

FEEDING URBAN ASIA: NEW APPROACHES FOR PROVIDING SAFE, NUTRITIOUS, AND AFFORDABLE FOOD

June 2018



INTRODUCTION

The United Nations Sustainable Development Goals (SDGs) have built momentum towards a more resilient and inclusive world. As the countdown to 2030 begins, there is growing consensus on the importance of public-private sector collaboration to achieve the SDGs. Businesses are starting to seize the US\$12 trillion worth of opportunities in addressing our most pressing social and environmental challenges. Technology disruptions and demographic shifts will significantly change the way we learn, work, and live. The time is ripe to translate our collective action into impact and tangible outcomes for our future generations.

Ecosperity is a series of sustainability-focussed conferences presented by Singapore-based investment company Temasek. The conference brings together corporate leaders, innovators, policy-makers, and experts from around the world to explore the latest issues on sustainability growth. The name 'Ecosperity' twins ecology with prosperity – recognising that growth can and should take place in a sustainable manner.

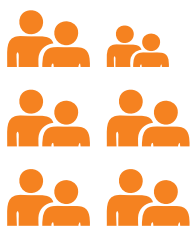
The 5th Ecosperity Conference will be held on 5th June 2018 in conjunction with United Nations World Environment Day. Themed "Tomorrow Starts Today! From Ideas to Impact", it will explore new approaches to education, food, and healthcare to achieve impact at scale and build resilient societies in an increasingly digital and urban future.

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A RISING URBAN POPULATION IN ASIA WILL PLACE PRESSURES ON THE FOOD SYSTEM...

EXAMPLES OF CHALLENGES



OVER 550 MILLION PEOPLE are likely to move to cities in Asia-Pacific by 2030

By 2030,
60% OF THE WORLD'S POPULATION will live in cities



RISING URBAN POPULATION...

By 2030, there could be **OVER 2.3 BILLION** new middle-class consumers emerge, with **ALMOST 90% IN THE ASIA-PACIFIC**



In India, calorie intake per person could

RISE BY 20%

to 2030, while per capita meat consumption in China could

INCREASE BY 40%



...FUELING DEMAND FOR FOOD

Number of farmers in Indonesia could **FALL BY 8 MILLION** by 2030 as people move to cities



Urbanisation could lead to the loss of an estimated **2 MILLION HECTARES** per year, with about three-quarters of that being agricultural land



Climate change and land degradation could together lead to agricultural yield declines resulting in the need for an

ADDITIONAL 75 MILLION HECTARES OF LAND

to satisfy 2030 food and feed demand



...AND WITH RISING CONSTRAINTS ON SUPPLY





...AND WILL REQUIRE A NEW APPROACH TO PROVIDE SAFE, NUTRITIOUS, AND AFFORDABLE FOOD

TRANSFORMATION IS NEEDED IN FOUR AREAS

PRODUCTION



- Rethinking agricultural production to take advantage of underutilised areas in cities and apply new technologies
- There are significant environmental efficiencies from indoor farming – indoor vertical farming in Japan can **SAVE UP TO 99% OF WATER** compared to outdoor field farms

FOOD WASTE



- Taking a holistic approach to food waste management, from farmgate to fork
- Total annual food waste is **WORTH ABOUT US\$1 TRILLION** – roughly US\$680 billion is lost in industrialised countries and US\$310 billion in developing countries

TRACEABILITY



- Applying new technologies to improve traceability of food, helping to promote price transparency, enhance food safety, and reduce food fraud
- Current cost of food safety is estimated at up to **US\$23 BILLION**

NUTRITION



- Rethinking food intake, through exploring new sources of nutrition with lower environmental impacts and greater health benefits
- **OVER 40%** of adults in Asia-Pacific are overweight or obese

EXAMPLES OF NEW BUSINESS OPPORTUNITIES

1

Market size of vertical farming in 2016 for Asia-Pacific was estimated at **US\$355 BILLION**

2

Reducing food waste (in the value chain & at consumption) could create savings worth **US\$625 BILLION GLOBALLY IN 2030, OF WHICH ALMOST 60% IS IN ASIA**

3

The global diagnostic food safety testing market was estimated to be worth **US\$5 BILLION IN 2015**

4

The global gluten-free products market was estimated to be **US\$5 BILLION IN 2015**






KEY MESSAGES

- **A rising urban population in Asia will place pressures on the food system. 555 million people** are expected to move to cities in Asia by 2030. Providing this population with safe, nutritious, and affordable food will become an increasing challenge, not only due to the scale of demand but also due to supply-side issues. Urbanisation could lead to the loss of an estimated **2 million hectares per year**, with about three-quarters of that being agricultural land.¹ While there has been significant research on understanding how to enhance the productivity of smallholder and large-scale farms, there has been more limited research into how cities themselves could help address the looming food challenge.
- **A new approach is needed to provide safe, nutritious, and affordable food.** This research identifies four broad shifts needed in cities to provide safe, nutritious, and affordable food:
 1. **Production:** Rethinking agricultural production to take advantage of underutilised areas in cities and apply new technologies to transform yield growth, manage environmental risks, and bring production closer to sources of demand.
 2. **Food waste:** Taking a holistic approach to food waste management, from farmgate to fork, which focuses on a range of options including better urban design, consumer behavioural change, and investments in new technologies and infrastructure.
 3. **Traceability:** Applying new technologies to improve traceability of food, helping to promote price transparency, enhance food safety, and prevent food fraud.
 4. **Nutrition:** Rethinking food intake, through exploring new sources of nutrition with lower environmental impacts (e.g. insects) and greater health benefits (e.g. food fortification, functional foods, reformulated food, “free-from” foods).
- **These shifts will create significant new business opportunities.** In each of these four areas, there is a range of large new business opportunities in Asia. In total, our research estimates that the 2030 opportunity could be worth at least **US\$920 billion** in Asia alone. Some of the major opportunities include reducing food waste in the value chain, food fortification, reducing consumer food waste, fresh food, product reformulation, and urban agriculture.

1. World Bank (2015), *The dynamics of global urban expansion*. Available at: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/dynamics_urban_expansion.pdf



Chapter 1:

FOOD DEMAND TRENDS IN ASIA

More than 550 million people are expected to move to cities in Asia by 2030. At the same time, urbanisation will reduce the amount of arable land available for farming, and lead to a reduction in the number of farmers.

555 MILLION ARE EXPECTED TO MOVE TO CITIES IN ASIA BY 2030

By 2030, 60 percent of the world's population will live in cities, up from about 54 percent today – adding over 1 billion people to cities over the next 15 years.² Asia is at the heart of this urbanisation wave, with more than 550 million people expected to move to cities in Asia-Pacific by 2030 (Exhibit 1), where they will create more than 85 percent of gross domestic product.³

Economic growth is increasingly happening not only in mega-cities such as Jakarta, Mumbai, Shanghai, Manila, and Bangkok but also in middleweight regions, with a population between 500,000 and 5 million (Exhibit 2).

BY 2030, 60 PERCENT OF THE WORLD'S POPULATION WILL LIVE IN CITIES, UP FROM ABOUT 54 PERCENT TODAY – ADDING OVER 1 BILLION PEOPLE TO CITIES OVER THE NEXT 15 YEARS

THIS GROWTH IN URBANISATION WILL FUEL DEMAND FOR FOOD

This urbanisation process will not only support economic growth in Asia but also demand for food. Urbanisation is a crucial driver of economic growth by providing more-productive jobs for those leaving the farms for employment in urban manufacturing and services, and also through offering the critical mass and density for economies of scale and network effects. The labour productivity of a city with 200,000 people is, on average, 3 to 8 percent higher than one with 100,000 residents.⁴ In fact, no country has ever climbed from low-income to middle-income status without a significant population shift into cities.⁵ As millions move to cities in Asia for better job opportunities, the region is gaining a new wave of consumers with considerable spending power.

THE LABOUR PRODUCTIVITY OF A CITY WITH 200,000 PEOPLE IS, ON AVERAGE, 3 TO 8 PERCENT HIGHER THAN ONE WITH 100,000 RESIDENTS (BASED ON GLOBAL EMPIRICAL ANALYSIS)

IT TOOK 150 YEARS FOR THE MIDDLE CLASS TO REACH 1 BILLION. THE NEXT BILLION COULD BE ADDED IN JUST 7 YEARS

The Brookings Institute estimates that there were approximately 3.2 billion people in the middle class globally at the end of 2016.⁶ The rate of increase of the middle class, in absolute numbers, is approaching its all-time peak. It took 150 years after the start of the Industrial Revolution in Europe for the middle class to reach 1 billion people globally. The next billion were added to the global middle class in 21 years. The third billion was added in just 9 years, and the next billion could arrive in just 7 years. An overwhelming majority of new entrants into the middle class— over 88 percent of the next billion—will live in Asia. By 2030, over 2.2 billion could join the middle class in Asia (Exhibit 3).

This growth in the middle class will fuel demand for more and new types of food. Global food demand is expected

2. United Nations (2016), *The World's Cities in 2016*.

Available at: http://www.un.org/en/development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2016_data_booklet.pdf

3. McKinsey & Company (2015), *No Ordinary Disruption: The forces reshaping Asia*.

Available at: <https://www.mckinsey.com/global-themes/asia-pacific/no-ordinary-disruption-the-forces-reshaping-asia>

4. Stuart S. Rosenthal and William C. Strange (2004), "Evidence on the nature and sources of agglomeration economies," in *Handbook of Urban and Regional Economics*, 1st ed., volume 4, J. V. Henderson and J. F. Thisse, eds., Elsevier.

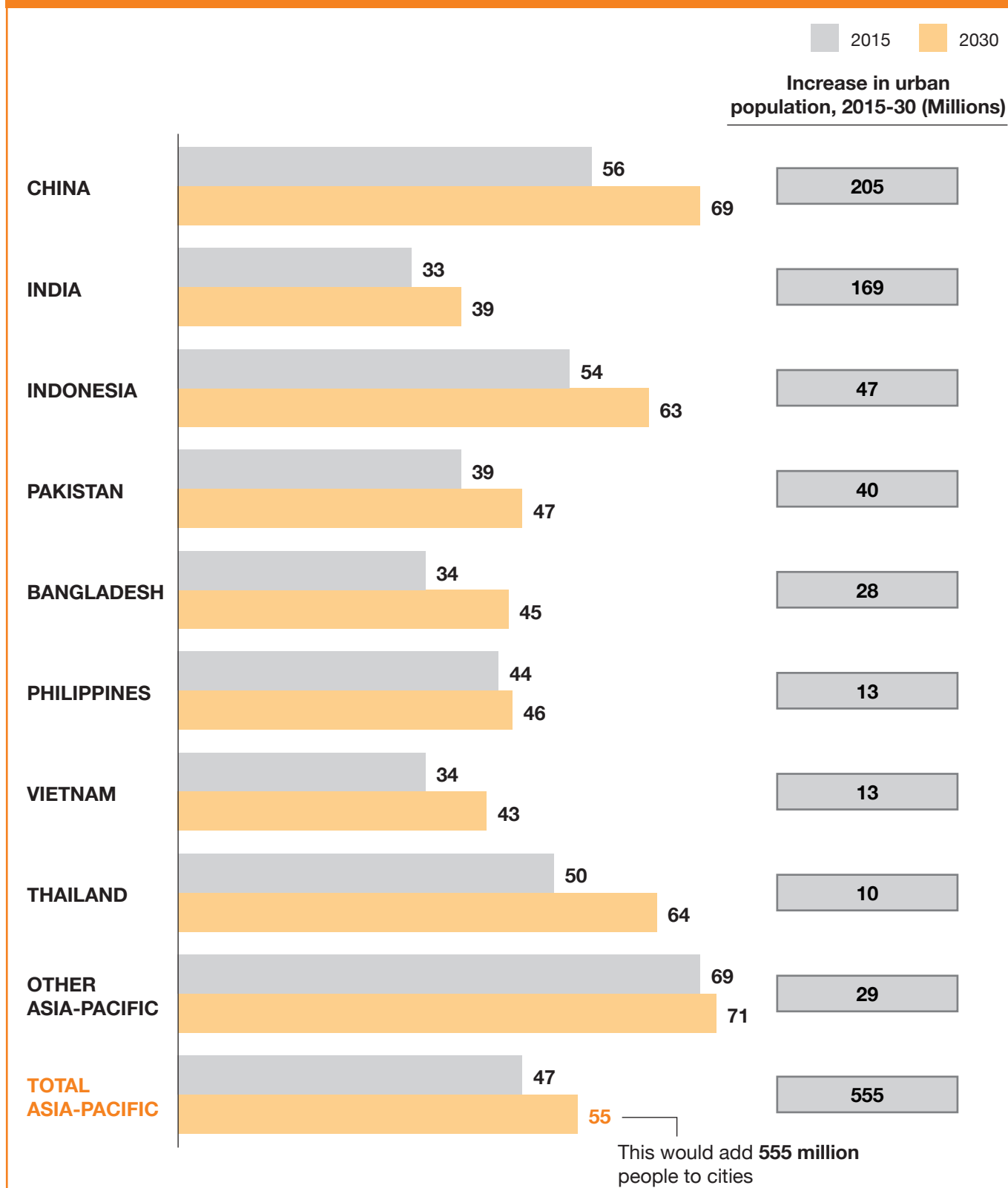
Available at: <https://www.sciencedirect.com/science/article/pii/S1574008004800063>

5. World Bank (2009), *Urbanisation and growth*. Available at: https://siteresources.worldbank.org/EXTPREMNET/Resources/489960-1338997241035/Growth_Commission_Vol1_Urbanization_Growth.pdf

6. Brookings Institute (2017), *The unprecedented expansion of the global middle class*. Available at: https://www.brookings.edu/wp-content/uploads/2017/02/global_20170228_global-middle-class.pdf. The income range for middle-class families is defined by Brookings as ranging from US\$11 to US\$110 income per day in 2011 Purchasing Power Parity (PPP) terms.

EXHIBIT 1:

555 MILLION PEOPLE ARE EXPECTED TO MOVE TO CITIES IN ASIA-PACIFIC BY 2030

SHARE OF COUNTRY URBAN POPULATION, 2015–2030
(PERCENT)

NOTE: Numbers may not sum due to rounding.

SOURCE: United Nations Population Division; AlphaBeta analysis

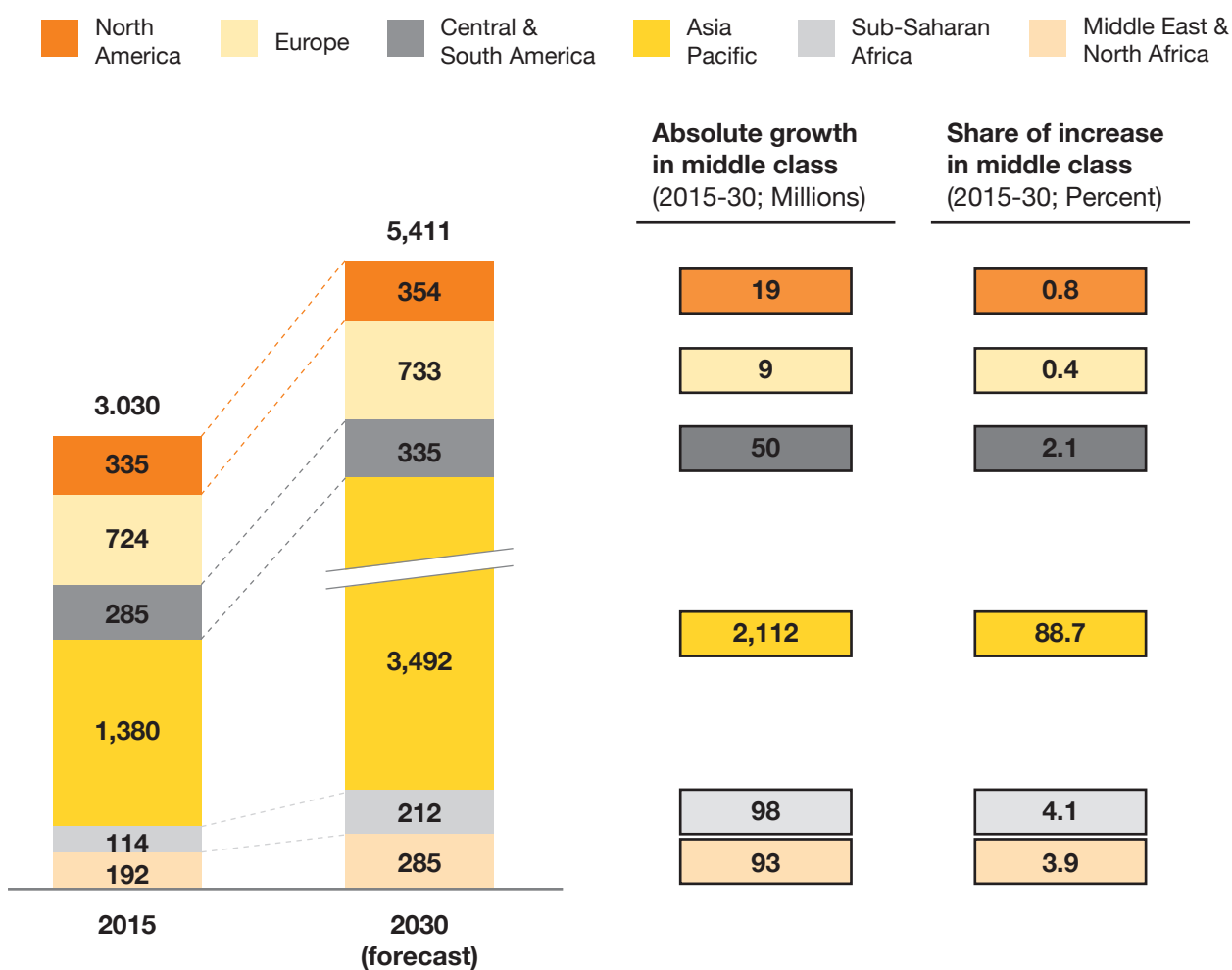
EXHIBIT 2:

MIDDLEWEIGHTS, NOT MEGA REGIONS, ARE GROWING THE FASTEST IN ASEAN

	Compound annual growth rate of real GDP (Percent)		# of regions 2015	Share of real GDP 2015	Share of Pop. 2015
	2010-2015	2015-2020			
MEGA REGIONS 5 million and above	5.0	5.5	8	33%	11%
LARGE MIDDLEWEIGHTS 1 million – 5 million	5.7	6.9	184	32%	48%
SMALL MIDDLEWEIGHTS 500,000 – 1 million	4.8	5.8	191	16%	22%
SMALL REGIONS 300,000 – 500,000	5.0	6.0	143	8%	9%
RURAL REGIONS Below 300,000	4.2	5.5	448	11%	10%
TOTAL	5.1	6.0	974		

SOURCE: AlphaBeta ASEAN Economic database

EXHIBIT 3:

ALMOST 90 PERCENT OF THE GROWTH IN THE GLOBAL MIDDLE CLASS TO 2030
WILL BE IN ASIANUMBER OF THE GLOBAL MIDDLE CLASS BY REGION¹
(MILLIONS)

¹ The income range for middle-class families is defined by Brookings as ranging from \$11 to \$110 income per day in 2011 Purchasing Power Parity (PPP) terms.
SOURCE: Homi Kharas (Brookings Institute); Team analysis

to increase anywhere between 59 percent to 98 percent by 2050.⁷

Food demand is expected to come largely from the developing economies of China, India, and other Asian countries, as well as Africa.⁸ In India, calorie intake per person could rise by 20 percent to 2030, while per capita meat consumption in China could increase by 40 percent.⁹

URBANISATION TRENDS WILL ALSO PUT PRESSURE ON THE SUPPLY OF FOOD

The growth of cities could encroach on arable land and lead to the loss of an estimated 2 million hectares per year, with about three-quarters of that being agricultural land.¹⁰ In addition, there will be a loss of workers in the agricultural sector as people move to cities. In Indonesia, for example, urbanisation could result in about 8 million fewer farmers by 2030 as people migrate from rural areas to cities.¹¹

GLOBAL FOOD DEMAND IS EXPECTED TO INCREASE ANYWHERE BETWEEN 59 PERCENT TO 98 PERCENT BY 2050



URBANISATION COULD RESULT IN ABOUT 8 MILLION FEWER FARMERS BY 2030 IN INDONESIA AS PEOPLE MIGRATE FROM RURAL AREAS TO CITIES

IF NOT MANAGED WELL, THERE ARE A NUMBER OF RISKS TO FOOD SAFETY, NUTRITION, AND AFFORDABILITY

There could be challenges to food safety, nutrition, and affordability from these trends:

- **Food safety.** There are increasing concerns about food safety and food fraud, particularly as consumers become more disconnected from the production and origin of food with the move into cities. Foodborne illness is a major issue around the world as food products can be easily contaminated with pathogens such as Salmonella, E. Coli, or Campylobacter in different stages of the supply chain. This, in turn, might lead to food poisoning cases, lost productivity,

and even deaths. Food fraud is a related concern. According to the Food Fraud initiative from the Michigan State University, food fraud is defined as the “deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging; or false or misleading statements made about a product, for economic gain” and is economically motivated.¹²

In China in 2015, there was a major food fraud case of fake rice, intentionally constructed from sweet potatoes and synthetic resin.¹³ Another high-profile

7. This forecast was made for the period 2005-2050. See Hugo Valin et. al. (2013), *The future of food demand: Understanding differences in global economic models*. Agricultural Economics. Available at: <https://onlinelibrary.wiley.com/doi/abs/10.1111/agec.12089>

8. McKinsey Global Institute (2011). *Resource revolution: Meeting the world's energy, materials, food, and water needs*.

Available at: <https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution>

9. McKinsey Global Institute (2011). *Resource revolution: Meeting the world's energy, materials, food, and water needs*.

Available at: <https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution>

10. World Bank (2015), *The dynamics of global urban expansion*.

Available at: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/dynamics_urban_expansion.pdf

11. McKinsey Global Institute (2012), *The archipelago economy: Unleashing Indonesia's potential*.

Available at: <https://www.mckinsey.com/global-themes/asia-pacific/the-archipelago-economy>

12. Michigan State University (2011), “Backgrounder: Defining the Public Health threat of Food Fraud”.

Available at: <http://foodfraud.msu.edu/wp-content/uploads/2014/07/food-fraud-ffg-background-er-v11-Final.pdf>

13. Shanghaiist (2015), “Fake rice made with plastic reportedly spreading across Asia”.

Available at: <http://shanghaiist.com/2015/05/20/fake-rice-made-with-plastic-spreading-across-asia.php>

case is the 2008 milk scandal, which impacted 300,000 babies in China after they consumed milk tainted with melamine.¹⁴ A 2016 study by Zhang and Xue analysed 1,553 media reports on food fraud cases in China and concluded that food fraud is prevalent in the country and many adulterants and contaminants can be found across food types.¹⁵ In India, the FSSAI found that over two-thirds of milk sold in India was contaminated with detergent and other substances.¹⁶ In Indonesia, there have also been some recent high-profile cases of companies being convicted of falsifying halal compliance of products.¹⁷

- **Nutrition.** People who move to cities must adopt new methods of acquiring, preparing, and eating food. Poor shelter, lack of sanitation and hygiene and insufficient social services in slum areas can create further challenges. 36 million children under the age of five in Asia-Pacific are suffering from

36 MILLION CHILDREN UNDER THE AGE OF FIVE IN ASIA-PACIFIC ARE SUFFERING FROM “WASTING” – WHICH REFERS TO LOW WEIGHT-TO-HEIGHT AND IS A FORM OF CHRONIC UNDERNUTRITION

“wasting” – which refers to low weight-to-height and is a form of chronic undernutrition.¹⁸ On the other end of the spectrum, excessive intake of energy, coupled with limited physical activity, can also lead to rising problems of obesity and diet-related chronic diseases in most cities. Nearly 41 percent of adults in Asia-Pacific are overweight or obese.¹⁹

THE WORLD'S POOREST SPEND AS MUCH AS 60 PERCENT OF THEIR INCOME ON FOOD

- **Affordability.** The world's poorest spend as much as 60 percent of their income on food.²⁰ Despite this, calorie deficiency and malnourishment persist as populations cannot access or afford enough of the right kinds of food.²¹ Many households in Sub-Saharan Africa and South Asia still face deficits of 200 to 500 kilocalories per day.²² Even in developed countries, there have always been concerns whether low-income households consume only junk food or have access to affordable healthy food options.²³ For example, a meta-analysis of 27 studies across 10 countries has found that the cost of adopting a healthy diet could increase grocery costs by more than US\$2,000 for a family of four annually in the US.²⁴

14. Forbes (2014), “The 2008 Milk Scandal Revisited”.

Available at: <https://www.forbes.com/sites/yanzhonghuang/2014/07/16/the-2008-milk-scandal-revisited/#3bc78cb24105>

15. Zhang Wenjing and Xue Jianhong (2016), “Economically motivated food fraud and adulteration in China: An analysis based on 1553 media reports”, Food Control Volume 67. Available at: <https://www.sciencedirect.com/science/article/pii/S0956713516301098>

16. Securing Industry (2017), “India considers tougher sentences for food fraud”.

Available at: <https://www.securindustry.com/food-and-beverage/india-considers-tougher-sentences-for-food-fraud/s104/a3199/#.WLacBIV95EY>

17. Jakarta Post (2016), “Halal foods pioneer sentenced for export fraud to Indonesia, Malaysia”. Available at: <https://www.thejakartapost.com/news/2016/02/26/halal-foods-pioneer-sentenced-export-fraud-indonesia-malaysia.html>

18. “Wasting” refers to low weight-to-height and is a form of chronic undernutrition. See UNICEF / WHO / World Bank (2017), Levels and trends in child malnutrition. Available at: https://data.unicef.org/wp-content/uploads/2017/06/JME-2017_brochure_June-25.pdf

19. Nikkei Asian Review (2017), “Indonesia and Malaysia follow Singapore’s lead in tackling obesity”. Available at: <https://asia.nikkei.com/Politics-Economy/Policy-Politics/Indonesia-and-Malaysia-follow-Singapore-s-lead-in-tackling-obesity>

20. World Food Programme (2012), “How High Food Prices Affect The World’s Poor”

Available at: <https://www.wfp.org/stories/how-high-food-prices-affect-worlds-poor>

21. FAO (2015), The state of food insecurity in the world 2015. Available at: <http://www.fao.org/3/a-i4646e.pdf>

22. Based on UN FAO data, as used by: Max Roser and Hannah Ritchie / Our World in Data (2016), Hunger and Undernourishment.

Available at: <https://ourworldindata.org/hunger-and-undernourishment>

23. There is still ongoing debate on these issues. Some articles can be found here: The Guardian (2015), “It’s simply harder to eat well when you are poor”. Available at: <https://www.theguardian.com/commentisfree/2015/nov/29/kis-junk-food-dont-blame-parents>, The Conversation (2014), “Poor diet is the result of poverty not lack of education”. Available at: <https://theconversation.com/poor-diet-is-the-result-of-poverty-not-lack-of-education-26246>, and Business Insider (2017), “New research challenges the assumption that poor Americans eat more junk food than the rich”.

Available at: <http://www.businessinsider.com/poor-wealthy-income-junk-food-research-2017-6/?IR=T>

24. Rao M, Afshin A, Singh G, et al (2013), Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. BMJ Open. Available at: <http://bmjopen.bmj.com/content/3/12/e004277>



Chapter 2:

A NEW APPROACH TO PROVIDING SAFE, NUTRITIOUS, AND AFFORDABLE FOOD IN ASIA'S GROWING CITIES

Providing safe, nutritious, and affordable food requires a rethink of traditional approaches to the food system. Much of the existing research has been on how to drive productivity of farms. While this is important, it is also important to think how cities could play a role in supporting this food supply.

Four broad shifts are needed in cities to provide safe, nutritious, and affordable food.

FOUR BROAD SHIFTS ARE NEEDED IN CITIES TO MEET THE FOOD CHALLENGE

Four broad shifts are needed in cities to provide safe, nutritious food, and affordable (Exhibit 4):

1. **Rethinking Agricultural Production as a Manufacturing process:** Rethinking agricultural production to take advantage of underutilised areas in cities and apply new technologies to transform yield growth, manage environmental risks, and bring production closer to sources of demand.
2. **Systematic Approach to Food Waste:** Taking a holistic approach to food waste management, from farmgate to fork, which focuses on a range of options including better urban design, consumer behavioural change, and investments in new technologies and infrastructure.
3. **Enhancing Traceability via Technology:** Applying new technologies to improve traceability of food, helping to promote price transparency, enhance food safety, and prevent food fraud.
4. **Redefining Nutrition:** Rethinking food intake, through exploring new sources of nutrition with lower environmental impacts (e.g. insects) and greater health benefits (e.g. food fortification, functional foods, reformulated food, “free-from” foods).

1. PRODUCTION

According to the RUAF Foundation, urban agriculture is defined as the growing of plants and the raising of animals within cities and in peri-urban areas.²⁵ It includes vertical indoor farms and community gardens. The adoption of urban agriculture is rising rapidly in Asia in response to the growth of cities and the rise of new technologies. Currently, technology has reached a point where we can overcome physical constraints such as land and weather conditions. For example, vertical farming, integrated sensors, and controlled lighting allow cities to use

266 MILLION HOUSEHOLDS IN DEVELOPING COUNTRIES ARE ENGAGED IN URBAN FARMING

relatively small plots of land to grow crops (even those that are not possible in Asian climate) faster.²⁶

Growing food in urban areas could be important for food security, as well as increase access to fresh food sources. Urban agriculture improves the food security of cities by increasing the supply of food to growing urban populations and lowering costs due to reduced transportation and storage. 266 million households in developing countries (over 65 percent from Asia) are already engaged in urban farming and a quarter of those engaged earn an income from it.²⁷ Furthermore, there are significant environmental efficiencies from indoor farming – for instance, studies by the Japan Plant Factory Association (JPFA) and SPREAD, a Kyoto-based vertical farming company, have highlighted that indoor vertical farming in Japan can save up to 99 percent of water compared to outdoor field farms²⁸

There are key differences regarding urban agriculture across Asia in terms of the level of adoption and commercialisation as well as the technology used. For example, Singapore has been leveraging technological advances in vertical farming, utilising methods such as hydroponics and aeroponic. The number of vertical farms has grown from just one in 2012 to seven in 2016, producing a range of produce from vegetables to aquaculture.²⁹ For example, the Apollo Aquaculture Group has created a local “high-rise” seafood farming project that produces six times more than a traditional aquaculture project, where everything is remotely controlled and carefully managed, including the amount of fish feed dispensed.³⁰ Urban agriculture is a crucial component of Japan's economy and food ecosystem. Up to one-third of Japan's agriculture output is generated in urban areas,

25. RUAF Foundation (2018), “Urban agriculture: what and why?”. Available at: <http://www.ruaf.org/urban-agriculture-what-and-why>

26. EcoWatch (2015), “3 Creative Solutions Emerging in Urban Farming”. Available at: <https://www.ecowatch.com/3-creative-solutions-emerging-in-urban-farming-1882052831.html> and Ayoka Systems (2016), “7 Emerging Agriculture Technologies”. Available at: <https://www.ayokasystems.com/news/emerging-agriculture-technologies/>

27. Andrew J. Hamilton et al. (2014), “Give peas a chance? Urban agriculture in developing countries. A review”, *Agronomy for Sustainable Development*. Available at: <https://link.springer.com/article/10.1007/s13593-013-0155-8>

28. Microsoft (2018), “Indoor vertical farming in Asia and beyond: Digging deep in data”. Available at: <https://news.microsoft.com/apac/features/indoor-vertical-farming-digging-deep-data/>; and Ozy (2017), “The Robots Are Coming ... For the Farms”. Available at: <https://www.ozy.com/rising-stars/the-robots-are-coming-for-the-farms/70693>

29. The Straits Times (2016), “Vertical farms on the rise in land scarce Singapore”. Available at: <http://www.straitstimes.com/lifestyle/vertical-farms-on-the-rise-in-land-scarce-singapore>

30. The Straits Times (2017), “Next-gen farming concepts on show at exhibition”. Available at: <http://www.straitstimes.com/singapore/next-gen-farming-concepts-on-show-at-exhibition>

EXHIBIT 4:

**FOUR SHIFTS ARE NEEDED IN CITIES TO SUPPORT ACCESS TO SAFE,
AFFORDABLE AND NUTRITIOUS FOOD**

VALUE CHAIN AREA	FROM...	TO...
Production 	Urbanisation encroaching on agricultural land	Taking advantage of utilised land in cities for urban agriculture
	More complex and lengthy distribution channels to supply food to urban areas	Minimising time to market by concentrating production in cities
	Climate and land degradation impacting crop yields	Environmentally-controlled conditions to maximise production
	Traditional agricultural techniques	Sophisticated vertical farming, applying latest technologies
Food Waste 	Lack of storage facilities	Modern, cold storage systems
	Restaurant waste	Internet of Things (IoT) in the kitchen
	Low consumer awareness	Taxes and information campaigns to raise awareness
	Limited waste capture	Composting and energy capture
Traceability 	Limited traceability of food from farmgate to fork	IoT and fully traceable supply chains
	Limited price transparency, and risks of food fraud and food safety concerns	Greater price transparency, and better management of food fraud and food safety risks
Nutrition 	Consumption of highly processed and junk food	Healthy and affordable fresh food available with maximum convenience
	Growing cases of food allergies	"Free-from" foods tailored to allergies
	Unfortified food	Food fortification
	High sugar/fat products	Product reformulation, low fat/sugar products

with urban farmers accounting for a quarter of farming households in the country.³¹ Urban agriculture in Japan is highly commercialised. Across Japan, urban farms have grown from 641 hectares in 2005 to 877 hectares in 2015.³² Japan is also a hotbed for technology advances in urban farming and is a pioneer in developments including ICT-enabled indoor crop production and using drones for harvesting, as well as innovative green applications such as using edible crops to provide insulation for buildings.³³

Urban agriculture is also increasingly important in China due to rapid urbanisation as it provides income opportunities and food security for residents. Environmental factors in China such as depleting arable land and water contamination also make it more important for cities to engage in urban agriculture.³⁴ For instance, the number of greenhouse companies have grown from 5 in the 1980s to about 400 by 2010, boosting the indoor agriculture industry.³⁵ Urban agriculture is less commercialised and sophisticated in India (in general), but still growing quickly. Urban agriculture is popular in Hyderabad and Delhi where state agencies have actively encouraged the practice by providing subsidised inputs.³⁶

In developing countries, poor infrastructure, and lack of financial support from governments are commonly cited obstacles for urban agriculture. For instance, citizens in developing countries might lack access to financial or natural resources (such as land, seeds, water, and fertilisers) needed to set up production.³⁷ In developed countries, there are other sets of challenges such as land scarcity, high upfront capital costs, uncertain regulations, and entrenched consumer behaviour. For instance, in highly urbanised Singapore, barriers include limited

land allocated for farming (less than 0.10 percent), low consumer awareness as well as general resistance to purchasing pricier urban agriculture products due to the availability of other relatively cheap food sources.³⁸ As a result, there might not be an attractive consumer market for urban agriculture goods, hindering its adoption.

Governments can use a range of levers to encourage urban agriculture, from streamlining regulations to providing technical assistance and funding. Examples include:

- Streamlining regulatory requirements:** Governments across Asia have implemented a range of measures to create a more supportive environment for urban agriculture. For example, in Singapore, the Urban Redevelopment Authority (URA) has lowered the barriers for urban farming by allowing urban farms and communal gardens on rooftops to contribute towards the landscape replacement requirements.³⁹ In addition, longer urban farm leases (20 years instead of 10 years) can also encourage greater uptake of expensive farming technologies.⁴⁰ Another example is Beijing which was one of the first cities to integrate urban agriculture into its overall development strategy by developing “agro-parks” in 5 dedicated zones. The city also attempted to institutionalise urban agriculture by measuring and documenting its economic, social, and environmental impact in official records since 2010.⁴¹ In Japan, the authorities have designated 134 square kilometres of land for urban agriculture and have promoted the rental of urban farmland.⁴²

31. United Nations University (2011), “Japan’s Urban Agriculture: Cultivating Sustainability and Well-being”.

Available at: <https://unu.edu/publications/articles/japan-s-urban-agriculture-what-does-the-future-hold.html>

32. The Straits Times (2018), “Goats, pigs and veggies crop up in urban Tokyo”.

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33. World Positive (2017), “The Future of Agriculture is already here”. Available at: <https://worldpositive.com/the-future-of-agriculture-is-already-here-1267a01dff09> and United Nations University (2011), “Japan’s Urban Agriculture: Cultivating Sustainability and Well-being”.

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34. Bloomberg (2017), “Plant Factories’ Churn Out Clean Food in China’s Dirty Cities”.

Available at: <https://www.bloomberg.com/news/features/2017-05-25/-plant-factories-churn-out-clean-food-in-china-s-dirty-cities>

35. Smart Agriculture Analytics (2015), “China’s Indoor Agriculture Industry”.

Available at: <https://vertical-farming.net/wp-content/uploads/2015/02/Chinas-Indoor-Agriculture-Industry-Infographics-revised.pdf>

36. Times of India (2013), “Urban agriculture booms in Hyderabad”.

Available at: <http://timesofindia.indiatimes.com/city/hyderabad/Urban-agriculture-booms-in-Hyderabad/articleshow/19886364.cms>

37. Power House Growers (2017), “Urban farming in developing versus developed countries”.

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38. Stella Liu (2017), Lessons Learned from Growing Food in 100% Urbanised Singapore. Available at: https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2017/06/1_StellaLiu_Lessons-Learned-from-Growing-Food-in-100_-Urbanized-Singapore.pdf

39. The Straits Times (2017), “More rooftop gardens, urban farms planned”. Available at: <http://www.straitstimes.com/singapore/environment/more-rooftop-gardens-urban-farms-planned>, SRX (2017), “Rooftop farms now allowed under landscape replacement policy”.

Available at: <https://www.srx.com.sg/singapore-property-news/42652/rooftop-farms-now-allowed-under-landscape-replacement-policy>, and URA (2017), “Updates to the Landscaping for Urban Spaces and High-Rises (LUSH) Programme: LUSH 3.0”. Available at: <https://www.ura.gov.sg/Corporate/Guidelines/Circulars/dc17-06>

40. SG SME (2017), “36 new plots of farm land spanning 60ha to be up for bidding to boost Singapore’s food security; priority given to high-tech farmers”. Available at: <http://www.sgsme.sg/news/36-new-plots-farm-land-spanning-60ha-be-bidding-boost-singapores-food-security-priority-given>

41. China Dialogue (2014), “Urban agriculture makes China’s cities more liveable”. Available at: <https://www.chinadialogue.net/article/show/single/en/7091-Urban-agriculture-makes-China-s-cities-more-liveable>

42. The Japan Times (2017), “Japan’s farm ministry to promote rental of urban farmland”. Available at: <https://www.japantimes.co.jp/news/2017/08/20/national/social-issues/japans-agricultural-ministry-promote-urban-farmland-leasing/#.WtQfPy5uapo>

- **Offering financial and technical assistance:**

By connecting urban farmers to regional supply chains and offering training and better equipment, productivity can be significantly increased. For example, in recent years, cities in Latin America have been successful at improving the incomes of households which are involved in urban agriculture by facilitating the growth of networks and businesses which provide productivity-enhancing services.⁴³ In Singapore, urban farmers can leverage the Agri-Food & Veterinary Authority's (AVA) US\$47 million Agriculture Productivity Fund to defray the high adoption costs.⁴⁴ In China, the Shanghai government has launched programmes to create a sustainable system of urban farming, including systems of quality control as well as government funded campaigns to promote food safety and consumer acceptance.⁴⁵ At the national level, the Research Centre for Protected Agriculture & Environmental Engineering (CPAE), part of the Ministry of Agriculture, has around 40 research institutes working on solutions that will boost efficiencies across various forms of urban agriculture such as vertical and indoor farming.⁴⁶



IN CHINA, EDIBLE FOOD THROWN OUT BY RESTAURANTS EACH YEAR IS EQUIVALENT TO NEARLY 10 PERCENT OF THE COUNTRY'S ANNUAL CROP PRODUCTION, OR ENOUGH TO FEED 200 MILLION PEOPLE

infrastructure mean that a significant share of food is wasted after harvest. There is a range of investment opportunities, ranging from data systems to better manage production processes, through to investment in cold storage facilities.

In China, over US\$32 billion worth of food was thrown away in 2013.⁴⁹ Researchers from China Agricultural University found that edible food thrown out by restaurants each year is equivalent to nearly 10 percent of the country's annual crop production, or enough to feed 200 million people.

Examples of policy action include:

2. FOOD WASTE

There is significant potential to reduce food waste and strengthen food security. According to the Food and Agriculture Organisation (FAO), total food waste is worth about US\$1 trillion today - roughly US\$680 billion is lost in industrialised countries and US\$310 billion in developing countries.⁴⁷ WRI estimates that roughly 35 percent of food is wasted at the consumption level, with the remainder lost during production and in the value chain.⁴⁸ The majority of losses in the value chain occur in developing countries, where poor storage facilities and inadequate transport

- **Collaboration with the private sector to better match food supply with demand:** The Japan Weather Association has collaborated with food producers such as Mizkan Holdings and Sagamiya Foods to develop a novel artificial intelligence system to predict food demand based on weather information and sales data.⁵⁰ This system aims to help companies scale back redundant production and cut food inventory losses.
- **Raising consumer and retailer awareness:** In some countries, governments have focused on raising public awareness regarding food waste. In Japan, the Consumer Affairs Agency was founded in 2009 to raise awareness of issues such as expiry labels and to clarify terminologies such as "used by date" and "best before date".⁵¹ In Singapore, the National Environment Agency (NEA) has released a step-

US\$1 TRILLION OF FOOD IS WASTED ANNUALLY ACROSS THE WORLD, EITHER IN THE VALUE CHAIN OR AT THE POINT OF CONSUMPTION

43. FAO (2014), *Growing Greener Cities in Latin America and the Caribbean*. Available at: <http://www.fao.org/3/a-i3696e.pdf>

44. AVA (2015), "Raising the bar for local farm productivity".

Available at: https://www.ava.gov.sg/files/avavision/Issue1_2015/food-bites-raising-the-bar-for-local-farm-productivity.html

45. WWF (2012), "Shanghai urban farming". Available at: http://www.panda.org/wwf_news/?204455%2FShanghai-urban-farming

46. Smart Cities Dive (2017), "How China Leads the World in Indoor Farming".

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47. FAO (2017), "Save Food: Global Initiative on Food Loss and Waste Reduction". Available at: <http://www.fao.org/save-food/resources/keyfindings/en/>

48. World Resources Institute and UNEP (2013), "Reducing food loss and waste".

Available at: <http://www.wri.org/events/2013/06/unep-wri-press-conference-reducing-food-loss-and-waste>

49. Worldwatch Institute (2013), "Food Waste and Recycling in China: A Growing Trend?".

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50. Nikkei Asian Review (2016), "AI could solve Japan's food waste problem".

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51. USDA (2011), "Consumer Affairs Agency Defines "Used By Date" and "Best Before Date". Available at: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Consumer%20Affairs%20Agency%20Defines%20%E2%80%9CUsed%20by%20date%E2%80%9D%20and%20%E2%80%9CBest%20before%20date_Tokyo_Japan_12-28-2011.pdf



by-step guide on how food retailers can develop a food waste reduction plan.⁵² Governments can also collaborate with grassroots organisations like the “Clean Plate Initiative” in China, which advocates for zero food waste when dining out.⁵³

- **Delegating responsibilities (supported by penalties for non-compliance):** Authorities can mobilise and guide different stakeholders in the supply chain to combat food waste. In Chinese cities like Zhuhai and Beijing, restaurants have the responsibility of educating consumers and reducing food waste. If there are serious cases of food waste, restaurants can be fined and even suspended.⁵⁴ Other cities in China (such as Hangzhou and Shenzhen) are making waste sorting compulsory and introducing fines for non-compliance. Japan enacted a “Food Wastage Act” in 2001 and revised it in 2007 to establish recycling targets and encourage businesses to create manufacturing processes that would reduce and reuse food waste (e.g., convert it into compost).⁵⁵

- **Imposing the true cost of food waste:** Most consumers do not consider the total cost of waste when they discard food – they typically do not think about the landfill space required, the emissions from decaying food, and the extractive value of the food waste. Taxes could help to plug that gap in some instances. In Seoul, the authorities introduced a policy in 2013 that mandates households pay for recycling services according to the quantity of food waste disposed. The volume of food waste has since reduced by 10 percent (compared to 2014 levels) in Seoul and the policy has since been extended to 16 additional South Korean cities.⁵⁶



IN SEOUL, THE AUTHORITIES INTRODUCED A POLICY IN 2013 THAT MANDATES THAT HOUSEHOLDS PAY FOR RECYCLING SERVICES ACCORDING TO THE QUANTITY OF FOOD WASTE DISPOSED

52. *The Straits Times* (2016), “E-guidebook to reduce food waste launched for retail food establishments”.

Available at: <http://www.straitstimes.com/singapore/environment/e-guidebook-to-reduce-food-waste-launched-for-retail-food-establishments>

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56. Winnow (2018), “How governments around the world are encouraging food waste initiatives”.

Available at: <http://blog.winnowsolutions.com/how-governments-around-the-world-are-encouraging-food-waste-initiatives>



3. TRACEABILITY

The lack of traceability of food across different stages of the value chain can create issues not only for price transparency, but also for food safety and food fraud. The current cost of food safety in lost productivity, medical claims and bills is estimated at up to US\$23 billion annually in the United States.⁵⁷ Food fraud is estimated to cost an additional US\$15 billion annually around the world.⁵⁸

THE CURRENT COST OF FOOD SAFETY IN LOST PRODUCTIVITY, MEDICAL CLAIMS AND BILLS IS ESTIMATED AT UP TO US\$23 BILLION PER ANNUM GLOBALLY

Food fraud and safety is complicated by globalisation which increases the complexity of supply chains, back-dated regulations, and under-investment in supply chain security and risk management.⁵⁹ Developing countries also suffer from possible corruption, underdeveloped

food regulation policies, and the lack of enforcement capabilities. Another challenge is the lack of harmonisation of food standards – for example, Indonesia has different halal food standards than Malaysia and Saudi Arabia.⁶⁰ Examples of opportunities for governments include:

- **Introducing new diagnostic tools to promote price transparency:** Eurostat has launched a new food price monitoring tool visualising the development of agricultural prices, import prices and producer and consumer prices, broken down by product categories and/or country.⁶¹ The tool can show to what extent price increases and decreases are transmitted from one stage of the supply chain to the next, what impact they have and how quickly. Transparency in prices has been shown to be a powerful driver of lower food prices for consumers.⁶²
- **Ensuring adequate regulatory frameworks:** Stricter enforcement and penalty frameworks can help deter potential cases of food fraud and breaches of food safety requirements. Since the spate of food safety incidents, China has rolled out several regulations such as the Food Safety Law and the establishment

57. The University of Rhode Island (2017), "Current Food Safety Issues". Available at: <https://web.uri.edu/foodsafety/current-food-safety-issues/>

58. GMA (2010), Consumer Product Fraud: Deterrence and Detection.

Available at: <https://www.gmaonline.org/downloads/research-and-reports/consumerproductfraud.pdf>

59. Food Industry Asia (2016), "Food Fraud: Eliminating the Risk to Consumers and Industry".

Available at: <https://foodindustry.asia/food-fraud-eliminating-the-risk-to-consumers-and-industry>

60. McKinsey Global Institute (2014), Southeast Asia at the crossroads: Three paths to prosperity.

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61. EU Commission (2017), "New tool enhances price transparency along the food supply chain".

Available at: https://ec.europa.eu/info/news/new-tool-enhances-price-transparency-along-food-supply-chain-2017-jun-13_en

62. Vox (2018), "The effects of mandatory disclosure of supermarket prices". Available at: <https://voxeu.org/article/supermarket-transparency-lowers-prices>

of the China Food and Drug Administration aiming to prosecute offenders and prevent future cases.⁶³

Currently, food fraudsters in India face minimal punishment; the Law Commission of India is pushing for stricter sentences for food fraudsters, ranging from life sentences for those whose food products injure or kill consumers, to hefty fines of US\$15,000 for other cases.⁶⁴

- **Enhancing communication channels:** It is difficult for consumers to keep track of announcements of product recalls, particularly in large markets such as China and India. Furthermore, there could be unintended food wastage as consumers avoid perfectly safe food items. For instance, a recall on a specific batch of apples might result in lost sales for the whole fruit category. One way which governments can mitigate such occurrences is enhancing communication with consumers via technology. The Australian Competition and Consumer Commission, a government agency, has launched a mobile app which notifies consumers of all food product recalls in real-time.⁶⁵ This way, consumers (even those in developing countries since smartphone penetration is high) can make better-informed decisions when purchasing or discarding food items.
- **Promoting certification for global food safety standards:** One way to improve food safety and reduce food fraud is through getting certification for global food safety standards such as the Global Food Safety Initiative (GFSI) schemes. These certifications encompass monitoring the entire supply chain, which helps reduce food fraud in general, and many are adding specific requirements for food fraud avoidance.⁶⁶

4. NUTRITION

As Asia develops economically and urbanisation rates increase, there has been increasing emphasis placed on convenience – this can give rise to greater consumption of processed, instant (i.e., ready-to-eat meals), and fast foods.⁶⁷ For instance, Indonesia's processed meat and poultry markets grew at an annualised growth rate of 27 percent between 2011 and 2015.⁶⁸ Therefore, there could be significant resistance from consumers towards efforts that might reduce their convenience. The transition to better nutrition (e.g., fresh food and “free-from” food) and other alternative sources of nutrition (e.g., insects) faces several other issues. These include the fiscal capacity of low-income consumers, lack of access to healthier food (e.g., time limitations to prepare fresh food), information failures (meaning that consumers don't often understand key dietary guidelines or allergens), and significant behavioural shifts required. For instance, although insects require much less feed and water, are a good source of energy and micronutrients, and produce lesser emissions, there are still microbial risks, allergen concerns, and consumer acceptance challenges.⁶⁹ With families in low- and middle-income countries spending a disproportionate amount of household income on food, price sensitivity could keep demand low.⁷⁰ Furthermore, there are also barriers to implementing nutrition education, in countries such as South Korea, including the lack of a systematic curriculum and the lack of continuing education for nutrition teachers.⁷¹

There is a range of different policy levers available, ranging from raising consumer awareness through to regulatory requirements for food safety (e.g., testing of the new food items), packaging, and labelling. These policy levers are discussed in further detail in the Ecosperity research on health (“Prevention is the best medicine: Rethinking healthcare in Asia”).

63. Forbes (2014), “The 2008 Milk Scandal Revisited”.

Available at: <https://www.forbes.com/sites/yanzhonghuang/2014/07/16/the-2008-milk-scandal-revisited/#3bc78cb24105>

64. Securing Industry (2017), “India considers tougher sentences for food fraud”.

Available at: <https://www.securindustry.com/food-and-beverage/india-considers-tougher-sentences-for-food-fraud/s104/a3199/#.WLaCBIV95EY>

65. REID (2013), “Mobile phone app aids food safety and prevents food waste”. Available at: <http://reid.wrap.org.uk/item.php?id=367>

66. AP Food Online (2017), “Food Fraud across the Global Supply Chain”.

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67. Channel NewsAsia (2017), “Instant meals: A hindrance to healthy eating?”.

Available at: <https://www.channelnewsasia.com/news/singapore/instant-meals-a-hindrance-to-healthy-eating-7608614> and Euromonitor (2017), “Fast Food in Asia-Pacific is on the Rise”. Available at: <https://blog.euromonitor.com/2017/10/fast-food-asia-pacific.html>

68. Mintel (2017), “Indonesia and India Among the World's Fastest Growing Processed Food Retail Markets”.


Available at: <http://www.mintel.com/press-centre/food-and-drink/convenience-in-asia>

69. The Straits Times (2017), “Eating bugs can help the environment. But will people eat them?”. Available at: <http://www.straitstimes.com/lifestyle/food/eating-bugs-can-help-the-environment-but-will-people-eat-them> and D. Dobermann et al (2017), “Opportunities and hurdles of edible insects for food and feed”, Nutrition Bulletin, Volume 42 Issue 4. Available at: <https://onlinelibrary.wiley.com/doi/full/10.1111/nbu.12291>

70. Hindustan Times (2017), “How do people in developing countries spending their money?”

Available at: <https://www.hindustantimes.com/interactives/how-do-people-in-developing-countries-spend-money/>

71. Jounghee Lee and Youngsun Hong (2015), “Identifying barriers to the implementation of nutrition education in South Korea”. Asia-Pacific Journal of Clinical Nutrition. Available at: <http://apjcn.nhri.org.tw/server/APJCN/24/3/533.pdf>

An aerial photograph of a construction site, showing a large excavator and a conveyor system moving material. The image is in grayscale. Overlaid on the image is a large, white hexagonal shape with a thick orange border. The text is centered within this hexagon.

Chapter 3:

EMERGING BUSINESS OPPORTUNITIES

While policy levers can support a shift in approach to provide safe, nutritious, and affordable food in cities, there are also several new business opportunities that can create significant value, while also supporting this shift in approach.

BUSINESS OPPORTUNITIES ASSOCIATED WITH A SHIFT IN FOCUS TO PROVIDE SAFE, NUTRITIOUS, AND AFFORDABLE FOOD COULD BE SIGNIFICANT IN ASIA

Exhibit 5 provides data on the estimated business value of different opportunities in each of the four broad areas of production, food waste, traceability, and nutrition.⁷²

1. PRODUCTION

The global opportunity for urban agriculture in 2030 is estimated to be US\$40 billion, of which roughly half is in Asia.⁷³ Specific opportunities include:

- **Utilising existing spaces for urban farming.** It has been estimated that there are about 1,000 underutilised hectares of rooftops in Singapore which can be converted into urban farms.⁷⁴ Several commercial entities are already dedicating floor space for rooftop farms. For instance, the Funan integrated development includes Comcrop's 600 square metres farm and CapitaLand's future 490 square metres farm.⁷⁵ In Japan, examples include Ginza Rice Farm, which is a rice paddy situated on an empty lot in Tokyo's Ginza shopping district; and Ginza Honeybee Project, which is a rooftop bee yard that is home to 150,000 bees and produces 300 kilogrammes of honey annually.⁷⁶ Building

owners can also explore plot-share options.

The more prominent players include Agrimedia Corporation which operates 20 plot-share farms in Tokyo and charges a rental fee for use of land.⁷⁷ Rooftop Republic, a startup in Hong Kong, has collaborated with corporates, such as Cathay Pacific Airways, to identify and design excess spaces for urban agriculture, establishing about 30 projects.⁷⁸ Conglomerates, such as Fujitsu, are also exploring urban agriculture. For instance, Fujitsu makes use of excess spaces in its semiconductor plant in Fukushima to grow low-potassium lettuce.⁷⁹

- **Providing technical advice and equipment.** In India, there are several local companies providing technical advice and equipment to support urban farming. For example, Living Greens Organics specialises in providing equipment and advice for a range of urban agriculture applications including rooftop farming, indoor and outdoor green walls and balcony stands.⁸⁰ Another example is Hamari Krishi, a small company in India that markets equipment used in aeroponic and hydroponic farms.⁸¹ Singapore-based Upgrown Farming Company provides cost-effective vertical farming solutions such as racks, towers, and lighting systems for both commercial and household urban growers.⁸² Global lighting and electronics firm, Philips, has also invested resources to create tailor-made lighting systems for urban agriculture. For example, its "GreenPower LED" lights are optimised for closed, climate-controlled cultivation facilities.⁸³



**THERE ARE ABOUT 1,000
UNDERUTILISED HECTARES
OF ROOFTOPS IN SINGAPORE
WHICH CAN BE CONVERTED
INTO URBAN FARMS**

72. The detailed assumptions for these market sizings can be found in the appendix.

73. AlphaBeta and the Business & Sustainable Development Commission (2017). *Valuing the SDG prize: Unlocking business opportunities to accelerate sustainable and inclusive growth*. Available at: <http://businesscommission.org/our-work/valuing-the-sdg-prize-unlocking-business-opportunities-to-accelerate-sustainable-and-inclusive-growth> and BSDC, Temasek, and AlphaBeta (2017), *Better Business, Better World Asia*. Available at: <http://businesscommission.org/news/sustainable-businesses-can-unlock-us-5-trillion-in-new-market-value-in-asia-by-2030>

74. Stella Liu (2017), *Lessons Learned from Growing Food in 100% Urbanised Singapore*. Available at: https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2017/06/1_StellaLiu_Lessons-Learned-from-Growing-Food-in-100_-Urbanized-Singapore.pdf

75. The Straits Times (2017), "Bigger push for high-intensity, large-scale commercial farms".

Available at: <http://www.straitstimes.com/singapore/bigger-push-for-high-intensity-large-scale-commercial-farms>

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77. Food Tank (2015), "Ten Unique Urban Agriculture Projects in Tokyo".

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79. The Japan Times (2014), "Fujitsu harvests low-potassium lettuce grown in semiconductor plant". Available at: <https://www.japantimes.co.jp/news/2014/05/13/national/science-health/fujitsu-harvests-low-potassium-lettuce-grown-plant-clean-room/#.WtQ3li5uapo>

80. The Living Greens (2018), "About Us". Available at: <http://thelivinggreens.com/about-us.html>

81. Hamari Krishi (2018), "About Us". Available at: <http://www.hamarikrishi.com/about-hamarikrishi/>

82. Upgrown Farming Company (2018), "About Us". Available at: <https://upgrownfarming.co/about>

83. Philips (2018), "Philips GreenPower LED production module". Available at: <http://www.lighting.philips.com/main/products/horticulture/products/greenpower-led-production-module> and Philips (2018), "Tailor-made light recipes for growers". Available at: <http://www.lighting.philips.com/main/products/horticulture#>

EXHIBIT 5:

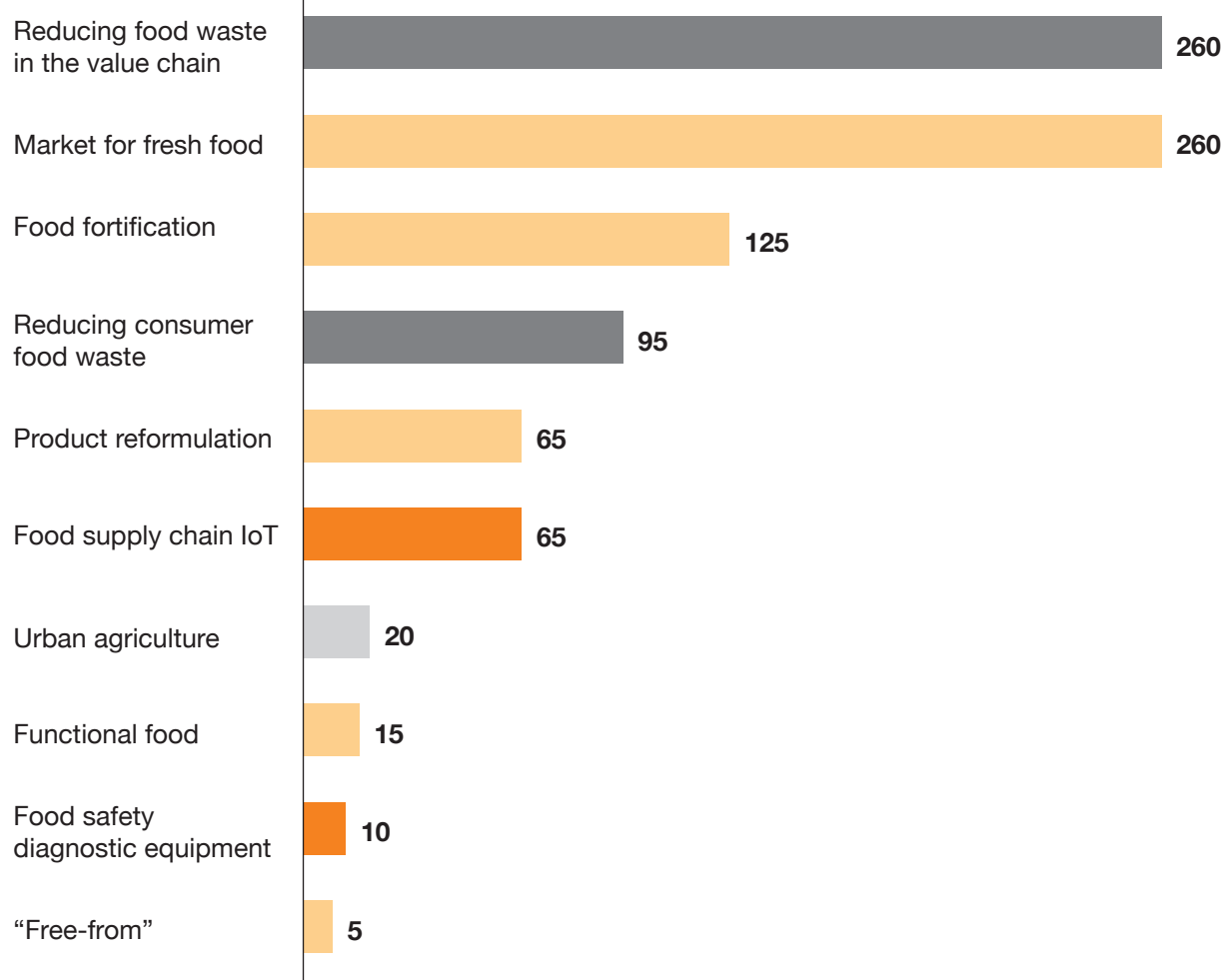
THERE ARE A RANGE OF BUSINESS OPPORTUNITIES ASSOCIATED WITH PROVIDING SAFE, NUTRITIOUS, AND AFFORDABLE FOOD IN CITIES



**SIZE OF INCREMENTAL BUSINESS OPPORTUNITY IN ASIA
(US\$ BILLIONS, 2030¹)**

Selected Opportunities

Production Food Waste Traceability Nutrition



1. Business & Sustainable Development Commission (BSDC) methodology based on estimated savings or projected market sizings in each area for Asia in 2030 (relative to a "business-as-usual" scenario). Only the high case opportunity is shown here. Sizings for food fortification, fresh food, functional food, "Free-from" food, food supply chain IoT, and food diagnostic equipment are based on market sizing of 2030 opportunity from analyst reports (relative to a "business-as-usual" opportunity where the market today grows at the average rate of global food demand of 1.5 percent annually). Rounded to nearest US\$5 billion.

SOURCE: BSDC; Market reports; AlphaBeta analysis



- **Adopting innovative technologies.** The vertical farming market in Asia-Pacific was estimated to be worth US\$355 billion in 2016.⁸⁴ Urban farmers are increasingly using high-tech and high-yield methods to run indoor vertical vegetable farms in stacked layers. One such farm is Sustenir Agriculture, which produces about 54 tonnes of vegetables (such as Kale) a year on less than 350 square metres of space.⁸⁵ By building a highly controlled environment, Sustenir can grow crops much quicker, with less water wastage, and with a lower carbon footprint.
- **Exploring multiple income streams.** One way to overcome the high startup costs of establishing urban farms is to have multiple income streams. For example, in addition to selling produce to local supermarkets, Sky Greens also export technologies (e.g., A-Go-Grow Towers) to clients abroad in China and Thailand.⁸⁶

1. FOOD WASTE

Reducing food waste (in the value chain and at consumption) could create savings worth US\$625 billion globally in 2030, of which almost 60 percent is in Asia.⁸⁷ Along the value chain, the global opportunity to reduce food waste is estimated to be worth US\$405 billion, of which US\$260 billion is in Asia. At the consumer level, the global opportunity for reducing food waste is estimated to be US\$220 billion, of which US\$95 billion is in Asia. Business models associated with reducing food waste include:

- **Investment in cold storage systems.** There is a range of investment opportunities related to cold storage systems, which can help to reduce food losses in the value chain. Solar E. Technology, which has offices in Australia and Bangladesh, and Bangladesh Clean Technology Company Ltd

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Available at: <https://www.statista.com/statistics/752410/projection-vertical-farming-market-worldwide/>

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Available at: <http://www.straitstimes.com/singapore/high-tech-farmers-cropping-up> and CNET (2017), "This veggie garden is basically an organic server farm of kale". Available at: <https://www.cnet.com/news/sustenir-organic-server-farm-of-kale/>

86. Stella Liu (2017), Lessons Learned from Growing Food in 100% Urbanised Singapore. Available at: https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2017/06/1_StellaLiu_Lessons-Learned-from-Growing-Food-in-100-Urbanized-Singapore.pdf

87. AlphaBeta and the Business & Sustainable Development Commission (2017). Valuing the SDG prize: Unlocking business opportunities to accelerate sustainable and inclusive growth. Available at: <http://businesscommission.org/our-work/valuing-the-sdg-prize-unlocking-business-opportunities-to-accelerate-sustainable-and-inclusive-growth> and BSDC, Temasek, and AlphaBeta (2017), Better Business, Better World Asia.

Available at: <http://businesscommission.org/news/sustainable-businesses-can-unlock-us-5-trillion-in-new-market-value-in-asia-by-2030>

are introducing affordable solar-based micro cold storages to farmers in Bangladesh to replace traditional ammonia-based cold stores.⁸⁸ In countries like China and Malaysia, more companies are building automated freezer storage that use robots to stack and retrieve food products efficiently, reducing food wasted through human error or delays. New technologies to reduce ozone-destroying emissions in cold storage are also emerging. For example, Hitachi manufactures and sells hydrofluorocarbons (HFC) and chlorofluorocarbons (CFC) free refrigeration solutions to both commercial and home users.

- **Adopting behavioural levers.** Some business models are addressing behavioural shifts in consumer waste. For example, all-you-can-eat food outlets are retrofitting dining facilities to switch to trayless dining and smaller plates to nudge customers to waste less food. The results have been promising - the Nordic Choice chain of 52 hotels took part in an experiment by shrinking the size of its plates and placing small signs on food waste at its breakfast buffet.⁸⁹ As a result, there was a reduction of 20 percent in food waste. In other countries, similar reductions are observed.⁹⁰

Other behavioural levers include modifying the “Buy one, get one free” model and adjusting portion sizes. For instance, Sainsbury and Tesco in the UK are pursuing “Buy one, get one later” campaigns for consumers to claim the free goods later with vouchers, allowing retailers to prevent household food spoilage and still achieve their marketing purposes.⁹¹

Food manufacturers can also pack food into smaller portions. In a survey of over 440 households in

Singapore, it is revealed that about 54 percent of them agreed that food retailers and manufacturers could help them reduce food waste.⁹² For example, Heinz has developed microwaveable snap pots for its baked beans to cater to small households, promote more efficient portion control, and reduce less food waste.⁹³ Several food outlets are also modifying staff’s behaviours by removing trash bins in the kitchens, thus forcing them to rethink whenever food is discarded.⁹⁴

- **Plugging knowledge gaps.** There are already several campaigns and products to minimise food waste and to educate the public. For instance, a local supermarket chain in Singapore, NTUC Fairprice, has started the “Great Taste, Less Waste Selection” at some outlets to sell blemished food items and implemented a Food Waste Index across stores to measure the total food waste.⁹⁵ Another example is the Date Mate Labels, which allows consumers to easily monitor the remaining shelf life of food items once they are opened.⁹⁶
- **Leveraging new technologies.** The high cost of full inventory management systems (over US\$10,000), combined with the time required to train staff and maintain the system, can deter restaurants from pursuing technologies to track and reduce food waste.⁹⁷ New technologies are emerging which are less expensive and simpler for staff to use. One food waste tracking software provider is Winnow, a London-based start-up (with operations across Asia) that uses smart meters to track everything thrown away (detailing where it comes from, food type, and the specific product) and allows staff to alter the meals based on data. Users of Winnow have experienced up to 50 percent reduction in food waste.⁹⁸ Case studies have shown that clients are

88. Solar E. Technology Bangladesh (2017). “Solar Energy for Cold Stores”. Available at: <http://www.solar-e-technology-bd.com/solar-energy-cold-storage>

89. News (2012), “Smaller plates, less waste”. Available at: <http://www.newsenglish.no/2012/11/20/smaller-plates-less-waste/>

90. Huffington Post (2016), “How To Control Portions and Reduce Food Waste”. Available at: https://www.huffingtonpost.com/selina-juul/portion-control-reduce-food-waste_b_9022674.html and Juvan E et al (2018), “Biting Off More Than They Can Chew - Food Waste at Hotel Breakfast Buffets”.

Journal of Travel Research. Available at: <http://journals.sagepub.com/doi/abs/10.1177/0047287516688321>

91. Planet Retail (2011), The Challenge of Food Waste. Available at: https://www.gs1.org/sites/default/files/gs1_uk_the_challenge_of_food_waste.pdf

92. National Environment Agency (2017), “Half Of Food Waste Thrown Away By Singapore Households Can Be Prevented: NEA Household Waste Study”. Available at: <http://www.nea.gov.sg/corporate-functions/newsroom/news-releases/half-of-food-waste-thrown-away-by-singapore-households-can-be-prevented-nea-household-waste-study>

93. REID (2013), “Snap pot technology”. Available at: <http://reid.wrap.org.uk/item.php?id=443>

94. National Public Radio (2012), “For restaurants, food waste is seen as low priority”.

Available at: <https://www.npr.org/sections/thesalt/2012/11/27/165907972/for-restaurants-food-waste-is-seen-as-low-priority>

95. Eco-Business (2015), “Rethinking production and consumption for a zero-waste Singapore”. Available at: <http://www.eco-business.com/news/rethinking-production-and-consumption-for-a-zero-waste-singapore/> and Zero Waste SG (2015), “NTUC FairPrice takes the lead to measure and reduce food waste”. Available at: <http://www.zerowastesg.com/2015/05/28/ntuc-fairprice-takes-the-lead-to-measure-and-reduce-food-waste/#more-2274>

96. REID (2013), “Date Mate Labels”. Available at: <http://reid.wrap.org.uk/item.php?id=186>

97. Food News Feed (2016), “Inventory Management: Too Expensive to Ignore and Too Complicated for Spreadsheets”.

Available at: <https://www.foodnewsfeed.com/fsr/vendor-bylines/inventory-management-too-expensive-ignore-and-too-complicated-spreadsheets>

98. The Guardian (2016), “The smart tech startup helping restaurants cut food waste by 50 percent”. Available at: <https://www.theguardian.com/sustainable-business/2016/may/27/startup-smart-tech-cut-food-waste-winnow-awards-winner> and Compass UK (2017), “Leading the fight against food waste”.

Available at: <https://www.compass-group.co.uk/media/blog/leading-the-fight-against-food-waste/>

expected to break even after the second month of operations and monitoring costs are kept minimal (e.g., each transaction takes only about 3 seconds on the Winnow System).⁹⁹ Lawson, a Japanese convenience store chain, has also been contributing to food waste reduction by using sales data to optimise the merchandise assortment in stores, reducing the cases of expired food products.¹⁰⁰ In households, consumers can make use of smart labels that indicate product shelf life (e.g., a type of label is activated upon opening and changes colour from green to red).¹⁰¹ This way, households can adjust their consumption patterns based on clear visual tools.

- **Developing products to increase the shelf life of fresh food.** Consumers are often dismayed by not only the higher price of fresh fruit and vegetables as opposed to processed products but also their short shelf-life.¹⁰² Several new innovations go beyond Ziplock bags and refrigeration to extend the shelf-life of fresh produce. For instance, Fresh Pod is a company producing biodegradable packaging alternatives that extend the life of fresh fruit and vegetables by up to four times, that range from small sachets for homes to large filtering machines for warehouses.¹⁰³ Similarly, FreshPaper is a food-safe paper product infused with low-cost organic spices and is used as a retail pack in many American supermarkets which keeps fresh produce consumable for up to four times longer.¹⁰⁴ BluWrap also provides packaging solutions to avoid spoilage with its ethylene-removal technology.¹⁰⁵ Another invention is the BerryBreeze, a compact battery-operated device, which generates ozone inside a refrigerator to slow down food spoilage by up to three times.¹⁰⁶

- **Creating value for food waste reuse.** The lack of end markets for food waste is also a key barrier to change. Business models to address this barrier include the promotion of “secondary retailers” who can make products from the still-usable produce.¹⁰⁷ For instance, Lawson supplies its food waste to animal feed recycling programmes which benefit prefectures such as Kanagawa and Kagoshima.¹⁰⁸ Another example is the Shanghai Tongji Plant Biomass Energy, which started in 2012, and has built waste-to-energy plants across China to turn food waste into biogas, fertilisers and building materials.¹⁰⁹

3. TRACEABILITY

There is a range of business models to enhance the traceability of food in order to reduce food fraud, improve food safety, and provide greater transparency:

- **Adopting anti-fraud solutions.** Because of food fraud, there has been an increase in demand for anti-counterfeit packaging (ACP) which consists of smart packagings such as radio-frequency identification (RFID) technology, Near Field Communications (NFC), and holograms to beef up food security.¹¹⁰ RFID tags can be used by companies to track food products from the factories to the supermarkets, providing another level of checks. A NFC firm, ThinFilm, which is based in Oslo, has developed a smart wine bottle which allows users to verify if the bottle has been tampered with.¹¹¹ Newer technologies are also being developed as more players enter the space – DNATrax can record data about a product when it is sprayed onto it or mixed with it. Analysts can then decode the substance to establish the authenticity of the product.¹¹² Alibaba announced in 2017 that it is working with Australia

99. Winnow (2018), “FAQs”. Available at: <http://www.winnowsolutions.com/faq>

100. Lawson (2017), “Waste Reduction”. Available at: http://lawson.jp/en/csr/waste/in_store/

101. REID (2013), “Smart labels indicate product shelf life”. Available at: <http://reid.wrap.org.uk/item.php?id=310> and REID (2013), “Active tags mirror product decay cycle”. Available at: <http://reid.wrap.org.uk/item.php?id=214>

102. Sirane (n.d.), “The shelf-life problem”.

Available at: <http://www.thinking-fruitandveg.com/index.php/shelf-life-extension/the-shelf-life-problem-for-packaging-fruit-and-veg>

103. REID (2013), “Fresh Pod”. Available at: <http://reid.wrap.org.uk/item.php?id=447>

104. REID (2013), “FreshPaper by Fenugreek”. Available at: <http://reid.wrap.org.uk/item.php?id=453>

105. ReFED (2016), A roadmap to reduce US food waste by 20 percent. Available at: https://www.refed.com/downloads/ReFED_Report_2016.pdf

106. REID (2013), “BerryBreeze”. Available at: <http://reid.wrap.org.uk/item.php?id=409>

107. ReFED (2016), A roadmap to reduce US food waste by 20 percent. Available at: https://www.refed.com/downloads/ReFED_Report_2016.pdf

108. Lawson (2017), “Waste Reduction”. Available at: http://lawson.jp/en/csr/waste/in_store/

109. Eco-Business (2016), “One company’s mission to turn China’s waste into energy”.

Available at: <http://www.eco-business.com/news/one-companys-mission-to-turn-chinas-waste-into-energy/>

110. Pack World (2015). “Trends and Issues”.

Available at: <https://www.packworld.com/trends-and-issues/traceability-authentication-serialization/major-growth-predicted-anti-counterfeit>

111. Future Ready Singapore (2016), “Keeping an eye on food fraud in Asia”.

Available at: <https://www.futurereadysingapore.com/2016/keeping-an-eye-on-food-fraud-in-asia.html>

112. Future Ready Singapore (2016), “Keeping an eye on food fraud in Asia”.

Available at: <https://www.futurereadysingapore.com/2016/keeping-an-eye-on-food-fraud-in-asia.html>

Post, Blackmores and PWC to explore using blockchain technology to map food products along their supply chain. The idea is to attach a digital copy of the DNA in the food sample on the packaging so that businesses can trace the origin of the product at every stage of the supply chain.¹¹³

- **Exploring food diagnostic technology.** The global diagnostic food safety testing market was estimated to be worth US\$5 billion in 2015.¹¹⁴ The food safety diagnostic market has seen growth over recent years as food companies and regulators invest in food safety testing equipment and services to reduce the incidences of foodborne illness. Food safety testing services cover a wide range of testing methods for different strains of pathogens. For instance, the Polymerase-chain-reaction (PCR) testing identifies major pathogens such as E. Coli. Service providers can also check for allergens such as almond or peanut for food companies.¹¹⁵ To date, many of the largest players in this space are from North America and Europe.
- **Using antibacterial proteins.** Certain proteins have antibacterial properties that neutralise produced food that has been genetically modified and is prone to infection. Such applications can target specific strains of bacteria and can greatly improve food safety at the mass market level. AvidBiotics is currently developing “Purocin” that has food safety applications including against salmonella.¹¹⁶

4. NUTRITION

The opportunities related to food fortification, product reformulation, and functional foods are discussed in the Ecosperity research on health (“Prevention is the

best medicine: Rethinking healthcare in Asia”), as such, the focus in this section is on the other opportunities associated with better nutrition: fresh food, “free-from” food, and new forms of food with a lower environmental footprint. The fresh food global figure, by volume, stands at 2 billion tonnes in 2016; driven mainly by China and India, two of the world’s most populous countries.¹¹⁷

China has seen strong volume growth in the demand for fresh food in 2015 as more consumers demand healthier foods.¹¹⁸ The global gluten-free products market was estimated to be US\$5 billion in 2015.¹¹⁹ “Free-from” foods are receiving considerable attention; especially gluten-free and casein-free food products. There are a few reasons for this development, particularly in developing countries. For instance, it has been estimated that about 1 percent of the population suffers from celiac disease (an immune reaction to eating gluten) in Indonesia.¹²⁰ There is also a perceived image of “free-from” foods as healthier and premium, and the mass media has raised awareness of this sub-segment in many countries in Asia.

Specific business models related to these opportunities include:

- **Making healthy food more accessible (and affordable).** Several enterprises are opting to sell fresh foods via more convenient channels to encourage consumption. One example is Shake Salad which restocks its salads daily and operates 18 vending machines throughout the central business district of Singapore.¹²¹ Furthermore, companies could incentivise consumers to choose healthier options, making better nutrition more affordable. The AIA Vitality Programme enables subscribers to receive up to 25 percent cashback on healthier purchases at the supermarkets.¹²²

113. ACI (2017), “Food or Faux? The Case of Food Safety in Asia”.

Available at: http://www.aci-institute.com/wp-content/uploads/2017/08/Food-safety-JZ-E-Lim_INSIGHT-.pdf

114. McKinsey & Company (2015), *Pursuing the global opportunity in food and agribusiness*.

Available at: <https://www.mckinsey.com/industries/chemicals/our-insights/pursuing-the-global-opportunity-in-food-and-agribusiness>

115. Marshfield Food Safety (2017), “Food testing”. http://www.marshfieldfoodsafetyllc.com/food_testing/

116. REID (2013), “Antibacterial protein has the potential to increase food safety and extend shelf life”.

Available at: <http://reid.wrap.org.uk/item.php?id=358>

117. Euromonitor (2017), “New insights on fresh food” Available at: <https://blog.euromonitor.com/2017/10/new-insights-fresh-food.html>

118. Euromonitor (2016), “Fresh food in China”. Available at: <http://www.euromonitor.com/fresh-food-in-china/report>

119. Jolly Masih and Amita Sharma (2016), “Study on Consumer Behaviour and Economic Advancements of Gluten-free Products”, *American Journal of Experimental Agriculture*. Available at: http://www.journalrepository.org/media/journals/AJEA_2/2016/Mar/Masih1212016AJEA24737.pdf

120. Mini Me Insights (2016), “Why gluten-free diet is trending in Indonesia”.

Available at: <http://www.minimeinsights.com/2016/09/04/why-gluten-free-diet-is-trending-in-indonesia/>

121. Channel NewsAsia (2017), “Instant meals: A hindrance to healthy eating?”.

Available at: <https://www.channelnewsasia.com/news/singapore/instant-meals-a-hindrance-to-healthy-eating-7608614>

122. The Straits Times (2017), “Staying healthy can be a rewarding exercise”.

Available at: <http://www.straitstimes.com/singapore/health/every-step-counts-for-vitality-members-and-AIA-Vitality> (2018), “Healthy Eating”.

Available at: https://www.aiavitality.com.sg/memberportal/improve_your_health/healthy_eating

- **Going digital.** Improvement in technology has resulted in the greater supply of fresh food products in the market. In a survey of online users in China in 2015, almost 25 percent of them said that they had purchased fresh food online.¹²³ Online fresh food sales were estimated to be US\$15 billion in 2016 in China, implying an annual growth rate of more than 80 percent.¹²⁴ Practicality, time savings, easy access to information for comparability, and the desire for multi-cuisine meals are some drivers for the boom in online food purchase. Fruit-specific B2C websites such as Yiguo.com and Tiantian Guoyuan as well as internet retailers like Tmall.com are focusing specifically on fresh food distribution and sales.¹²⁵ In Indonesia, Green Initiative and Green Valley are online retailers in the fresh foods space.¹²⁶ The rise of shared mobility service providers could further accelerate growth. For example, in Indonesia, shared mobility provider Go-Jek allows consumers to order fresh food and cooked meals via the app, which can be delivered quickly and at affordable prices.
- **“Free-from” food business models.** Specific opportunities include developing food products for individuals with various allergies and investing in research to expand the range of food which everyone can safely consume. For instance, restaurants such as Bliss Restaurant and the Swensen’s chain of outlets in Singapore are willing to make accommodations to their menus (e.g., replacing eggs or peanuts) to help customers manage their allergies.¹²⁷ Many companies have conducted research to replace ingredients causing allergies with other safer ones such as pulses, seeds, and grains.¹²⁸ For example, GoodMills Innovation collaborated with scientists, grain breeders, and nutritionists, to

THE GLOBAL GLUTEN-FREE PRODUCTS MARKET WAS ESTIMATED TO BE US\$5 BILLION IN 2015

introduce a wheat flour that is consumable by people sensitive to gluten and still produces baked goods with the same texture and taste to those made with traditional wheat.¹²⁹

- **Low environmental footprint sustenance.** A range of new forms of food is emerging with the aim of providing sufficient nutrients and calories, while preserving the environment. For example, companies like Beyond Meat and Impossible Foods in the United States have developed plant-based burgers that look and taste more like meat. Given that beef has almost 30 times the Greenhouse Gas (GHG) emissions per calorie of vegetables such as lentils, this shift can have a potentially significant impact on overall emissions.¹³⁰ Other emerging food innovations include insects such as crickets, which are consumed in powdered-form and contain more protein and micronutrients per pound than beef. A further example is Kernza, a perennial plant that produces grain for five years (as opposed to wheat’s single year of production) which can be used in baking and beer production. It has numerous ecological benefits, due to its deep roots providing drought resilience, as well as depositing carbon into the soil, and boosting overall soil health.¹³¹ Even algae is being used to produce a new form of oil, which could potentially act as a substitute for palm oil.

123. eMarketer (2015), “In China, Fresh Food Is a Digital Draw”. Available at: <https://www.emarketer.com/Article/China-Fresh-Food-Digital-Draw/1012778>

124. Internet Retailer (2017), “Cross-border e-commerce and online food sales grow over 80% in China”. Available at: <https://www.internetretailer.com/2017/02/17/cross-border-e-commerce-and-online-food-sales-boom-china>

125. Euromonitor (2016), “Fresh food in China”. Available at: <http://www.euromonitor.com/fresh-food-in-china/report>

126. TechinAsia (2016), “List of Indonesian Organic Food E-commerce stores”.

Available at: <https://www.techinasia.com/list-of-indonesian-organic-food-e-commerce-stores>

127. Channel NewsAsia (2016), “Managing food allergies: Restaurants that make accommodations”.

Available at: <https://www.channelnewsasia.com/news/singapore/managing-food-allergies-restaurants-that-make-accommodations-7966286>

128. IFT (2013), “New Technologies and Ingredients Provide Better Options for Gluten-Free Eating”. Available at: <http://www.ift.org/newsroom/news-releases/2013/july/17/new-technology-gluten-free.aspx>, Food Business News (2014), “Innovation on the gluten-free frontier”. Available at: <https://www.foodbusinessnews.net/articles/3323-innovation-on-the-gluten-free-frontier>, and DSM (2018), “Gluten-Free bread: Innovation Opportunities”.

Available at: https://www.dsm.com/markets/foodandbeverages/en_US/news-insights/campaigns/gluten-free-bread-innovation-opportunities.html

129. Bakery (2017), “GoodMills Innovation introduces wheat flour free from gluten genome”. Available at: <https://www.bakeryandsnacks.com/Article/2017/09/28/GoodMills-Innovation-introduces-wheat-flour-free-from-gluten-genome>

130. Washington Post (2014), “Vegetarian or omnivore: The environmental implications of diet.” Available at: https://www.washingtonpost.com/lifestyle/food/vegetarian-or-omnivore-the-environmental-implications-of-diet/2014/03/10/648fdb8-a495-11e3-a5fa-55f0c77bf39c_story.html?hpid=hp_hp-top-table-main-food-choices%3Avegetarian%3Ahomepage%2Fstory&hpid=hp_hp-top-table-main-food-choices%3Avegetarian%3Ahomepage%2Fstory

131. National Geographic (2018), “Menu of the Future: Insects, Weeds, and Bleeding Veggie Burgers.” Available at: <https://news.nationalgeographic.com/future-of-food/future-of-food-agriculture-ecology/>



Appendix:

**METHODOLOGY
FOR SIZING BUSINESS
OPPORTUNITIES**

The dollar value of each opportunity represents the incremental annual value in 2030. Some of these estimates are taken from the Business & Sustainable Development Commission (BSDC) research on Asia, while others have been estimated based on market research reports. The detailed assumptions and sources for each opportunity are provided below.¹³²

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
REDUCING FOOD WASTE IN THE VALUE CHAIN (US\$260 BILLION IN ASIA)		
Reduction in supply chain food waste, including post harvest	<p>BAU: The Food and Agriculture Organisation (FAO) estimates US\$1 trillion worth of food is wasted globally at present. Applying a growth rate of demand for food of 1.5 percent implies US\$1.25 trillion worth of food will be wasted globally in 2030. The World Resources Institute (WRI) estimates that 65 percent of waste occurs in the value chain.</p> <p>High-side: WRI estimates that food waste is reduced by 50 percent, in keeping with SDG targets.</p> <p>An alternative estimate by McKinsey Global Institute (MGI) is used to form our estimated range.</p> <p>Regional breakdown: The regional breakdown is based on the WRI's analysis of regional share of global supply chain food waste. For individual country breakdowns, we use a country's share of its regional GDP to apportion its share of food waste and loss.</p>	<p>FAO Food Loss¹³³</p> <p>WRI Reducing Food Loss and Waste¹³⁴</p> <p>MGI Resource Revolution¹³⁵</p>
MARKET FOR FRESH FOOD (US\$260 BILLION IN ASIA)		
Opportunities from rising awareness of healthier eating with higher quality and non-processed foods	<p>BAU: Global sales of fresh food are forecasted to reach US\$2,265 billion in 2030 based on the annualised food demand growth rate of 1.5 percent.</p> <p>High-side: Taking the historical compound annual growth rate (CAGR) of global fresh food sales growth of 2.5 percent as a proxy, we obtain the market value of US\$2,624 billion in 2030.</p> <p>Regional breakdown: The regional breakdown is based on the market size, estimated from the total volume of fresh food, by country.</p>	<p>PR Newswire¹³⁶</p> <p>FAO Food Loss¹³⁷</p> <p>Euromonitor¹³⁸</p>

132. BSDC, Temasek, and AlphaBeta (2017), *Better Business, Better World Asia*.

Available at: <http://businesscommission.org/news/sustainable-businesses-can-unlock-us-5-trillion-in-new-market-value-in-asia-by-2030>

133. FAO (2011), *Seeking an end to loss and waste of food*.

Available at: <http://www.fao.org/in-action/seeking-end-to-loss-and-waste-of-food-along-production-chain/en/>

134. World Resources Institute and UNEP (2013), "Reducing food loss and waste".

Available at: <http://www.wri.org/events/2013/06/unep-wri-press-conference-reducing-food-loss-and-waste>

135. McKinsey Global Institute (2011), *Resource revolution: Meeting the world's energy, materials, food, and water needs*.

Available at: <https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution>

136. PR Newswire (2015), "Global Fresh Food Market 2015-2019".

Available at: <http://www.prnewswire.com/news-releases/global-fresh-food-market-2015-2019-300197995.html>

137. FAO (2011), *Seeking an end to loss and waste of food*.

Available at: <http://www.fao.org/in-action/seeking-end-to-loss-and-waste-of-food-along-production-chain/en/>

138. Euromonitor (2016), "2015 Fresh Food Data: What is it Telling Us".

Available at: <http://blog.euromonitor.com/2016/04/2015-fresh-food-data-update.html>

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
FOOD FORTIFICATION (US\$125 BILLION IN ASIA)		
Opportunities related to food fortification to support nutrient intakes and address health concerns	<p>BAU: Estimated market size of US\$57.7 billion in 2015. We assume that the market today grows at the average rate of global food demand of 1.5 percent annually, resulting in a US\$72 billion market in 2030.</p> <p>High-side: We assume that the global fortified food market grows at a CAGR of 10.5 percent till 2030, this will imply a market size of US\$257.8 billion.</p> <p>Regional breakdown: We consider the population living under the poverty line of US\$1.25 as fortified foods are more prevalent in these locations.</p>	Research Nester ¹³⁹
REDUCING CONSUMER FOOD WASTE (US\$95 BILLION IN ASIA)		
Fifty percent reduction in food thrown out at the consumption level	<p>BAU: FAO estimates US\$1 trillion worth of food is wasted globally at present. Applying a growth rate of demand for food of 1.5 percent implies US\$1 trillion to US\$1.25 trillion worth of food wasted globally in 2030. WRI estimates 35 percent of waste occurs at consumption.</p> <p>High-side: WRI estimates that food waste is reduced by 50 percent, in keeping with SDG targets.</p> <p>Regional breakdown: The regional breakdown is based on the WRI's analysis of regional share of global consumer food waste. For individual country breakdowns, we use a country's share of its regional GDP to apportion its share of food waste and loss.</p>	<p>FAO Food Loss¹⁴⁰</p> <p>WRI Reducing Food Loss and Waste¹⁴¹</p>
PRODUCT REFORMULATION (US\$65 BILLION IN ASIA)		
Decreasing incidence of obesity by amending the composition of foods so they are healthier (e.g., sugar-free varieties)	<p>BAU: The reformulated food market, estimated by Sustainable Asset Management (SAM) AG to be worth US\$60 billion in 2009, grows at the lower end of the estimated 3 to 6 percent rate range, implying a US\$112 billion value in 2030.</p> <p>High-side: The global market is worth US\$204 billion, growing at the higher end of SAM AG's estimated range at 6 percent.</p> <p>Regional breakdown: We use the country's share of regional 2030 forecasted GDP estimates.</p>	<p>Healthy Living, SAM AG¹⁴²</p> <p>World Development Index¹⁴³</p>

139. Research Nester (2010), *Fortified food market global demand analysis opportunity outlook 2021*.

Available at: <https://www.researchnester.com/reports/fortified-food-market-global-demand-analysis-opportunity-outlook-2021/53>

140. FAO (2011), *Seeking an end to loss and waste of food*.

Available at: <http://www.fao.org/in-action/seeking-end-to-loss-and-waste-of-food-along-production-chain/en/>

141. World Resources Institute and UNEP (2013), *"Reducing food loss and waste"*.

Available at: <http://www.wri.org/events/2013/06/unep-wri-press-conference-reducing-food-loss-and-waste>

142. Sustainable Asset Management AG (2012). *Healthy Living: Obesity – A Heavy Burden*.

Available at: <http://docplayer.net/27548858-Healthy-living-obesity-a-heavy-burden.html>

143. World Bank (2016), *"GDP growth"*. Available at: <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG>

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
FOOD SUPPLY CHAIN INTERNET OF THINGS (US\$65 BILLION IN ASIA)		
Supply chain traceability and logistical innovations linked to shared mobility	<p>BAU: Based on the food supply chain IoT estimates from Digital Trends and MGI, annualised food demand growth rate of 1.5 percent, and AlphaBeta estimates for food share of retail trade, we estimate a 2030 market value of US\$26 billion.</p> <p>High-side: Global spending on IoT is US\$699 billion and expected to reach US\$3.3 trillion in 2025 based on estimated growth rate of 16.7 percent. Assuming this projected growth rate, the high-side estimate is US\$326 billion in 2030.</p> <p>Regional breakdown: This opportunity is broken down by each region's (or country's) share of global agriculture imports and exports in 2013 (latest available data) using FAO statistics.</p>	<p>Digital Trends¹⁴⁴</p> <p>MGI¹⁴⁵</p> <p>FAOStat</p>
URBAN AGRICULTURE (US\$20 BILLION IN ASIA)		
Improving the scale and efficiency of food grown in urban environments, especially in developing countries	<p>BAU: The productivity of urban farms remains constant, while population grows at current rates. Academic estimates are that a quarter of the 800 million people engaged in urban agriculture earn an income from it. Average of African and Latin American case studies by the FAO indicates an annual income of US\$600–1,300 per household. Population is estimated to grow at 1.3 percent and a household is assumed to include four people.</p> <p>High-side: We assume a 50 percent yield improvement (using the MGI estimate of smallholder yield growth potential in developing countries).</p> <p>Regional breakdown: Broken down by urban population.</p>	<p>FAO Urban Agriculture¹⁴⁶</p> <p>Urban Agriculture: A Review¹⁴⁷</p> <p>MGI Resource Revolution¹⁴⁸</p> <p>UN Population Division, World Urbanisation Trends</p>
FUNCTIONAL FOOD (US\$15 BILLION IN ASIA)		
Opportunities related to functional foods	<p>BAU: We apply the annualised food demand growth rate of 1.5 percent to the functional food market estimate by SAM AG, resulting in a value of US\$49 billion in 2030.</p> <p>High-side: We apply a CAGR of 7 percent to obtain US\$120 billion in 2030 (based on the forecasted growth of functional foods from SAM AG).</p> <p>Regional breakdown: The regional breakdown is based on the share of people in the global consuming class by region in 2009 (according to OECD definitions), as these opportunities tend to be more relevant for higher income regions. For country breakdowns (with regions), we use the country's share of regional 2030 forecasted GDP estimates.</p>	<p>SAM AG¹⁴⁹</p> <p>OECD¹⁵⁰</p>

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DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
FOOD SAFETY DIAGNOSTIC EQUIPMENT (US\$10 BILLION IN ASIA)		
Opportunities related to food safety testing and pathogen control	BAU: The global food safety diagnostic market was estimated to be between US\$5 billion and US\$9.8 billion in 2015. We apply the annualised food demand growth rate of 1.5 percent, resulting in 2030 estimates of between US\$6 billion to US\$12.2 billion.	McKinsey ¹⁵¹ Markets and Markets (updated report) ¹⁵²
	High-side: McKinsey estimates the market to grow at CAGR of 7.5 percent to 2020. Extending this to 2030 implies the market size to be worth between US\$14.8 billion and US\$28.9 billion in 2030.	FAOStat
	Regional breakdown: The opportunity can be broken down by the value of agriculture production in each region using statistics from the FAO database.	
“FREE-FROM” FOOD (US\$5 BILLION IN ASIA)		
Opportunities from rising awareness of healthier eating with higher quality and non-processed foods	BAU: Global market for gluten-free food is estimated at US\$4.6 billion in 2015. Euromonitor estimates share of gluten-free food to total food intolerance market to be 28 percent, resulting in a global “free-from” food market to be US\$16.4 billion in 2015. We apply the annualised food demand growth rate of 1.5 percent to the global gluten-free food market, resulting in a value of US\$21 billion in 2030.	Markets and Markets (updated report) ¹⁵³ Euromonitor Passport FIBL & AMI ¹⁵⁴
	High-side: Extending the growth rate of 10 percent (derived from historical trends) till 2030 implies a market worth US\$72 billion.	
	Regional breakdown: We use the regional share of global organic sales share in 2014 as a proxy for the regional opportunity.	

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