (including millets among other food categories) through PDS may play an important role in addressing the problem of malnutrition in India.

2.3.3. Minimum support price (MSP) for only major millets

Until recently, millets were not included in the Government's procurement policy. The procurement policy of coarse cereals mostly revolved around maize, ignoring millets for the most part. While the MSP is decided by the Commission for Agricultural Costs and Prices (CACP) each year for major millets (i.e. pearl, sorghum and finger millets), small millets have not been included in the procurement policy, with no MSP being fixed by the Government.

50. Ibid.
51. Assessment of existing small millet processing equipment in India, September 2016, DHAN Foundation
52. NAAS 2022. Promoting millet production, value addition and consumption. Policy Paper No. 114, National Academy of Agricultural Sciences, New Delhi
53. https://milletadvisor.com/opportunities-and-challenges-in-millet-sector/
54. https://www.millets.res.in/farmer/Latest_Millet_English_Full_Book_2020.pdf
55. Assessment of existing small millet processing equipment in India, September 2016, DHAN Foundation (https://www.dhan.org/smallmillets2/file/Assessment%20report%20of%20existing%20SM%20processing%20equipment%20in%20India.pdf)
56 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1863875#:~:text=It%20is%20estimated%20that%20as,and%20136%20LMT%20of%20rice
57. PwC research and analysis
58. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1910061#:~:text=Coverage%20under%20the%20Act%20is,presently%20covered%20under%20the%20Act
59. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1816459
60. http://rchiips.org/nfhs/NFHS-5_FCTS/India.pdf

2.3.4. Less dedicated research and development (R&D) support

While the ICAR-IIMR has recently been christened as the Global Centre of Excellence on Millets, it has historically focused mainly on sorghum research. Although there are 14 research centres across the country undertaking the AICRP on Small Millets, there is no crop-wise dedicated research centre or institute for minor millets. The IIMR notes that there were only 14 varieties released till 2012 for commercial cultivation of minor millets – five each in kodo and proso millets, three in little millet and one in barnyard millet.[61] Also, there is a lack of processing-friendly millet hybrids or varieties overall, which needs concerted R&D focus in order to enhance the market demand by multifold. For example, Kufri Chipsona varieties of potato brought about a significant economic upturn for the food processing industry in India.

It has been observed that policy push from the central level has helped various agri-segments to make great strides in terms of modernisation or advancement. For example, one dedicated policy measure for advancement in farm mechanisation through the sub-mission of agricultural mechanisation (SMAM) helped enhance farm-level mech/tech adoption by about 45%, in just three years of its launch.[62]

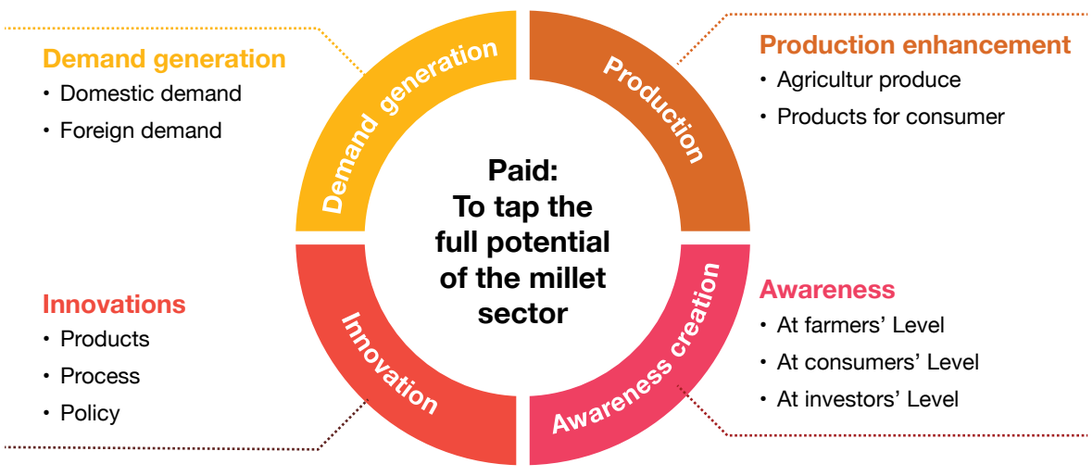
Despite the above-discussed limiting factors, millets are steadily getting their due attention through collective efforts of the stakeholders in the millet value chain. However, there is a further need to adopt a multi-pronged approach to take the global millet ecosystem to the next level.

61. https://www.millets.res.in/aicrp_small.php
62. https://farmech.dac.gov.in/SMAM/Evaluation%20Report%20SMAM/Final%20Report%20M&E%20SMAM%20.pdf

3. Mainstreaming millets

As discussed before, millets offer numerous benefits, including high nutritional value, climate resilience and environmental sustainability. Thus, it could be beneficial to mainstream these nutri cereals by including them in people's staple diet and agricultural practices. In order to tap into the full potential of millets, one can adopt a four-pronged strategy coined as 'PAID' – **p**roduction enhancement, **a**wareness creation, **i**nnovation and **d**emand generation.

The proposed four-pronged strategy for mainstreaming millets



Source: PwC analysis

3.1. Production enhancement

Millets, being climate-resilient and nutrient-dense grains, offer a sustainable solution to various food and environmental challenges. Considering promotional efforts to increase domestic consumption, and the projected export demand of millets being 0.56 million metric tonnes,[63] it is essential to boost production to have market supply and demand equilibrium.

3.1.1. Ways to enhance millet production

Increasing land under millet cultivation:
Setting state-wise year-on-year targets for increasing the land under millet cultivation is a crucial step towards mainstreaming millets and ensuring their contribution to sustainable agriculture and nutrition security. For example, in states where millet cultivation is already prevalent, the focus can be on maintaining and expanding the existing cultivation areas by 5% annually. In states with moderate millet cultivation, the target could be more ambitious, aiming to increase the land under millets by 10% each year. This approach seeks to capitalise on the potential for expansion and diversification of crops. In states where millet cultivation is limited, the focus could be on rapid expansion of millet cultivation. The target for such states could include doubling the land under millet cultivation each year, combined with support for capacity building and research to encourage farmers to increase millet production.

Improving the seed replacement ratio (SRR):
Monitoring and keeping a tab on the SRR could prove to be instrumental in promoting millet cultivation and enhancing crop productivity. The SRR can be improved by tracking the percentage of farmers who adopt improved and certified millet seeds in each cropping season. A higher SRR indicates increased acceptance and utilisation of improved seeds, which can lead to better yields, disease resistance and overall crop performance.

63. https://apeda.gov.in/milletportal/files/Indian_Superfood_Millet_APEDA_Report.pdf

Participation of FPOs:
The participation of FPOs can enable collective bargaining, resource sharing and better access to markets for millet farmers. Therefore, it can be beneficial to encourage the formation of more FPOs.

Incentivising farmers:
In order to promote millet cultivation and its adoption, farmers can be given targets along with incentives associated with them. These targets may vary based on the current state of millet cultivation, agricultural potential and the Government's priorities.

However, it is important to align these targets with the overall vision of promoting millet cultivation as part of sustainable agriculture, improving food and nutrition security, and empowering rural communities. Therefore, regular monitoring and progress evaluation can help in ensuring the effectiveness of the incentives and guide policy adjustments to achieve the desired outcomes.

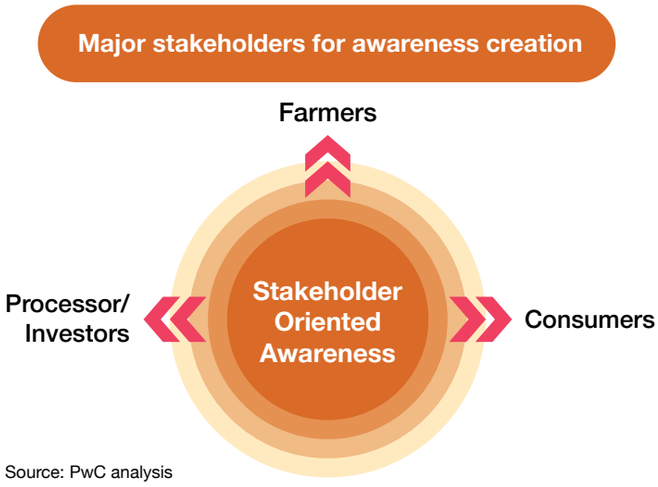
3.1.2. Increasing production of millet-based products

Enhancing the production of millet-based products is a transformative step towards promoting them and diversifying our food choices. The Nutrihub Technology Business Incubator (TBI) at ICAR-IIMR, Hyderabad is an organisation that aims to bolster and nurture the millet start-up ecosystem. These start-ups receive comprehensive assistance, including technology support, mentoring, capacity building, financial aid, marketing facilitation and access to infrastructure for manufacturing their value-added products using various processing lines. However, having a single such organisation is not enough to create an impact. Therefore, there is a pressing need for more millet-focused business incubators throughout the country, to bring millets to the centre stage of private investment. Following measures can be taken to boost the production of millet-based products in the market:

- **Streamline the regulatory framework** related to millet production, processing, distribution and marketing ventures.
- **Lower the GST rates** on millet-based products to reduce the price and increase affordability.
- **Enable market access** for millet producers by connecting them with potential buyers, retailers and exporters. Encourage public–private partnerships to create robust market **linkages**.
- **Incentivise the processing and export** of millet products, encouraging large private companies to aggressively adopt millets into their product portfolio, in order to increase overall demand.
- **Establish quality testing labs** to assess the nutritional value and quality of millet grains. This ensures compliance with quality standards and builds consumer trust.

3.2. Raising awareness

The combination of awareness and R&D can be quite useful in promoting millet-based products. The dissemination of research findings helps in highlighting the positive attributes of millets, making them more appealing to consumers. At the same time, public interest and demand for millets create a market pull, encouraging further investment in R&D to enhance millet cultivation, processing and value addition.



Source: PwC analysis

3.2.1. Creating awareness among farmers

Creating effective awareness strategies for farmers is crucial to promote millet cultivation by focusing on the benefits, cultivation techniques, market potential and overall sustainability of millet production. Some of these strategies are outlined below:

Production package and practices:
Provide detailed information about millet cultivation and best practices to ensure a successful millet crop.

Production benefits:
Inform farmers about the growing market demand for millet-based products, making them aware about both domestic and international market opportunities.

Farm economics:
Highlight the fact that millets often require fewer inputs, such as fertilisers and pesticides, and irrigation. Also explain how crop diversity can improve overall farm productivity by enhancing soil health, reducing pest infestation and plant diseases.

Climate resilience:
Explain the climate-resilient nature of millets and how millets are suitable for regions with water scarcity or erratic rain patterns. Emphasise on how they can be a sustainable option in the face of climate change.

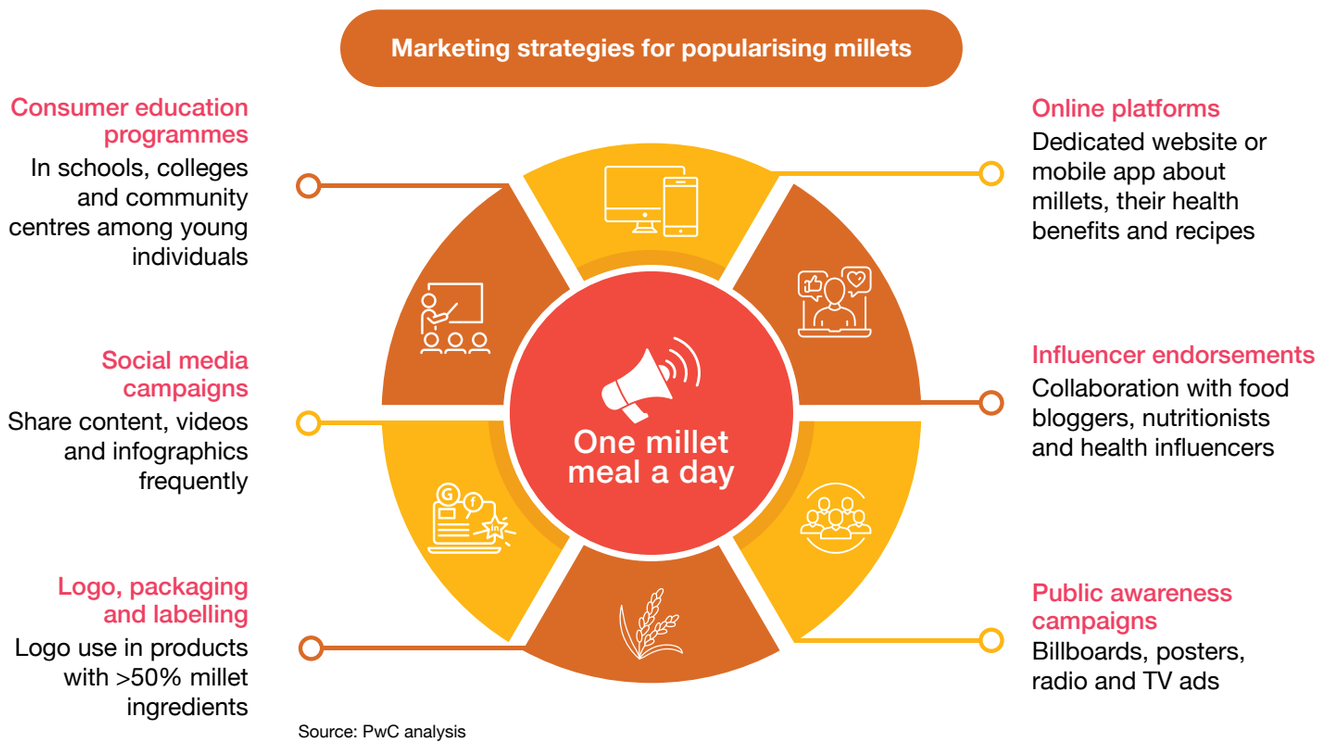
Government support:
Inform farmers about Government policies, schemes and subsidies to promote millet cultivation. Help them navigate through the available resources to access financial assistance and technical support easily.

Tools to raise awareness about millets

- Farmer field school
- Demonstration plots
- Training programmes
- Extension services
- Farmer meetings and conferences
- Radio and television programmes
- Engaging input shops

3.2.2. Creating awareness among consumers

Awareness among consumers is a crucial aspect of promoting millets and integrating them into their daily diet. Sustained awareness is essential for top-of-mind product recall, which can be facilitated by a widespread campaign to promote millet consumption. For example, the NECC campaign on egg consumption, 'Sunday *ho ya* Monday, *roz khao andey*' was a majorly successful campaign.[64] Similarly, millets can be promoted through similar programmes to enhance their adoption.



Source: PwC analysis

3.2.3. Creating awareness among investors and food processors

By raising awareness about millets, investors will soon be able to recognise the economic viability and growth potential of millet-related ventures, leading to increased investments in millet processing industries and value-added product development. Additionally, food processors, equipped with knowledge about millets' nutritional benefits and diverse applications, can incorporate these grains into their product portfolios, catering to the growing consumer demand for healthy and eco-friendly food options. By following targeted awareness initiatives, stakeholders in the food industry can collectively contribute to a more sustainable and nutritious food future by embracing the untapped potential of millets. Some strategies to do this have been highlighted below:

- **Organise investment forums and conferences** that highlight opportunities in the millet sector, showcasing its potential for growth, profitability and sustainability. **Conduct seminars** tailored for investors, providing in-depth insights into the millet value chain, market trends and the business potential of millet-based products.

64. https://www.forbesindia.com/article/storyboard18/throwback-neccs-eggcellent-roz-khao-ande/75431/1

- **Disseminate information about Government incentives** for millet-based businesses to investors and food processors to make them aware about various subsidies, tax benefits and grants.
- **Facilitate collaboration with industry associations** and chambers of commerce to advocate for millets and promote their inclusion in investment portfolios.
- **Organise networking events** where investors and food processors can interact with millet farmers, entrepreneurs and industry experts to foster potential collaborations. Explore collaboration opportunities with existing millet processing units or farmers' cooperatives or FPOs to demonstrate successful partnerships and shared benefits.

By implementing these strategies, awareness among investors and food processors can be increased significantly, thus driving investments in millet processing industries and stimulating the growth of millet-based products in the market.

3.3. Innovations

Innovation in product, process and policy plays a crucial role in mainstreaming millets. Innovative efforts are essential to enhance the productivity, quality and marketability of millets. Therefore, a holistic approach towards innovative endeavours will empower millets to become a key driver of sustainable agriculture, food security and nutritional well-being for future generations.

3.3.1. New crop and varietal innovations

Innovations in R&D will enable enhancement of millet production and productivity and development of high-yield varieties and value-added millet products. Some of the leading organisations for this sector are the ICAR, IIMR, Indian Institute of Food Processing Technology (IIFPT) and International Crops Research Institute for the Semi-arid Tropics (ICRISAT). The IIMR coordinates and facilitates millet research at the national level through the AICRP on sorghum, pearl millet and small millets and provides linkages with various national and international agencies.

Recently, hybrids and high-yield varieties were launched on important traits – for example, CSH 48 early maturing hybrid and CSV 50 medium maturing variety with increased productivity than earlier varieties of sorghum, CSH 22SS sweet sorghum hybrid with juice yield, MPMH 21 hybrid of pearl millet with climate resilient variety, gene(s) introgression from wild to cultivated for the diversification of finger millets. Although efforts are being made to increase the overall productivity of millet crops, the focus of R&D is currently limited to a few major millets at present. As India has various types of millets being grown in different regions, the R&D departments should adopt new approaches to use suitable breeding and genetic improvement technologies for millet production. They should also focus on developing varieties which can overcome the challenges of the current millet market such as:

varieties with longer shelf life or non-rancid properties

varieties having easier and better baking qualities with specific protein content

varieties having better milling percentage, ultimately yielding a higher proportion of desirable end product

varieties that are more input-responsive, requiring lesser consumption of fertilisers, pesticides and herbicide.

Actionable strategies to promote innovation in millet crops

1 	**Allocating dedicated funds**	The Government should allocate dedicated funds for millet-specific R&D initiatives, distributed in proportion among all major and minor millets.
2 	**Promoting PPP projects**	Facilitate collaborations between research institutions, universities and agri-business organisations to undertake joint projects aimed at increasing millet yields.
3 	**Establishing millet-specific research centres**	Every state should have a specialised research centre, or must take measures to improve existing ones, focused on state-specific millets. These centres can collaborate with farmers, scientists and industry experts to drive innovation and promote higher-yield techniques.
4 	**Providing knowledge-sharing dashboards**	Leverage technology to encourage access to research findings and enable collaboration between various research institutions to foster knowledge sharing in both domestic and international markets.
5 	**Establishing millet seed banks**	Establish millet seed banks in India which encompass all millet varieties in one place in order to conserve the genetic diversity of millets.

3.3.2. Value-added product innovations

Value addition in millet production involves processing raw agricultural produce into more refined and diverse forms. For consumers, value-added products provide convenience, quality and a broader range of choices – like how wheat is consumed in diverse forms (fine flour (maida), whole wheat flour (atta), broken wheat (dalia), sooji, etc. In order to enhance value, it is important to conduct thorough research to overcome the following challenges:

i. **Enhance shelf life and preservation:** Compared to refined cereals like rice or wheat, millet-based processed products have shorter shelf lives and are not suitable for consumption post that. Therefore, changes in processing or packaging techniques should be introduced for the development of newer products which can be made from different types of millets.

ii. **Processing of by-products:** Proper utilisation of processing by-products and waste is also a challenge as the husk-to-grain ratio in millets is high. Thus, appropriate R&D is required to find economically viable and sustainable ways to utilise by-products for a circular economy approach.

iii. **Culinary innovations:** Collaboration with chefs, food experts and culinary schools must be encouraged to create innovative and appealing millet recipes and consumer-friendly ready-to-eat/cook millet-based products. As present-day consumers often choose foods on the basis of various factors such as palate preference and easily digestible properties, such collaborations can help in experimenting with flavours, textures and cooking techniques to make millet products more enticing to the consumers.

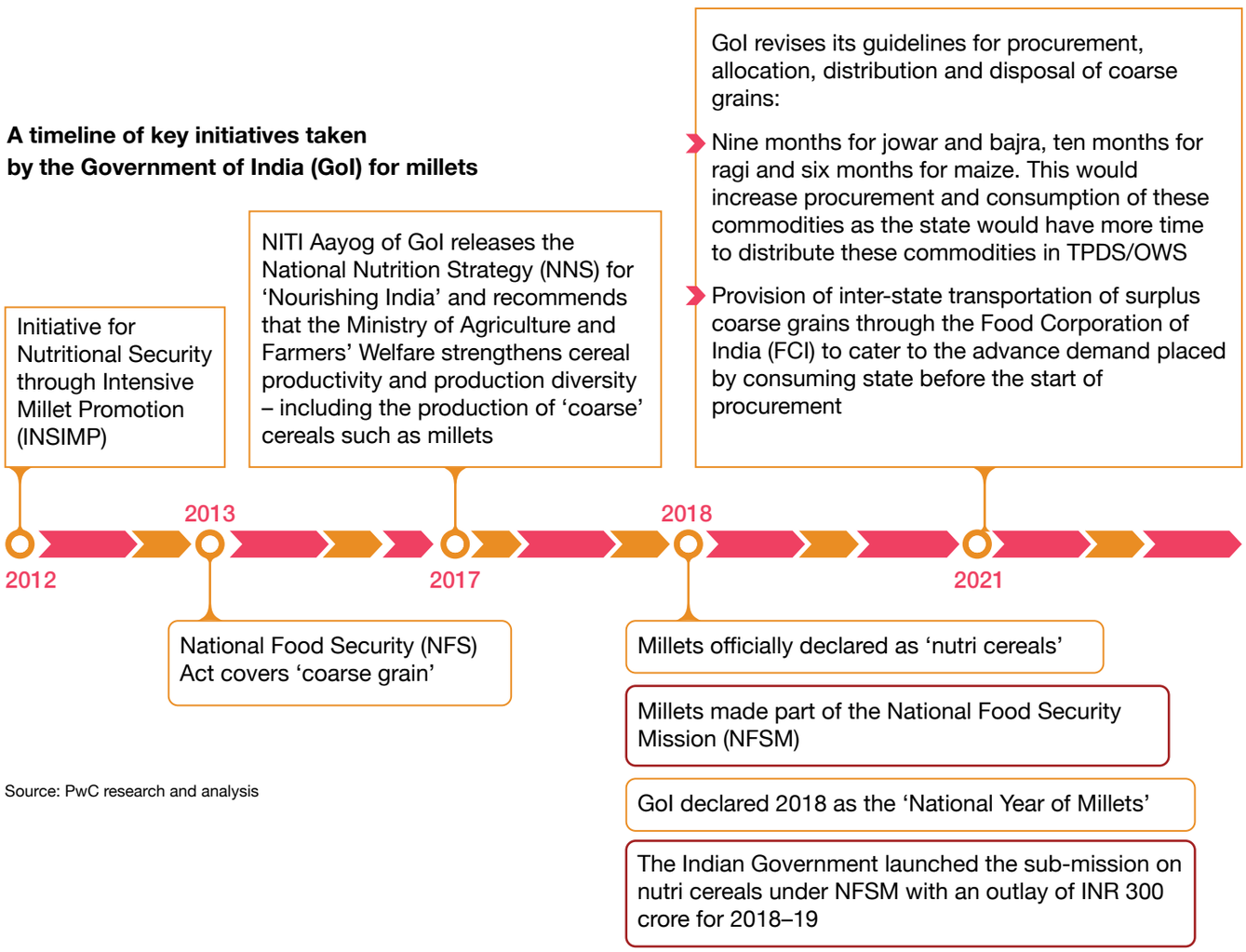
3.3.3. Farming and processing equipment innovation for millets

There is a need to develop customised processing equipment for different type of millets, such as:

i. **Manufacturing of modern harvesting equipment:** Millet harvesting is a labour-intensive process, as it often involves manual cutting and threshing of small grain heads. The lack of modern harvesting equipment that is tailored to different sizes of millet fields and millet grains makes harvesting less efficient and increases labour costs.

ii. **Development of efficient processing equipment:** Millets have certain intrinsic qualities such as small grain size, high husk content and harder grain texture. These qualities make it difficult to process millets and increase the processing time and energy requirements. As a result, this leads to lesser number of millet processors in the vicinity of farms. Therefore, it is necessary to develop millet processing equipment that is affordable and adjustable to different grain sizes.

A timeline of key initiatives taken by the Government of India (GoI) for millets



Source: PwC research and analysis

3.3.4. Policy innovations – boosting millet production and consumption

Policy innovation is crucial to foster the growth and mainstreaming of millets by creating an enabling environment through supportive policies that incentivise millet cultivation, promote market linkages and integrate millets into public food schemes.

GoI has been in the process of promoting millet production through multiple schemes launched over the past decade. A few state governments have also launched schemes and initiatives to promote millet production and consumption. However, there is a need for more comprehensive and long-term nutritional and health security programme.

Select states and initiatives taken to promote millets

Karnataka	Andhra Pradesh	Telangana	Odisha	Rajasthan
Food of the Future initiatives and Karnataka Organic Farming Policy	Smart Food Andhra Pradesh and Comprehensive Revival of Millets Cultivation in the tribal region	Telangana Millet Mission	Odisha Millet Mission	Rajasthan State Food and Nutrition Security Policy

A. Five-year National Millet Mission

A long-term national-level mission on millets is needed to give impetus to the mainstreaming of millets within a stipulated period of time. The mission should include guidelines for all state governments that cover aspects such as FPOs, infrastructure, seed hubs, farming incentives, farm-gate value addition and capacity building. In order to increase the area under millet cultivation and support the sustainable cultivation, processing and consumption of millets, the country requires forward-thinking and comprehensive policy reforms.

Development of a five-year National Millet Mission plan

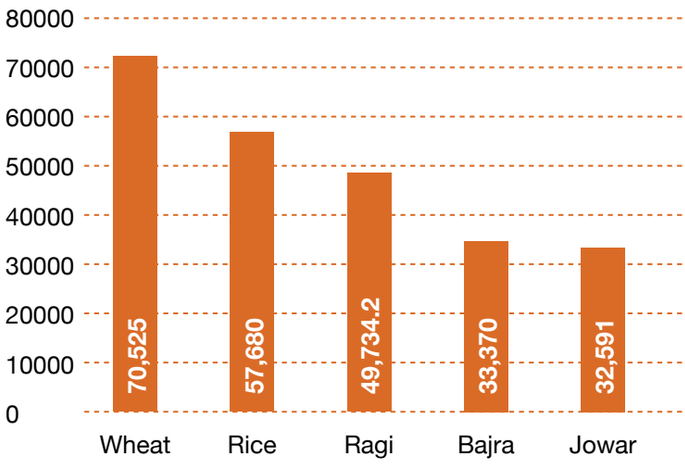
Scope	Extends across all states and union territories
Benefits	Production support for seeds/fertiliser/farm mechanisations/other inputs Credit Linked Subsidy Scheme for processing infrastructure creation in millet-based products Enhanced interest subvention benefits under the Agri Infrastructure Fund (AIF) Scheme (e.g. 5%) Promoting PPP in infrastructure creation through viability gap funding Branding/marketing /awareness support
Mode of implementation	Five-year mission to be monitored by GoI and implemented by state governments. A separate directorate/technical support agency at the state level to be constituted to serve as the nodal implementation agency

B. Production incentives for millets – going beyond MSP

At present, the central agency – the CACP declares the MSP for 22 mandated crops, including three of the major millets – sorghum (jowar), pearl millet (bajra) and finger millet (ragi). However, according to the Handbook of Statistics on Indian Economy 2021-22 by the Reserve Bank of India (RBI), except for ragi (25%), Government agencies procured less than 5% (Handbook of Statistics on Indian Economy 2021-22) of the total production of the other two major millets. On the other hand, the Government has neither procured nor declared an MSP for **any of the minor millets**.

Select states and initiatives taken to promote millets

Net revenue earned by a farmer cultivating 1 ha of land



Crop	MSP (in INR per quintal) for 2022–23 except wheat (for 2012-22)	Average productivity in the country (in MT/ Ha)
Wheat	2015	3.5
Rice	2060	2.8
Ragi	3578	1.39
Bajra	2350	1.42
Jowar	2990	1.09

(Source: https://farmer.gov.in and https://pib.gov.in)

Key takeaways:

Cultivating wheat in a hectare of land yields the highest return of around INR 70,000, followed by paddy, ragi, bajra and jowar in descending order.

Thus, mainstreaming of millet production by replacing paddy in the kharif season and wheat in the rabi season can only be done by incentivising farmers.

Apart from declaring an MSP for millets and procuring the crop, the Government needs to incentivise farmers for cultivating a crop that is environmentally friendly, as well as compensate them for any losses from the present opportunity cost of growing paddy or any other crop. Strategies for this purpose must encompass:

- increase MSP or what may be termed as 'planet supportive price (PSP)' for millets
- increase the premium on millet procurement to boost production
- declare an MSP for other minor millets
- carbon credit certificate issuance for growing millets in a paddy field and a mechanism to transfer benefits to farmers.

3.4. Demand generation for mainstreaming millets

Millet demand generation would depend on consumer enthusiasm and greater nutritional awareness through education, product innovation, partnerships, sustainability, and solutions to social challenges. By creating a positive and inclusive narrative around millets, their integration into mainstream diets can be fostered, benefiting both consumers and the environment.

Demand generation for both domestic and export markets involves a combination of consumer awareness, product diversification, retailer engagement, government support, market research, trade promotion, sustainability initiatives and adherence to international quality standards.

3.4.1. Creating domestic demand for millets

A sustainable approach for mainstreaming millets is the development of a demand/market-driven production system and the use of a **push strategy by the Government** and a **pull strategy for households and private players**.

- The initial thrust will come from the Government through the issuance of guidelines for all state governments on including millets in their PDS, mid-day meals, Government canteens such as those in hospitals and colleges. Also, the consumption of millets should be made compulsory at military and police canteens/camps.
- Household consumers in both urban and rural areas need to be motivated to choose millets over fine cereals by promoting their health benefits. This would require coordination across different medical associations, nutritionists and chefs' clubs.
- Setting up millet cafés in public places all over the country could help in popularising diverse millet-based products by increasing accessibility and availability. These restaurants may be Government-owned or based on a PPP model, with checks on the sale of products other than those that are millet based. This will also serve as a selling point for products from different millet-based start-ups.
- For greater visibility of millets at retail stores, retail chain players must be instructed to display millet-based products in prominent positions in the first aisle of the food segment of stores.

3.4.2. Increasing global demand for millets

Initiatives by the GoI to increase demand for millets in the international market focus on elevating their prominence as a versatile and nutritious food source. Globally, 28% of millets produced are utilised as animal feed and rest 72% is used for food, seed and industrial purposes (FSI).[66] India's production doesn't match the global demand of preferred millets in the world and exports very less to top importers (value wise), fetching lesser returns.

Through a comprehensive approach, this campaign aims to create awareness and generate enthusiasm among global consumers about the numerous health benefits of millet consumption by the Government, private players, export authorities and industry associations. Along with collaborations with international organisations, trade fairs and digital marketing efforts, the campaign seeks to showcase the diversity of millet-based products and recipes, catering to different cultural preferences.

Factors driving the promotion of exports and creating global demand for Indian millets

Catalysts for creating a global demand for millets	
Quality assurance	High-quality millet products that meet international standards, strict quality control measures throughout the supply chain
Market research	Identify potential export markets and consumer preferences to understand the demands and tastes of the target countries
Product diversification	Offering a diverse range of millet-based products that can appeal to a broader international audience
Government support	Collaboration with Government trade promotion agencies, financial incentives, and support in navigating export regulations and procedures
Export incentives	Export subsidies or tax benefits, freight subsidy on millets and millet-based products, exemption/reduced tax on sales and purchase of millet-processing machineries across the country
Certification and traceability	Relevant certifications for organic, fair trade, or sustainable production practices to enhance the credibility of Indian millets and appeal to environmentally and socially conscious consumers in the global market

Source: PwC analysis

Millets will also help India achieve its net zero greenhouse gas emission commitment by contributing to carbon sequestration through improved soil health and reducing greenhouse gas emissions from agriculture. India can effectively promote its millet products in the global market and expand its international presence by increasing millet exports.

The holistic development and mainstreaming of millets can be achieved through the above multi-faceted approach which aims at revitalising the demand for these nutritious grains and making them an integral part of people's lifestyles and nutritional choices.

66. APEDA and PwC analysis

4. Conclusion

Millets – or Shree Anna or nutri cereals – have significant importance both for the world and for India. Their resurgence is driven by a combination of nutritional, environmental and economic factors.

Globally, millets can have a significant and positive impact on people's health and wellbeing, and their exceptional nutritional profile has earned them recognition as a superfood. Rich in protein, dietary fibre, vitamins and minerals, the nutritional impact of millets on people's live is undeniable, and these grains can serve as a sustainable solution to the problems of food and nutritional security.

Millets are also known for their adaptability to diverse climatic conditions, their robustness in withstanding erratic rainfall patterns, water scarcity and heat stress. This makes them an essential crop for maintaining agricultural productivity. Due to these climate resilience properties, millets are an invaluable asset in our ongoing efforts to mitigate the impacts of climate change and builds a sustainable future for our planet.

As a crop, millets demand minimal inputs. This makes them well suited for small-scale farmers who follow cost-effective and sustainable agricultural practices. The economic benefits of millets extend far beyond field yields as they empower farmers, stimulate local economies and foster entrepreneurship while tapping into a growing global market for sustainable and nutritious foods. By recognising and investing in the economic potential of millets, we can pave the way for greater prosperity, enabling this resilient and versatile crop to contribute significantly to the well-being of communities and the growth of economies, both at home and abroad.

However, to achieve the desired level of growth, it is an opportune time to catapult from celebrating the IYoM to celebrating a Decade of Millets (DeOM) to tap the intrinsic potential of this wonder crop.

About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialisation and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policymakers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policymakers and the international business community.

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Notes

Notes

About PwC

At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 152 countries with over 328,000 people who are committed to delivering quality in assurance, advisory and tax services. Find out more and tell us what matters to you by visiting us at www.pwc.com. PwC refers to the PwC network and/or one or more of its member firms, each of which is a separate legal entity.

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The team comprises professionals who have an extensive experience in various aspects of agriculture, including advisory in the agriculture and food domain, supply chain management, public-private partnerships, policy advocacy, agri economics, agri retail, agri marketing, farm inputs and banking.

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