

## THE FIGHT FOR (GOOD) FOOD

# THINK

### **Climate Change and Nutrition: The Role of Underutilised Plants**

Prof Paul Teng

### **Nutrition Literacy in Indonesia: Cooking Change with Fire from Both Sides**

Dr Judhiastuty Februhartanty

### **Waste Not, Want Not**

An Interview with Dr Kwan Lui

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## THINK

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### ON COVER

Fight for good food

Photo: Unsplash / Boglárka Salamon

# Editorial

Food enters our lives quietly, through the routines of breakfast, school lunches, family meals, market visits and festive tables. It is comfort, memory, culture and care. Yet every meal also reveals something larger: what we can afford, what we have been taught, what our communities make possible, and what our food systems choose to value.

Behind every plate lies a chain of decisions involving farmers, educators, policymakers, scientists, businesses, families and communities. In this issue of THINK, we examine “The Fight for (Good) Food” as a broader challenge of nourishment, resilience, access and responsibility.

Our contributors approach this challenge from different but connected perspectives. **Prof Paul Teng** reminds us that food security cannot be reduced to calories alone, drawing attention to underutilised plants that may help build resilient diets. **Asst Prof Yanyan Cheng** examines trade-offs between food, water, land, energy, carbon and climate, cautioning that well-intentioned green solutions can carry unintended consequences. **Prof Cecilia Tortajada** and **Prof Asit K Biswas** show that innovation is not enough unless implemented inclusively and coherently. **Prof William Chen** expands the horizon of future food systems, where novel foods, alternative proteins, urban farming and public trust must come together.

The issue also brings the discussion closer to daily life. **Dr Maleena Suppiah Cavert** reflects on how cost, convenience, habit, family and community shape what people eat. **Elyssa Ludher** invites us to imagine cities as places that can grow, share and value food, not merely consume it. **Dr Judhiastuty Februhartanty** shows how nutrition literacy in Indonesian schools requires both grassroots ownership and policy support. **Dr Kwan Lui** challenges us to rethink waste, abundance and what can be transformed through upcycling. **Jieun Wrigley** reminds us that childhood malnutrition now takes more than one form, with stunting and obesity emerging from fractured food environments. **Fiona Chia** turns our attention to healthy ageing, asking whether a society that lives longer is nourishing the strength needed to live well.

Together, these contributions point to a simple but demanding conclusion: good food is not only grown, bought, cooked, or consumed. It is enabled by fairer systems, better science, thoughtful policy, stronger communities, informed families, and a willingness to value nourishment over mere consumption.

Together, these contributions point to a simple but demanding conclusion: good food is not only grown, bought, cooked or consumed. It is enabled by fairer systems, better science, thoughtful policy, stronger communities, informed families and a willingness to value nourishment over mere consumption.

For The HEAD Foundation, this issue also speaks closely to our own evolving work across education, health and community well-being. If we care about how children learn, we must also care about whether they are nourished. If we care about resilient communities, we must also care about the systems that shape what they can put on the table. And if we care about the future of Southeast Asia, then food, in all its complexity, must remain part of the conversation.

The fight for good food is therefore not only about what is on our plates today. It is about the kind of societies we are preparing for tomorrow. We hope this issue gives you much to think about, and perhaps, the next time you sit down to a meal, a little more to chew on.

**Vignesh Louis Naidu**  
Chief Editor

## FEATURE

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He has held senior roles including Deputy Director-General of the WorldFish Centre and Senior Adviser at A\*STAR's BioMedical Research Council. He currently advises climate and agri-tech start-ups and is Co-Founder of Asia BioBusiness and Terrasys Innovation Systems. He is a recipient of the Eriksson Prize from the Royal Swedish Academy of Science and has authored or co-authored 15 books and over 250 technical papers.

PROF PAUL TENG

# Climate Change and Nutrition

## The Role of Underutilised Plants

Most concerns about climate change's impact on food security have focused on the quantity of food produced, such as reductions in crop yield or slower growth rates in animals, with much less attention given to the nutritional quality of the food. As climate change increasingly affects food production, its impact on the nutritional quality of plant foods and possible ways to address it will receive greater attention.

### When crops come under stress

Frequent and prolonged droughts in the Lower Mekong region and Cambodia, alongside recurring dry conditions in central Myanmar, are affecting key crops such as rice, cassava, sugarcane, and rubber, impacting both production and nutritional quality.

Photo: Favor\_of\_God / iStock

### IMPORTANCE OF NUTRITION QUALITY IN FOOD

A seminal report released in October 2025, the EAT-Lancet Commission 2.0 report ("Report 2"), highlights food quality and nutritional value as central to nutrition, emphasising that the quality of food consumed is an important matter for health.<sup>1</sup> Report 2 frames nutritious, high-quality diets as foundational — not optional — for good health. The "what" we eat (food quality, nutrition) matters as much as the "how much" (calories) and is essential for achieving the twin goals of human health and environmental sustainability. Without attention to nutritional value, a global food transition risks merely safeguarding calories — not lives, health, or equity. To address this, a key recommendation of the report is the **Planetary Health Diet**.

The Planetary Health Diet (PHD) specifies food groups and portions to ensure nutrient adequacy: whole grains, vegetables, fruits, legumes, nuts, and limited amounts of animal protein, saturated fat, sugar, and processed foods.<sup>2</sup> The diet aims to provide a balanced mix of macronutrients, fibre, vitamins, and minerals, rather than just "enough calories." Its flexibility allows adaptation to local diets and cultural traditions — recognising that "healthy" nutrition varies by location.<sup>3</sup> The goal is not merely to provide enough calories, a concern rooted in the Second World War, but to ensure healthy, nutrient-adequate diets for everyone. Although global food production generates enough calories overall, many people still suffer from malnutrition, poor diets, or overconsumption of unhealthy foods.<sup>4</sup> The PHD offers a better balance of macro- and micronutrients, fibre, vitamins, minerals, and important bioactive compounds that support long-term health, lower disease risk, and improve quality of life.<sup>3</sup>

**The "what" we eat (food quality, nutrition) matters as much as the "how much" (calories) and is essential for achieving the twin goals of human health and environmental sustainability.**

## Widespread micronutrient deficiencies mean many children and adults may suffer from “hidden hunger” — lacking essential vitamins and minerals even if they consume enough calories.



### Not all plates are equal

A 2024 report by the Access to Nutrition Initiative (ATNI) found that major global food companies including Nestlé, PepsiCo and Unilever sell less healthy products in low-income countries than in high-income ones, with average health scores of 1.8/5 compared to 2.3/5 in richer markets.

Photo: andresr / iStock

Given global inequalities — with some populations under-consuming and others over-consuming — focusing on food quality helps address both undernutrition and overnutrition/diet-related disease in a balanced way.<sup>5</sup> Nutritious diets are therefore part of a broader “safe and just space”: what people eat must sustain both human health and environmental health.

Approximately 17.9 million children are stunted, and 5.4 million children suffer from wasting (acute undernutrition) across ASEAN Member States. Micronutrient deficiencies, such as anaemia and lack of vitamins and minerals, remain widespread. In many Southeast Asian countries, this is classified as a moderate or severe public health problem among children (6–59 months), women of reproductive age, and pregnant or lactating women.<sup>6</sup> Around 63.4 million people continue to be undernourished in ASEAN, based on 2017–2019 data.<sup>7</sup> An estimated one in two children in the region has at least one micronutrient deficiency.<sup>8</sup> Widespread micronutrient deficiencies mean many children and adults may suffer from “hidden hunger” — lacking essential vitamins and minerals even if they consume enough calories. This undermines health, immunity, and development.

Poor-quality diets, even when providing enough energy, also contribute to chronic diseases such as heart disease, diabetes, cancer, and obesity. The Report 2.0 argues that transforming diets globally could prevent up to 15 million premature deaths each year.<sup>1</sup>

Climate change (CC) can lower nutrition levels in food, leading to malnutrition, an important aspect of food insecurity.

### CLIMATE CHANGE CAUSED BY INCREASED GREENHOUSE GAS EMISSIONS

Climate change phenomena such as drought and high temperatures are caused by increased emissions of greenhouse gases (GHGs), primarily carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). These three GHGs are responsible for most of the global warming related to climate change, especially in affecting weather patterns and causing sudden severe weather events. GHGs are known to affect crop growth, yield, and composition.



### The cost of clearing land

Southeast Asia contributes about one-third of global land-use emissions, driven by deforestation and the clearing of peatlands and mangroves for agriculture. When intact, these ecosystems serve as major carbon sinks, storing vast amounts of carbon.

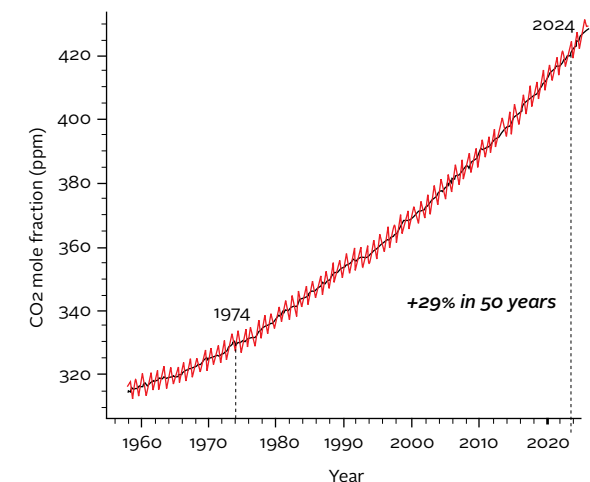
Photo: richcarey / iStock

Carbon dioxide makes up about 0.042%, or about 420 parts per million (ppm),<sup>9</sup> of the air we breathe and is essential for a plant process called photosynthesis. Photosynthesis uses CO<sub>2</sub> to produce sugars and other organic compounds. Therefore, increasing the CO<sub>2</sub> level can increase the rate of production of these compounds, as long as other factors are not limiting.

The reference CO<sub>2</sub> monitor is located at Mauna Loa in Hawaii, and levels have been rising from the pre-industrial reference of 280 ppm to 330 ppm in 1974, and reaching 425 ppm in 2024. This is a 29% increase over the past fifty years.

The phenomenon of rising CO<sub>2</sub> levels impacting plants is known as CO<sub>2</sub> fertilisation, and research shows that it affects the nutritional quality of crops used for human consumption. The CO<sub>2</sub> fertilisation effect can lead to decreases in essential nutrients such as protein and minerals in some crops, resulting in lower nutritional value and potential health consequences for humans and animals that rely on these crops.

Rising atmospheric CO<sub>2</sub> levels (Mauna Loa)<sup>9</sup>










Monthly mean atmospheric CO<sub>2</sub> measured at Mauna Loa Observatory, Hawaii — the longest continuous record of direct atmospheric CO<sub>2</sub> measurements (NOAA; Scripps Institution of Oceanography).

## The phenomenon of rising CO<sub>2</sub> levels impacting plants is known as CO<sub>2</sub> fertilisation, and research shows that it affects the nutritional quality of crops used for human consumption.

### THE EVIDENCE OF CLIMATE IMPACT ON FOOD

There is extensive data on the impact of selected climate change phenomena on food quantity and quality, as summarised in the table below.

Climate change phenomena	Quantity impact	Quality impact
 HIGH, RISING TEMPERATURES	Lower yields, crop failure due to heat stress, shorter growing season	Protein content, grain size, flavour
 PRECIPITATION PATTERN CHANGES	Lower yields due to delay planting or harvest, water stress and submergence	Reduced nutrient content such as minerals, vitamins
 DROUGHT	Lower yields due to reduced crop performance	Elevated sugar content, altered oil content
 EXTREME WEATHER EVENTS	Crop losses due to high winds and rain	Cosmetic defects reducing market value, physical damage leading to post-harvest diseases
 SOIL DEGRADATION	Lower yields due to reduced nutrients	Changes in plant composition
 SEA LEVEL RISE	Lower yields, crop destruction in coastal regions	Change in flavour (taste), reduced marketability
 HEAT STRESS	Lower yield or crop loss from pollination loss and reduced grain setting	Uneven ripening with uneven nutrient distribution

Data compiled by the author from multiple sources.<sup>11</sup>

However, apart from the CC phenomena caused by rising levels of GHGs, each GHG itself has the potential to affect crop quality. Increased Carbon Dioxide (CO<sub>2</sub>) reduces protein and micronutrients (iron, zinc), may increase carbohydrate content, decrease protein, B vitamins, zinc, iron, and amylose. Increased Methane (CH<sub>4</sub>) leads to a decrease in protein and amino acids indirectly due to climate change effects such as warming and water regime changes; it also indirectly reduces grain quality through warming, negatively impacting grain filling, as well as protein and starch composition. Increased release of N<sub>2</sub>O leads to reduced nitrogen for plants, affecting protein balance and grain uniformity. Excessive nitrogen use to compensate for N<sub>2</sub>O reduces grain quality and increases nitrate accumulation in soils.

Protecting food quality from the impacts of increasing greenhouse gases (GHGs) such as CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub> will require a combination of agricultural adaptation, emission reduction, and nutritional monitoring.



#### The hidden loss in rice

Rice grown under elevated CO<sub>2</sub> levels can contain significantly less protein, iron, zinc and B vitamins, according to field studies in Asia. While yields may be maintained, the nutritional value declines, leaving staple foods that look unchanged but provide fewer essential nutrients to millions who rely on them daily.

Photo: Willy Sebastian / iStock

## Underutilised plants hold great potential to become the “future food” that transforms food systems, making them more resilient to climate change and supply chain disruptions.

### UNDERUTILISED PLANTS TO IMPROVE NUTRITION

One often overlooked way to address nutrition inadequacies and simultaneously enhance climate resilience is the increased use of underutilised foods in diets, especially among impoverished rural communities. As the EAT-Lancet PHD highlights the importance of resilient, diverse plant-based foods, these recommendations become more urgent as climate impacts intensify. The transition to nutrient-rich, climate-resilient crops (such as pulses, nuts, fruits, and coarse grains) becomes even more critical, some of which may be among the “underutilised crops”.<sup>11</sup>

Traditional diets are more diverse, especially in the consumption of plants that provide minerals, vitamins, and other phytochemicals essential for balanced nutrition. However, modern food supply chains and the “supermarket phenomenon” have narrowed the range of vegetables consumed, especially among urban consumers. There is now renewed interest in so-called “underutilised” plants as supplements to modern diets,<sup>12</sup> especially to provide more balanced nutrition and as a buffer against climate change, since many of these plants are indigenous and have adapted well over aeons to variable weather conditions. They also require less fertiliser, water, and care. Underutilised plants hold great potential to become the “future food” that transforms food systems, making them more resilient to climate change and supply chain disruptions. This point has also been recognised in the EAT-Lancet Report 2.



#### Not all plates are equal

Tribal women in Gujarat prepare pappad from finger millet (*Eleusine coracana*), a traditional crop rich in nutrients and well adapted to dry conditions. Long overlooked in modern food systems, such underutilised crops are gaining renewed attention for their potential to improve nutrition and strengthen resilience to climate change.

Source: *Crops for the Future* (CC BY-SA 3.0)

**Southeast Asia is home to many underutilised plants that show promise for future food systems. These plants have high nutritional, ecological, and cultural value and are climate-adaptive.**

Several underutilised crops that have recently been commercialised and made available to urban consumers include Duckweed (*Wolffia spp.*), Tiger nut (*Cyperus esculentus*), and Adlai rice (*Coix lacryma-jobi*). Seaweeds, for example, have long been consumed in Sabah as salads, with the puree used to make fish sausages, noodles, and bakery products. In Indonesia, many coastal communities use sea grape species and other red seaweeds for food, seasonings, and traditional medicine. Sea grapes (*Caulerpa lentillifera*) are already being cultivated and processed in the region, and for export to markets such as Japan, the Philippines, and China.

Many local communities use wild leafy greens to supplement diets, but they are not widely cultivated or commercialised. A case in point is the Paku fern, which is popular in Sarawak, Malaysia, due to its unique nutritional properties.

Roots and tubers, such as yams, in rainfed regions of Southeast Asia are also the main source of carbohydrates for energy in areas where rice cannot be grown. Likewise, many legume species have been consumed for their protein content.

Many plants are being rediscovered, but their cultivation requires scaling up and commercialisation. These plants have great potential as alternative food sources:



Foxtail millet  
(*Setaria italica*)



Drumstick/Moringa  
(*Moringa oleifera*)



Winged bean  
(*Psophocarpus tetragonolobus*)



Bambara nut  
(*Vigna subterranea*)



Rice bean  
(*Vigna umbellata*)

Southeast Asia is home to many underutilised plants that show promise for future food systems. These plants have high nutritional, ecological, and cultural value and are climate-adaptive. Only a small fraction of Southeast Asia's plant biodiversity has been exploited. The search for more underutilised crops of the future is being led by many international agricultural research centres, such as the Crops for the Future Research Centre and the World Vegetable Centre. Underutilised plants possess many qualities desirable for future food systems, particularly their adaptation to local environments, climate resilience, nutritional quality, and ease of cultivation.

As climate change intensifies and impacts plants and their nutritional value, and as nutritionists promote a more plant-based diet for health, it becomes necessary to expand the range of plants available to consumers. Underutilised plants can meet this need. ∞

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Her Climate and Hydrology for Earth and Ecosystem Resilience and Sustainability (CHEERS) group combines Earth system models, hydrological models, ecosystem demography models, integrated assessment models, field observations, remote sensing datasets, and modern optimisation and ML/AI techniques to evaluate ecosystem services, resilience, robustness, and risks associated with diverse nature-based climate solutions.

ASST PROF YANYAN CHENG

# Feeding the Future Without Draining the Planet

Climate change is no longer a distant threat to food systems. It is already reshaping where, when, and how food is grown, and how much can be produced. Rising temperatures, shifting rainfall patterns, and more frequent extreme events like droughts and floods are disrupting crop yields, increasing price volatility, jeopardising supply chains, and threatening livelihoods.<sup>1</sup> At the same time, agriculture itself is a major source of greenhouse gas emissions, contributing to the very climate risks that undermine food security. This creates a dangerous feedback loop: to feed a growing population, we need to intensify agriculture, which, in turn, accelerates environmental degradation and climate change.

Addressing food security, therefore, requires a systems perspective — one that recognises the deep interconnections among food, water, energy, carbon, land, socioeconomics, and climate. Recent climate research, including studies on bioenergy expansion and land-use changes, highlights the need for next-generation, integrated approaches that can guide the design of food systems that are productive, climate-resilient, and environmentally sustainable.

## Perennial bioenergy crops in agricultural fields

Perennial bioenergy crops, such as prairie grasses, contribute to rebuilding soil carbon stocks and are used within farming systems as part of broader land management practices.

Source: Michigan State University

## MORE FOOD, MORE PRESSURE? THE HIDDEN COSTS OF INTENSIFICATION

Feeding a growing global population requires more crop production. In many regions, especially arid and semi-arid ones, this involves expanding irrigation and fertiliser use to boost yields. Although these practices can improve food output in the short term, they could also introduce hidden, long-lasting pressures on the very resources that agriculture depends on.


Expanded irrigation places heavy demands on freshwater resources, intensifying competition of water use between agriculture, industry, and ecosystems. At the same time, fertilisers can leach into groundwater and run off into rivers and coastal waters, degrading water quality, threatening drinking water supplies, and damaging fisheries and marine ecosystems. What begins as an effort to increase food production can, paradoxically, undermine food security by degrading the very water and ecosystem services on which agriculture depends. In many regions, farmers are increasingly forced into difficult trade-offs: producing more food today at the expense of water security, ecosystem health, and long-term agricultural resilience tomorrow.

Climate change further amplifies these pressures. Rising temperatures increase crop water demand, deepening reliance on irrigation, while shifting rainfall patterns and more frequent extreme events make water availability more unpredictable.

**What begins as an effort to increase food production can, paradoxically, undermine food security by degrading the very water and ecosystem services on which agriculture depends.**

These challenges are especially acute in Asia, where land and water resources are already under intense pressure. The region must feed large and growing populations while facing escalating climate risks, including heatwaves, droughts, floods, and sea-level rise. Agriculture across much of Asia is highly water-dependent, making it particularly vulnerable to climate variability. Increasingly unpredictable and abnormal rainfall under climate change makes it more difficult for local farmers to plan planting, irrigation, and harvesting. Communities with fewer resources and limited adaptive capacity are therefore more likely to bear disproportionate impacts, further widening existing inequalities in water access, food security, and livelihoods.



An aerial photograph of a palm oil plantation. The image shows a dense forest of palm trees with vibrant green fronds. A narrow, reddish-brown dirt road winds through the center of the plantation. In the lower-middle part of the road, a yellow tractor with a large, rectangular, metal mesh trailer is driving away from the viewer. The lighting is bright, suggesting a sunny day, and the overall scene depicts a typical agricultural landscape in a tropical region.

## Land-based climate solutions must be evaluated across multiple dimensions — climate, land, food, water, energy, and carbon systems — and across both local and remote impacts, rather than in isolation.

### NOT ALL GREEN SOLUTIONS ARE RISK-FREE

As climate change intensifies, the search for mitigation solutions becomes ever more urgent. Many proposed strategies rely heavily on land.<sup>2,3</sup> Bioenergy — energy derived from crop grains, stems, and leaves — has gained attention as an alternative to fossil fuels. Bioenergy crops can absorb carbon dioxide as they grow, and when combined with carbon capture technologies, they are often promoted as a pathway to “negative emissions”.<sup>4,5</sup> Perennial bioenergy crops, in particular, have attracted interest because they do not directly compete with food crops and are often assumed to pose lower risks to food security.

However, land-based climate solutions are not automatically compatible with food and water security.<sup>6,7</sup> My previous research shows that large-scale expansion of perennial bioenergy crops can create significant risks across land, water, food, and climate systems. In our 2022 study published in *Science Advances*, we used advanced Earth system models — tools that simulate how climate, ocean, land, water, carbon, energy, ecosystems, and agriculture interact under different future land-use pathways. We found that converting land to bioenergy crops can release large amounts of carbon during land conversion, increase irrigation demand, and exacerbate water-quality-related stress, especially in regions that are already water-limited.

Our follow-up studies further revealed that these impacts are not confined to where bioenergy is grown. Large-scale bioenergy expansion can alter atmospheric and ocean circulation, affecting rainfall and temperature patterns far beyond the regions directly involved. At the same time, significant uncertainties in future bioenergy crop yields, energy conversion efficiency, and carbon capture effectiveness further complicate the assessment of their true carbon sequestration benefits. Together, these findings underscore a critical lesson: land-based climate solutions must be evaluated across multiple dimensions — climate, land, food,

water, energy, and carbon systems — and across both local and remote impacts, rather than in isolation.

Other land-based mitigation strategies, such as forest conservation, reforestation, and afforestation, require the same level of careful assessment. While forests can deliver important climate benefits, their success depends on being placed on climatically suitable land. In our 2024 study published in *Proceedings of the National Academy of Sciences*, we found that some areas targeted for reforestation or afforestation may become increasingly drought-prone by mid-century, making them unsuitable for sustained forest growth. Poorly sited forestation efforts risk maladaptive investments and can exacerbate water scarcity, with downstream implications for regional food systems and water security.

### SAFEGUARD FOOD SECURITY: AN IMPERATIVE FOR TRANSDISCIPLINARY APPROACHES

Together, these examples illustrate a broader point: food security sits at the intersection of climate mitigation, land use, water availability, ecosystem health, and human decision-making. Addressing these trade-offs cannot rely on single-sector solutions or simple accounting of emissions or crop yields. Instead, safeguarding food security under climate change requires integrated, next-generation approaches that connect climate, land, water, energy, and carbon dynamics with ecosystem processes and socioeconomic systems. Integrated human-Earth system modelling, enhanced with AI, provides a framework to evaluate land-based climate solutions holistically, identify unintended risks early, and design strategies that protect food and water security while delivering credible climate benefits.

#### Palm oil and changing land use

In Indonesia, palm oil is both a major food crop and a source of biofuel, with government support increasing demand for production and land. As plantations expand, forests and peatlands have been cleared, creating tensions between food production, energy use, and environmental sustainability.

*Photo: Anks Rachman / iStock*

## Food security sits at the intersection of climate mitigation, land use, water availability, ecosystem health, and human decision-making.

From the human system side, integrated assessment models are essential tools for exploring climate mitigation pathways.<sup>8</sup> Integrated assessment models explicitly represent interactions among socioeconomic development, energy systems, land use, water use, and climate, and they operate by testing assumptions about future policies, technologies, and economic and demographic trends.<sup>9–11</sup> Under these assumptions and constraints, integrated assessment models examine which combinations of solutions could meet climate targets and quantify their timing, scale, and sequencing. In this way, integrated assessment models do not prescribe a single “optimal” future,

but instead help identify plausible pathways — outlining what actions could be taken, where they might occur, and when they would need to be implemented across the food-water-energy-carbon-land-socioeconomic nexus.

Earth system models complement integrated assessment models by simulating the physical and biological responses of the Earth system, including interactions among climate, land, oceans, ecosystems, and agriculture.<sup>12–15</sup> They allow scientists to evaluate how proposed land-based climate solutions affect food production, water availability, and climate feedback simultaneously, revealing not only intended benefits but also potential risks and trade-offs. When coupled with integrated assessment models, these models can help policymakers evaluate questions such as:

### Fruits of expansion

The new Laos–China railway has enabled faster fruit exports from Laos to China, attracting investment in large-scale banana and durian plantations. This growth, driven by regional demand, has contributed to deforestation. In 2023 alone, Laos lost more than 136,500 hectares of primary forest — around 3.5 times the size of Singapore.

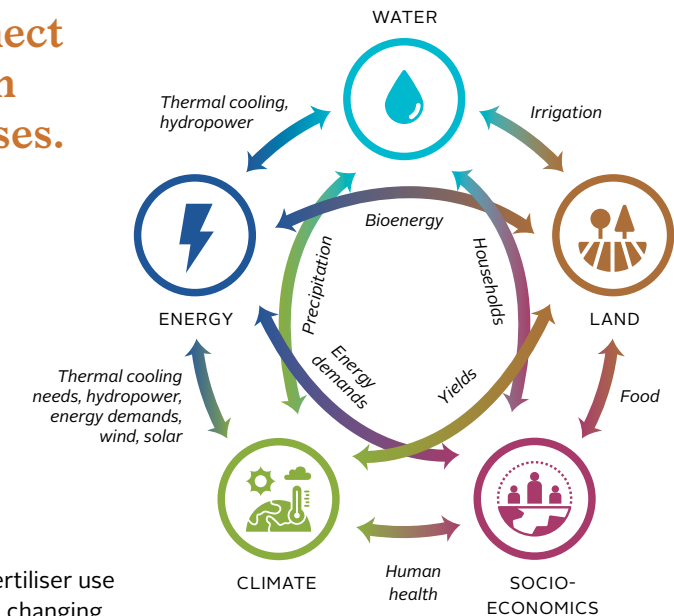
Source: Rainforest Investigation Network



## Integrated human-Earth system modelling provides the structure to connect human decisions with Earth system responses.

Complex interactions between land, water, energy, climate, and socio-economic systems shape food production and environmental outcomes.

Source: Pacific Northwest National Laboratory



- How might expanding irrigation and fertiliser use affect water availability and stress in a changing climate, and how can we optimise their use?
- What are the long-term consequences of land-use changes, such as converting forests to croplands, and how can we manage these impacts to safeguard food production and ecosystem health?
- How can we increase food production while protecting water availability and quality, and maintaining healthy ecosystems?

These questions lie at the heart of nutrition and food security and highlight the need for truly coordinated, interdisciplinary approaches. Integrated human-Earth system modelling provides the structure to connect human decisions with Earth system responses. With recent advances in AI, we can further enhance this framework by improving both model performance and data foundations. More specifically, physics-informed AI methods can reduce the computational cost of Earth system simulations while preserving physical realism, enabling faster and more actionable insights. At the same time, reliable, high-resolution data on land-use and land-cover changes are critical for identifying and determining what solutions to deploy, where, and when. Such data are often fragmented and inconsistent across regions.

AI-based data compilation and harmonisation techniques can help integrate diverse datasets into coherent, regionally consistent inputs, supporting downstream applications in models and enabling more sustainable and equitable land-use decision-making.

Because these solutions are intended to inform real-world policy and planning, co-production with stakeholders beyond academia — including policymakers, practitioners, and local communities — is essential to ensure national relevance and societal benefit. Addressing knowledge and communication gaps between scientific outputs and on-the-ground decision-making is particularly important so that local farmers can effectively access, understand, and use information derived from advanced technologies. Ensuring that findings are clearly communicated and accessible is therefore a critical component of impact. Taken together, transdisciplinary, AI-enabled integrated human-Earth system modelling approaches are imperative for safeguarding food security in a changing climate.



#### Footprint beyond its borders

Singapore is increasingly involved in forestry and restoration projects across Southeast Asia. Initiatives include WWF-Singapore's *Canopy* facility, supporting 12,000 hectares of restoration, and the NUS-led Carbon Integrity SG project (USD 15 million), focused on developing high-integrity carbon credits.

Photo: tdub303 / iStock

#### WHY SINGAPORE HAS A STAKE

Although Singapore produces little of its own food, it is deeply connected to regional food, water, carbon, land, and climate systems. As a major food importer and a growing hub for green climate-finance and carbon markets, Singapore's decisions and investments influence land-use practices across Southeast Asia, from agriculture to forestry and plantation management.

Singapore's ambition to achieve net-zero emissions by 2050 includes purchasing high-quality carbon credits from the region. Many of these credits are tied to land-based projects, such as forest conservation and reforestation. Ensuring that these projects do not compromise food security or water resources is essential: not only for environmental integrity, but also for regional stability and trust in carbon markets.

## Ensuring that these projects do not compromise food security or water resources is essential: not only for environmental integrity, but also for regional stability and trust in carbon markets.

Next-generation climate research can help Singapore identify solutions that are not only effective but also equitable, sustainable, and resilient. By using science-based assessment frameworks, Singapore can help set standards for sustainable land use that protect both people and ecosystems while promoting climate justice across the region.

#### A CALL FOR COORDINATED ACTION ACROSS SCIENCE, POLICY, AND LOCAL COMMUNITIES

Food security under climate change is not just about producing more calories. It is about ensuring access to nutritious food without degrading the natural systems that sustain life. Climate research shows that choices about land use — whether for food, energy, or carbon mitigation — have far-reaching consequences for food, energy, water, ecosystems, and human well-being.

The lesson from bioenergy and land-use studies is clear: there are no simple solutions. Climate mitigation strategies must be evaluated through a climate-land-food-energy-water-carbon-socioeconomic lens, grounded in robust science and informed by local contexts.

For Asia, and for green, climate-finance, and carbon hubs like Singapore, the opportunity also lies in leadership — bringing together science, policy, finance, and communities to design food systems that are resilient, equitable, just, and sustainable. By integrating traditional knowledge with cutting-edge, next-generation climate and AI research, we can move beyond trade-offs toward solutions that nourish both people and the planet in the era of AI and big data. ∞

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#### The low-emission rice challenge

Rice production in Southeast Asia is central to food security, but also a major source of methane emissions. For many farmers, shifting to lower-emission practices remains difficult, as they face higher costs and uncertain returns.

Photo: Preeyaporn Kaewsard / iStock

## FEATURE

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PROF CECILIA TORTAJADA & PROF ASIT K BISWAS

# Innovations and Pathways for Food Security and Nutrition

**F**ood security, defined as sustained access to safe, sufficient, and nutritious food, is increasingly under strain, with direct and far-reaching implications for nutrition, human health, and well-being. Food insecurity is driven by a complex set of interrelated factors. Poverty remains a fundamental concern, further exacerbated by food-price inflation, inadequate infrastructure across the food production, transportation and supply chain, climate-induced droughts and floods, and limited access to critical resources, including arable land, water, and financial resources.

The magnitude of the problem is significant. According to the Food and Agriculture Organization (FAO) of the United Nations, 673 million people experienced hunger in 2024, while 319 million people faced acute levels of food insecurity across the 67 countries in which the organisation operates. These figures underscore both the scale and the urgency of the food security challenge, particularly in low- and middle-income countries. From a regional perspective, food insecurity is falling in Latin America and the Caribbean and increasing in Africa. It has been decreasing gradually in Asia for several consecutive years, while in Oceania and in Northern America and Europe, new estimates point to a slight decline. Globally, and in almost every region, food insecurity is more prevalent in rural areas than in urban areas and affects more women than men.



### Rooted nutrition

Biofortified orange-fleshed sweet potato has been introduced across parts of sub-Saharan Africa to combat vitamin A deficiency. Rich in provitamin A, it has significantly improved intake among children and women, reducing the risk of blindness and strengthening immune health.

Source: CGIAR

**The main challenge lies in translating this knowledge into coherent, adequately financed, and effectively implemented long-term policies.**

The challenge is not one of insufficient knowledge: substantial evidence, data, and technical solutions already exist to address multiple vulnerabilities along the food chain, from production to consumption. Instead, the main challenge lies in translating this knowledge into coherent, adequately financed, and effectively implemented long-term policies that can protect vulnerable populations, strengthen agrifood systems, and ensure sustained access to affordable, healthy diets for all irrespective of their income and purchasing power.

Several innovations in different parts of the world are contributing to improve food security at local levels. These range from digital agriculture and extension services that help smallholders make more timely production and input decisions, with global evidence showing the strongest outcomes around knowledge gains and practice

change, to nutrition-sensitive crop innovation such as biofortified staples, eg, provitamin A-rich orange sweet potato and cassava interventions. Interlinkages have been evaluated through large-scale impact studies and linked to improved vitamin A intake and status among vulnerable populations. In parallel, renewable-energy irrigation is being deployed to reduce dependence on rainfall and expand productive capacity. In this regard, FAO has highlighted the potential of solar irrigation to unlock agricultural growth in water-stressed regions, while India's PM-KUSUM programme formalises a national pathway for scaling solar pumps and decentralised renewable energy to support farm operations. Finally, institutional procurement models, including home-grown school feeding and public purchasing from smallholders, create stable local markets that can strengthen rural livelihoods while improving access to food for nutritionally vulnerable groups.

As these innovations scale, the main risks that have been identified for their implementation can also be treated as design levers for improving effectiveness and equity. For digital advisory and other ICT-enabled services, a consistent caveat is that benefits can concentrate among users who already have reliable connectivity, access to electricity, devices, and time, often excluding poorer households and also women. This points to the opportunity to pair digital tools with inclusion measures such as affordability policies, shared or public access points, and gender-intentional delivery models so that women and marginalised farmers can participate on equal terms. For biofortification, nutritional potential depends on sustained adoption and consumption but relies on dependable seed and planting-material systems, market availability, consumer trust and long-term funding. This turns the adoption constraint into an implementation opportunity that includes strengthening local seed systems, integrating biofortified varieties into procurement and value chains, and using credible nutrition information to increase consumer willingness to adopt and pay for nutrient-enriched staples. For solar-powered irrigation, the widely discussed downside is that lowering the marginal cost of pumping can intensify groundwater abstraction in water-

stressed areas, therefore, affecting the farmers over the long term. However, the same technology can be redirected toward conservation when coupled with incentives, especially mechanisms that enable farmers to earn by exporting surplus electricity to the grid creating financial incentives to pump less, alongside monitoring and locally enforceable groundwater management practices.

Another innovation is high-tech farming. As this has matured, evidence from countries in the global North and South shows measurable progress alongside substantial upside potential for food security and supply resilience. In developed agri-food systems, controlled environment agriculture including advanced greenhouses and indoor vertical systems, has expanded as a strategy for more predictable, year-round production and shorter supply chains. In Europe, public institutions describe rapid mainstreaming of precision technologies into machinery markets, an indicator of diffusion

#### Panels and paddy

The solar boom has led many farmers in Pakistan to install solar-powered tube wells for irrigation. While offering cheap, clean energy, it has also accelerated groundwater depletion with little regulation, threatening long-term agricultural sustainability.

*Photo: Akhtar Soomro / Reuters*



#### Innovation landscape: Benefits, risks, and responses



#### DIGITAL AGRICULTURE

*Data-driven farming decisions*

- + BENEFIT** Boosts efficiency and productivity
- RISK** Excludes farmers without access
- RESPONSE** Expand access and inclusion



#### BIOFORTIFICATION

*Nutrient-enriched staple crops*

- + BENEFIT** Improves diet quality at scale
- RISK** Relies on adoption and trust
- RESPONSE** Strengthen seed systems and markets



#### SOLAR IRRIGATION

*Solar-powered water pumping*

- + BENEFIT** Reduces reliance on rainfall
- RISK** Risk of groundwater overuse
- RESPONSE** Incentivise conservation and monitoring



#### HIGH-TECH FARMING

*AI, robotics, controlled systems*

- + BENEFIT** High yields and stable production
- RISK** High cost and unequal access
- RESPONSE** Invest in skills and inclusive scaling

potential where farm structure, connectivity, and skills allow uptake. In the Netherlands, high-tech greenhouse horticulture remains a core pathway for intensive, climate-controlled production, with Wageningen University & Research emphasising innovation trajectories toward more energy-efficient and ultimately climate-neutral greenhouse systems while maintaining, and even enhancing, yield and quality. In Japan, national policy has explicitly pushed smart agriculture like robotics and ICT to save labour and sustain productivity amid workforce decline.

The situation is different in countries in the global South, where the trajectory is slower. In India, NITI Aayog's roadmap, for example, frames frontier technologies such as artificial intelligence, machine learning, IoT-enabled precision agriculture, drones, and satellite imaging as central to raising productivity and resilience by putting actionable data into farmers' hands. In East Africa, rigorous evaluation evidence also suggests that relatively low-cost high-tech interventions like mobile-phone extension that has been used before for water management decision-making, can reach large numbers of smallholders and improve practices, indicating a pathway for progress where capital-intensive automation has been slower to diffuse.

Despite this progress, several structural downsides must be addressed for high-tech farming to realise its full potential for food security and nutrition. A central concern is unequal access and capital intensity: many high-tech systems, such as advanced precision machinery, robotics, and controlled-environment agriculture, require substantial upfront investment and technical capacity, which can exclude small and medium-scale farmers and reinforce concentration in wealthier regions or among larger farms.

OECD analyses show that without targeted policies, digitalisation and automation in agriculture risk widening productivity and income gaps rather than reducing them. Skills and labour displacement are another challenge: while smart technologies can address labour shortages in ageing farming populations, studies also warn that insufficient training and advisory systems can limit effective use, and that automation may displace certain categories of agricultural labour if transitions are not managed through reskilling and inclusive rural development strategies.

**Food insecurity is not inevitable but addressing it requires deliberate choices about how innovations are designed, governed, scaled, and implemented.**

Environmental trade-offs also remain unresolved. For example, energy-intensive indoor and vertical farming systems can reduce land and water use but may generate high carbon footprints if powered by fossil-based electricity, a risk highlighted in life-cycle assessments of controlled-environment agriculture. Finally, data governance and ownership pose growing challenges: academic and policy reviews note that farmers often lack control over data generated by digital platforms and machinery, raising concerns about privacy, market power, and dependency on a small number of technology providers. Addressing these economic, social, environmental, and governance constraints is therefore essential if high-tech farming is to contribute equitably and sustainably to global food security in the coming decades.

Food insecurity is not inevitable but addressing it requires deliberate choices about how innovations are designed, governed, scaled, and implemented. The persistence of hunger and malnutrition, despite the availability of technical solutions, reinforces the core message that progress depends less on discovery than on implementation, coordination, inclusion and long-term commitment. Innovations in digital agriculture, biofortification, renewable-energy irrigation, and high-tech farming demonstrate tangible gains at local and national levels, yet their impacts are highly contingent on enabling conditions such as functioning institutions, resilient infrastructure, skill upgrades, and governance frameworks.

From a future perspective, the key opportunity lies in integrating innovation with systems-level safeguards. It is necessary to embed equity considerations like affordability, gender inclusion, and smallholder access, directly into technological introduction, rather than treating them as afterthoughts. Similarly, environmental risks associated with intensification and automation, including groundwater depletion and high energy use, underscore the importance of coupling innovation with strong natural resource governance and climate-aligned incentives, as highlighted in research on solar irrigation and controlled-environment agriculture.

The future potential of high-tech and low-tech innovations alike depends on policy coherence and public investment. Evidence from developed and developing countries suggests that when governments align agricultural, energy, digital, and social protection policies while investing in human capital and data systems, innovations are more likely to translate into durable food security and improved nutrition outcomes. In this sense, innovation should be understood not as a substitute for public action, but as a multiplier of it.

Achieving sustainable food security in the coming decades will therefore hinge on whether existing knowledge and technologies can be mobilised through inclusive, well-governed, and forward-looking food system strategies that place nutrition and well-being at their core. ∞



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#### 12x more tomatoes

In the Netherlands, climate-controlled greenhouses produce up to 12 times more tomatoes than the global average, using precision technology to maximise yield while reducing water — just 4 litres per kilogram compared to over 200 litres globally — though at high energy and capital costs.

*Photo: Michael Kooren / Reuters*



# The Food Choices within Our Reach

A Conversation with  
**Dr Maleena Suppiah Cavert**



**Dr Maleena Suppiah Cavert** is an advocate for health and education, focusing on Lifestyle Medicine with emphasis on a preventative approach to health. She is an adjunct assistant professor at the NUS School of Medicine. Until earlier this year, she was Chief of Learning & Culture at the Tsao Foundation. She previously served as Chief Wellbeing Officer at the National University Health System, supporting the health and wellbeing of 16,000 employees.

A certified Mindfulness-Based Stress Reduction (MBSR) facilitator, she has worked closely with healthcare professionals and students to build resilience and address burnout. Her career spans over 38 years across six countries, with experience in healthcare, education, longevity and ageing, food security and food science.

She holds a Doctorate in Education, an MBA, and a BSc in Food Science, and is a sought-after speaker on healthy ageing, nutrition and physical activity, resilience, empathy, and behaviour change.

The realities of modern food production and living have influenced what we eat. Cost and convenience, even culture and community play a role in how our meal comes together. We spoke to Dr Maleena Suppiah Cavert on the nuanced challenges that ordinary people deal with daily when it comes to food, and the little things we can do to eat better.



## THE COST PARADOX

**What do you think is the biggest food problem today? Not just in Singapore, but more generally, in terms of what we eat and our nutrition.**

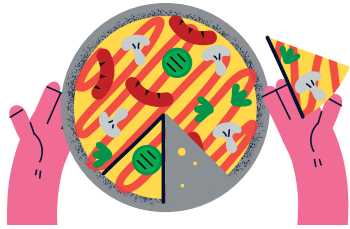
Almost everybody has to pay rent or a mortgage. Everybody needs to eat. Everybody has utility bills and other expenses. All of this is competing for the same few dollars that we have. So, we tend to sting on food. When people can't afford much, they buy the cheaper, more readily available options, and those often turn out to be the worst kinds of food for you.

Paradoxically, when you look at poorer populations with lower health literacy, they are less likely to buy fresh food or spend time cooking. Instead, they turn to ready-made food, like fast food, instant noodles, potato chips, because they just don't want to feel hungry. There's also a culture of snacking. These options are cheap, filling, and tasty. You don't feel hungry, but you don't realise that what your body actually needs nutritionally is more expensive and

needs some effort to prepare. This also requires some education. We can see that awareness may be low; nutrition is generally not taught in schools or universities. If a child grows up eating mostly instant noodles and packaged snacks, with maybe an occasional banana, they won't have a balanced diet. Later on, when they're given vegetables, they wonder why there's "green stuff" on their plate. Most processed foods look the same: bland colours, similar textures. Therefore, colourful, fresh food feels unfamiliar and somewhat 'unfriendly' to the palate.

This is where health literacy and nutritional literacy come in, along with cost. Another paradox you see is smoking. You'll notice people gathering outside, often F&B workers, and they work very hard, and long hours for often meagre wages. Cigarettes are expensive, but people will still pay for them. That's addiction. People won't pay extra for food because hunger can be satisfied more easily or cheaply than the urge to smoke. This is how we sometimes end up with this paradox of addiction and poor nutrition among lower income groups.

When people can't afford much, they buy the cheaper, more readily available options, **and those often turn out to be the worst kinds of food for you.**



**It sounds like you're saying that healthy food is more expensive. Why is that? Is it simply a matter of supply and demand, given that it's more natural and less processed?**

Yes. In an urban setting, will you find fresh lettuce or tomatoes in a 7-Eleven? You won't. You won't see oranges or watermelons either. Maybe just a small cut portion packaged as a snack. That's because fresh food is expensive and has a short shelf life.

The first things you throw out from your fridge are usually wilted vegetables. Fresh fish doesn't keep long. Fruits like strawberries go mouldy quickly. But industrially-made bread can last a week or more. Processed sausages can sit there for a long time and nothing happens. Ketchup and mustard seem to last forever. They don't go bad because of the chemicals which act as preservatives inside. They're also cheap to produce because they're made in large quantities in factories.

Fresh food is different. It requires proper food supply logistics, like fridge to fridge, storage to storage without disrupting the cold chain, and that drives costs up. Shelf life is only two or three days and there is a cost to storage. If it doesn't sell, you have to throw it away. So why would businesses prioritise that?

Cooking oils, sauces, all these things don't change much over time. With a packet of instant noodles, all you need is water. The most luxurious addition might be an egg you crack into it.

#### URBANISATION AND FOOD SYSTEMS

**So it's not really the cost of the food itself, but the cost of making it available — storage, transport, and labour. In the end, is this a result of urbanisation?**

Partly. If countries have farms near cities, on the periphery, and they supply the urban population at affordable prices, there isn't really a problem. Before we became so urbanised, people had to live near farms to eat fresh food. If you wanted vegetables or pork and there were no farms or pigs nearby, you simply couldn't get them. There were no freezers, no refrigerated trucks to bring food long distances. Today, we have fast rail and good roads. In theory, it should be even easier to access fresh food. We can fly cherries from Chile or South Africa at any time of the year. But there is a carbon footprint to all of this, and there are deeper structural issues.

From a farmer's perspective, the same piece of land can earn more money growing tobacco than growing fresh vegetables. Tobacco leaves can be dried, they



#### Sweetness starts early

UNICEF found that more than half of children aged 6–23 months in many low- and middle-income countries consume sugary snacks or drinks on any given day. These foods are often introduced before age one, during a critical window for brain and physical development.

Photo: Didi Supriadi / Shutterstock



#### Feeding markets, not communities

Across the Amazon, deforestation continues to make way for soybean production driven by global demand, with around 80% used for animal feed, often at the expense of local food diversity and sustainability.

Photo: Parallax / iStock

don't rot, and they can be turned into cigarettes. But if there is a famine, you cannot eat tobacco. A farmer who grows carrots, pumpkin, or potatoes can survive and will not die of starvation. That is the difference between cash crops and edible crops, and it comes down to sustainability.

**The same argument applies to land being used for condominiums instead of farming, right?**

Yes, to satisfy urban population density and housing needs. From a land use for agricultural purposes, you may have heard of slash-and-burn practices. Large parts of Borneo were once natural forests. They were cleared, crops were introduced, and eventually oil palm trees became the dominant crop on vast plantations. Oil palm is a cash crop grown for money, not for direct consumption.

In parts of Malaysia and elsewhere, this has led to soil erosion. Palm trees have shallow root systems, so when there is heavy rain, the soil washes away. The same thing happens in the Amazon, leading to earth not firmly held in place and hence landslides.

#### POLICY AND GOVERNANCE

**From a governance perspective, we have the Ministry of Health and other authorities regulating what enters the market. Can they ensure that people are eating well?**

That happens at a very macro level, but it doesn't always translate into everyday realities. If I want 300 grams of fresh fish, what does that cost? Maybe around ten dollars for a fillet. Beef might cost slightly less. If I buy celery or chye sim (Chinese flowering greens) and I live far from a farmer's market, that also comes at a certain cost.

But compare that to eating a slice of white processed bread with some Spam and drinking a bottle of Coke. For an inexpensive and modest meal, I'm full and happy because it's tasty. It's full of unhealthy fats, processed carbohydrates from bread that isn't whole grain, and sugar from the Coke. That still counts as a meal.

Now compare that to a meal with a lean cut of meat or fish, some broccoli, carrots, peas, maybe a piece of cheese for dairy, or finishing with yoghurt. The first meal example might cost two or three dollars. The second could easily cost fifteen dollars. Yes, it's healthier, but if you're not used to it, why would you eat all these seemingly strange foods?

**Taking Singapore as an example, policies like reducing sugar in drinks seem driven by rising healthcare costs, particularly diabetes. Without immediate incentives, is it much harder for governments to intervene in what we eat and drink from a long-term health perspective?**

They can't, in practical terms. Singapore has a large bottling industry. We don't produce Coke itself, but

companies like F&N prepare the syrups and sugars that go into Sprite, Coke, and Pepsi. Malaysia does the same. We supply the basic ingredients that allow these drinks to be produced. Very often, the sugar used is in the form of high-fructose corn syrup. It's much cheaper and about 1.7 times sweeter than normal table sugar (sucrose). It's also very stable because the molecule is altered, so it doesn't change or denature, or affect taste over time. The food industry is designed to make us keep buying the same products — a taste that triggers reward centres in the brain and makes us feel happy. That sweet spot of sugar, salt, and oil keeps us coming back. Home-cooked food is usually more bland. Restaurant food tends to have more oil, more flavour, and sometimes more deep-frying. I'm not saying they add MSG, but it's richer or more complex in taste. In general, home-cooked food, although 'less exciting', is better for us.

Countries want to make sure their populations don't go hungry. That's the priority. There's a big difference, and this is something people aren't taught properly. We hear messages like *less sugar, less sodium, healthier options*. What they should also explain is that when you eat well and train your taste buds, you start to feel uncomfortable when something is too sweet. You don't even need to buy "less sugar" products — your body will tell you, *this is too sweet*.

*The food industry is designed to make us keep buying the same products... That sweet spot of sugar, salt, and oil keeps us coming back.*



What they don't emphasise is fibre. Even if you don't get diabetes, a diet high in processed bread and low in fibre increases the risk of colon cancer. Among Chinese Singaporean men, colon cancer has one of the highest incidence rates. We're told not to eat too much fat, but not all fats are bad — olive oil is a good fat. Exercise protects the heart and raises good cholesterol. Instead, people only receive part of the message.

### Why is that?

If I say this, I might get into trouble. Bodies or agencies that are in charge of health promotion, which oversee many of these policies, tend to communicate partially. This may be in the form of a campaign which does not offer a fuller picture. They are slowly trying to change, but if I truly wanted a healthy nation, I would start by putting kitchens in schools. I would bring in vegetables and teach children how to recognise brinjals (eggplant), carrots, lady's fingers (okra), spinach, and how to cook them, incorporating them into delicious meals.

We only really learn to cook when we go to university or leave home, having to fend for ourselves. Even then, we choose cheaper options (as we may be on a tight budget) just so we're not hungry and can focus on studying and partaking in new experiences. We're not throwing dinner parties with curated recipes or more elaborate meals, that's for sure.



#### The school kitchen

In Japan's school lunch system, or *kyūshoku*, meals are often prepared fresh onsite and treated as part of education. Students help serve food and clean up afterward, reinforcing healthy eating habits and communal responsibility from a young age.

Source: Kyodo News



#### A meal without barriers

At Sikh gurdwaras, langar is a free community meal open to all, regardless of background or income. Rooted in principles of equality and service, it brings people together over simple vegetarian food, with some gurdwaras serving tens of thousands of meals daily, sustained entirely by volunteers.

Photo: Dinodia Photos / Alamy

Coming back to food access, if I'm at a hawker centre and I ask for extra kang kong or chye sim, they'll often say that's not possible. Every bowl has a fixed portion of its constituent ingredients, normally. If the stallholder didn't plan to order extra vegetables, he or she may only have enough ingredients for say about 200 bowls. If they start customising portions, the last few customers won't get the same amount, and complaints may arise. So structurally, it's easier to keep portions fixed, even though intuitively, people should eat more vegetables and fruit. Some have adapted and have larger stocks of vegetables and can charge for a request of more greens. For leafy vegetables, being highly perishable, that is a risk, as unsold vegetables will often go to waste — that is a loss for the vendor.

**In the end, for people to eat better, consumers still need to be educated. They have to ask for better options or be willing to pay a bit more, and then suppliers and producers will respond. In supermarkets, healthier options are usually in a separate section and they're always more expensive.**

Mexico introduced a sugar tax. There are two policy approaches to this — you can tax unhealthy, readily available foods and subsidise fresh vegetables or lean meats. But governments often avoid this because it disrupts the natural market mechanisms. Fishermen work hard to catch fish and are paid a certain amount. If the government later intervenes to lower the price at the supermarket, it creates tension in the system and other unintended problems.

What we actually need, even if it sounds old-fashioned, is community-based solutions. Have you been to a Sikh temple, a Gurdwara? I didn't know about this before. Every morning, people gather there. I wake up, drink my coffee, read the papers, then go to the Gurdwara. I chop vegetables and help cook. By around six, anyone can come and eat. There's a free flow of vegetable and lentil dishes, chapati, and rice. The food is fresh, cooked that morning with good ingredients, and it's very healthy. There are basins for washing the dishes or food recipients properly once one has finished eating. People clean up after themselves. The entire experience is communal and people-centred. Some volunteers cook, others shop. It provides one nutritious meal a day for the community, and guest diners don't have to pay. Foreign workers come, families come. There's a wide variety of vegetables, from lady's potatoes to long beans, peas, and carrots. As one volunteer put it, "If I wake up every day, I'm not poor if I have food and a roof over my head. I give thanks and spend one hour chopping vegetables and cooking." Families sit on mats on the floor, cross-legged, talking. When they're done, they leave and the next group comes in. It's a communal effort, and I find it very meaningful — healthy for the body and healthy for the soul.

#### INDIVIDUAL EFFORTS AND COMMUNITY

**How can we eat healthily if systemic or structural change takes a long time? For a middle-class family in Singapore, what practices can help them eat well and avoid long-term health problems linked to processed or unhealthy food, within a system they cannot easily change?**

It starts very early. During pregnancy, mothers and fathers should both be educated about nutrition. We shouldn't make parents feel guilty by saying they must buy only one expensive brand of milk or else their child won't develop properly. Those advertisements are not helpful. You see rural communities without all these products, and their children still grow up well if the mother's breastmilk provides enough nutrients complemented by nutritious semi-solid and solid food later.

Breastfeeding where possible is important, unless the child or the mother has an illness or is unable to breastfeed. Then this education should continue



#### Healthy meals delivered

Meal-prep and nutrition-focused delivery services are growing rapidly in Singapore as increasingly health-conscious consumers seek convenient ways to manage macro tracking, portion control, fitness goals, and balanced nutrition without cooking daily.

Source: Nutrition Kitchen

in schools. Nutrition should be treated as seriously as mathematics or language. You eat three times a day for your whole life. If you feed your body wrongly every day, the long-term impact is huge, possibly bigger than inhaling haze particles for one month a year, because this is something that happens daily. [laughs] Do not quote me as an encourager of environmental haze!

**But as you mentioned earlier, eating well costs more. Is there a reasonably affordable way to eat healthy, especially if you don't have much time to cook and rely on hawker centres or restaurants?**

It sounds a bit silly, but you do have to spend time. Take pai kua (pork rib bones) or fish bones after the flesh has been removed. Boil them into a rich stock, then add winter melon, lotus root, or peanuts, and you have a nutritious soup that doesn't cost much. If you prefer something Western, you can make tomato, carrot, or pumpkin soup. Soup is very good because it packs vegetables into an easy-to-eat form. You can drink it on its own or have it with wholemeal bread or a slither of cheese. It's filling, and most soups are vegetable-based anyway.

**Consuming food is not just about feeling sated. It carries significant cultural and social meaning, and that's really important.**



What I used to do was cook in batches on weekends. I'd go to Tekka Market early on Saturday morning, buy my ingredients, and then cook. One pot would be soup, another would be pasta sauce like Bolognese with tomatoes, carrots, and lean beef. Then I'd freeze everything in portions. On a weekday, you just take one portion out in the morning, let it thaw, and dinner is ready. It takes some education to know how to prepare and freeze food, but students can do this too. I used to teach university students how to feed themselves well on a budget.

Beyond food, people need to schedule exercise or meditation two or three times a week and make sure they get enough sleep. Stress management is another pillar of health. You can eat well and not smoke, but if your stress levels are very high over a long period of time, you may still be at risk for cardiovascular incidents — heart attacks, strokes, or high blood pressure. Stress is one factor, but combined with other unhealthy behaviours, compounds the ill effects on health.

Social connection is an often-forgotten pillar for good overall health. Food and eating are very social. Even during this interview, we're talking whilst eating. Birthdays involve meals, cake, and candles. Festivals are centred around food. A baby's 100th day comes with the traditional red-dye eggs. Consuming food is not just about feeling sated. It carries significant cultural and social meaning, and that's really important.

**Does this mean it's healthier to eat with other people than to eat alone? That seems more like a mental or emotional aspect rather than something that directly affects nutrition.**



#### Eating alone together

Solo dining is becoming an increasingly visible part of urban food culture, with eateries adapting through counter seating and solo-friendly layouts as more people eat alone amid changing work patterns and increasingly individualised lifestyles.

Source: Rice Media, photo by Stephanie Lee

Eating alone can be depressing sometimes. It can affect nutrition because if you are socially isolated or depressed, you may not feel like eating or may lose your appetite altogether. Older persons who are isolated often don't eat very well. But when you bring them together to eat, play mahjong or bingo, or go for a walk, they are very happy because they have friends to do these things with. I can tell you, when I'm living alone, most of the time I'll be checking my emails, trying to clear things, and then quickly swallowing something, not paying attention or eating 'mindfully'.

**I noticed something similar when I ate at a hawker centre last night. Many people were eating alone, scrolling on their**

#### Beyond cheap calories

Volunteer-run community kitchens such as Willing Hearts prepare and distribute thousands of freshly cooked meals daily, reflecting growing civic efforts to ensure that lower-income communities are not limited to cheap, highly processed food options.

Source: National Volunteer & Philanthropy Centre Facebook, photo by Caroline Chia

**phones. After a long day of work, they have little time to cook, so eating out is convenient and inexpensive. Yet many seem quite lonely.**

This is also a phenomenon linked to the dissolution of the family unit. When you come home to your grandma, grandpa or your parents, you already smell mouthwatering aromas when you walk through the front door. Soup has a smell, fried rice has a smell. You put your bag down, take a shower, sit down to eat, and everyone has a place at the dining table. It's a very social and very important bonding time for families. But when everyone starts eating alone, and you don't pay attention to eating together and sharing, you also stop paying attention to what's in your bowl or on your plate. Eating becomes secondary. You eat perfunctorily. You check your phone, eat quickly, and go home. You don't even have to wash up if food comes in styrofoam or disposable containers. If there is a roster among siblings from young — who helps when in food preparation, in washing up, in taking out the trash — a normal culture of food and food appreciation together within the household will form and be perpetuated. Deliberate rostering

**It's about being creative with similar ingredients in different styles. One can be a cold meal like a sandwich, the other a hot meal.**



of duties engage family members to own activities around feeding themselves. If I say, "I don't have time to get groceries after work, and I do not have all the ingredients to make this particular dish," I ask who can pick up specific ingredients from a store or market (that I will pay for). They have to participate, so they own the meal preparation process with me.

These days, eating out in restaurants can be expensive. When my children come to Singapore for a visit, I take them out and they want to try everything. But after one chilli crab meal, they already feel *jelak* (Malay term for overkill or sick of eating) because the sauces and gravy are very rich. They go back to simpler or 'clean' foods and they're quite content. How we educate the palate determines what we look for, or crave, when we eat.

**You're very familiar with both Western and Asian food cultures. You've sometimes described Western food as simpler, with more raw ingredients and less emphasis on chopping, frying or spices. Do you see different strengths or drawbacks in these approaches to food?**

Preparing meals can take a lot of time, and people get tired of it. In Western food, salads are common. Olives are not cooked; they're already pickled or preserved. Cheese is taken straight off the shelf. There's

no need to cook. Tasty, nutritious, simple. But one must be introduced to eating salads or raw food at a fairly early age to appreciate it.

People get sick of eating the same thing, so you need to vary food options. I can open a can of tuna, which is much better than corned beef or spam. I can chop some tomatoes and baby onions and make a tuna sandwich. Or I can use the same can of tuna to make fried rice with tuna flakes instead of leftover pork or char siew. It's about being creative with similar ingredients in different styles. One can be a cold meal like a sandwich, the other a hot meal. With tuna, rice, a few peas and an egg, you have fried rice. Eat it with chilli sauce and you're done. You have protein and vegetables. Rice does not contain gluten and is extremely gut-friendly. You can also cook extra and freeze it — fried rice freezes very well. Back to the topic of convenience and time-saving attributes of batch cooking!

**Thinking about it, we have far more food variety today than when we were younger. I remember growing up without McDonald's or Burger King. Is variety a good thing, or is it better to stick to one kind of diet?**

If it's available and affordable, variety is good. But if I lived in a small village in rural surroundings, and had never seen these more 'urban' foods, I wouldn't know what I was missing. If I suddenly went to study in a country that has very different food than what I am used to, I would definitely miss my home food because I find the food there bland or unfamiliar, and I would feel homesick. Food offers a lot of comfort too.

**But after a while, you have more options. When you start cooking healthily, you can choose from different ingredients and ways of preparing food. That seems like a positive side of urbanisation and globalisation.**

But it starts very young. Have you seen children who only eat one or two things and refuse everything else? Do you blame the child, or do you hypothesise that the people feeding the child didn't make the effort to vary the food and develop the palate? Education is important. An interesting example is the



Seventh-day Adventists community in Loma Linda California — yes, one of the Blue Zone communities! They are brought up with certain ‘habits’ that seem to help them live to a hundred: they don’t drink alcohol or smoke, they consume less meat and have a mainly plant-based diet, they have strong family and community ties, they walk and move regularly, they drink lots of water, they have spiritual they’re healthier. From young, whether through religion or community beliefs, those practices can pretty much determine one’s health trajectory (barring the influence from one’s genes).

If parents can’t afford fresh leafy vegetables and rely on canned or frozen versions because they’re cheaper, it’s not bad parenting. They didn’t mean to deprive the child. It’s about what they can afford after paying for everything else, including electricity bills, buying school books and uniforms. If you have to take a loan just to buy food or rely on food stamps, that’s very sad and something would need to be done to change that.



*The choices you make matter because, as people always say, you are what you eat.*



**Philosophically, I feel that eating and food have become more complex than they should be. Food is supposed to nourish us and then let us get on with life. But nowadays, every meal feels complicated. I walk into a restaurant and there are so many choices and decisions to make. Has food become too big a part of daily life?**

In a nutshell, yes, eating and food need not be complicated. Choices available in F&B outlets are partly driven by consumer requests, by fads, by commercial pushes. Ready-to-consume options can sometimes seem complex. I like to quote Michael Pollan, a writer on food, agriculture, human nutrition and our natural environment: “Eat food. Not too much. Mostly plants.” Simple and very sound advice. The choices you make matter because, as people always say, you are what you eat. Genetics plays a big role, but the rest depends on whether you exercise too and how you live. ∞

**The choices we learn**

Eating habits are established early in life and often continue into adulthood. Family routines, cultural exposure, education, and repeated food experiences play an important role in shaping the food choices people make later in life.

Photo: Tommaa Wang / Unsplash

**PERSPECTIVE**

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PROF WILLIAM CHEN

# Novel Foods and Alternative Proteins for a Sustainable Urban Food System



Photo: Getty Images / Unsplash

With the world's population projected to reach 9 billion in 2050, food security is becoming an increasingly important global issue. The increase in population, changes in consumer taste, climate change, resource scarcity, and the COVID-19 pandemic make meeting the potential 60% increase in demand for food even more challenging.

To achieve sustainable food production, novel food systems beyond traditional farming are needed to address the following key challenges:

1. Increase the variety of crops for primary production and explore alternative food sources.
2. Reduce food loss and food waste, which can go up to 40% at the post-harvest level.
3. Understand the minimal nutritional requirement.
4. Establish a closer relationship with consumers to achieve greater awareness of new foods.
5. Incorporate urban farming and technological advancements to enhance and modernise current food systems.

## URBAN FARMING AND AN EFFICIENT FOOD SYSTEM

With the increasing urbanisation in the world, urban farming would provide a sustainable solution to complement traditional farming. Urban farming contributes to resilience against climate change and environmental hazards, while providing fresher food with higher nutritional value and reduced food losses. Due to limited space, lower yields, crop suitability, and high infrastructure costs, urban farming can complement but not replace traditional farming.

Singapore's food security is interconnected with the global food supply, with 90% of food being imported from over 180 countries. Technology-driven urban farming would ease the burden on food imports and establish a more efficient food system, which can be propagated globally. The resilient food system is outlined in the recently announced 'Singapore Food Story 2,' which covers diversifying import sources,



### Growing food in a vertical city

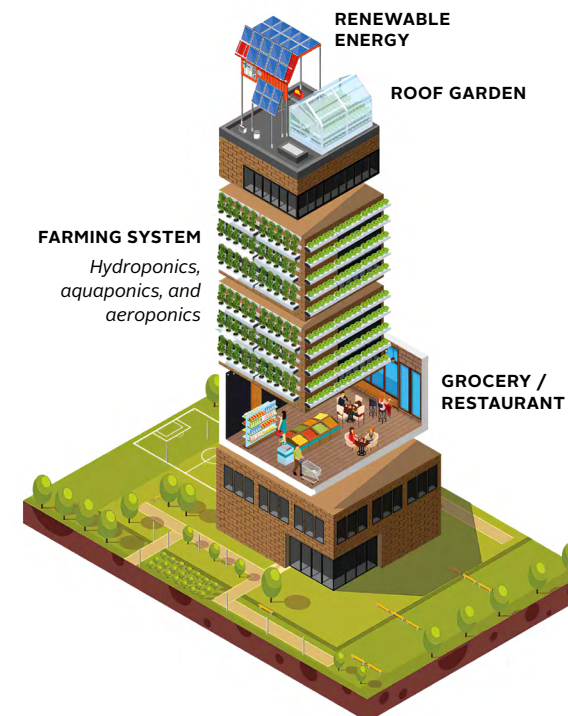
Singapore is increasingly investing in technology-driven urban farming as part of broader efforts to strengthen food resilience, diversify food sources, and reduce vulnerability to global supply-chain disruptions under its Singapore Food Story 2 strategy.

Photo: AzmanL / iStock

boosting local production, stockpiling, and global partnerships. Our strong research and development capabilities would also contribute to 'Singapore Food Story 2,' under our government's vision, with defined targets for two commodity groups: fibres and proteins by 2035.

Urban farming offers localised food production that can enhance food security, reduce supply chain dependence, and promote community engagement. By utilising rooftops, vertical gardens, and small-scale plots, urban farming provides fresh produce with lower transportation costs and environmental impact. It can diversify food sources, support sustainable diets, and foster awareness of healthy eating. Integrating urban farming with conventional agriculture creates a resilient and adaptive food system, bridging gaps between production, accessibility, and consumer connection to food origins.

### Advantages of urban farming



## DIVERSIFICATION OF FOOD SOURCES

Despite the constraints mentioned above, urban farming can complement and go far beyond traditional farming by striking the right partnership between nature and technology. One example would be to use technology to develop alternative proteins in the urban farming framework (eg, microalgae, plant-based, and cell-based meat). In addition, crop and aquatic food diversification, together with the application of fermentation technologies, represent key strategies for broadening and diversifying food sources.

A recent report by the Good Food Institute (GFI) stated that "governments around the world announced about USD 510 million in new committed support for alternative proteins, including increases in research and development." Furthermore, new GFI data shows that from 2016 to 2025, over USD 19 billion was invested in industries developing sustainable alternatives to conventional animal-based foods, including plant-based, cultivated, and fermentation-derived proteins.

- Weatherproof**  
Crops grown in controlled environment
- Year-round crop production**  
No more "seasonal crops" continuous production
- No running out of land**  
Indoor growing conditions eliminate the use of chemical pesticides
- Environment-friendly**  
No soil or new land required
- Increased yield**  
Produces the same yield as a traditional 4-6 acre farm
- Water conservation**  
Hydroponics uses 70% less water

Source: <https://theasianpost.com/article/farming-city>

# Urban farming can complement and go far beyond traditional farming by striking the right partnership between nature and technology.

## THE DIFFERENT TYPES OF FUTURE FOOD

### 1. Microalgae



Microalgae provide sustainable large-scale production with the potential of growing on non-arable land using undrinkable water or seawater and high biomass yields per area. Their

microscopic feature enables simpler genetic manipulation, higher protein content, and easier scale-up. However, challenges remain in large-scale production, particularly the yield optimisation and improvement of organoleptic characteristics to enhance consumer acceptance. In urban settings, circular economy models can be implemented for sustainable microalgae production. Researchers from Nanyang Technological University's Food Science and Technology Program (NTU FST), in collaboration with industry partners, have successfully replaced the commercial microalgae culture medium with fermented food processing side-streams.

### 2. Plant-based meat (PBM)



PBM has gained attention due to environmental, health, and ethical considerations, though improving sensory traits and consumer acceptance remain key challenges. PBM products

can be made from pulses, cereals, tubers, fruits, and food industry by-products, which offer a rich profile of fibre, protein, and micronutrients, desirable physical and mechanical properties, phytochemicals (eg, antioxidants), and low cholesterol content. For example, proteins from soy, cottonseed, and wheat gluten are used to develop meat alternatives. Texturisation is achieved through

extrusion, spinning, or shear-cell technology, while thermal treatment, drying, or coagulation solidifies the structure. The PBM industry currently focuses on products such as burger patties, minced meat, steaks, and sausages, with companies like Beyond Meat and Impossible Foods successfully providing PBM products.

### 3. Insect-based meat (IBM)



Edible insects are a promising future food due to their high protein and micronutrient content, low fat and energy, improved digestibility, low land and water use, and reduced

greenhouse gas emissions, though challenges remain in investment and consumer acceptance. One hundred grams of edible insects supplies ~750 kcal, comparable to traditional meat or PBM. Over 2,100 species are recognised globally, with about 30% of people in over 113 countries consuming IBM, mainly as snacks, side dishes, or integrated with staple foods. Insects are popular street food in Southern Africa and Southeast Asia, and in the West, mealworms and crickets are increasingly used in snacks, protein bars, burgers, and pasta. There is a growing number of companies developing IBM, like Ÿnsect, Protix, Aspire Food Group, InnovaFeed, and Entomo Farms. As edible insects are considered novel foods in many regions, they require extensive safety assessments and regulatory frameworks, and large-scale production demand advancements in breeding techniques, processing methods, and automation.

### 4. Mycelium-based meat



Mycelium-based foods are commonly classified into mushrooms and mycoproteins. Mushrooms are valued for their high protein and fibre contents, low calorie density,

and low levels of fat and sodium. When used as meat extenders, mushrooms contribute health-promoting compounds, reduce meat content, and enhance flavour intensity and saltiness perception through umami compounds. Global mushroom and truffle production increased by 403.44% between 2000 and 2021. In 2021, China dominated production (93.03%), followed by the EU (3.40%), Japan (1.06%), and the USA (0.78%).

Nutritional comparison of novel foods vs conventional foods

Food category	Protein quantity & quality	Fat profile	Key micronutrients	Fibre	Other nutritional features
<b>LIVESTOCK MEAT</b>	19.4–24.2% High-quality and bioavailability, complete protein	1.3–31.7% Mostly high saturated fat; presence of cholesterol	Iron, zinc, vitamin B12	None	High energy density
<b>SEAFOOD</b>	17.0–27.0% High-quality and bioavailability; complete protein	1.0–10.0% Low saturated fat	Iodine, selenium, calcium, iron, zinc, vitamin D and B12	None	Essential long-chain omega-3 fatty acids (EPA and DHA)
<b>STAPLE CROPS</b> (rice, wheat, maize)	6.8–11.8% Incomplete	0.7–3.4%	B vitamins, magnesium, vitamin A precursor (carotenoids), fortified zinc, iron	3.5–12.2%	High carbohydrates (74.1–78.9%); energy source
<b>PLANT-BASED MEAT ALTERNATIVES</b>	14.1–19.8% Near complete	4.0–12.8% Low-moderate saturated fat; lower in cholesterol	Iron, fortified vitamin B12, zinc	2.4–6.3%	Low-moderate carbohydrates (1.62–8.49%); higher sodium; processed
<b>CULTURED MEAT</b>	14.5–22.5% Identical to conventional meat	1.5–3.5% Customisable (lower saturated fat possible)	Iron, fortified zinc, vitamin B12, selenium	None	High consistency, no antibiotics
<b>INSECT-BASED MEAT</b>	15.2–35.2% Mostly complete	4.3–24.9% High unsaturated fats	Iron, zinc, calcium, copper, vitamin B12, manganese	1.0–7.4% Mostly chitin	High nutrient density
<b>MICROALGAE</b> (Spirulina, Chlorella)	30–70% Good amino acid profile	4–20% Omega-3 / omega-6 rich	Iron, iodine, vitamins B1, B2, B3, B9, B12, E and K, carotenoids	5.6–8.5%	Moderate carbohydrates (12–30%); antioxidants; bioactive compounds
<b>MYCELIUM-BASED FOOD</b>	2.1–12.6% Good digestibility; near complete	0.4–2.9% No cholesterol	Potassium, zinc, iron, B vitamins	1.3–6% Mostly β-glucans and chitin	Naturally fibrous; low GI
<b>UNDERUTILISED CROPS</b> (millets, pulses, tubers)	2.0–28.50% Incomplete	0.1–9.7%	Iron, zinc, calcium, magnesium, vitamins B, C, E, A	3.8–38%	Carbohydrates (9.4–74%), climate-resilient; low GI, variation depending on the species; bioactive compounds

Mycoprotein (eg, Quorn™) is widely consumed across 17 countries and is characterised by low fat and energy content, alongside high fibre and high-quality protein with a fibrous texture. Commercial Quorn products include chunks, sausages, and burgers. Research on its metabolic, anabolic, and broader health effects is growing. Mycoprotein is rich in essential amino acids, accounting for approximately 41% of total protein.

### 5. Cultured meat (CM)



CM is bio-artificial muscle mass produced through in vitro cultivation of animal muscle stem cells (myosatellite cells) and is available as minced meat and hamburgers. Advances

in cell culture techniques in cell density, doubling time, and bioreactor efficiency have indicated major cost reductions, with one optimised system lowering costs from USD 437,000 to USD 1.95/kg. The nutritional profile of cultured meat is comparable to that of conventional meat. CM can lower greenhouse gas emissions and land and water use by approximately 80–90% relative to livestock production, while being energy efficient and safe for individuals with soy, nut, and wheat allergies.

However, limitations include low consumer acceptance due to perceptions of unnaturalness, limited information on long-term health effects, and challenges in cell engineering. Surveys denote that acceptance could rise by 27–55% if costs match or fall below those of conventional meat. Eliminating foetal bovine serum and antibiotics from growth media is essential to create sustainable and acceptable CM. In this context, food technology innovations are critical; notably, researchers at NTU FST Program have replaced foetal bovine serum with fermented soybean residues, offering long-term cost savings for large-scale production.

### 6. Underutilised crops



Although over 30,000 edible plant species exist globally, fewer than 150 are commercially cultivated, and 20 species provide 90% of the global food supply. Three staples

(rice, wheat, and maize) contribute about 50% of global food energy. Low crop diversification, high consumption of processed foods, and sedentary lifestyles have led to malnutrition in 2 billion people and obesity or non-communicable diseases in 1.9 billion.

One solution is biofortification of crops through plant breeding or genetic engineering. Neglected and underutilised species (NUS) can meet micronutrient needs and provide health benefits along with their climate resilience, adaptability, low input requirements, genetic diversity, and nutrient richness. Thus, NUS could support efforts to combat hunger, malnutrition, and poverty. Research on NUS is increasing, with Asia, followed by Africa, holding the greatest genetic diversity. NUS can be broadly categorised into five groups: pseudocereals and millets, grain legumes, roots and tubers, leafy vegetables, and fruits.



#### Rediscovering underutilised crops

Long consumed across Southeast Asia, crops such as winged beans, taro, and other neglected species are regaining attention for their nutritional richness, climate resilience, and potential to reduce global dependence on a narrow group of staple crops.

Photo: Thai Liang Lim / iStock



#### The next frontier of food

Singapore's approved novel foods now include cultivated chicken and quail, fungal mycoproteins, algae-derived foods, and precision-fermented ingredients, reflecting how future food technologies are expanding far beyond plant-based meat substitutes.

Source: UPSIDE Foods

### 7. Seafood



Fish are highly efficient at converting feed into biomass compared to terrestrial livestock, and the availability of ocean space makes seafood a promising protein source.

Although production is expected to increase by 2050, seafood currently accounts for only about 17% of edible animal protein. With policy reforms and technological advancements, global seafood production could increase by 21–44 million tonnes by 2050, representing a 36–74% rise from current levels and contributing 12–25% of the projected increase in meat demand. As several countries, including China, have imposed limits on land and freshwater use, much of this growth is expected to come from mariculture.

Mariculture production still depends on feed inputs such as fishmeal and fish oil; however, due to ecological constraints, alternative feed ingredients are being actively developed. These include seafood processing residues, plant- and animal-based proteins, algae, microbial biomass, insects, and genetically modified crops.

**Together, nature-based and technology-driven foods should be viewed not as competing solutions but as complementary components of a resilient, sustainable, and diversified food system.**

### NATURE-BASED ALTERNATIVE FOODS VS TECHNOLOGY DRIVEN NOVEL FOODS

Nature-based alternative foods and technology-driven novel foods represent two complementary pathways for diversifying future food systems. Nature-based alternatives, such as legumes, cereals, mushrooms, seaweeds, insects, traditional fermented foods, and underutilised crops, rely on naturally occurring biological resources and relatively low levels of processing, providing immediate advantages in sustainability, scalability, nutritional quality, cultural familiarity, and consumer acceptance.

In contrast, technology-driven novel foods, including cultivated meat, precision-fermentation-derived proteins, microalgae, and highly engineered plant-based products, leverage advanced technologies to replicate or enhance animal-derived foods, with the potential to significantly reduce long-term environmental impacts and address growing dietary requirements in the world. However, some challenges related to high energy use, production costs, scalability, regulatory complexity, and consumer trust exist in these technologies. Together, nature-based and technology-driven foods should be viewed not as competing solutions but as complementary components of a resilient, sustainable, and diversified food system.

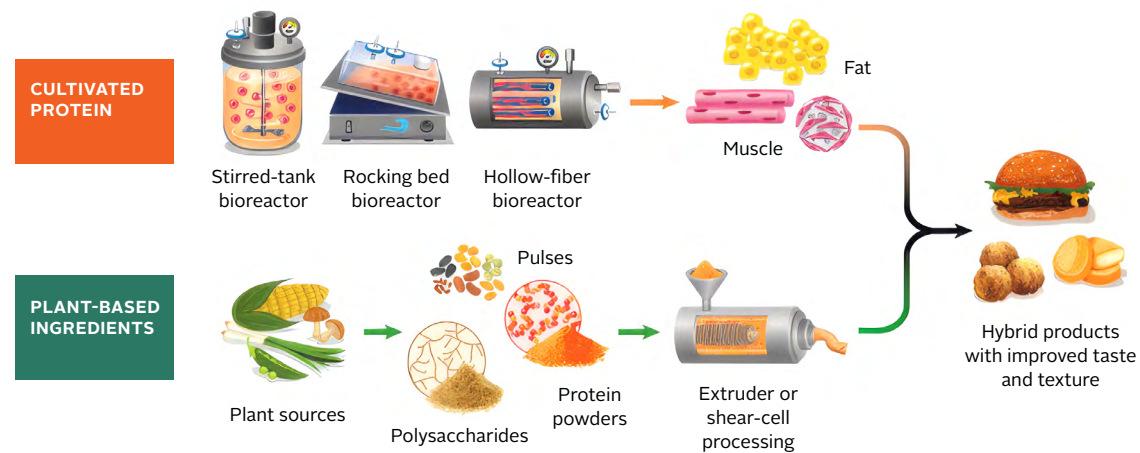
## HYBRID FOODS

Hybrid foods that combine plant and animal proteins can offer a pragmatic approach to protein diversification while balancing sustainability, nutrition, and consumer acceptance. Partially replacing animal proteins with plant-based ingredients (hybrid products) can cause lower environmental impacts (ie, greenhouse gas emissions and land use) while preserving the sensory attributes, functionality, and nutritional completeness. From a nutritional perspective, hybrid foods can deliver high-quality protein with improved fibre content and a more favourable fat profile. Importantly, they align well with consumer preferences, as they require minimal dietary change and can be perceived as more natural and affordable than fully animal-free or highly engineered alternatives. For example, the potential of mushrooms as meat extenders has been demonstrated through partial substitution with mushrooms in beef patties, nuggets, and sausages, highlighting several benefits, including the presence of nutraceutical compounds, enhanced overall flavour, reduced meat content, improved shelf life, and increased perception of saltiness.

The production of hybrid foods not only supports the continued use of conventional ingredients but also enables the incorporation of emerging protein sources through blending, providing a pathway to address certain challenges related to consumer perception, cost, and taste, while enhancing nutritional quality and sustainability.

## CONSUMER PERCEPTION OF PROCESSED FOODS

Consumer perception of processed and ultra-processed foods (UPFs) reflects a mix of caution and appreciation. Many consumers associate higher processing with lower healthiness and express limited trust in manufacturers, particularly regarding contaminants or chemical residues. At the same time, food processing plays an important role in improving safety, nutritional quality, taste, and shelf life. Emerging processing technologies offer further benefits but face challenges in consumers' and stakeholders' acceptance due to cost, limited information, and perceived risks. Professionals note blurred definitions and classifications of



**Hybrid alternative proteins using plant-based and cultivated ingredients**

Source: <https://www.sciencedirect.com/science/article/edited-volume/pii/B9780443187674000329>

### The ultra-processing question

A 2026 study in *Frontiers in Sustainable Food Systems* found that consumer concerns over ultra-processing, alongside high prices and product limitations, have contributed to slowing growth in the plant-based meat market.

Source: Beyond Meat



processed foods, underscoring the need for clearer communication. Greater transparency, public education, and interdisciplinary dialogue can help consumers make informed dietary choices while recognising both the advantages and limitations of food processing.

PBM can be in ultra-processed forms (eg, burgers and sausages) while often using purified plant proteins instead of whole foods. In one study, some participants perceived meat alternatives as legumes, while others saw them as highly-processed burgers. The market for ultra-processed plant-based meat substitutes is growing, while they may pose higher environmental impacts. Further research is needed to compare processed PBM and conventional foods, particularly regarding nutritional values, sensory attributes, health effects, and environmental impacts.

## COST-EFFECTIVENESS OF FUTURE FARMING

Cost-effectiveness of future farming denotes the capacity of emerging agricultural systems to produce sufficient, nutritious food at competitive costs while reducing environmental impact and resource utilisation. Several key dimensions can be suggested: precision and digital agriculture, urban and controlled-environment farming, crop diversification and biofortification, alternative proteins, and incorporation of circular economy approaches.

The application of technologies such as the Internet of Things (IoT), machine learning, and artificial intelligence (AI) can enhance monitoring, control, and overall efficiency in future food systems through automation, real-time data integration, early detection of pests, diseases, and system failures, predictive analytics, and decision support. They can enable precise resource optimisation (water, energy, nutrients, and inputs), improved traceability and food safety, better yield forecasting, and reduced labour requirements, leading to lower costs, minimised waste, and improved system resilience.

In urban settings, vertical farms, indoor farms, container or modular systems, and rooftop or community-based farms reduce land dependency and transportation costs but may balance high energy and capital investments through efficiency gains. Urban and controlled-environment agriculture offers advantages, including high space efficiency, scalability, year-round production, resilience to adverse climate and weather conditions, integration with climate control technologies, reduced food miles, local food production, and enhanced community engagement and awareness.

The aforementioned alternative proteins are being explored by food scientists and manufacturers to reduce long-term costs relative to livestock by improving feed conversion efficiency and scalability, while contributing to sustainable and food-secure systems. However, several challenges related to production scale, safety regulations, limited data on nutritional and health profiles, and consumer acceptance remain and must be addressed.

Crop diversification and biofortification can improve nutritional quality and system resilience without proportionally increasing agricultural inputs, thereby enhancing cost efficiency. However, achieving a balanced and diverse diet remains challenging for many populations, leading to persistent micronutrient deficiencies, particularly in low-income settings. Food-based approaches such as fortification and dietary diversification are widely used to address these gaps. Crop diversification, which is defined as the cultivation of multiple crop species or varieties within the same area over a given period, offers a strategy to reduce reliance on monocultures and strengthen the resilience of food systems.

Circular economy enables the valorisation of food side-streams and waste, and reduces input costs. By closing loops within the food system, they promote regenerative practices, minimise food losses across the supply chain, and convert by-products into valuable resources such as animal feed, alternative foods, bioenergy, or nutrient amendments.

## The establishment of food laws and regulations is required to protect health, satisfy consumer needs, and ensure fair trade practices.

### THE KEY ROLE OF THE PUBLIC SECTOR IN SUPPORTING THE FUTURE FOOD SYSTEM

Governments play a crucial role in achieving food security and supplying the estimated future food demand. The establishment of food laws and regulations is required to protect health, satisfy consumer needs, and ensure fair trade practices.

The importance of governments in driving food innovations for a sustainable food system is also

reflected in a report by the Tony Blair Institute for Global Change. It stated that “scaling food technologies requires overcoming several barriers”. There are some key barriers to scaling up food technologies: vested interests, lack of demand, lack of risk capital, infrastructure, and inputs such as power, regulatory burdens, and basic science or research and development. Although overcoming these barriers will require several role players (innovators, scientists, and investors) to come together, governments hold ambition and drive the direction of significant responsibility for setting the change. Governments also have a role to play in providing funding, infrastructure, and innovative regulation.

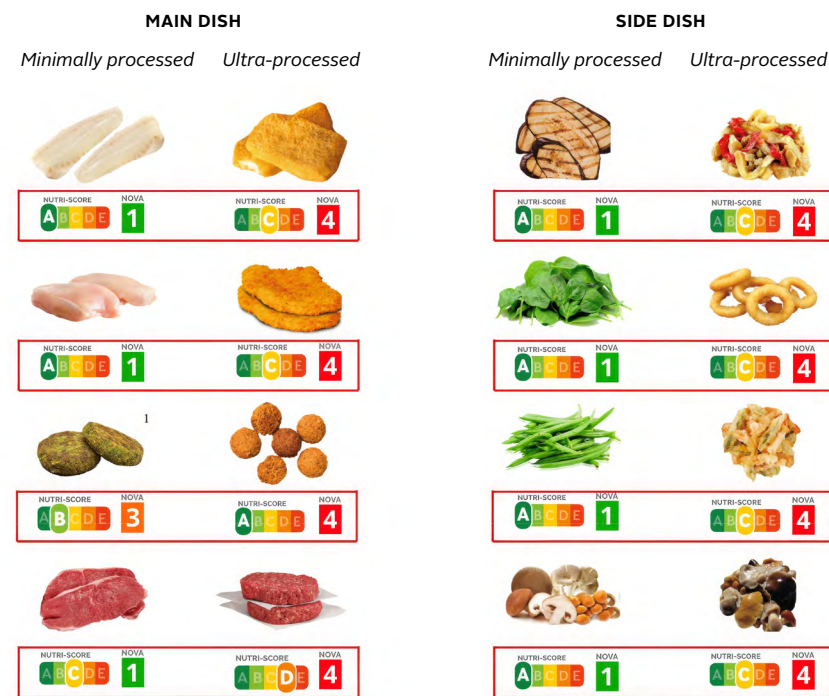
### CONCLUSIONS AND FUTURE PROSPECTS

A sustainable alternative food system requires an integrated approach spanning crop selection, future farming technologies, urban agriculture, hybrid foods, and efficient processing. Source crops should be nutrient-rich, climate-resilient, and familiar to farmers, such as underutilised legumes.

Transitioning from livestock to crop-based systems should be gradual to safeguard livelihoods. Urban and controlled-environment farming can reduce land dependency, enhance year-round production, and improve supply chain efficiency. Hybrid foods and alternative foods like plant-based, mycelium-based, and cultured proteins offer nutritional, environmental, and economic benefits. Efficient food systems must integrate farming, processing, and nutrition, including reducing food waste through innovations like NTU’s zero-waste fermentation of post-harvest side-streams. Strong public-private and regional partnerships are crucial to scaling technologies and innovations, exemplified by Singapore Agri-Food Innovation Lab and ‘Singapore Food Story 2’ initiative.

Together, these strategies can create resilient, sustainable, and nutritious food systems capable of meeting future demands while promoting environmental sustainability. ∞

*Acknowledgments: We would like to thank NTU Singapore for their continued support. We would like to thank Dr Malsha Samarasiri for her assistance in data sourcing and review.*



NOVA and Nutri-Score values of a selection of minimally processed vs ultra-processed foods

Source: <https://www.sciencedirect.com/science/article/pii/S0950329325000321#foo25>



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ELYSSA LUDHER

# Plotting for Health

## Urban Agriculture's Answer to Malnutrition

**W**e often associate malnutrition with rural areas. In the era of urbanisation, this is changing.

While rural areas still show higher percentages of malnutrition, the absolute number of residents in urban areas facing hunger and malnutrition is much higher. This is because more than half the global population live in urban and peri-urban areas. A 2024 report by the High Level Panel of Experts on Food Security and Nutrition of the UN Committee on World Food Security found that three-quarters of the world's malnourished populations — 1.7 billion of the 2.2 billion — live in urban and peri-urban spaces.<sup>1</sup>

Indeed, food expenditure in cities dropped during the COVID-19 lockdowns, which resulted in supply chain breakdowns or their residents losing income.<sup>2</sup> Some cities and towns addressed this by encouraging urban agriculture by distributing seeds and facilitating plots of land for community farms. One study in the West found that community farms increased 25% and 16% between 2020 and 2021, and 2021 to 2022, respectively, after seeing a 0.32% reduction between 2019 and 2020.<sup>3</sup>

### The rise of community gardening

First piloted at HortPark in 2016, Singapore's Allotment Gardening Scheme aims to encourage urban farming, strengthen community ties, and reconnect city dwellers with food production by allowing residents to lease small plots for about S\$65 a year to grow edible plants.

Photo: Kandl / iStock

Moreover, such a movement is also beneficial in alleviating malnutrition. Urban agriculture can provide more nutritious foods to urban residents alongside environmental, social, and economic benefits.

As 70% of the global population is expected to be urban by 2050, and we are losing 1.6 to 3.3 million hectares of prime agricultural land to urbanisation annually,<sup>4</sup> it is not only unsustainable but also inequitable that food production is left to rural areas.

### WHY IS MALNUTRITION RISING IN CITIES AND TOWNS?

The rise of malnutrition — across all socio-economic levels in cities and towns — is worsened by a complex interplay of rising urbanisation, high food prices, deteriorating living and lifestyle conditions, and limited access to nutritious foods. These frequently give rise to the “double burden” of malnutrition, characterised by the coexistence of undernutrition and overnutrition within the same communities. Undernutrition is caused by

inadequate access to nutritious food, poor health and sanitation, and a lack of understanding of healthy diets. Overnutrition, which often leads to obesity, results from excessive intake of energy-dense, nutrient-poor fatty or sugary foods, combined with low physical activity.

Unlike rural populations, who may have access to subsistence produce, urban dwellers are almost entirely dependent on cash income for food. Longer work hours and the higher share of parents or carers in the workforce deter home cooking of whole foods. Residents hence turn to convenience or purchased food. In recent years, high food price inflation, which is on average cumulatively 35% higher than pre-pandemic levels globally,<sup>5</sup> coupled with climbing living costs, has frequently forced families to choose between quantity and quality. Those impacted shift away from nutrient-dense whole-food diets to cheaper street or ultra-processed convenience foods that may be high in fats, sugars, and salt but low in essential vitamins. Furthermore, as farms move farther away due to urban sprawl, longer supply chains and higher food miles add to the cost of food.



## WHAT IS URBAN AGRICULTURE, AND HOW CAN IT HELP?

There are four main types of urban agriculture: home-based, community-based, commercial, and institutional agriculture (Table 1). These may produce vegetables, herbs, fish, insects (and their products, such as honey), livestock (including their products, such as eggs or milk), or mushrooms. They can be low- or high-tech and may incorporate mixed cropping systems, ornamental plants, hydroponic systems or aquaponic systems.

Types of urban agriculture	Examples of spaces and typologies
<b>HOME-BASED</b>	Balconies, rooftops, front/backyards, windowsills, indoor spaces under specialised grow lights, using soil or hydroponics.
<b>COMMUNITY-BASED</b>	Outdoor farms in underutilised residential, recreational, industrial, commercial or educational spaces, farmed by two or more people. Can range from two square metres to hundreds, farmed collectively or in allotments. They could be for members' consumption, for welfare, or for sale. Some may use regenerative farming methods, hydroponics, and/or combined with fish or livestock.
<b>COMMERCIAL FARMS</b>	May be outdoor peri-urban farms or indoor controlled environment agriculture (CEA) farms, contributing commercial-scale production of horticulture, aquaculture, livestock or fungi.
<b>INSTITUTIONAL FARMS</b>	Farming within institutions — such as prisons, universities, schools, hospitals, army camps, and others — that cater for its community, often for social benefits such as interaction, mental health, education, and others.

Table 1: Summary of types of urban agriculture

Localised food production enables ready access to diverse fresh produce and medicinal herbs that retain nutrition for longer and can contribute to overall health. Food purchased in supermarkets is typically stored for many days. Imported food may be stored for periods of up to months or even years. As vitamins and trace nutrients degrade immediately after harvest, even when refrigerated, extended storage reduces the nutrients eventually consumed. For example, one study found that various salad leaves lost between 35% to 86% of their vitamin C 10 days after harvest, even if stored at 4°C.<sup>6</sup>

Urban farms may also allow on-demand harvesting, which means yields over time are higher, and there is less waste. If the urban farm also uses organic or regenerative principles, the produce could also be a richer source of vitamins, micronutrients, fibre, and protein compared to factory-farmed food.

Furthermore, urban agriculture encourages active lifestyles, as people toil the soil and care for plants. Availability of greenery mitigates air and noise pollution and reduces heat exposure. Better access to green spaces is also correlated with lower stress levels, lower cardiovascular disease rates and lower mortality.<sup>7</sup> Community and institutional farms also contribute to improved mental health due to greater community interaction. Research has found that people involved in community gardens reported higher levels of optimism, resilience, social empowerment, and a sense of belonging to the community.<sup>8,9</sup>

## Localised food production enables ready access to diverse fresh produce and medicinal herbs that retain nutrition for longer and can contribute to overall health.

Beyond its nutritional, health, and social benefits, urban agriculture also has economic and environmental benefits (Figure 1). It is a buffer against sudden food price spikes due to supply chain breakdowns and price hikes. It can be an additional source of income if farms produce in excess; for this reason, it has been tied to youth employment, urban poverty alleviation, and women empowerment programmes. Outdoor farms can contribute to the environment by slowing stormwater runoff, sponging up precipitation to replenish groundwater, and alleviating the urban heat island effect. Ecologically, it provides services such as ecological corridors, wildlife habitats, and pollination pathways. One study found that globally, urban agriculture provides up to USD 33 billion of ecosystem services annually.<sup>10</sup>

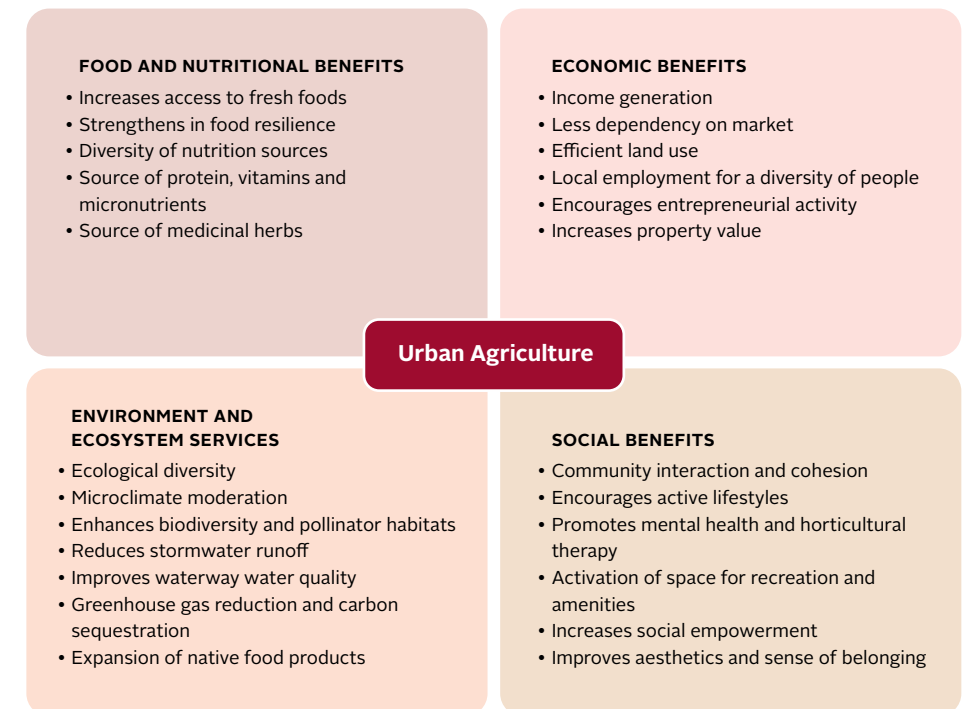


Figure 1: Benefits of urban agriculture

Source: Author's work<sup>11</sup>

## WHAT IS LIMITING URBAN AGRICULTURE, AND HOW CAN ITS GROWTH BE FACILITATED?

While urban agriculture has numerous benefits, it accounts for only a relatively small portion of the global food supply, estimated at 5% to 20%.<sup>12</sup> Urban and peri-urban farms are often converted to uses perceived as higher in monetary value, such as residential, commercial, industrial, or institutional projects. Some farms may be forced to move or close due to prohibitive zoning, land/space frictions relating to noise, smell and water pollution, or rising operational costs. It is a phenomenon that is challenging to slow or halt without regulatory protection of farming lands.

However, urban agriculture can evolve to different spaces. Cities often have underutilised spaces that are viable for food production. Furthermore, intensive farming technologies are now available, including vertical farming systems, grow lights, and hydroponic technologies. This has made it increasingly possible to grow food in smaller spaces. Science-informed and environmentally conscious farming methods can reduce nuisance or polluting elements.

### Seoul's "Metro Farm"

Described as the world's first smart farm inside a subway station, Seoul's "Metro Farm" reflects South Korea's creative reuse of dense urban spaces for food production, with similar AI-powered farms now expanding into libraries, abandoned underground walkways, shipping containers, and disused public infrastructure.

Source: Metro Farm

## Consumers can only gain benefits from urban farms if they trust the quality of the produce and are assured it is contamination-free.

Increasing urban agriculture requires deliberate, facilitative policies by national, state, or local governments. A 2019 World Bank study discovered that out of 170 surveyed Asian cities, most had policies concerning food; however, 3 in 4 reported that their policies were ineffective due to inadequate leadership, prioritisation, capabilities, or financial support.<sup>13</sup> Robust policy framework can enable urban agriculture to flourish. South Korea's 2011 *Act on Development and Support of Urban Agriculture* led to a rise in urban farming participants from 45,000 in 2011 to 647,000 in Seoul by 2019, with allocated land for urban farming expanding from 29 hectares to 202 hectares within the same timeframe.<sup>14</sup> Other facilitative policies could involve grants, licensing, tenancy, taxes, and utility expenses.

Improving nutrition also requires attention to food safety systems in urban farms. Consumers can only gain benefits from urban farms if they trust the quality of the produce and are assured it is contamination-free. Indeed, some farms in rural and urban areas alike bio-contaminate their produce by applying sewage water or inappropriate faeces as fertiliser. However, it is often not economical or feasible to monitor or conduct safety checks on small, decentralised farms. To counter this, those who would like to sell their produce could join cooperatives or social enterprises that use trust-based and self-testing technological solutions to distinguish the quality of produce. For example, in Seoul, the proliferation of urban farms has led to cooperative marketplaces, where farmers can test, label, and package their produce; as a result, consumers develop relationships with the farms over time, which in turn has increased the demand for local produce.



### More than garnishes

Research shows microgreens deliver 4 to 40 times higher concentrations of vitamins and antioxidants than fully grown vegetables. Crucially, they can be grown indoors in under 14 days, allowing growers to respond rapidly to local nutritional deficiencies — regardless of season.

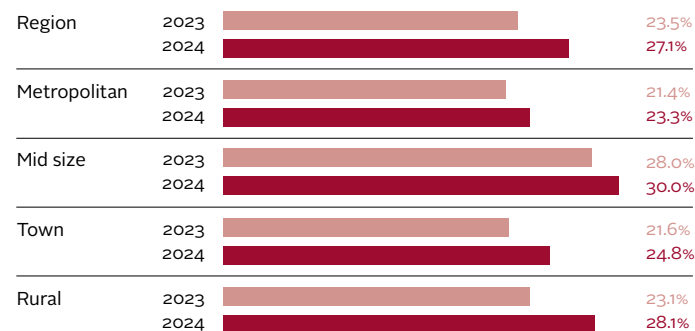
Photo: South\_agency / iStock

## EVOLVING FROM A FOOD PURCHASER TO A FOOD PRODUCER

Urbanisation and climate change will continue to disrupt our food supplies, impacting the cost and availability of nutritious food. This can only increase malnutrition rates.

Individuals, communities, and policy makers can turn this around by increasing access to locally grown food. It requires making it easier and socially rewarding for residents to participate in food growing. If residents see it as visibly valuable, internalise the health benefits and feel the support of institutions, more may take up the opportunity to grow food and consume local foods. The annual Climate Outlook survey by ISEAS Yusof Ishak Institute found that an increasing number of respondents from cities and towns in Southeast Asia have grown food, increasing by approximately 2% between 2023 and 2024 in metropolitan cities, mid-sized cities and towns alike (Figure 2).





**Figure 2: Choosing to grow one's own food because of concern about climate change's impact on food availability**

Source: Southeast Asia Climate Outlook 2024 Survey Report<sup>5</sup>



### The alternative stock exchange

Seed exchanges in Chennai are driven by urban gardening communities and grassroots initiatives — without storefront or funding. Gardeners trade traditional, native, and heirloom seeds freely, gathering at seasonal swap events or coordinating through local digital networks.

Source: tellmystory.in

There are a host of ways to improve the proliferation of urban agriculture, but to specifically facilitate its expansion to further nutrition goals, some of the following actions should be considered:

#### Grow nutrition-dense foods:

- Provide starter kits and dedicate spaces in farms for nutrient-dense crops such as leafy greens, legumes, fruits, superfoods, and herbs
- Promote seasonal crop or microgreen planning aligning with local dietary gaps
- Promote diversity of crops and colours for “rainbow” diets
- Encourage small livestock or aquaculture that produce eggs and fish where possible
- Teach regenerative farming techniques, including composting and soil carbon farming

#### Turn nutrition eating into a goal:

- Support the availability of “master gardeners” and extension services, which can proliferate nutritious gardens or farms
- Encourage the nutrition labelling of crops, including information about which parts should be consumed to maximise nutrition
- Encourage on-site/in-farm cooking demos
- Share nutrition-maximising food preparation tips, such as salad making, steaming or fermenting
- Give out awards for highly nutritive crops or healthy cooking competitions

#### Provide spaces for social exchange:

- Have community kitchen/communal cooking days at harvest
- Facilitate seed banks and seed swaps
- Encourage partnerships between local farms and research institutions to develop biofortified crops
- Link farms with vulnerable group programmes, such as for pregnant women, children in poverty or people suffering from obesity

#### Improve access to nutritious foods:

- Promote “Gardens-to-Kitchen” or “Eat-What-You-Grow” programmes, especially in schools, health facilities and institutions
- Facilitate community market days or stores to sell locally produced foods
- Facilitate food boxes or vouchers for local produce

## Learning to maximise nutrition in what we eat is a skill, but it also requires access to high-nutrient foods.

In today's volatile world, the adage “we are what we eat” holds true more than ever. Learning to maximise nutrition in what we eat is a skill, but it also requires access to high-nutrient foods. Urban agriculture emerges as a powerful solution, offering city dwellers access to fresh, nutritious food. This not only builds a city's resilience, but it is also a vital contributor to our physical, mental, and environmental well-being. By embracing urban agriculture, we can reshape our cities into vibrant centres of health and ecological balance. ∞

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## PERSPECTIVE

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DR JUDHIASTUTY FEBRUHARTANTY

# Nutrition Literacy in Indonesia

## Cooking Change with Fire from Both Sides



**Nutrition literacy is not simply about knowing what is healthy and nutritious; it is about navigating choices, environments, culture, economics, and power.**

**I**n many Indonesian classrooms, nutrition is taught quietly using modest approaches that help teachers feel at ease when delivering the nutrition messages. To the extreme, this can include a scene in which a poster about balanced meals hangs slightly crooked on the wall in schools in rural Indonesia. Teachers in many urban schools reported having to repeatedly remind students to eat breakfast before exams.

Nevertheless, a contrasting view remains outside the school gate: brightly coloured carts selling attractive sugary drinks, fried snacks, and instant noodles for a few thousand rupiah (about USD 0.10–0.30). The lesson inside schools and the reality outside rarely meet.

This gap captures the challenge of nutrition literacy in Indonesia today. Nutrition literacy is not simply about knowing what is healthy and nutritious; it is about navigating choices, environments, culture, economics, and power. It is the ability to understand food, evaluate information, and make decisions that support health, both individually and collectively. In a country as vast and diverse as Indonesia, building nutrition literacy requires more than textbooks or campaigns. It requires trust, relevance, and a careful balance between grassroots motivation and systemic support.

Like cooking a cake, nutrition literacy needs heat from both the bottom and the top.

### Urban plates, changing tastes

In Indonesia's cities, traditional home-cooked meals are increasingly giving way to pizza, fried chicken, and other fast foods. Expanding chains, delivery platforms, and social media are reshaping how young people access, perceive, and consume food in everyday life.

*Photo: rudi\_suardi / iStock*



### A generation still at risk

While Indonesia has made progress in reducing stunting, nearly one in five children are still affected, posing significant risks to cognitive development and long-term productivity.

*Photo: As Arsyil / Shutterstock*

### THE STATE OF THE ART: NUTRITION LITERACY BEYOND KNOWLEDGE

Globally, nutrition literacy has evolved from a narrow focus on nutrients to a broader understanding that includes food systems, culture, media influence, and social norms. Best practices emphasise experiential learning, critical thinking, and supportive environments — not just for information delivery, but for developing nutrition literacy.

In Indonesia, this evolution is both necessary and urgent. Children and adolescents face a triple burden of malnutrition: undernutrition and micronutrient deficiencies coexist with rising overweight and diet-related non-communicable diseases. A lack of fruit and vegetable consumption, coupled with a sedentary lifestyle, has been persistently associated with these poor health outcomes. We are just recently aware that ultra-processed foods are increasingly accessible, while traditional dietary patterns are eroding. In addition, social media floods young people with conflicting nutrition messages, often driven by trends rather than evidence.

## Children and adolescents face a triple burden of malnutrition: undernutrition and micronutrient deficiencies coexist with rising overweight and diet-related non-communicable diseases.

Schools and communities sit at the centre of this transformation. They are where habits are formed, identities are shaped, and social norms are negotiated. Yet schools are also constrained by crowded curricula, limited resources, and competing priorities. Community-level initiatives face similar challenges, especially when programmes are perceived as externally imposed or disconnected from local realities.

This is where many well-intentioned nutrition programmes struggle: they either rely too heavily on top-down mandates or remain small, inspirational pilots that fade when funding ends.

Across Indonesia and the broader Southeast Asian region, several best practices in nutrition literacy have emerged:

### 1. Embedding nutrition into daily school life

Not just lessons — through extra-curricular activities, school canteens, routine school agendas, and role modelling by teachers.

### 2. Using participatory approaches

Where students discuss, reflect, and create rather than passively receive information.

### 3. Engaging families and communities

Recognising that food choices extend far beyond school walls.

### 4. Respecting local food culture

Rather than replacing it with generic “healthy eating” messages.

### 5. Building capacity and empowerment

By equipping teachers and school leaders with confidence, fostering ownership among school communities (both internal and external school stakeholders).

Yet even when these elements are present, sustainability remains the hardest challenge. Programmes often depend on champions — an enthusiastic principal, a dedicated teacher, or a committed local partner. When leadership changes or funding cycles end, momentum is lost. This is complicated by a lack of community participation and a weak sense of belonging to the programme.

What is missing is balance.

## THE INDONESIAN CONTEXT: WHY BALANCE MATTERS

Indonesia’s education and governance systems are complex. Schools operate with a degree of autonomy but are also shaped by national curricula, provincial and district-level priorities, and ministerial regulations. Nutrition, meanwhile, spans multiple sectors — education, health, social protection, food systems — each with its own mandates and bureaucracies.

In this context, sustainability cannot rely on pressure alone. If schools feel burdened by yet another programme, resistance grows. If government involvement is absent, programmes remain fragile and peripheral.

Indonesia needs approaches that motivate schools from within, while being recognised and supported from above.



### To feed a nation

Launched in 2024 as a government-led national initiative, Indonesia’s Free Nutritious Meal Programme (Makan Bergizi Gratis) aims to deliver daily meals to millions of schoolchildren — a scale that requires substantial coordination and resources to sustain.

*Photo: Verra Rizkana Safitri / Shutterstock*



**Food as education**

Hands-on food education, including visits to hydroponic farms, is gaining momentum in Indonesia as schools and communities explore new ways to strengthen nutrition awareness, food security, and environmental literacy among children through direct engagement with food production.

*Photo: HarfiBimantara / Shutterstock*

**NUTRITION GOES TO SCHOOL: FIRE FROM THE BOTTOM AND THE TOP**

The Nutrition Goes to School (NGTS) programme offers a compelling example of how this balance can be achieved.

At its core, NGTS starts from the bottom. It respects schools as living ecosystems rather than passive recipients of instructions. Teachers are not treated as mere implementers, but as co-creators. School leaders are encouraged to reflect on their own contexts — urban or rural, public or private, resource-rich or constrained — and to aspire to achieve specific school awards, and to adapt activities accordingly to the set school priorities.

Rather than overwhelming schools with technical jargon, NGTS focuses on practical, relatable concepts: breakfast habits, snacking choices, and food diversity. NGTS also encourages schools to align their activities to support healthier food environments through food modification at the school canteens and food education through the school garden. Students are exposed to dialogues and observations through their own food environments. So, learning becomes personal.

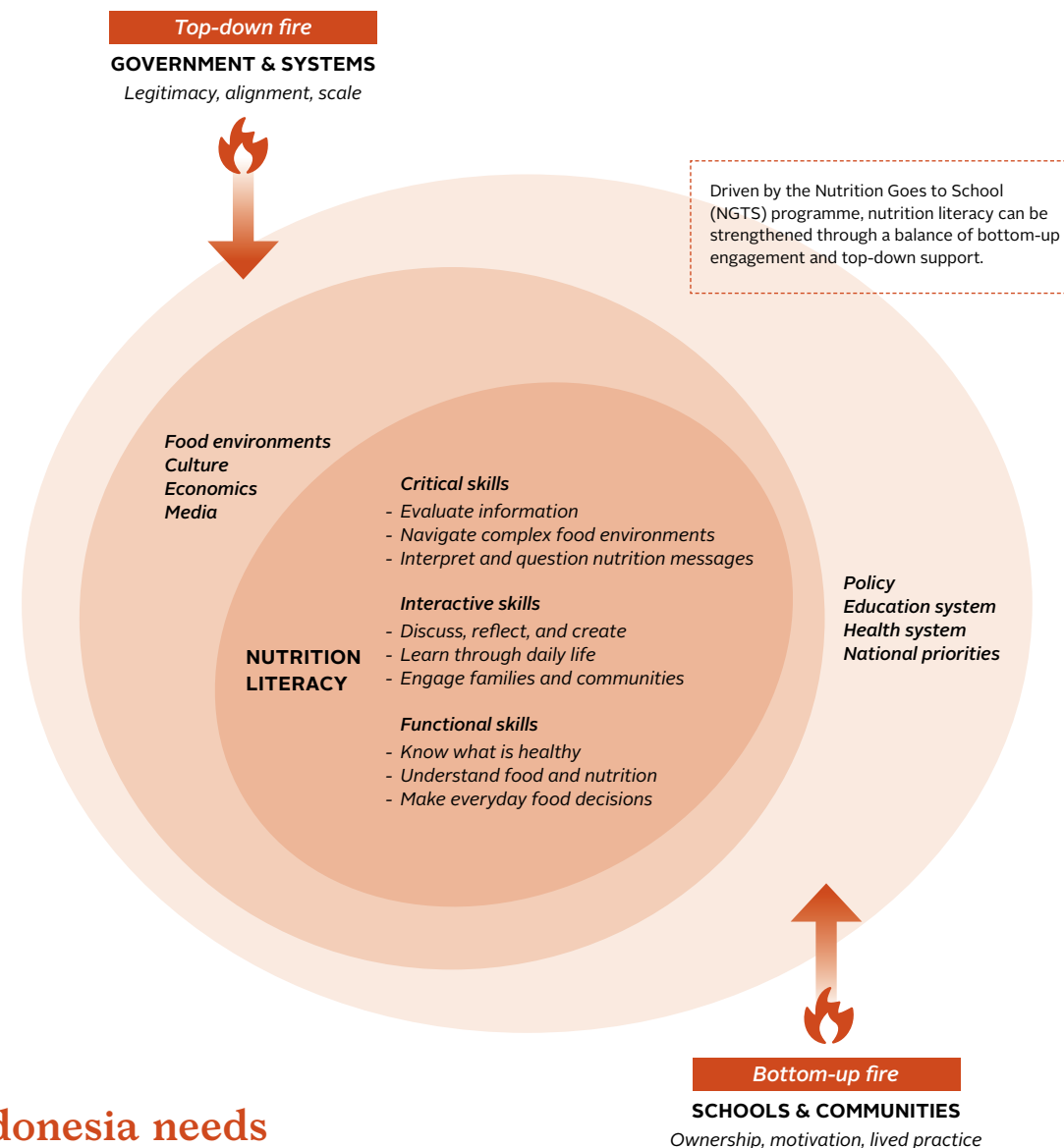
This bottom-up fire creates motivation. Schools feel ownership. Teachers feel capable. Students feel seen.

But NGTS does not stop there.

Recognising that aspiration alone cannot sustain change, the programme must actively engage government stakeholders. This aligns with national nutrition priorities, education standards, and school students' health strategies. By speaking the language of policy without losing its human touch, NGTS positions itself not as an extra burden, but as a solution that helps institutions meet their goals.

Since its conception in 2016, the NGTS programme has aimed to assist schools in enhancing their existing School Health Unit (*Unit Kesehatan Sekolah*) and to facilitate their achievement of nationally recognised school awards such as Healthy School (*Sekolah Sehat*), Environmentally Friendly School (*Sekolah Adiwiyata*), and many others. Although originally developed to support school programmes and activities under the coordination of the Indonesian Ministry of Education, NGTS has also benefited madrasahs (Islamic schools) coordinated under the Ministry of Religious Affairs.

**Nutrition Literacy: “Fire from Both Sides”**



**Indonesia needs approaches that motivate schools from within, while being recognised and supported from above.**

NGTS works through stages: schools are first exposed to NGTS training (initiation phase), then receive technical support from local partners (strengthening phase), and finally show independence in programme monitoring and documentation for reporting to the local education office (institutionalisation phase). So far, the programme has completed two rounds of school institutionalisation and reached 41 schools and madrasahs intended to inspire nearby schools. This achievement has gained the awareness and support of the local and central governments.

This top-down fire provides legitimacy. It opens doors to scale-up, integration, and long-term support.

Like a cake baked evenly, the programme benefits from heat below and above.



#### What children can afford

Food choices are often shaped less by knowledge than by affordability, access, and environment. Across Indonesia, inexpensive street snacks and sweetened drinks sold outside schools remain a daily part of children's diets, often costing less than healthier alternatives.

Photo: kallipatvideoart / Shutterstock

#### NGTS IMPLEMENTATION CHALLENGES: THE REALITY CHECK

Even with a balanced approach, challenges remain.

The programme's front-line providers of technical assistance are local academic partners. Like many academics, they are expected to excel in three areas — teaching, research, and community service — while managing multiple responsibilities at once.

At the school level, teachers are busy. School leaders juggle administrative demands. In addition, nutrition is often perceived as “important but not urgent.” Monitoring quality across diverse regions is complex. Funding landscapes shift. Coordination across sectors takes patience and trust.

At the community level, economic constraints shape food choices more powerfully than knowledge alone. Nutrition literacy initiatives must avoid blaming individuals for structural limitations. Empowerment, not guilt, is key.

As it may seem easier said than done, NGTS tries its best to address these challenges, not by pretending they do not exist, but by designing with them in mind. Flexibility is built in. When planned frequencies are no longer feasible in the implementation stage, options are discussed. In a more recent national agenda, the Free Nutritious Meal (*Makan Bergizi Gratis*) programme is well-embraced into NGTS as an opportunity to align the nutrition education messages with the actual food plates brought to schools by the government. Students-initiated attempts to handle food surplus (not eaten by students due to various reasons) are reported as inspirational stories by the teachers, who feel that wasting food is against their teachings. This level of flexibility may not always be feasible for other schools. But reflection is encouraged.

Success is defined not only by immediate behaviour change, but by strengthened systems and relationships. Progress is built through sustained dialogue and advocacy at many levels. The work is demanding, but necessary. While school empowerment moves slowly, we are confident this approach leads to lasting change.

## Sustainable change happens when schools are inspired, and governments are engaged — when local voices are amplified within supportive systems.

#### WHY THIS MATTERS BEYOND INDONESIA

For readers across Southeast Asia and beyond, Indonesia's experience offers a lesson: nutrition literacy is not just a technical intervention; it is a social process.

Programmes that rely only on policy risk become checklists. Programmes that rely only on passion risk burning out. Sustainable change happens when schools are inspired, and governments are engaged — when local voices are amplified within supportive systems.

The metaphor of baking a cake may sound simple, but it captures a profound truth. Too much heat from one side burns; too little leaves the centre uncooked. Balance matters.

#### A CALL TO ACTION: RETHINKING HOW WE NOURISH MINDS

Nutrition literacy is ultimately about dignity. It is about giving young people the tools to navigate a complex food world with confidence and care. It is about supporting schools not as sites of compliance, but as communities of learning. It is about governments enabling, not suffocating, innovation.

Indonesia's journey, with initiatives like NGTS, shows that it is possible to cook change thoughtfully. Slowly. Evenly. With intention.

For educators, policymakers, practitioners, and communities across Southeast Asia, the message is clear: when we light the fire from both the top and the bottom, we give nutrition literacy the chance not just to survive, but to rise. ∞



Photo: Dimas Misa / Shutterstock



**Dr Kwan Lui** is an entrepreneur and educator, the founder of numerous companies, educational institutions, and well-known product brands. Born in Myanmar, she has lived in Hong Kong, Thailand, and the USA before settling in Singapore, where she resides.

In 2001, Dr Lui founded At-Sunrice GlobalChef Academy, a premier cooking and baking school in Singapore that offers an education-to-career pathway for young people in Asia to pursue their aspirations of becoming global chefs. The academy has since welcomed students from over 35 countries.

Dr Lui also founded WellSpent Upcycling, which upcycles fibre- and nutrient-rich food products. It hosts monthly “Saturday Luxe” events featuring gourmet meals, a produce market, interactive workshops, and more to promote sustainability, food security, and gut health.

# WASTE NOT, WANT NOT

## An Interview with **Dr Kwan Lui**

In an era where sustainability is now a matter of survival rather than a corporate buzzword, food waste has become a necessary part of the conversation. We spoke with Dr Kwan Lui, Founder of At-Sunrice GlobalChef Academy and WellSpent Upcycling to get a glimpse into the heart of her innovative food upcycling business and how she plans to expand its philosophy.

### Waste by design

A significant share of food loss occurs before it reaches consumers, with around 13% lost between harvest and retail. During manufacturing, edible materials are routinely trimmed, separated, or discarded as by-products, alongside losses from inefficiencies and quality control.

*Photo: Ahmet Kurt / Unsplash*



**Could you share how your interest in food upcycling began, and how it connects to your work at At-Sunrice?**

We started WellSpent about five years ago. I didn't like the word "waste" because it has a negative connotation. When I found the word "spent," which means food that has already been processed once before, a lightbulb went off in my head. I also like the notion that one's money is spent well, twice. That's how the name came about.

When I started At-Sunrice, I wasn't a chef. I was just someone interested in food, cuisine, and education. Those were my three words for my retirement venture.

For 24 years, we've been teaching culinary arts, and you quickly learn that many food waste streams, like okara, moromi, orange peel, or even eggshells, are still highly nutritious. They're thrown away mainly for convenience, not because they lack value.

As a culinary school, we buy, we cook, we serve, we eat, and we throw. That's the chain. Then I asked, how do we then make it circular? And so, this was the inspiration.

I've always emphasised gut health, fibre, and whole foods. So upcycling was about applying what we already know to reduce waste, improve nutrition, and create new products that taste good.

**What philosophy guides your upcycling work at WellSpent?**





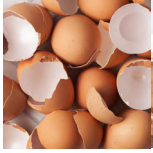




The idea is circularity. We want to show people that many so-called "waste," sidestreams or spent ingredients, are actually nutrient-rich and flavourful. Why let it go to waste if humans can still benefit from or consume it?

Many sustainability efforts divert waste into animal feed, compost, or fuel. That's fine, but I think the highest value use is still human consumption.

Upcycling is not only about sustainability or food security; it's about public health and nutritional quality. What you throw away should come back to nourish you.

*Upcycling is not only about sustainability; it's about public health and nutritional quality. **What you throw away should come back to nourish you.***

**From Waste to Value**  
Spent ingredients as functional nutrients

		
<b>BREWER'S SPENT GRAIN</b> Fibre, protein	<b>OKARA</b> Fibre, protein	<b>FRUIT PEELS</b> Antioxidants, fibre
		
<b>MOROMI</b> Umami, probiotics	<b>EGGSHELLS</b> Calcium, minerals	<b>DEFATTED COCONUT</b> Fibre, protein
		
<b>COFFEE GROUNDS</b> Antioxidants, fibre	<b>TEA LEAVES</b> Antioxidants, polyphenols	<b>CRUSTACEAN SHELLS</b> Calcium, chitin

**What are some challenges or barriers specific to upcycling?**

When we speak with other food waste recycling companies, there's always a question of collection and transport. There's a cost to collecting food waste, even things that are thrown away from bakeries every night.

Moreover, upcycling requires more effort and processing, so public adoption is very slow. Ideally, we would like to achieve institutional feeding to army camps, schools, hospitals etc.

**Can upcycling truly be a profitable business? What does the upcycling process look like at WellSpent?**

Yes, it can be profitable because the government usually subsidises it at a certain scale. If I could, I would want to create just one product: for example, the Orange Peel Magic. I would upcycle the orange peel and sell it. But because we are a culinary academy, I decided to create a range of products as well.

We have an ecosystem set up from point A to Z. We source spent ingredients locally by partnering with factories that we know have ample supply. All of the spent conversion, R&D, cooking, fermenting, baking, quality control, and testing are done in-house.

We take quality control very seriously as well. We tightly monitor hygiene, volume consistency, nutritional, and ingredient stability.

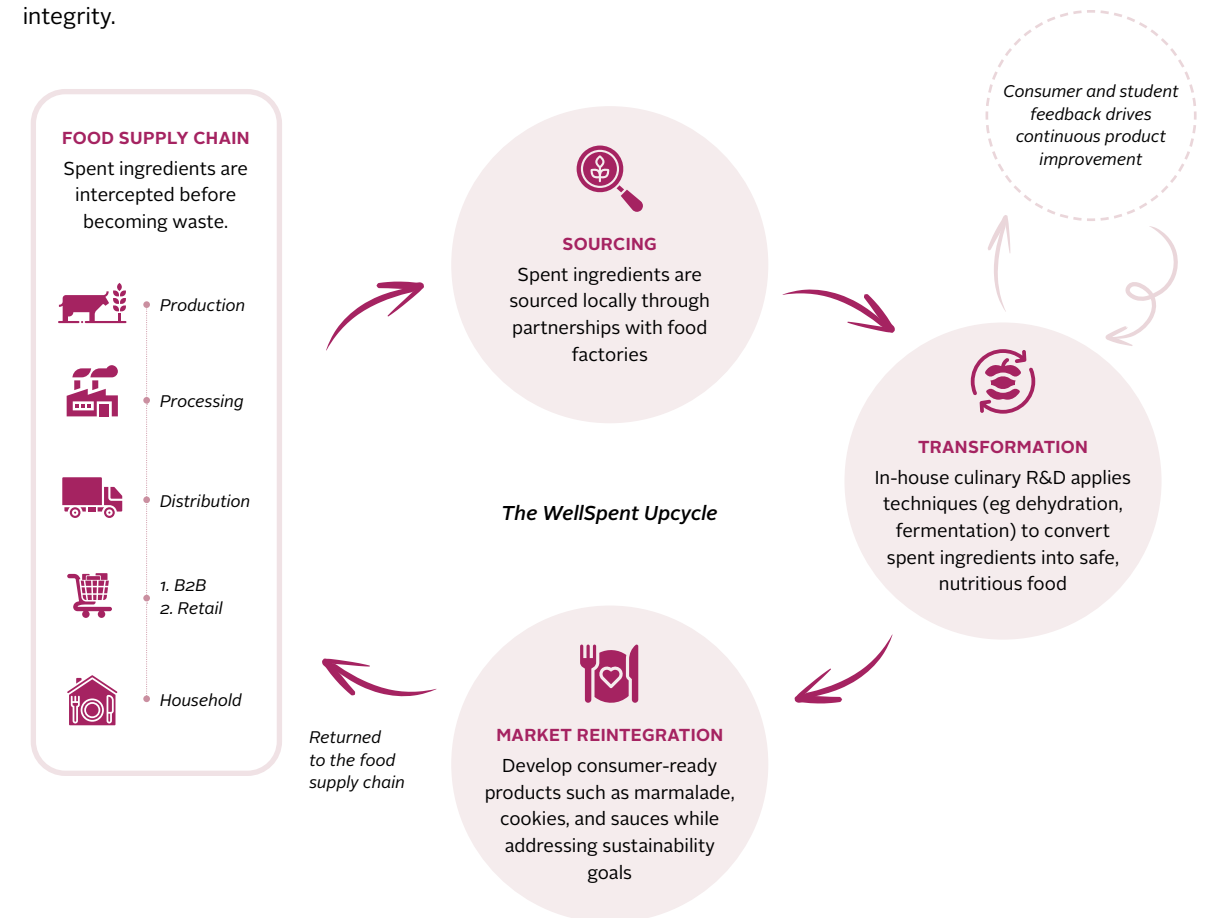
Then, we sell the ready-to-ship products via our own ecommerce platform and others like Shopee. We do this to ensure that the entire value chain maintains integrity.



**The citrus magic**

Tangerine peels, often discarded, are dried into *chenpi*, a key ingredient in traditional Chinese medicine. It is used to regulate *qi*, aid digestion, reduce bloating, and help relieve coughs and phlegm, and is also commonly used in Chinese cuisine.

Source: dingnan.gov.cn



**What does the upcycling landscape look like internationally?**

It's still in its early stages. In Japan, okara and moromi are used as products, but rarely in finished consumer goods. In the US, there are small initiatives, but nothing at scale.

What we're doing — culinary-led upcycling into ready-to-ship products — is still quite rare. However, since it's not difficult to replicate, I'm worried that people will not really promote the mission but try to commercialise it.

*My long-term plan is to license or franchise our upcycled product lines to local manufacturers around the world... Export the knowledge, not the product.*

**What challenges do you face when trying to scale upcycled food production?**

We've exhibited at food shows and received some regional attention and interest. However, I decided not to continue because I'm still very idealistic at this point. I hope to build and maintain an ethical, sustainable circular ecosystem.

Once you scale, you face storage needs, warehousing, logistics, preservatives, and food safety standards. And ironically, if you start shipping upcycled products overseas, you may increase your carbon footprint, which defeats the point.

That's why we have designed a licensing-franchise model that enables us to license our recipes and processes to local manufacturers around the world. We believe in exporting the knowledge, not the product.

My long-term plan is to license or franchise our upcycled product lines to local manufacturers around the world, instead of exporting the food itself. Export the knowledge, not the product.

**A tradition of using what remains**

In Japan, concepts such as *mottainai* (don't waste) are part of everyday cooking, where by-products are routinely used. *Nukazuke*, a vegetable pickle fermented in rice bran — a by-product of milling — is one example, developed in response to vitamin B1 deficiency during the Edo period.

Photo: winhorse / iStock



**Barley + murukku = Party Mix**

Reimagining a classic snack, WellSpent's Party Mix uses upcycled brewer's spent grain and eggshell mala sea salt, combining waste reduction, nutrition, and taste in everyday food production.



**Happy Gut Stop Breakfast**

Open to public participation, the Happy Gut Stop Breakfast event presents an assortment of fibre-rich, probiotic- and prebiotic-packed dishes, promoting gut health and everyday nutrition.



**The upcycled table**

At-Sunrice's Luxe Series features themed cooking and tasting sessions where guest chefs work with upcycled ingredients, offering a closer look at how spent ingredients are incorporated into creative and flavourful dishes.

Source: WellSpent GourmetzGo facebook

**How does your approach to R&D differ from scientific or laboratory-driven upcycling models?**

We are a culinary school, so our R&D focuses on flavour, texture, and usability. We don't work to prove that foods like tofu (or its byproduct, okara) are nutritious, because we already know they are.

We don't work from the scientific side of "validate first, process later." We work from the culinary side: "develop first, improve continuously."

Our R&D is primarily product development. We work to improve the taste, texture, and, of course, the nutrition. We don't add too much sugar or salt. We try to rely on natural, spent ingredients like eggshell salt or moromi, which enhances the umami flavour.

We use a hands-on approach, asking questions like, "what percentage of a spent ingredient can we include because it affects taste?"

Our okara cookies have evolved over the years. We started with a relatively small amount first, before slowly introducing a larger percentage of spent with subsequent generations. We've become more confident over the years after learning that people are

willing to eat more of the spent, and that they also seem to like the taste.

I love 老婆饼 (*lao po bing*, wife cake). I came back from Hong Kong last week with a box of it. The filling is winter melon, and the *lao po bing* usually contains a lot of animal fat and sugar. But I've asked the chefs to create a version that uses our Orange Peel Magic as the filling. So, we'll have a tasting session later this week with this new Orange Peel *bing*.

### What are your hopes for the future of upcycling?

I hope to see the upcycling ecosystem become more circular. Idealistically, everything should be relatively local. Instead of shipping upcycled products across continents, we should empower people everywhere to upcycle their own waste sidestreams.

I want to see a new generation of culinary innovators who can turn food waste into high-value products; people trained not just in cooking, but in nutrition, R&D, and circular thinking.

Our role is to build the ecosystem; from waste, processing, formulation, product development, to training and licensing. That's the future I hope to contribute to.

### What does sustainability look like at At-Sunrice?

We're cautious about our food waste here in At-Sunrice. We're careful about how much we buy, how much we cook, how much we use and consume, so we try not to serve or cook too much.

We don't use our own food waste for the work we do with WellSpent, because the supply chain may not be as reliable. When you work with spent ingredients, you need a consistent volume. That's why we source from food factories, not our own kitchens.

### What type of programmes do you run in At-Sunrice?

We run diploma programmes in culinary, pastry bakery, specialist diplomas in food entrepreneurship and culinary wellness as well as a bachelor's degree in business entrepreneurship. We also have food safety and continuous education programmes, which are open to everyone. We offer private chef classes, and other leisure and creative classes with no prerequisites. Some of our courses include Creative Patisserie, Baking Café-style Bread, Chocolate Confections, Dim Sum Dishes, and Discover the World of Wine.

We once had a clan come over to take a course together. They said, Wow, this was such a good experience for us because now the clan is so close. You know, those who eat together, stay together, right?

We're seeing more career changers, including retirees and mid-career professionals, interested in learning about upcycling and healthy food development.

From 2026, subsidies may become more targeted, so only industry professionals may be eligible for funding. But we'll continue designing programmes that blend cooking, nutrition, and sustainability.

### Among the many upcycled products you've developed, which stand out to you?

My favourite has got to be the Orange Peel Magic. It's actually the first product we developed at WellSpent — we initially called it Orange Peel Marmalade. We quickly discovered that we could use it as an ingredient in all sorts of our dishes. It was so versatile, we decided to rename it Orange Peel Magic.

I also like our eggshell sea salt, which is naturally low in sodium but still full of minerals; moromi chocolate cake, which uses fermented by-products for deep umami; gluten-free cakes (developed at the request of JP Morgan); and spicy sauces made from green mango peel.

Many of our spent ingredients and products are gut-friendly, high-fibre, and high-protein. We also have our savoury foods, for example, the butter chicken or the lamb shank, which come in a cook-chill. We try to make it as clean and convenient as possible.

Because we're based out of At-Sunrice, we have hundreds of students to help us taste-test. Therefore, our feedback loop is quick.

***If we take care of our health, we'll have a good, good life for years, instead of years to life. We need to rethink what "healthy" really means, especially for the next generation.***

### Many people assume healthy food is expensive. What are your thoughts on nutrition and public health in Singapore today?

As a developed country, we have more choices than ever. It also means that a lot of us have less physical activity as a result. Chronic conditions like diabetes and mental stress are rising.

Processed foods and artificial sweeteners are a real concern. Artificial sugars are especially bad for the gut microbiome, as they cheat it into thinking that it's not real sugar. These have substantial consequences on the gut microbiome and even the brain. And because they are marketed aggressively, people think they're safe with 'healthier choices' when they're not.

A few days ago, I read an article about full-cream milk and how it's more nutritious than skimmed milk. Skimmed milk is a little more expensive because another process removes the fat. However, healthier options tend to be indeed more expensive. It takes the whole value chain to really promote a few ingredients to become common, more affordable ingredients. And of course, the government can definitely promote as well.

We are super agers in Singapore. If we take care of our health, we'll have a good, good life for years, instead of years to life. We need to rethink what "healthy" really means, especially for the next generation. ∞



#### Anyone can cook

An experiential learning space, EasyChef Lab brings together participants of all backgrounds for hands-on cooking sessions focused on cuisine, nutrition, and sustainable food practices, while fostering social bonding.

Source: At-Sunrice website

Photo: Getty Images / Unsplash



## PERSPECTIVE

**JIEUN WRIGLEY** is a functional nutritionist and founder of Rapid Nutrition Therapy, a bespoke Singapore-based nutrition consultancy. She also serves as a functional nutritionist at COMO Shambhala Singapore. After graduating from Brown University, she earned a Master's in Nutrition Science from Tufts University, US, and is currently a doctoral candidate in Clinical Nutrition. She is a member of the American Society for Nutrition and the Singapore Nutrition and Dietetics Association.

With a global perspective shaped by years spent in Singapore, Hong Kong, and Dubai, she supports clients in addressing the root causes of health issues, including gut and brain health, hormonal imbalances, and metabolic function. She works collaboratively with medical professionals to integrate nutritional frameworks into patient care. She is also a contributing nutrition writer for *The Straits Times*.

JIEUN WRIGLEY

# Feeding Children in a Changing World

## Navigating the Dual Burden of Malnutrition

**G**lobally, and increasingly across Southeast Asia, malnutrition no longer presents as a single story of undernourished children. Rather, like a forked road, malnutrition is bifurcating into two alarming and growing extremes: stunting on one side and childhood obesity on the other.

I see this not just in statistics or clinical reports, but in everyday moments — school mornings, on the bus, in supermarket aisles, and in the consulting room.

As a mother, I've packed lunchboxes that look full, yet I still pause and wonder: Is this nourishing, or simply filling? As a functional nutritionist, I sit with families who are trying their best, yet feel confused by conflicting messages. Parents are worried about children who eat "enough" but who are smaller than their peers, constantly off school with illness, or slow to meet developmental milestones. In other settings, sometimes within the same day, I meet families grappling with the opposite concern: children gaining weight rapidly, already showing signs of high cholesterol, insulin resistance or metabolic-associated fatty liver disease before they reach their teenage years.



### A tale of two extremes

India is home to one of the world's largest populations of undernourished children, with 35.5% of children under five stunted, even as more than 41 million children aged 5–19 have excess weight, including around 14 million with obesity. These extremes of malnutrition often coexist within the same communities, households, and even children.<sup>1</sup>

*Photo: Davide Bonaldo / Alamy*

**Stunting and childhood obesity are not separate crises — they are two visible outcomes of the same invisible forces.**

This is the paradox of modern childhood nutrition. Malnutrition is no longer only about the absence of food. Malnutrition represents profound disruptions in growth, development and lifelong health for our next generation. Today, stunting and childhood obesity are not separate crises — they are two visible outcomes of the same invisible forces. And both are symptoms of a deeper systemic problem: how our modern environments shape the way children eat, move, grow, and thrive.

As a functional nutritionist and mother, I'm troubled by both roads, as they're widening, yet often start at the same beginning. I often hear a few commonalities — "my child has a sweet tooth", or "my child loves junk food", or "we rarely cook at home". On the surface, their symptoms differ. Underneath, inflammation is the common thread.

What makes today's split landscape particularly complex is that these extremes — stunting and obesity — now coexist within the same communities, and even sometimes in the same households. It is not uncommon for a child to be stunted in height due to poor undernutrition in early years, only to be obese with increased risks of metabolic syndrome later on. To the untrained eye, this seems contradictory. How can a child be both under- and over-nourished?

The answer lies beyond calories. It lives in inflammation, in gut health, and in our food environments.



### Not as innocent as they look

From breakfast cereals and yoghurt drinks to chicken nuggets and processed cheese slices, many foods seen as child-friendly are ultra-processed, containing additives and refined ingredients increasingly linked to chronic inflammation.

*Photo: AMR Image / iStock*

Even if linear growth is later regained, the long shadow of early stunting often remains — shaping educational attainment, earnings and long-term health in ways that cannot be entirely undone.

### STUNTING: THE SILENT SIDE OF MALNUTRITION

Stunting, defined as low height for age, is primarily caused by chronic, long-term poor nutrition. Stunting is the story of early life nutritional deprivation and inflammation during some of the most critical periods of a child's brain and body development. According to the Global Nutrition Report, the prevalence of stunting in Southeast Asia is 27.4%. It is these first 1,000 days of life — from conception to around age 3 — that form a foundational period for brain, immune and metabolic health. This window, which includes maternal and neonatal diet, mode of delivery, antibiotic use, and first foods, all have profound impacts on the developing microbiome and can alter the trajectory of the microbiome as well as the foundations for lifelong health.<sup>2</sup> I often describe the microbiome to parents as the “software that runs our internal hardware.” If that software is disrupted early on, the system requires much more work to try to fix, and even more to update correctly and optimally.

But it is not just a matter of nutrient availability, but also about nutrient absorption. Children living in high-burden environments, such as rural or underserved areas in Southeast Asia, often face enteric infections due to contaminated water and exposure to toxins. Children are more susceptible to these environmental factors, and enteric dysfunction can impair nutrient absorption, even if food is available. More calories don't fix this problem, especially if the gut is inflamed and unable to do its job of absorbing vital nutrients.



#### Arsenic exposure and child growth

In Bangladesh, exposure to arsenic-contaminated drinking water has been associated with poorer child growth outcomes, with studies linking higher arsenic exposure to reduced body size and impaired growth in early childhood.<sup>3</sup>

Photo: ZUMA Press / Alamy

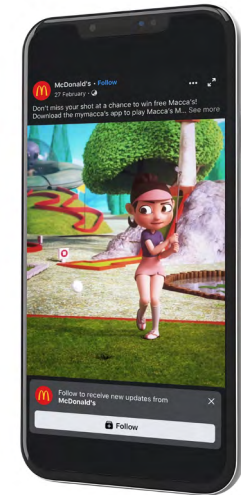
Stunting, therefore, is not only a failure of food availability. It reflects a deeper systemic failure to provide children with non-inflammatory food, nutrient-dense food environments, safe sanitation, and reliable access to healthcare. Even if linear growth is later regained, the long shadow of early stunting often remains — shaping educational attainment, earnings and long-term health in ways that cannot be entirely undone.

### CHILDHOOD OBESITY: THE OTHER SIDE OF THE SAME PROBLEM

On the other side of the forked road lies childhood obesity, rising rapidly in children and adolescents across most low and middle-income countries.<sup>4</sup> According to the Global Nutrition Report, in Southeast Asia, the average prevalence of overweight is 7.5%, which is higher than the global average of 5.7%. The rising number of childhood obesity cases reflects our society's increasing overexposure to cheap, low-nutrient quality, highly processed foods. This description of food has become a default for many modern families. And the societal acceptance of ultra-processed foods as

somehow “normal” or “cultural” should be changed. Sugar in various forms, refined starches, industrial oils, flavourings and other additives and preservatives found in ultra-processed foods (UPFs), snacks, and beverages alter appetite regulation, disrupt insulin sensitivity and create inflammation in developing bodies. Paradoxically, the co-occurrence of stunting and overweight or obesity in the same individual has become an emerging layer of malnutrition.<sup>5</sup>

These products are no longer sold as simply “junk food”, but they are sold as childhood itself — wrapped in nostalgia.



As a parent, walking down grocery aisles or into any convenience store, I'm overwhelmed by the number of UPFs targeting children. Shelves are lined with chocolate drinks, isotonic drinks, all sorts of sweetened beverages, cookies, crisps, candies, and the list goes on. These UPFs are created to be highly palatable and addictive. These products are no longer sold as simply “junk food”, but they are sold as childhood itself — wrapped in nostalgia. The danger is not the occasional treat but this normalisation. When UPFs become daily staples, children tend to consume more calories but are functionally malnourished.<sup>4</sup>

#### Too much, too fast

China has the world's highest number of children with obesity, with rates rising rapidly, especially in urban areas. This reflects a broader global trend, where childhood overweight has surged from around 4% in 1990 to over 20% today, with more children now expected to live with obesity than underweight worldwide for the first time.<sup>6</sup>

Photo: Imaginechina / Alamy

#### Designed to crave

Junk food companies are targeting children on social media through personalised, immersive content that promotes ultra-processed foods. Constant and often invisible, these digital campaigns are far harder to regulate than traditional advertising.

Source: The Conversation UK



Stunting and obesity as a double burden of childhood malnutrition pose a real public health challenge. Obesity in childhood is strongly associated with increased risk for chronic diseases such as non-alcoholic fatty liver disease (NAFLD), also known as metabolic-associated steatotic liver disease (MASLD), type 2 diabetes, cardiovascular disease, metabolic diseases, orthopaedic issues and psychosocial problems.<sup>7</sup> Much like stunting, environmental factors make this not just a simple matter of individual choice but the product of structural forces and systems. Aggressive food marketing, as well as economics, where the cheapest calories are often the least healthy, is prevalent across the globe, but seeing it more and more in Southeast Asia.

#### Who owns their appetite?

Bite Back 2030 is a UK-based, youth-led movement campaigning to end the aggressive marketing of junk food to children. It challenges public advertising, pushes for policy change, and exposes how food corporations shape young people's choices to create healthier environments.

Source: Bite Back 2030

## Through the gut, we can either nurture resilience or exacerbate vulnerability.

### THE GUT MICROBIOME: THE MISSING LINK

Both ends of the malnutrition spectrum share a key underlying factor: disrupted gut microbiome development.

In healthy development, a diverse and resilient gut microbiome supports nutrient absorption, immune balance, metabolic regulation and appetite. Unfortunately, today, modern childhood is increasingly hostile to this process. Frequent antibiotic exposure, antimicrobial cleaning products, chemical pollutants and low-fibre diets — all disrupt microbial diversity. This disruption is known as dysbiosis, which has both short-term and potential long-term consequences, skewing the microbiome towards an inflammatory state.

While stunting and obesity outwardly look different, the standard pathway is inflammation. Inflammation diverts energy away from growth

#### A spoonful less

Malaysia's 2019 sugar tax was later reinforced by the Healthier Choice Logo initiative and mandatory front-of-pack nutrition grading. Since then, 242 ready-to-drink beverages have been reformulated with lower sugar content under the country's healthier labelling framework.<sup>8</sup>

Source: Kontan.co.id

and neurodevelopment and shifts the immune system toward heightened activation. Addressing malnutrition also means addressing inflammation through food quality, environment, and gut health — not just calories.

It seems time we recognise the longer and broader impacts of early exposures on a child's gut and understand that food is a powerful mediator of growth and metabolic health. Through the gut, we can either nurture resilience or exacerbate vulnerability.

### WHAT CAN BE DONE?

We often ascribe blame to genetics or human impulses or a myriad of other reasons, but in reality, both stunting and obesity are byproducts of a systemic problem. Systemic problems require systemic solutions. It sounds simple, but we need our policymakers to play a transformative role in improving child nutrition by helping create environments that make healthy choices accessible, affordable and appealing. From access to clean water to enhancing the quality of school meals to strengthening maternal and early childhood nutrition programmes, there are many tools available to public sector organisations once they are committed to solutions. But the key first step is to recognise the systemic nature of these conditions. We need to recognise that we need more stringent regulation regarding the marketing of UPFs to children and teens. We need to implement clear front-of-pack labelling of harmful ingredients and try to avoid them altogether. We need to better support local production of nutritious whole foods. To proactively shift population habits, we need first to recognise that our existing food ecosystem isn't matching up to our inner gut ecosystem's needs.

I understand the tensions between nutrition ideals and real-life pressures. Between rushing from school pickups and activities, budget constraints and the need for convenience and taste, it is unrealistic to



cook every meal from scratch or avoid all processed foods. So, as individuals, we have to learn to focus on consistency rather than perfection. Most days aim for whole foods, simple home-cooked meals and forgive the meals that might not go as planned. But at a societal level, should parents have to choose between affordability and nourishment?

While stunting and obesity may seem like two separate roads, they often begin with the same fractured starting point. Unless we call out the warning signs and acknowledge the potential danger ahead, we will keep steering the next generation in the same direction. Isn't it time we change course? ∞

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## PERSPECTIVE

**FIONA CHIA** is a Singapore-based nutritionist and founder of Health Can Be Fun, a consultancy that combines nutrition science with behavioural insights to make healthy eating practical, culturally relevant, and sustainable. Her work spans public health initiatives, corporate wellness programmes, and individual nutrition care, with a focus on healthy ageing, muscle health, and the unintended consequences of fear-based dietary restriction. She writes and speaks on how food

systems, health messaging, and lifestyle habits shape long-term health and resilience. As a new mother, Fiona's work has taken on renewed focus. She is committed to supporting women through life transitions, from perimenopause to pregnancy and early motherhood, advocating nourishment, strength, and confidence over restriction, and positioning nutrition as a foundation for vitality and longevity.

FIONA CHIA

# Are We Setting Ourselves Up for Frailty?



Unlike traditional Blue Zones, Singapore is often described as an engineered Blue Zone, one shaped by deliberate government policies, urban planning, and food systems rather than by geography or long-standing tradition. From Healthier Choice Symbols on food packaging and NutriGrade labelling to active ageing centres, the promotion of local food production, and widespread health campaigns, the intent is clear: to nudge the population towards healthier choices.

We also take pride in our medical advances and a healthcare system that excels at managing chronic diseases. Singaporeans are spoilt for choice when it comes to health monitoring tools — Healthy365, Health Discovery+, HealthTrack SG, Amped, and more. With all these systems firmly in place, one has to ask: how is it that our population remains at high risk of sarcopenia? (*Data from Tan Tock Seng Hospital's Integrated Geriatric Assessment highlights this growing concern.*)

Sarcopenia refers to the progressive loss of skeletal muscle mass, strength, and function. It significantly increases the risk of frailty, falls, and loss of independence, affecting daily activities such as climbing stairs, walking, and even basic mobility.

TODAY, NEARLY 50% OF THE OLDER ADULT POPULATION LIVES WITH AT LEAST ONE CHRONIC CONDITION AND IS HIGHLY AWARE OF THEIR HEALTH STATUS.

### Engineering longevity

From a life expectancy of 65 in 1960 to over 86 today, Singapore has been described as a "Blue Zone 2.0", where longer lives are driven by sustained public policy and planning.

*Photo: Chua Zi Hui / Unsplash*



### A slow, silent loss

After age 30, adults can lose 3–5% of muscle mass per decade, with the rate accelerating after 50. Even small losses can have outsized effects, as declines in muscle strength and function often exceed the rate of muscle loss.

*Photo: Lim Weixiang — Zeitgeist Photos / iStock*

So, the question inevitably arises: Are we truly living up to the ideals of a Blue Zone, or are we simply living longer with a poorer quality of life?

As a nutritionist working through Singapore's early struggles with rising chronic diseases, I witnessed firsthand how aggressively we fought against diabetes. Public health efforts have been highly effective in raising awareness about diabetes, cholesterol, and hypertension. Today, nearly 50% of the older adult population lives with at least one chronic condition and is highly aware of their health status.

However, this awareness has come at a cost.

In my conversations with individuals managing chronic diseases, a common theme appears: fear. Many become overly cautious. They proudly share how they have lost weight by cutting back on rice intake, avoiding their favourite high-fat meats, and consuming fewer calories overall.

The National Steps Challenge was also a success story, with many clocking 10,000 to 15,000 steps a day, earning points, rewards and better health. It became a lifestyle. For those with higher BMI, weight dropped and often settled within the "healthy" range.

But as they aged, many noticed something unsettling. Weight began creeping back despite walking more and eating less. Fatigue set in more easily. Physical recovery slowed. Something was no longer working the way it once did.

One case still stands out vividly.

An elderly man, aged 60, with a family of four, contacted me to discuss his cholesterol results. Despite drastically cutting back on hawker food and reducing his rice intake, his numbers were not improving as much as he had hoped. He had lost a substantial amount of weight but felt increasingly weak and joyless around food.

The more he restricted himself, the more he believed something was wrong with him.

#### Starting sooner than we think

A Singapore study found sarcopenia present in 6.9% of young and middle-aged adults, highlighting its early presence and links to low muscle-strengthening activity, inadequate protein intake, and sedentary lifestyles.

*Photo: joyt / iStock*

**SARCOPENIA IS OFTEN CONSIDERED A CONDITION OF OLD AGE, BUT MUSCLE LOSS CAN BEGIN MUCH EARLIER — SOMETIMES AS EARLY AS 35.**

In reality, he was malnourished not due to a lack of discipline, but because of fear. His muscle loss had progressed to the point where he felt unwell, reinforcing his belief that he needed to restrict even further. This is how a vicious cycle begins.

Sarcopenia is often considered a condition of old age, but muscle loss can begin much earlier — sometimes as early as 35, when growth and regenerative capacity begin to decline.



#### Beyond calories

Prawn bee hoon soup is often seen as a lighter hawker option, but meeting the body's protein needs for muscle health requires more than choosing lower-calorie meals.

*Photo: redonioni1515 / iStock*

At the same time, we witnessed a surge in endurance events and high-intensity fitness culture — marathons, cycling, HYROX, Spartan races, and relentless cardio-based training. An increasing number of individuals now train intensely but struggle to improve their performance or body composition. Many wonder why they feel constantly fatigued despite “doing everything right.”

The missing element is often nutrition literacy.

Without understanding how food fuels training and recovery, many unknowingly catabolise their own muscle mass. They train harder, eat less, and end up depleted.

Consider a runner whose caloric intake only meets basic daily energy needs. The intake did not account for sufficient protein and carbohydrates to support his or her running activity. Such a shortfall may hinder recovery and cause a deficiency in muscle growth. When the body runs on reserves, muscle tissue is sacrificed first.

As a result, despite being slender and physically active, a person's body fat percentage may be higher due to muscle mass depletion. With age, agility declines, joint pain increases, and resilience weakens. Often, these changes go unnoticed until a fall, fracture, or sudden decline in health occurs.

Preventing malnutrition begins with meeting total caloric needs with an appropriate balance of protein and carbohydrates to support one's lifestyle, in line with daily energy expenditure. From there, protein intake becomes essential.

When food intake — particularly protein and total energy — is chronically low, and when physical activity is either insufficient or excessive without adequate recovery, the body adapts. Muscle becomes expendable tissue.

As we age, recovery slows, and cellular repair becomes less efficient. Malnutrition today does not always manifest as being skinny or underweight. Many individuals maintain a normal or even slightly elevated BMI and still appear healthy on the surface.

Over the past decade, health trends have increasingly demonised sugar, refined carbohydrates, and rice, often portraying them as the primary drivers of weight gain. Entire populations have experimented with no-carb or ultra-low-calorie diets to improve metabolic health.

**WITHOUT UNDERSTANDING HOW FOOD FUELS TRAINING AND RECOVERY, MANY UNKNOWINGLY CATABOLISE THEIR OWN MUSCLE MASS. THEY TRAIN HARDER, EAT LESS, AND END UP DEPLETED.**



According to the guidelines of the Health Promotion Board:

- Adults aged 18–49 require approximately 0.8 g of protein per kg of body weight
- Adults aged 50 and above require 1.2 g per kg of body weight

This means:

- A woman weighing 65 kg aged 50+ requires approximately 78 g of protein daily
- A man weighing 75 kg aged 50+ requires approximately 90 g of protein daily

In practical terms, this might resemble:



1 palm-sized portion of **chicken breast** ( $\approx 25$  g protein)



2 **eggs** ( $\approx 16$  g protein)



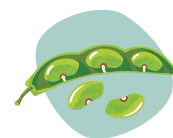
1 glass of **milk** ( $\approx 10$  g protein)



Half a block of **tofu** (150 g) ( $\approx 12$  g protein)



1 tub of **yoghurt** (150 g) ( $\approx 12$  g protein)



**Edamame** (200 g, in shells) ( $\approx 20$  g protein)

EATING ADEQUATELY OFTEN REQUIRES NUTRITION LITERACY, BASIC COOKING SKILLS, AND GREATER FINANCIAL AND TIME RESOURCES — BARRIERS THAT CANNOT BE IGNORED.

One of the main challenges in ensuring protein sufficiency is practicality. Many middle-aged adults no longer cook regularly; instead, they rely heavily on dining out or food delivery.

Hawker meals — economical and culturally cherished — are fundamental to the Singaporean diet. Wonton noodles, chicken rice, ban mian, char kway teow, Hokkien mee: these dishes are carbohydrate-heavy, with limited protein in both quantity and quality. Eating adequately often requires nutrition literacy, basic cooking skills, and greater financial and time resources — barriers that cannot be ignored.

Singapore is a pragmatic and financially savvy nation. As retirement ages extend, the question is no longer whether we will live longer, but how we will live.

Will we continue to enjoy marathons, golf, caring for grandchildren, social activities, and independence? Or will we simply extend life, while quietly losing strength, resilience, and joy?

Longevity without capability is not success. Strength, nourishment, and function must become central to how we define healthy ageing — before frailty becomes the unintended consequence of discipline. ∞

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# When eating enough is not enough, how do we eat right?



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