

SESSION 4.1:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS ON-FARM

**Future Smart Crops: the key to improving dietary diversity
and fighting hunger and malnutrition**

Professor Kadambot Siddique AM FTSE

Hackett Chair and Director, The University of Western Australia Institute of Agriculture

Abstract

Asia and the Pacific continue to suffer from a high prevalence of malnutrition. An estimated 479 million undernourished people, 58% of the worldwide total, live in this region. Chronic undernutrition is due to the persistent inability to meet minimum micronutrient and macronutrient requirements, or the frequent recurrence of acute malnutrition episodes, or a combination of both. Food-based approaches that address malnutrition, especially micronutrient deficiencies, are embedded in evidence-based healthy diet patterns, but they are disconnected from the current agricultural production system. Neglected and underutilised species (NUS) are fundamental to improving dietary and production diversity. These species are nutrient-dense, climate-resilient, profitable, adaptable, and locally available. 2023 is the UN International Year of Millets. This program, along with the 'Future Smart Food Initiative', is being led by the Food and Agriculture Organization of the United Nations (FAO) to harness the enormous benefits that millets and other NUS offer in the fight against hunger and malnutrition. Recognising that NUS cover crop, livestock, fisheries and aquaculture and forest, FAO sets *crop* as an entry point among NUS to address hunger and malnutrition. Many NUS can tolerate various stresses, which would make production systems not only more diverse but more sustainable and climate resilient. Their resistance to climate change implies that NUS can provide food when other crops fail. The book *Neglected and Underutilized Crops: Future Smart Food*, edited by Muhammad Farooq and Kadambot H.M. Siddique, was published in November 2022.



Thank you to the Crawford Fund for the invitation to this conference. The topic, Future Smart Crops for improving dietary diversity and fighting hunger and malnutrition, has already been mentioned by Cary Fowler and others. In this talk I'll add some numbers; and briefly touch on the global hunger and malnutrition situation, particularly malnutrition; the prevalence of an unhealthy diet – what it is causing, and how; challenges facing the food system and nutrition security; and diversification; and I will draw some conclusions and look at a way forward.

Looking back to 2019, 'Sustainable Development Goal 2: Zero Hunger', we thought then that we could achieve it, but it is getting extremely difficult. As Figure 1 shows, the number of hungry people could be 840 million or even 900 million by 2030. The coronavirus (COVID-19) has probably added 150 million to the number of undernourished people. Although there has been a reduction in hunger and improved nutrition security in the Asia Pacific, still it is very high with 93 million children under five years old stunted, 30% of the population. And in sub-Saharan Africa there is still a lot more work to be done, perhaps by ACIAR and US agencies and others.

Figure 2 shows seven sub-regions where there is very high or high malnutrition: in Oceania, South Asia and also East Africa and Middle Africa it is very high (2019 data). There are 30–40% of children under 5 years of age stunted in some of those countries, while the world average is 21.3%. As

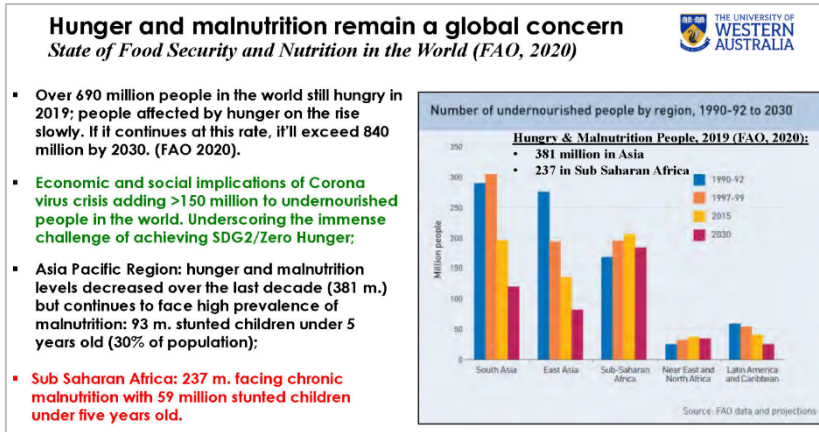


Figure 1.

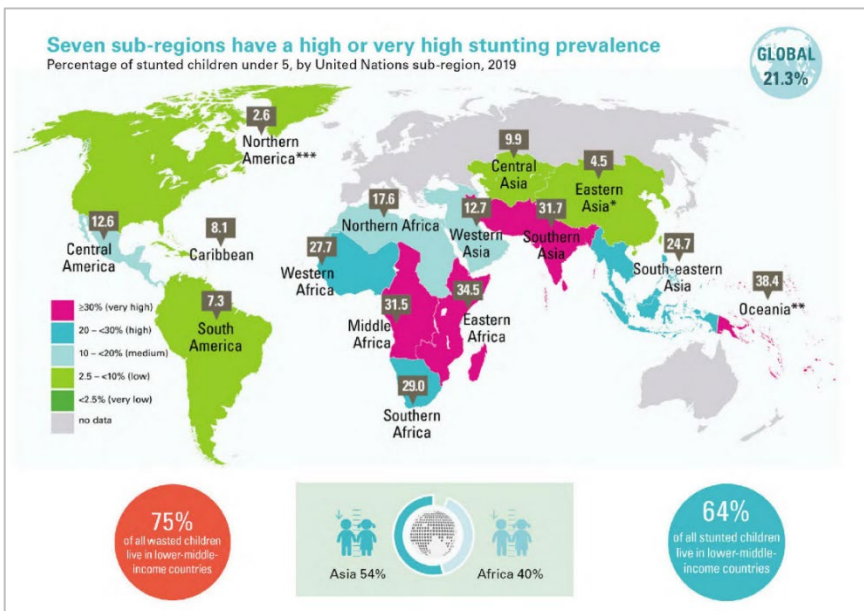


Figure 2. Source: UNICEF/WHO/The World Bank Group 2020.

already mentioned by Cary Fowler and others, those children will not develop very well, and are unlikely to get jobs since they will not complete their primary school education, and the vicious cycle will continue. This is a serious situation, with about 54% of children under 5 years old in Asia (in 2019) stunted, and about 40% in Africa.

In Figure 3, from 2005 the percentage of people undernourished was declining, but since 2019 the trend is upwards. It could reach 760 million, 820 million. To achieve SDG 2 by 2030 unfortunately is going to be difficult. That means we cannot be complacent. We have to start working hard on this.

More than half, about 425 million, of the people in the world affected by hunger or malnutrition are in Asia, and one-third, 278 million, are in Africa (Figure 4). Those are the numbers.

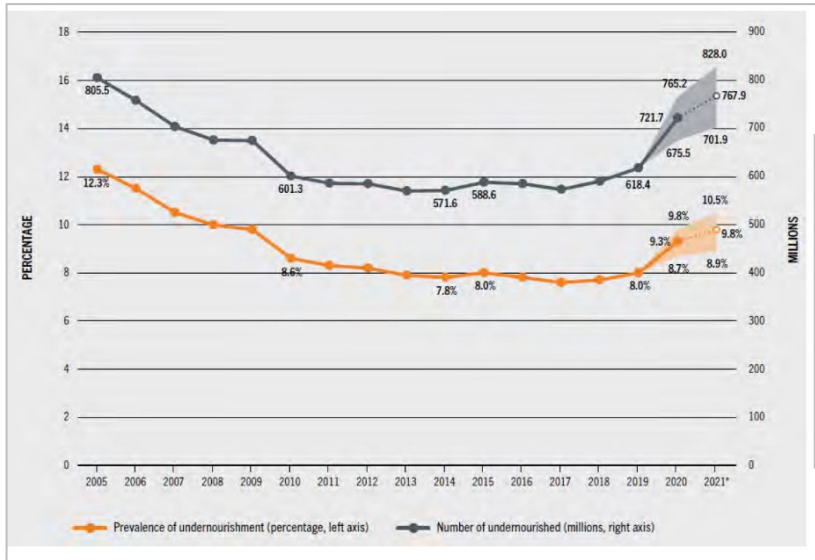


Figure 3. Between 702 million and 828 million people in the world faced hunger in 2021. **Considering the middle of the projected range (768 million), hunger affected 46 million more people in 2021 compared to 2020, and a total of 150 million more people since 2019, before the COVID-19 pandemic.** Source: FAO

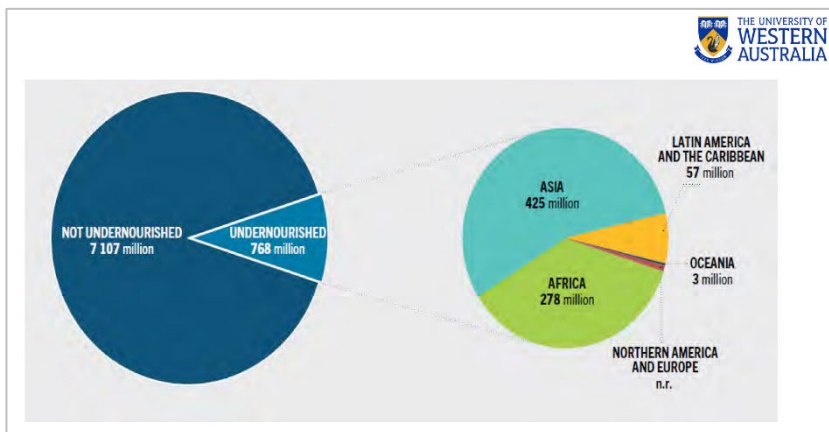


Figure 4. Source: FAO.

The food system

The food system is very complex. As defined by the High Level Panel of Experts on Food Security and Nutrition (HLPE) and the UN Committee on World Food Security (CFS), ‘A food system consists of all the elements (environment, people, inputs, processes, infrastructures, institutions) and activities that relate to the production, processing, distribution and marketing, preparation and consumption of food, and the outcomes of these activities, namely nutrition and health status, socio-economic growth, equity and environmental sustainability’. That means we just can’t have a silo type of project. We have to look at an integrated larger project, involving all the elements and all the activities listed in this definition.

What are the desired outcomes? As defined, we want to have better nutrition, health status, socio-economic growth. If people produce more vegetables, will that help them? Yes, it will help them, as we have heard today from Kym Anderson and others. Equity and environmental sustainability are increasingly important outcomes.

The problem is that we have done extremely well because of the Green Revolution, but three major crops – wheat, rice and maize – are dominating. I know that Tony Fischer will say that this is

important, and yes, it has been important. Those crops have fed the world. More recently there has been interest in oil crops – e.g. soybean, sunflower, oil palm – and for those who can afford meat and dairy products their consumption is increasing, and it’s increasingly difficult to get aquaculture, fish and wild catch.

The current unhealthy food consumption (Figure 5), which is leading to malnutrition, is due to two things: the high consumption of the so-called ‘bad’ foods – processed and/or salty, starchy; and the low consumption of ‘protective’ foods – fruits, vegetables, whole grains. Among protective foods are crops that are being neglected and underutilised. Malnutrition is leading to risk of non-communicable diseases and stunted children, and also increasing obesity in many of the developing countries.

The current agricultural system is based on a few staple crops, and they are environmentally vulnerable. Where a region relies on one variety of, say, corn and something happens to that crop, there is disaster. The ecosystem, food, diversity and health are all affected. Limited diversity in the food system means less diversity in the diet, and ultimately malnutrition. So, we *must* diversify the food system to enable balanced diets and to enhance adaptation to climate change.

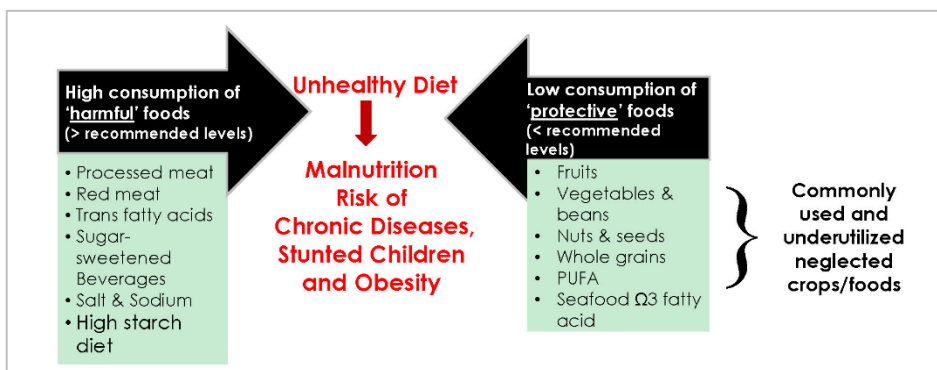


Figure 5. The unhealthy current food consumption patterns.
Adapted from Afshin et al. 2015.

- Environmental degradation continues due to unsustainable use of already limited natural resources: water, land and biodiversity;
- Producing more food with less resources;
- Coping with serious climate change implications;
- Lack of economic and social development;
- High birth rate in developing countries (2.3% average for NENA region compared to an average of 1.9% in other developing countries);
- Political unrest, wars and civil conflicts which exacerbate these challenges and contribute to increased poverty, hunger and malnutrition.

Figure 6. Major global challenges to enhance food security and nutrition.

Global challenges and solutions to enhance food security and nutrition

Figure 6 lists some of the challenges. Environmental degradation is continuing: there is less water, less land and bad effects on biodiversity. We need to produce more per unit area, per unit resources. We must cope with serious climate change. There is a lack of economic and social development in rural areas in developing countries. Birth rate has declined but it is still at an alarmingly high level in the Near East and North Africa (NENA) and many other countries. And political unrest is going to continue, and we must be prepared for that.

To address some of those challenges:

- we must bridge the production gap. We need about 50–70% more food, and I think existing technology can produce that, in many parts of the world. However, the potential for higher yields in traditional major crops is limited despite considerable investments in improvement. The yield increases possible via genetics have declined, and are now slightly more than 1% per year, which is not enough.
- The nutrition gap is widening because of the reliance on existing staples, but crop diversification is one solution that should produce healthy diets to reduce malnutrition.

As I have summarised in a 2021 article in *Nature Plants* (Siddique *et al.* 2021), we need to look back to Asia's forgotten crops to fight chronic and hidden hunger. I am not talking about domesticating wild crops; I am talking about the crops that used to be farmed in these landscapes. They were taken away by commercial agriculture.


Under the auspices of the United Nations we convened a workshop in Bangkok a few years ago, where we asked experts from each country to list potential neglected underutilised crops. They came up with a list of 150, which we then narrowed down 30 (Figure 7) – cereals, roots and tubers, pulses, fruits and vegetables, nuts, seeds and spices, and they vary from region to region. For example, **foxtail millet** (*Setaria italica*), **drumstick** (*Moringa oleifera*), **elephant foot yam** (*Amorphophallus paeoniifolius*), and **taro** (*Colocasia esculenta*) – which can tolerate waterlogging and drought and is a wonderful tuber crop rich in macro and micronutrients, iron, zinc, selenium and calcium, and rich in many vitamins including carotenoids, vitamins K, C and so on. The United Nations General Assembly declared 2021 as the International Year of Fruits and Vegetables.

Cereals	Roots and tubers	Pulses	Fruits and vegetables	Nuts, seeds and spices
<ul style="list-style-type: none"> • Sorghum • Pearl millet • Finger millet • Teff • African rice 	<ul style="list-style-type: none"> • Cassava • Yams • Sweet potatoes • Taro 	<ul style="list-style-type: none"> • Cowpea • Lablab Beans • Pigeon Peas • Chick pea 	<ul style="list-style-type: none"> • Guava • Loquarts • Baobab • Amarula • Nightshades • Spider Plant • Amaranth • Pumpkin • Moringa 	<ul style="list-style-type: none"> • Macadamia • Cashews, • Bambara nuts • Cumin • Saffron • Rosemary • Ginger • Nutmeg

Figure 7. Potential future smart foods. Source: Siddique et al. 2021.

We have all heard about **quinoa** (Figure 8). It has been grown in the Andes for 5000 years, and now is recognised as a wonderful food all over the world through simple promotion and the right approach. It has a lot of nutrients, is good for the environment, and Andean farmers are still growing it there as a cash crop.

International Year of Quinoa 2013



Based on FAO recommendation considering quinoa's exceptional nutritional value and health benefits, the United Nations General Assembly declared 2013 as the 'International Year of Quinoa', in recognition of ancestral practices of the Andean people, who have managed to preserve quinoa in its natural state as food for both present and future generations.




The Amazing Health Benefits of... Quinoa

- ✓ Source of complete protein
- ✓ Contains minerals including iron, calcium & magnesium
- ✓ Naturally gluten-free product - suitable for celiacs
- ✓ Provides balanced energy for active lifestyles
- ✓ Weight management - keeps you fuller for longer
- ✓ High in heart healthy fats
- ✓ High in complex carbohydrates
- ✓ Rich in fibre to promote healthy bowels & digestion
- ✓ Promotes healthy blood sugar levels
- ✓ High in lysine to protect against cold sores

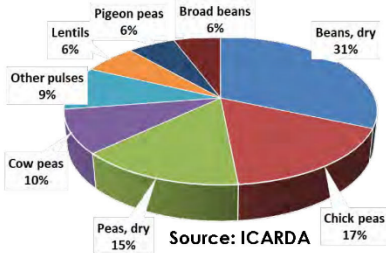
evergreen

Figure 8.

The UN General Assembly declared 2016 the International Year of Pulses (IYP), based on FAO recommendation, to raise public awareness of the nutritional benefits of **pulses** as part of sustainable food production, aiming for food security and nutrition. They are very important crops, but we were ridiculed in Australia 20 or 30 years ago when we talked about pulses. I was designated as the ambassador by the UN. We aimed to promote production and consumption of pulses worldwide, improve crop rotation and improve trade in pulses – and they are now mainstream crops. So that's how you bring new foods into the system.

'Poor man's meat' at affordable prices

- Pulses are three times richer in low fat protein (20 – 36%) as compared to cereals including rice and wheat (7 – 9%);
- Pulses have complementary Amino acid profile with cereals;
- High in Lysine;
- Micro-nutrient rich grains (Fe, Zn, Mg and Ca);
- Good quality carbohydrates make pulses great functional food;
- High in dietary fiber.



Source: ICARDA

Figure 9. Pulses offer many nutritional benefits.

Pulses (legumes) not only have many nutritional benefits (Figure 9) but they also can replace or supplement the nitrogen requirements of cereals in a crop rotation, while also improving the carbon footprint by putting carbon back into the soil (Figure 10). There is a lot of information on those topics.

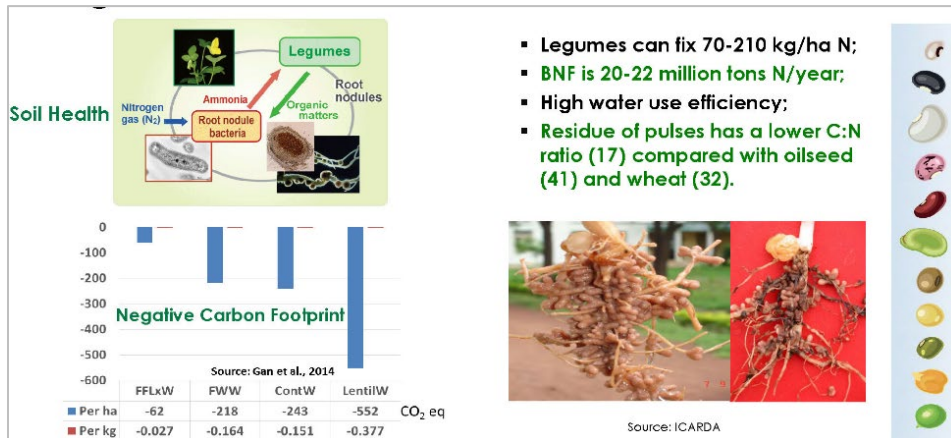


Figure 10. Legumes are essential for sustainable agriculture and soil health.

I want to emphasise that for these underutilised crops the investment in research, development and extension is still *too low* compared to the massive investment in rice, wheat and maize. I am not saying we should not invest in those. Rather, that we must *also* invest in some of these legume crops (see Foyer *et al.* 2016).

Millet is another major commodity that can make a huge difference, if it has the right promotion (Figure 11). It's now reaching mainstream agriculture. The Government of India proposed that 2023 be the International Year of Millets, and it is now being taken very seriously by a number of countries. There are different kinds of millets (Figure 12). Australia is already a good producer of sorghum, and there are other potential opportunities, such as in the northern part of Australia and the summer rainfall regions.

- Provide nutritious food, feed and fodder
- Less water consuming than other cereals
- Grow faster & putting less stress on environment
- Low insects, pests and diseases problem
- Can grow on marginal lands
- Complete food and nutritional security
- Will supplement the existing income of the farmers
 - ✓ reducing groundwater extraction,
 - ✓ combating desertification and
 - ✓ increasing farmer resilience to droughts brought on by climate change



Figure 11. Why millets.

The point is that millets must be integrated within the existing farming system, not replace existing crops. One of our studies has shown that integrating new crops into the existing system improves yields and returns to the farmer, and more importantly it also reduces the environmental footprint (Chai *et al.* 2021). All this is summarised in a free book (Li & Siddique 2018), and we have recently also published another book on neglected and underutilised crops (Farooq & Siddique 2022).

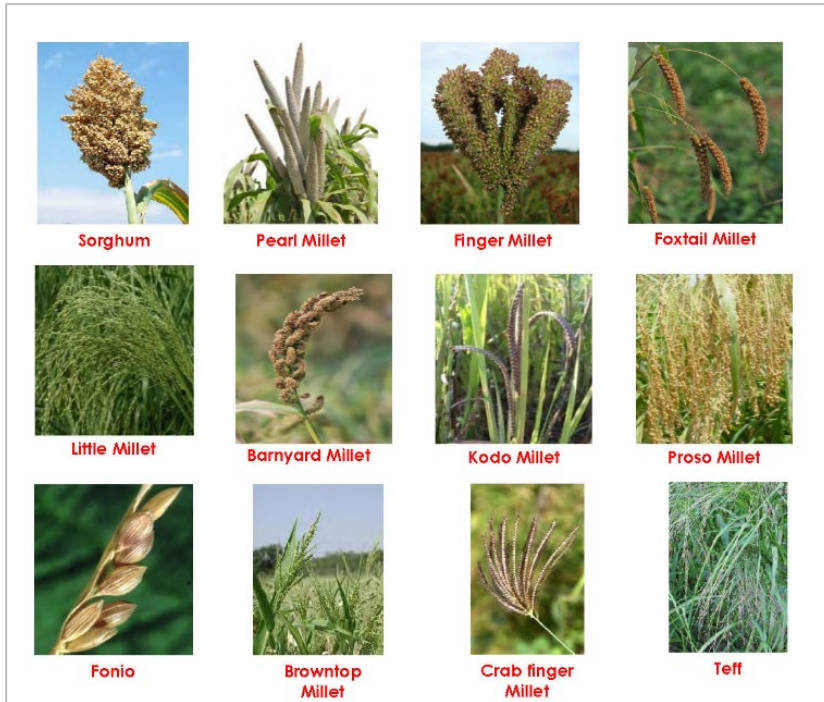


Figure 12. Millets

Transforming food systems for healthy diets

Figure 13 shows an approach for transforming a food system, via production, processing and distribution, marketing and consumption, and examples of interventions for healthy diets such as in a midday meal program, a school breakfast program, for indigenous and low socioeconomic communities.

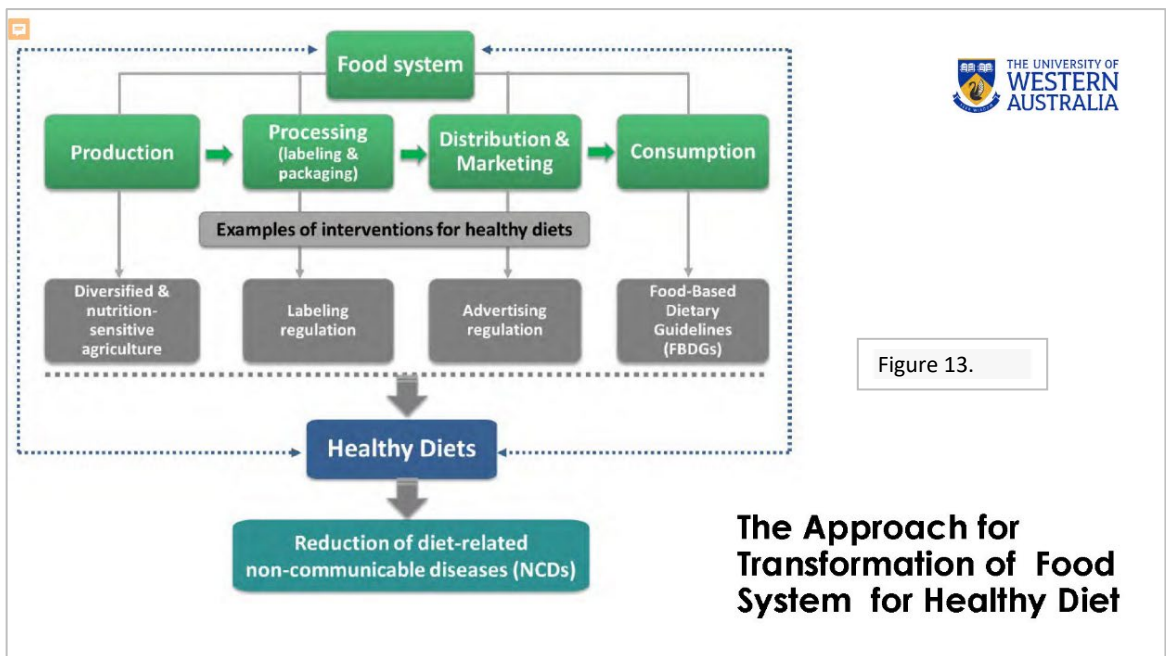


Figure 13.

The Approach for Transformation of Food System for Healthy Diet

In summary, traditional underutilised local crops offer these benefits:

- food and nutritional security;
- resilience to climate change;
- adaptation to harsh environments and low inputs;
- conservation of biodiversity;
- cultural diversity and heritage;
- improving livelihoods and rural development; and
- economic and social development.

Current food systems need to be transformed and diversified by incorporating Asia's and Africa's traditional crops to achieve healthier diets. Healthy diets will provide more protein, more macro- and micronutrients, and vitamins to reduce malnutrition, hidden hunger, stunted children and obesity. Traditional underutilised crops also offer adaptation to harsh environments, marginal land, low-input agriculture where they can be integrated into existing cropping systems, and resilience to climate change.

It is important to enhance policy makers' awareness of the value of diversified food systems: that they will raise national food security and nutrition. There needs to be investment in scientific research by public and private organisations, and increased awareness among producers and consumers about the nutritional, health, economic and environmental benefits available from these foods. There needs to be coordination and capacity development of stakeholders in the food chains and value chain, as well as greater access to information and technology transfer. You can't have research for each and every crop, so you need to have a coordinated approach and develop the platforms where we can share this information.

References and further reading

- Afshin A. *et al.* 2015. The impact of dietary habits and metabolic risk factors on cardiovascular and diabetes mortality in countries of the Middle East and North Africa in 2010: a comparative risk assessment analysis. *BMJ Open* 5(5): e006385. <http://dx.doi.org/10.1136/bmjopen-2014-006385>
- Chai Q. *et al.* 2021. Integrated farming with intercropping increases food production while reducing environmental footprint. *Proceedings of the National Academy of Science USA* 118(38): e21063382118. <https://www.pnas.org/doi/10.1073/pnas.2106382118>
- Farooq M., Siddique K.H.M. (Eds) 2022. *Neglected and underutilized crops: Future Smart Food*. Academic Press. 836pp.
- Foyer C.H. *et al.* 2016. Neglecting legumes has compromised human health and sustainable food production. *Nature Plants* 2: 16112. <https://www.nature.com/articles/nplants2016112>
- Li X., Siddique K.H.M. 2018. *Future Smart Food: Rediscovering hidden treasures of neglected and underutilized species for Zero Hunger in Asia*. FAO, Bangkok. <https://www.fao.org/documents/card/es/c/18907EN/>
- Siddique K.H.M., Li X., Gruber K. 2021. Rediscovering Asia's forgotten crops to fight chronic and hidden hunger. *Nature Plants* 7: 116–122. <https://www.nature.com/articles/s41477-021-00850-z>
- United Nations Children's Fund (UNICEF), World Health Organization, International Bank for Reconstruction and Development/The World Bank. Levels and trends in child malnutrition: Key Findings of the 2020 Edition of the Joint Child Malnutrition Estimates. Geneva: World Health Organization; 2020. Licence: CC BY-NC-SA 3.0 IGO.

Professor Siddique has over 30 years' experience in agricultural research, teaching and management in both Australia and overseas. He has developed a national and international reputation in agricultural science especially in the fields of crop physiology, production agronomy, farming systems, genetic resources, breeding research in cereal, grain and pasture legumes and oilseed crops. He has published >850 scientific papers, books and book chapters. Professor Siddique was the Highly Cited Researcher in Agricultural Science in 2018, 2019, 2020, 2021 and 2022. He is the Highly Cited Researcher (Hi Ci) in 2021 and 2022 in two categories: (i) Agricultural Sciences (ii) Plant and Animal Science (Thomson Reuters/ Clarivate Analytics). Google Scholar h-index: 104 and citations: 41,949 (15 May 2023). He is a Fellow of the Australian Academy of Technological Sciences and Engineering; Australian Agricultural Institute; Indian National Academy of Agricultural Sciences; Foreign Fellow of the Pakistan Academy of Sciences; and Fellow of African Academy of Sciences (first Australian to be elected to the Academy). Professor Siddique was designated by United National FAO as Special Ambassador for the International Year of Pulses 2016. Professor Siddique is the recipient of national and international awards including: Urrbrae Memorial Award, Member of the Order of Australia (AM), 2014 Western Australian Year of the Award (CitWA), the Dunhunag Award by China's Gansu Provincial Government. He received the Friendship Award from the Chinese Central Government (the highest award for a foreign expert) in recognition of his outstanding contributions to agricultural science and education in China over the years, and was the Western Australian Indian of the Year 2021. Professor Siddique was one of the three finalists for the Western Australian Scientist of the Year 2022 Award. He received the Sanquin Friendship Award from the Shaanxi Province China in April 2023. Professor Siddique has also trained numerous Honours, MSc and PhD students. He has developed an extensive network of scientists within Australia and has also established a diverse range of overseas (China, India, Turkey, Syria, Iraq, Iran, Saudi Arabia, Oman, Malaysia, East Timor, Nepal, Bangladesh, Pakistan, Europe, Canada, USA) collaborative research and educational projects. He holds a number of national and international committee positions.