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Orphan Crops for Sustainable Food and Nutrition Security

Promoting Neglected and Underutilized Species

Edited by Stefano Padulosi, E. D. Israel Oliver King, Danny Hunter and M. S. Swaminathan

Issues in Agricultural Biodiversity

ORPHAN CROPS FOR SUSTAINABLE FOOD AND NUTRITION SECURITY

Orphan Crops for Sustainable Food and Nutrition Security discusses the issues, challenges, needs and opportunities related to the promotion of orphan crops, known also as neglected and underutilized species (NUS).

The book is structured into six parts, covering the following themes: introduction to NUS, approaches, methods and tools for the use enhancement of NUS, integrated conservation and use of minor millets, nutritional and food security roles of minor millets, stakeholders and global champions, and, building an enabling environment. Presenting a number of case studies at the regional and country levels, the chapters cover different but highly interlinked aspects along the value chains, from acquisition and characterization of genetic diversity, cultivation and harvesting to value addition, marketing, consumption and policy for mainstreaming. Cross-cutting issues like gender, capacity building and empowerment of vulnerable groups are also addressed by authors. Representatives from communities, research for development agencies and the private sector also share their reflections on the needs for the use enhancement of NUS from their own perspectives.

This book will be of great interest to students and scholars of food security, sustainable agriculture, nutrition and health and development, as well as practitioners and policy-makers involved in building more resilient food and production systems.

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PREFACE AND ACKNOWLEDGMENTS

Today we are confronted with two major paradoxes globally – the persistence of hunger in the midst of an impressive technological capacity to grow more food; and the narrowing of crop diversity within global food systems in the face of a fast-growing world population. Both conditions call for urgent actions to ensure a world without hunger.

Agriculture is the mother of nutrition security. It is believed that agriculture or settled cultivation began over 12,000 years ago with women growing crops of importance to life on earth. Yet, over time, the importance of genetic variability was not given adequate recognition, leading to an over-reliance on a few crops such as rice, wheat and maize. Not only has this resulted in a large number of plants becoming extinct, but it has also put the food and nutrition security of the poor and marginalized, dependent on a range of crop species, at risk. With a focus on the standardization of production systems, not only are species lost, but so are markets – national and international – as is research interest in improving the productivity of these crops. This is why planned initiatives for the conservation, cultivation, consumption and commerce of genetic resources are important.

Maintaining the genetic diversity of crops is even more critical in today's context of climate change. It is, in fact, the dynamic maintenance of agrobiodiversity operated by farmers in situ/on farm that could help make our food systems more resilient. Whereas the world can feel relatively comforted by the 1,450 gene banks that have been built to safeguard crop diversity – including the Svalbard Vault in Norway – much more needs to be done to map, collect, characterize, document and evaluate the thousands of orphan and underutilized crops, today just marginally conserved in gene banks, but whose survival is thanks to the laborious work of millions of farming communities around the world, a service done for the public good – but at their own personal cost! In that regard, the work pursued by the M.S. Swaminathan Research Foundation and other NGOs

in building capacities of farmers in conserving local crop needs should be encouraged and supported.

Given the scarcity of land, we must recognize that ensuring food security cannot be addressed by expanding land available for agricultural activities. We need to embrace a different paradigm that, while using less land, can provide more food from crops that are better adapted to climate change. At the same time, we need to do more to safeguard biodiversity so as to kee foodscapes healthy and productive; reduce the depletion of finite resources like water and soil; promote equitable, gender-inclusive food systems and foster greater synergy between scientific and indigenous knowledge. The role of women in feeding the planet needs to be better recognized and supported.

One of the great achievements of science was the development of our ability to describe the genomic structure of major crop species and their wild relatives, which has provided a wealth of information useful for increasing both crop production and productivity. However, what we are witnessing now is that yields of major crops are reaching a plateau that may not be easy to overcome. More innovative solutions are needed to address the yield bottleneck. Leveraging agrobiodiversity to grow more and diverse nutritious food in difficult areas with poor soil and challenging climatic conditions should receive greater attention. This is not new to us, since risk-aversion practices have always guided generations of farmers who have been growing different crop and varietal mixes to buffer against shocks. Farming families have often been motivated by a desire to minimize risks, not just maximize profits; hence, the wisdom underlying the decisions to balance subsistence and market motivations needs to be recovered.

In fact, significant progress in agronomic research and the adoption of systems approaches have shown the many benefits that biodiversity-based practices can bring about in challenging conditions, not just to the environment, but equally to ensuring the food and nutrition security of local communities. Crops considered 'orphan, underutilized and neglected' are all extremely valuable as not only are they often more nutritious than the major cereals, but also tend to need less water and are more tolerant of high temperatures and grow better in difficult climatic conditions.

I have stressed, on various occasions, the disparities in access to technology that we are witnessing today. Despite the many exciting developments – be it in digital and precision agriculture, biotechnologies or ecotechnologies – we still register what I describe as a 'technological apartheid', which is contributing to 'orphan crops remaining orphans' in relation to the choice of research areas for their use enhancement. A good example is the case of technology for processing minor millets, which until recently was hardly accessible for rural households, discouraging the consumption of these nutritious foods where they are most needed.

Back in 1968, I warned that if all locally adapted crop varieties were replaced with one or two high-yielding strains, it could lead to serious damage from pests, pathogens and weeds, contributing to the making of major agricultural

and ecological disasters. Fifty years later, I believe we still face such a risk, and the diversification of crops and varieties in production systems has become even more critical to safeguarding our future. This is one reason why I emphasized the need for a new "ever-green revolution" guided by diverse nutritious crops to strengthen our diets, ones that would require less water and fewer chemicals and would be able to grow in periods of change. Orphan crops will be a big part of this revolution I am advocating. In October 2018, I proposed to the UN's Committee on Food Security that we have a year devoted to promoting these crops, to try and revive them by revitalizing markets, research and the culinary tradition that used them.

Very important here is the need to ensure farmers' engagement and, indeed, their food sovereignty. Unfortunately, while the concept of farmers' rights is widely discussed in national and international fora, its practical application remains largely inadequate. The international community should be made more aware of the fact that the loss of every gene and species limits our options for a secure future, particularly in the context of climate change and related unforeseen shocks.

This book covers many of the issues hindering the successful promotion of orphan crops in India and around the world. Minor millets are the leitmotif of this publication and are leveraged as an example to describe the needs, challenges and opportunities in bringing to scale the cultivations of orphan crops. More than 20 years ago, at an FAO conference, I pleaded that we should refer to millets as 'nutri-rich and climate smart' food grains. I felt that the change in the terminology being used to refer to these crops was much needed. It is heartening to acknowledge that the Indian government has taken a great step in including millets in the public distribution system under the 2013 National Food Security Act – a testimony to the fact that millets are no longer perceived as inferior foods.

The book covers numerous aspects related to the promotion of underutilized crops, including participatory approaches, methods and tools for their use enhancement, conservation methods, market analyses and promotional strategies and policy needs for their mainstreaming. Cross-cutting issues like gender, capacity-building and empowerment of vulnerable groups are also covered. Representatives from various local communities and the private sector also share their reflections and perspectives on the wider use of these crops, as do several international agencies. I would like to acknowledge and thank them for supporting numerous projects to advance the agenda of 'NUS' around the world.

Several chapters focusing on millets have been developed from talks delivered at the international conference on this theme that took place in April 2018 in Chennai, India. These have been complemented by additional studies focusing on other representative orphan crops from around the world. I believe that, together, these contributions will enrich the socio-cultural perspectives and the R&D outlook for the future of these crops to help build more inclusive and sustainable food systems.

The book is the result of a successful close cooperation between the M.S. Swaminathan Research Foundation (MSSRF) and Bioversity International (now The Alliance of Bioversity International and CIAT), an organization whose establishment I had the honor of contributing to some 46 years ago and whose mission I still see as being of high strategic value to the world.

We trust that such a publication will be of great use to students and scholars, practitioners and stakeholders, including policymakers involved in building more resilient food and production systems. I also believe that some of the insights in this book could contribute towards building farming systems for nutrition, a concept that signifies bringing agriculture, nutrition and health into a sustainable public-health management system.

I wish to thank Stefano Padulosi, Israel Oliver King and Danny Hunter for their invaluable ideas in conceiving and bringing this book to reality. Their highly committed compiling and editing efforts are much appreciated. I join them in expressing a special thanks to the Indo-Swiss Collaboration in Biotechnology – ISCB, Switzerland, for their financial contribution in support of this publication. Many are those organizations that have been supporting NUS projects around the world, leading to invaluable discoveries and lessons, now shared through this book. While acknowledging their support in each respective chapter, the other editors and I would like to convey our sincere gratitude to them for championing the NUS agenda at the national and international levels. I hope this book will be an inspiration to many others in further strengthening ongoing efforts for bringing NUS back to full fruition, for the benefit of current and future generations.

Prof. M.S Swaminathan

28

THE SMART FOOD APPROACH

The importance of the triple bottom line and diversifying staples

Joanna Kane-Potaka, Nigel Poole, Agathe Diama, Parkavi Kumar, Seetha Anitha and Oseyemi Akinbamijo

Food system solutions incorporating a Smart Food Triple Bottom Line approach

'Food security' was the key focus in developing countries while mass starvation was a real threat. Alleviating hunger was a driving force for the Green Revolution (Behera, 2017). Awareness of hidden hunger then surfaced, and '*nutrition security*' was added to the rhetoric. More recently, the UN and other organizations have underlined the imperative for '*sustainable diets',* defined as "diets with low environmental impacts which contribute to food and nutrition security", and the urgency to set targets to strive towards this.

The next critical step is to cater to all these needs and go one step further with solutions that are not only good for you and the planet, but also for the farmer. The Smart Food Triple Bottom Line advocates for solutions that approach all these three areas in unison. This is recommended as a framework for food system solutions. It will also help break down both discipline and sector silos.

Applying these solutions with crops that are 'smart foods', that is, foods that are inherently good for you, the planet and farmer, will strengthen our ability to achieve the 'Smart Food Triple Bottom Line'. Many NUS may fit the criteria of being a smart food. They may be good for the farmer and environment because they bring diversity to the farm, are more suitable crops for varying agro-ecologies, are crops that need fewer inputs and are resilient to the vagaries of climate change. However, without well-developed value chains that are sensitive to consumer awareness and demand, it is challenging to make them financially viable for the farmer.

It is paramount that having less-developed value chains do not become the excuse for continuing to support the same few major crops. It is regularly expressed that we need to transform the food system. A purposeful and consistent strategy

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for the said transformation becomes imperative and the 'Business as usual' will not achieve this. Changing where we invest resources and supporting policies are needed, and strengthening value chains of smart foods so as to mainstream them is an opportunity for us to contribute to many of the UN's Sustainable Development Goals (SDGs) in unison.

A project in Kenya applied the 'Smart Food Triple Bottom Line' approach with NUS, tackling diversity in diets, diversity on farms and diversity in incomes, with the aim of crops being commercially viable as well as being consumed by the local community to improve diet diversity and nutrition. Six smart foods including millets, sorghum and legumes were selected and focused on. Families of over 60,000 children below the age of five were reached through volunteer Smart Food Ambassadors, who spread nutrition messages and conducted fun activities like cook-offs. The integration of education, health, nutrition and a fun approach in conveying the same message imparted strong knowledge of millets, sorghum and legumes.

> In just one year, the behavior patterns of the women and children changed significantly towards adopting a more micronutrient-rich diet, indicated by an increase of 15% in dietary diversity score for women and of almost 80% in the children's dietary diversity score. Similarly, consumers showed a considerable change in buying patterns. Rich in iron and fiber, both cowpea and pearl millet sales at the farm level more than doubled. Production also increased for all the smart food crops except finger millet. Consumption of four of the smart food crops increased. Households became more commercially oriented and sales of four of the crops increased.
>
> *(ICRISAT, 2018)*

Diversifying staples with smart foods for big impacts

To complement this approach of all food solutions having a Smart Food Triple Bottom Line, there is also a specific objective under the Smart Food initiative to diversify staples. Big impacts can be achieved by focusing on diversifying staples, given that across Africa and Asia staples can typically constitute as much as 70% of what is on the plate, and are often refined and low-nutrient carbohydrates, with approximately 60% of calories in developing countries coming from cereals – a number that can even be more than 80% in the poorest countries (Awika, 2011; Anitha et al., 2019a).

The diversification of staples with foods that fit the smart food criteria of being good for you, good for the planet and good for the farmer will require dissolving the boundaries of the '***Food System Divide***', where the largest investments have for decades gone into the Big 3 staples – rice, wheat and maize – including government support, private industry investment, R&D, product development and even development aid.

NUS can regain their popularity and enter the mainstream through concerted multi-pronged efforts across the whole value chain. Lessons can also be learnt from the successes of the Big 3, but approaches must be applied in an appropriate, sustainable and healthy way.

Some steps key to diversifying staples being pursued as part of the Smart Food initiative are:

1 ***Dedicated effort on just a couple of smart foods***: Breaking the food system divide will take a focused approach and significant investments to develop value chains. Hence, an approach focused on just a couple of foods at a time is required. This complements initiatives that work broadly on popularizing NUS to bring diversity to farms and diets, and also builds niche markets that can be the springboard for larger markets in the future.

2 ***Selecting millets and sorghum first*:** Millets and sorghum were selected as the first foods to focus on and mainstream as they fit the profile of a smart food. Moreover, they were already the staples across many countries in Africa and Asia, with different millets originating from many countries and continents and growing from the Sahel to the Himalayas. They also fit into many global health food trends – being a super food, an ancient grain, gluten free with a low glycemic index (GI), high in fiber, good for managing weight, and good with strong health management.

   In particular, millets and sorghum are highly nutritious and fulfil some of the biggest health needs. For example, a few millets are very high in iron and zinc, which are among the top three micronutrient deficiencies globally. Taking bioavailability into account, the right varieties can provide as much iron as white or red meat. Finger millet has three times the amount of calcium found in milk. Most millets have a low GI, which is extremely beneficial within the context of community/public health due to the growing incidence of non-communicable metabolic disorders like diabetes; they are also a good alternative to other food sources high in complex carbohydrates like white refined rice (Anitha et al., 2021). They also have high fiber, reasonable levels of protein and, when combined with legumes, create a complete diet of protein with good levels of all the essential amino acids (Longvah et al., 2017; Anitha et al., 2019b).

   From a sustainable resource management point of view, millets and sorghum have a low carbon footprint. They are typically grown and thrive with minimal inputs like pesticides and fertilizers. They tolerate high temperatures and survive with very little water. They are often the last crop standing in times of drought, are climate smart and are a good risk-management strategy for farmers. They have multiple uses, from food, feed and fodder, to brewing and biofuels (Tonapi et al., 2015; Davis et al., 2019).

3 ***Create global commodities***: While the goal is to contribute to the SDGs and especially help poor and malnourished communities across Africa and Asia, in order to mainstream smart foods as staples, they need to be widely

adopted commodities globally. Focusing on portraying millets and sorghum as staples is also a key part of the plan for them to be affordable.

4 ***The consumer comes first:*** Most efforts and investments to date in millets and sorghum have been at the farm-production end. There is an urgent need to drive demand, by investing at the consumer end, changing perceptions, building awareness and creating a 'buzz' and desire around these smart foods. This is being achieved by working with food processors, governments and other key influencers.

Some key approaches that the Smart Food initiative has used to drive consumer demand include:

- **Working with the hidden middle**: Social entrepreneurs who genuinely want to change the food system for the better, and micro, small and medium enterprises (MSMEs) who are typically the pioneers in creating new consumer preferences, struggle as much as farmers do. Until MSMEs are equally supported, smart foods and NUS won't be available, affordable and, hence, accessible and demanded by consumers. They are often called 'the hidden middle' and need to be recognized as change-makers rather than only as operators in the value chain. Policy support is required to create a better enabling environment for MSMEs to thrive. The Smart Food initiative has launched a 'millet finder' that maps products around the globe to bring attention to the wide availability and silent revolution of millet and sorghum products being made available by MSMEs (smartfood.org, a).
- **Make it delicious, convenient and easy – the image and the reality:** For smart foods to be popularized, they have to be sought by the consumer. Although different foods are consumed for different purposes, to be popular in the mainstream and to reach the largest number of people, in general, food needs to be tasty, convenient and easy to make.
- **Promotion through chefs:** The catering sector is a conduit to taking new foods to the consumer as well as the way to change the food's image. The Smart Food initiative has engaged ambassador chefs, organized cooking master classes in West Africa, including with the President's chefs and a Smart Food Culinary Challenge for student chefs pan-India, and in Tanzania, chefs were introduced to street venders, who were trained on using millet and sorghum flour (smartfood.org, b).
- **Ambassadors and champions:** Influencers are important when perceptions and behavior need to be changed or significant awareness needs to be built. The Smart Food initiative has engaged VIPs to achieve this (smartfood.org, c), e.g., the First Lady of Niger, Dr. Malika Issoufou, became a Smart Ambassador, leading the way to a greater mobilization and commitment by the government for the cause of smart foods. She initiated an international millet festival (FESTIMIL), which captured a lot of attention among consumers, value-chain actors, farmers, processors and small and medium enterprises (SMEs) and served as a platform for a science and policy dialog on better developing value chains. This led

to Senegal announcing its interest in following suit to create an annual millet festival.

- **Media and social media outreach:** Outreach has been key in building awareness and reaching wider audiences (Diama et al., 2020). One example is the smart food reality show on Kenyan national television that reached 800,000 viewers (Vital, 2018).
- **International platforms**: Influencing researchers, governments, donors and industry are important and can be achieved through high-level panel discussions and international symposia (Diama et al., 2020).

5 **Scientific backing on nutritional benefits:** As far less R&D has been invested in NUS compared to the major staples, the field requires additional investment. The Smart Food initiative is currently collating and analyzing all existing nutrition studies on millets and sorghum, and is identifying research gaps. Some nutrition and consumer acceptance studies undertaken by the Smart Food initiative include:

- **India school feeding study:** A millet-based meal introduced for three months with 1,500 adolescent children had significantly higher nutritional levels compared to the control group of iron fortified rice-based meals, see Figure 28.1, and led to:

  – growth in terms of BMI and height, 50% more in the intervention group relative to the control group; and – high acceptance scoring ≥ 4.5 out of 5 for taste (Anitha et al., 2019a).

  Key lessons learnt on how to introduce millets to maximize nutritional benefits and acceptance, along with policy recommendations were identified and are shown in Figure 28.2.
- **Tanzania school feeding study:** Over 2,800 students in four boarding schools were introduced to finger millet and pigeon pea in their menu cycle in a participatory approach, taking into account cultural sensitivities. Fifteen months later, the schools were revisited and surveys identified that:
- 80% of the students changed their negative perception of finger millet;
- >95% of the students wanted to eat the finger millet dishes at school (Wangari et al., 2020).
- **Myanmar malnutrition and acceptance study:** This had a positive impact on the extent of wasting and underweight children between 2 and 14 months of age. Also sensory evaluations showed an average score of four out of five for all recipes and products (Anitha et al., 2019c).

Guiding the development of smart foods to keep or maximize their nutritional benefits is critical; this includes:

- **Popularize whole grain**: As most small millets have to be de-hulled, there is a risk they will also be polished to make them whiter and quicker to cook. It is important that consumers are exposed to the unrefined taste and

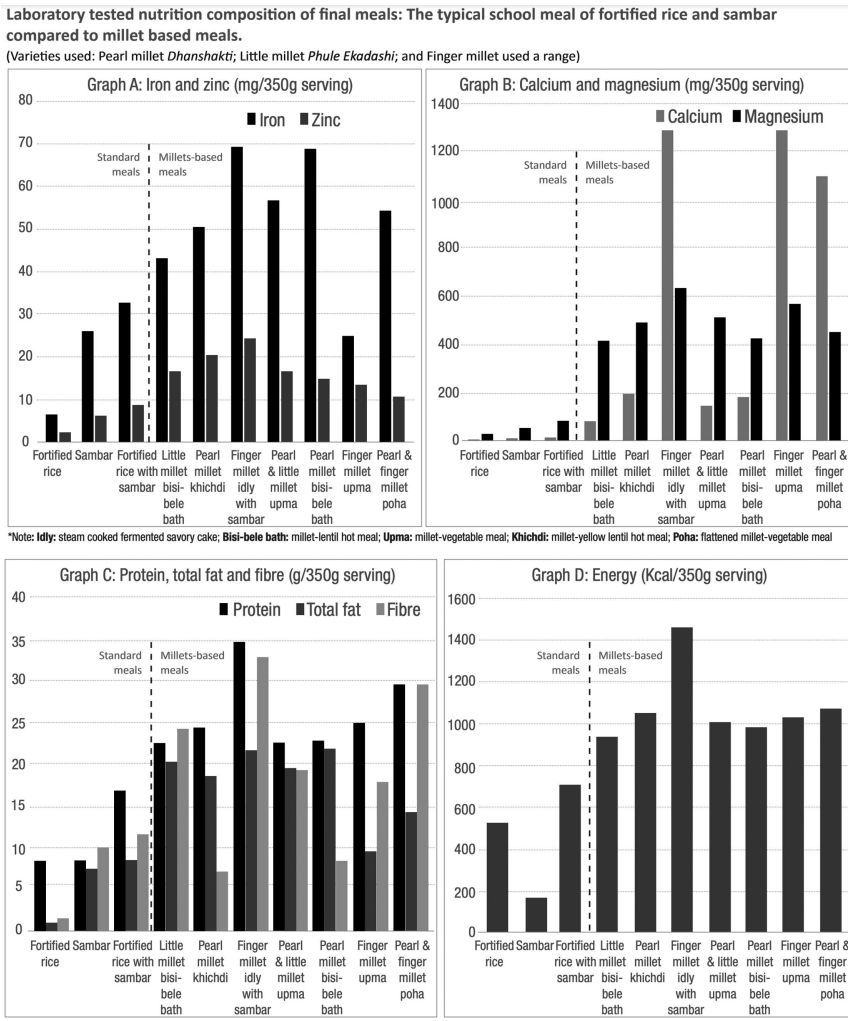

FIGURE 28.1 Nutritional value of fortified rice-based vs. millet-based meals. (ICRISAT, 2019).

convenient products made with the whole grain. Building awareness about the nutritional value of whole grain is essential.

- **Not ultra-processed or excessive added ingredients:** Efforts to diversify and popularize orphan crops will be to no avail if they are then over-processed and lose their nutritive value or if unhealthy ingredients like sugar, salt, saturated and trans fats and artificial additives are incorporated in high levels.
- **Selection of biofortified varieties:** Nutrition levels vary significantly by variety of the millets, so value chains from seed to consumer need to be

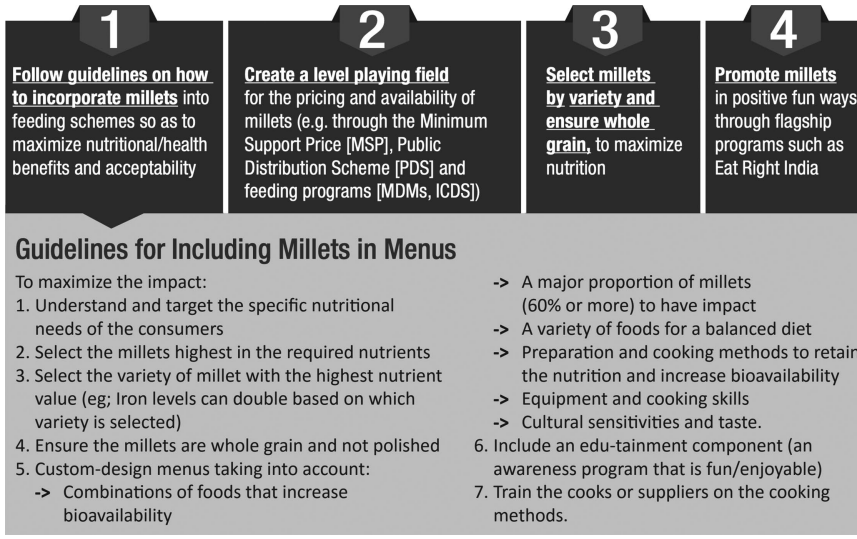

FIGURE 28.2 Policy recommendations for how to introduce millets into school meals.

developed and branded to recognize biofortified varieties in order to maximize the nutrition levels.

Conclusion

The Smart Food vision is a world where food is healthy, environmentally sustainable and contributes positively to the welfare of those who produce it, especially smallholder farmers. Studies have shown the positive nutritional benefits of millets and sorghum and high consumer acceptance for them. With 2023 declared by the UN as the International Year of Millets, this will be the turning point for millets to be globally recognized and popularized. Asia and Africa need value chains developed to be able to leverage the impending millet revolution. This can be the opportunity for millets and sorghum to return to their status as staples across many countries and be globally recognized, heralding their reach as a major staple, showing the potential for smart foods and NUS to gain popularity and acceptance and move into the mainstream.

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