The Multiple Burdens of Malnutrition

Food system drivers and solutions

Shauna Downs
Institute of Human Nutrition & Earth Institute, Columbia University, New York City, NY, USA

Key messages

- Although undernutrition persists in many low- and middle-income countries, rates of overweight and obesity are on the rise, particularly among women.
- Nearly all countries in the world now experience at least one form of malnutrition.
- Undernutrition and overweight/obesity can no longer be tackled independently of one another.
- Many countries of the developing world are experiencing a nutrition transition characterized by an increase in the consumption of energy-dense foods of low nutritional quality as well as high intakes of refined carbohydrates, added sugars and fats.
- The creation of a healthier food environment could lead to increased consumption of nutrient-rich foods while reducing consumption of energy-dense foods of low nutritional value.
- To make nutrient-rich foods more available, affordable and acceptable within the current food environment, changes are needed across the full breadth of the food system.

Multiple burdens of malnutrition

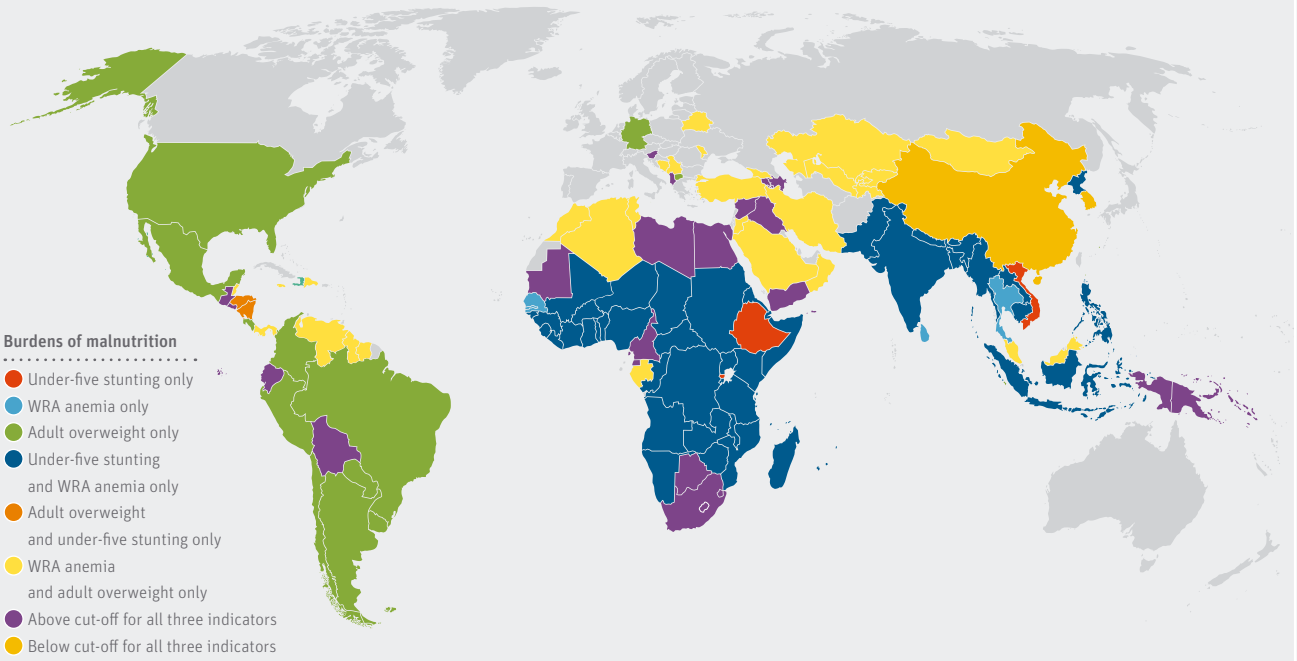
Overweight and obesity, and their associated diet-related non-communicable diseases (NCDs) including cardiovascular disease and diabetes, are no longer a problem exclusive to the developed world.[1] In the past, the main burden of nutrition-related disease in the developing world was undernutrition – stunting, underweight, wasting, and micronutrient deficiencies. However, in recent decades there has been a shift in the burden of malnutrition.[1] Although undernutrition continues to persist in many low- and middle-income countries,[2,3] rates of overweight and obesity are on the rise, particularly among women.[4] Between 1975 and 2014, the global prevalence of underweight in women decreased from 14.6% to 9.7%, whereas the obesity prevalence increased from 6.4% to 14.9% over the same period – and the same pattern was found in men.[1] Alongside these increases in overweight and obesity, there have been marked increases in the global prevalence of diabetes and cardiovascular disease.[5,6] The global prevalence of diabetes increased among women from 5% in 1974 to 7.9% in 2014; an appalling 422 million people worldwide now have diabetes.[1]

> "An appalling 422 million people worldwide now have diabetes"

Nearly all countries in the world now experience at least one form of malnutrition. Of the 122 countries examined in the 2014 Global Nutrition Report, all but two experienced high rates of at least one form of malnutrition (**Figure 1**).[7] Nearly half (45%) experienced at least one form of undernutrition (≥ 20% under-five stunting and/or anemia in women of reproductive age) in combination with high levels of overweight in adults (≥ 35%).[7] In addition to the multiple burdens of malnutrition within the same country, the phenomenon has also been observed within the same household. A study conducted in urban Kenya found a large proportion of mothers who were overweight (43%) or obese (37%) had stunted children.[8] This is not unique to Kenya. Multiple burdens of malnutrition within the same household have been observed in other countries worldwide.[9–13]

It is clear that undernutrition and overweight/obesity can no longer be tackled independently of one another. Given that one of the drivers of all forms of malnutrition is the food we consume (or do not consume), addressing the way in which the food

FIGURE 1: Burdens of malnutrition



Source: Adapted from the 2014 Global Nutrition Report[7]
WRA = women of reproductive age
Cut-offs for placing countries in each indicator were: under-five stunting ≥ 20%, WRA ≥ 20% and adult overweight ≥35%
Island states not included on map: Comoros (<5 stunting & WRA anemia); Saint Lucia (WRA anemia and adult overweight); Maldives, Sao Tome and Principe, Soloman Islands, Vanuatu (<5 stunting, WRA anemia and adult overweight)

system delivers the nutrition that is needed to promote health both in the context of undernutrition and overweight and obesity is imperative.

Food systems in the developing world are changing

The global food system is rapidly changing. As it has become more globalized, this has led to shifts in the availability, affordability and acceptability of food.[14,15] A nutrition transition has coincided with these changes in many countries in the developing world. This has been associated with an increase in the consumption of energy-dense foods of low nutritional quality as well as a high intake of refined carbohydrates, added sugars and fats, along with animal-source foods.[16]

There are several drivers of the nutrition transition and the changes in food environments worldwide. Globalization and trade liberalization have led to an influx of highly processed foods (e.g., soft drinks, fast foods and baked goods) and an expansion of transnational food companies, making these foods more widely available and affordable.[15,17] Moreover, companies have marketed these foods intensely in order to generate increased consumer demand.[18,19] In some cases, smaller portion sizes and packaging have been used to enable low-income consumers to purchase these products at a low price.[20] This has removed the price barrier, increasing access to these energy-dense foods of low nutritional value among the world's poor. At the same time, street foods and locally produced and prepared fried snacks and sweets are widely available.[21,22] These changes, combined with changes in physical activity patterns and an increase in sedentary behaviors, have led to the increased burden of overweight and obesity.[23]

> "Street foods and locally produced and prepared fried snacks and sweets are widely available"

Tackling the multiple burdens of malnutrition together

In order to tackle the multiple burdens of malnutrition, individual, community and broader food system changes are needed. At the individual level, addressing eating and feeding patterns in the first 1,000 days from conception until the child is

two years of age (including exclusive breastfeeding) can help reduce the risk of both undernutrition and overweight/obesity.[3] Providing nutritious food at the community level through school meals or food assistance can also help. However, in order to ensure that these interventions are feasible, the food system needs to be better equipped to deliver nutrient-rich foods at an affordable price, particularly for the most vulnerable populations. Addressing the set of underlying incentives and disincentives in the food system that make it difficult for people who are socioeconomically disadvantaged to access nutrient-rich foods will be necessary. Outlined below are examples of where to intervene at the individual, community and broader food-system level to address the underlying drivers of the multiple burdens of malnutrition.

The first 1,000 days

The first 1,000 days from conception to two years is a critical period for disease risk later in life: what women eat (or do not eat) during this period has lasting and irreversible consequences for their offspring.[24] Insufficient nutritional intake during pregnancy triggers anatomical, hormonal and physiological changes in the fetus that enhance its survival in "resource-poor" environments.[25] However, when these nutritional deficits are followed by periods of "excess," this can lead to the development of disease.[25] The developmental-origins hypothesis posits that the long-term risk of disease is initially induced through adaptive responses that the fetus or infant makes to cues from the mother about her state of health.[26] Both over- and under-eating during pregnancy can lead to accelerated weight gain in childhood and increase the offspring's risk of NCDs later in life.[26] Evidence to support this hypothesis is growing, and has been identified in birth cohorts from Brazil, Guatemala, India, the Philippines and South Africa.[27] Although this can be viewed as a challenge to tacking the multiple burdens of malnutrition, it is also an opportunity for early prevention.

> "Both over- and under-eating during pregnancy can lead to accelerated weight gain in childhood and increase the offspring's risk of NCDs later in life"

The 2013 Lancet Series on Maternal and Child Nutrition outlines interventions aimed at improving nutrition during this critical period. If delivered at scale, these interventions have the potential to help address part of the malnutrition burden worldwide. For example, exclusive breastfeeding until the infant is six months of age promotes optimal growth and development[28] while at the same time reducing the odds of type 2 diabetes and overweight/obesity in children.[29,30]

School meals

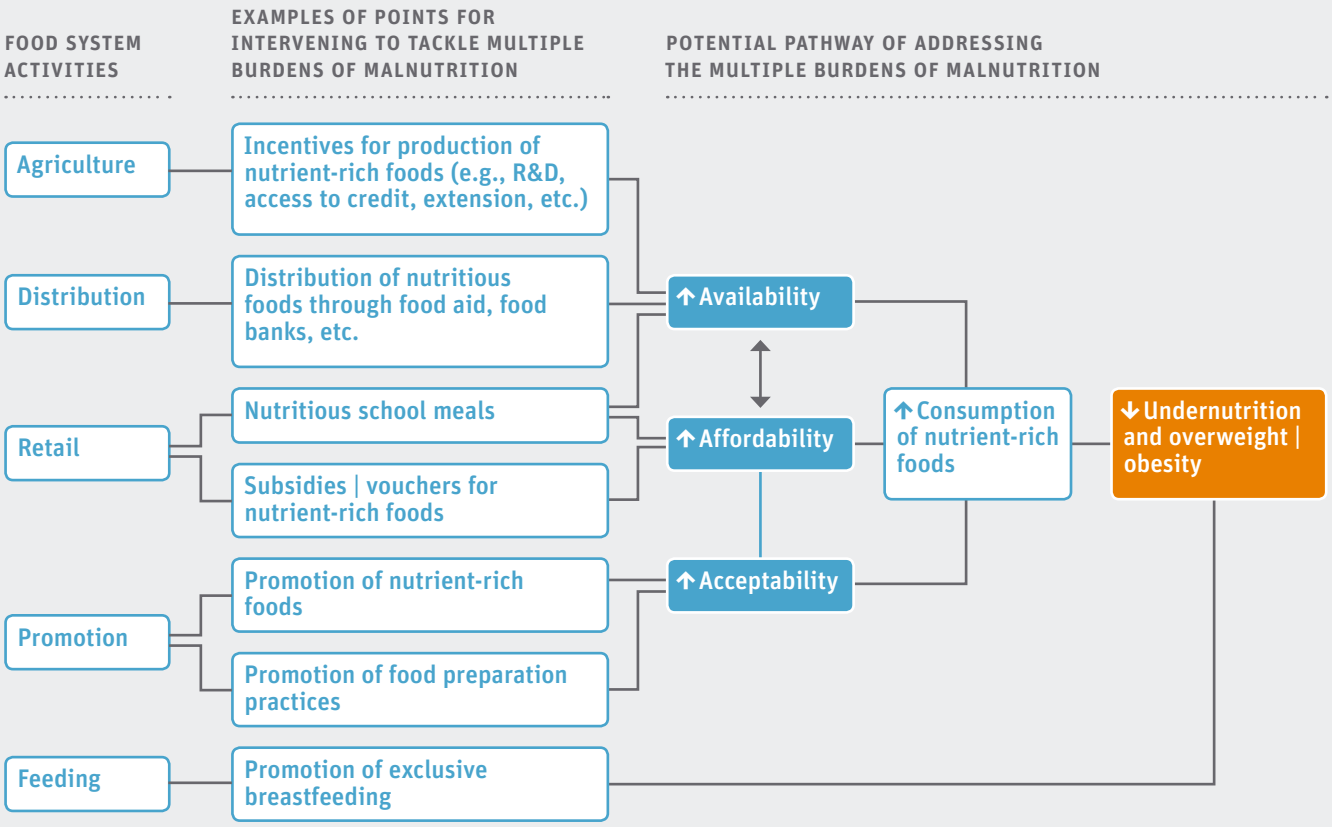
Providing healthy foods in schools in all countries worldwide is vital for improving school attendance and retention, particularly among girls, improving nutritional status and cognitive development, and combating overweight/obesity; schools are an important social safety net for low-income populations.[31] Providing nutrient-rich foods to schoolchildren ensures that even the poorest of children have at least one healthy meal throughout the day. This is important in both a developing- and developed-world context. However, for school meals to deliver for both undernutrition and overweight/obesity prevention, they need to include fresh, minimally processed, nutrient-rich foods. Developing clear guidelines and policies for school meals could help ensure that meals meet the nutritional needs of schoolchildren. However, these guidelines need to reflect the current state of the evidence in terms of what constitutes nutritious foods – something which does not always happen at present. For example, in an effort to reduce fat consumption, the United States National School Lunch Program bans full-fat milk but allows the sugar-sweetened low-fat chocolate variety.[32,33] The World Health Organization's Nutrition Friendly School Initiative is a school-based program aimed at preventing the double burden of malnutrition.[34] One of the components of that initiative is the development of school nutrition policies. A pilot study of the initiative conducted in Benin and Burkina Faso suggested that it had the potential to mobilize schools and communities for improved nutrition and health, but the approach would need to be adapted for local conditions with limited human and material resources in order to ensure its success.[35]

> "For school meals to deliver for both undernutrition and overweight/obesity, they need to include fresh, minimally processed, nutrient-rich foods"

Food assistance

The multiple burdens of malnutrition can exist even in the direst of circumstances. A study examining the multiple burdens of malnutrition among refugee populations in Western Sahara refugee camps in Algeria found the coexistence of undernutrition and overweight/obesity in 24.7% of households.[9] High levels of the coexistence of multiple burdens of malnutrition have also been found in the Gaza Strip.[11] Food assistance, cash transfers

FIGURE 2: Examples of potential food system interventions to address the multiple burdens of malnutrition



and vouchers, particularly in areas of prolonged conflict, need to deliver both in terms of energy/nutrient needs and in terms of broader food quality. Ensuring that high-quality, minimally processed foods are also available and affordable could help stave off overweight/obesity in these situations. For example, a World Food Programme (WFP) initiative in Gaza aims to address the double burden by providing vouchers that can be used to purchase fresh, nutritious produce in combination with a nutrition awareness pilot program.[36] The program provides interactive discussions and presentations on diet, hygiene, cooking, purchasing healthy food on a budget, and care of infants for women receiving WFP vouchers who are pregnant or have small children.[36]

Creating a supportive food system

A healthier food environment (i.e., the multitude of factors that affect food access) could lead to increased consumption of nutrient-rich foods while reducing consumption of energy-dense foods of low nutritional value. However, in order to make nutrient-rich foods more available, affordable and acceptable within the current food environment, changes are needed across the full breadth of the food system. These need to take place all along the value chain, from agricultural production all the way through to consumption.

Food system incentives that favor the production of cereals and cash crops over fruits, vegetables, nuts and legumes are one of the main underlying reasons that highly processed foods (e.g., sugar-sweetened beverages, biscuits and chips) have become so cheap and widely available worldwide. For example, incentives (i.e., subsidies, research & development, and crop insurance) for the production of corn and soybean oil in the United States have distorted the price of the "ingredients" of many highly processed foods. Palm oil, which is high in saturated fat, has become the most consumed oil on the planet after investment in its production by Malaysia and Indonesia, as well as support from the World Bank.[37] Half of all packaged food products now contain palm oil.[38] This may have implications for health (although additional evidence is needed)[32,39] as well as for the environment, given that the promotion of palm oil production has led to substantial deforestation and loss of biodiversity.[40] In order to ensure better access to healthy foods (produced in a sustainable way), and in an effort to avert the multiple burdens of malnutrition, food system incentives must be realigned to support a healthier food environment, thus making it easier for individuals to make healthier choices. Figure 2 provides examples of potential points at which to intervene in the food system to address the multiple burdens of malnutrition by improving the availabil-

ity, affordability and acceptability of nutritious foods. These examples would tackle both undernutrition and overweight/obesity simultaneously. However, as the overweight/obesity rates continue to increase worldwide, additional policy approaches such as taxation and improved labeling will be needed.[41,42]

Avoiding unintended consequences

In order to make progress toward addressing the multiple burdens of malnutrition, interventions need to ensure that efforts to address undernutrition do not have negative consequences for overweight/obesity. For example, Mexico's Progresa-Oportunidades conditional cash transfer program was successful in addressing undernutrition among socioeconomically disadvantaged Mexicans. However, the program was associated with an increased body mass index (BMI), higher diastolic blood pressure, and higher prevalence of overweight and obesity in participants.[43] Another potential intervention aimed at tackling undernutrition that has the potential for negative unintended consequences for overweight/obesity and diet-related NCDs is the fortification of some staple foods. Although these initiatives are important for delivering key micronutrients to populations at risk of deficiency, in some cases, the vehicles for fortification could be problematic if consumed in excess. For example, consuming fortified processed foods and condiments such as fortified sugar, salt and high-sodium sauces (e.g., soy and fish sauce) will likely improve micronutrient intakes,[44] but could have negative repercussions for overweight/obesity and diet-related NCDs if consumed in excess. These potential unintended consequences need to be acknowledged and addressed prior to program implementation. Supplementary feeding programs need to be constantly evaluated and grounded in the needs of the targeted population to ensure that there are no negative repercussions in terms of obesity risk.[45]

> "A joined-up approach to tackling all forms of malnutrition is essential"

Conclusions

Most countries worldwide are now battling multiple burdens of malnutrition. In order to make progress in tackling the multiple burdens, interventions throughout the food system to ensure that nutritious foods are available, affordable and acceptable for all populations worldwide will be needed. A joined-up approach to tackling all forms of malnutrition is essential.

Correspondence: ***Shauna Downs,***
Earth Institute and Institute of Human Nutrition, Columbia University, 475 Riverside Drive, Suite 525, New York, NY 11015, USA ***Email:*** *sd2944@cumc.columbia.edu*

References

01. NCD Risk Factor Collaboration. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. Lancet 2016;387:1377–1396.
02. UNICEF, WHO and World Bank. Levels and trends in child malnutrition. Available at: www.unicef.org/media/files/JME_2015_edition_Sept_2015.pdf. (Accessed March 25, 2016).
03. Black RE, CG Victora, SP Walker et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013;382:427–451.
04. Ng M, Fleming T, Robinson M et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014;384:766–781
05. Harikrishnan S, Leeder S, Huffman M et al. A Race Against Time: The Challenge of Cardiovascular Disease in Developing Economies. New Delhi, India: Centre for Chronic Disease Control, 2014.
06. NCD Risk Factor Collaboration. Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. Lancet 2016;387:1513–1530.
07. IFPRI. Global Nutrition Report 2014: Actions and Accountability to Advance Nutrition and Sustainable Development. Washington, DC: International Food Policy Research Institute, 2014
08. Kimani-Murage EW, Muthuri SK, Oti SO et al. Evidence of a Double Burden of Malnutrition in Urban Poor Settings in Nairobi, Kenya. PloS One 2015;10:e0129943.
09. Grijalva-Eternod CS, Wells JCK, Cortina-Borja M et al. The Double Burden of Obesity and Malnutrition in a Protracted Emergency Setting: A Cross-Sectional Study of Western Sahara Refugees. PLoS Med 2012;9:e1001320.
10. Oddo VM, Rah JH, Semba RD et al. Predictors of maternal and child double burden of malnutrition in rural Indonesia and Bangladesh. Am J Clin Nutr 2012;95:951–958.
11. El Kishawi RR, Soo KL, Abed YA et al. Prevalence and Associated Factors for Dual Form of Malnutrition in Mother-Child Pairs at the Same Household in the Gaza Strip-Palestine. PLoS ONE 2016;11:e0151494.
12. Sekiyama M, Jiang HW, Gunawan B et al. Double Burden of Malnutrition in Rural West Java: Household-Level Analysis for Father-Child and Mother-Child Pairs and the Association with Dietary Intake. Nutrients 2015;7:8376–8391.
13. Ramirez-Zea M, Kroker-Lobos MF, Close-Fernandez R et al. The double burden of malnutrition in indigenous and nonindigenous Guatemalan populations. Am J Clin Nutr 2014;100:1644S–51S.
14. Globalization and Health Knowledge Network. WHO Commission on Social Determinants of Health: Globalization, Food and Nutrition Transitions. Ottawa, ON: Globalization Knowledge Network, 2007.
15. Hawkes C. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and

diet-related chronic diseases. Glob Health 2006;2:4.

16. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev 2012;70:3–21.
17. Thow AM. Trade liberalisation and the nutrition transition: mapping the pathways for public health nutritionists. Public Health Nut 2009;12:2150–2158.
18. Moodie R, Stucker D, Monteiro C et al. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. Lancet 2013;381:670–679.
19. Stuckler D, McKee M, Ebrahim S et al. Manufacturing epidemics: the role of global producers in increased consumption of unhealthy commodities including processed foods, alcohol, and tobacco. PLoS Med 2012;9:e1001235.
21. Kearney AT. Serving the low income consumer: how to tackle this mostly ignored market, 2007. Available at: www.atkearney.com/documents/10192/314765/ServingLow-IncomeConsumer.pdf/343423c1-7053-45e8-8ab2-0d4b9cedb7a2. (Accessed April 1, 2016).
22. Gupta V, Downs SM, Ghosh-Jerath S et al. Unhealthy Fat in Street and Snack Foods in Low-Socioeconomic Settings in India: A Case Study of the Food Environments of Rural Villages and an Urban Slum. J Nutr Educ Behav 2016;48:269–279.
23. Steyn NP, Labadarios D. Street foods and fast foods: how much do South Africans of different ethnic groups consume? Ethn Dis 2011;21:462–466.
24. Hallal PC, Andersen LB, Bull FC et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380:247–257.
25. Horton R, Lo S. Nutrition: a quintessential sustainable development goal. Lancet 2013;382:371–372.
26. Gluckman PD, Hanson MA. Developmental Origins of Health and Disease. Cambridge, UK: Cambridge University Press, 2006.
27. Gluckman PD, Hanson MA, Cooper C et al. Effect of In Utero and Early-Life Conditions on Adult Health and Disease. N Engl J Med 2008;359:61–73.
28. Adair LS, Fall CHD, Osmond C et al. Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. Lancet 2013;382:525–534.
20. Kramer MS, Kakuma R. Optimal duration of exclusive breastfeeding. Cochrane Database Syst. Rev. 2012;8:CD003517.
29. Horta BL, Loret de Mola C, Victora CG. Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review and meta-analysis. Acta Paediatr 2015;104:30–37.
30. Yan J, Liu L, Zhu Y et al. The association between breastfeeding and childhood obesity: a meta-analysis. BMC Public Health 2014;14:1267 (2014).
31. Aliyar R, Gelli A, Hamdani SH. A Review of Nutritional Guidelines and Menu Compositions for School Feeding Programs in 12 Countries. Front Public Health 2015;3:148.
32. Mozaffarian D. Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity A Comprehensive Review. Circulation 2016;133:187–225.
33. Food and Nutrition Service, US Department of Agriculture. Nutrition Standards in the national school lunch and school breakfast programs, 2012. Available at: www.gpo.gov/fdsys/pkg/FR-2012-01-26/pdf/2012-1010.pdf. (Accessed April 9, 2016).
34. WHO. Nutrition-friendly schools initiative (NFSI). Available at: www.who.int/nutrition/topics/nutrition_friendly_schools_initiative/en/. (Accessed April 7, 2016).
35. Delisle HF, Receveur O, Agueh V et al. Pilot project of the Nutrition-Friendly School Initiative (NFSI) in Ouagadougou, Burkina Faso and Cotonou, Benin, in West Africa. Glob Health Promot 2013;20:39–49.
36. World Food Programme. In Gaza, WFP Turns Women Into Community Nutritionists | WFP | United Nations World Food Programme – Fighting Hunger Worldwide. Available at: www.wfp.org/stories/gaza-women-take-lead-ensure-good-nutrition-their-communities. (Accessed April 7, 2016)
37. World Bank. The World Bank Group Framework and IFC Strategy for Engagement in the Palm Oil Sector, 2011. Available at: SectorWBG+Framework+and+IFC+Strategy_FINAL_FOR+WEB.pdf (Accessed May 7, 2014).
38. Euromonitor International. Palm Oil to Create Winners and Losers in Packaged Food, 2014.
39. Sun Y, Neelakantan N, Wu Y et al. Palm Oil Consumption Increases LDL Cholesterol Compared with Vegetable Oils Low in Saturated Fat in a Meta-Analysis of Clinical Trials. J Nutr 2015;145:1549–1558.
40. Center for International Forestry Research. Palm oil and biodiversity, 2014. Available at: www.cifor.org/publications/pdf_files/infobrief/4559-infobrief.pdf. (Accessed April 10, 2016).
41. Hawkes C, Jewell J, Allen K. A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: the NOURISHING framework. Obes Rev 2013;14:159–168.
42. Afshin A, Penalvo J, Del Gobbo L et al. CVD Prevention Through Policy: a Review of Mass Media, Food/Menu Labeling, Taxation/Subsidies, Built Environment, School Procurement, Worksite Wellness, and Marketing Standards to Improve Diet. Curr Cardiol Rep 2015;17:98.
43. Fernald LCH, Gertler PJ, Hou X. Cash component of conditional cash transfer program is associated with higher body mass index and blood pressure in adults. J Nutr 2008;138:2250–2257.
44. WHO & FAO. Guidelines on food fortification with micronutrients, 2006. Available at: www.who.int/nutrition/publications/guide_food_fortification_micronutrients.pdf. (Accessed April 1, 2016).
45. Uauy R, Kain J. The epidemiological transition: need to incorporate obesity prevention into nutrition programmes. Public Health Nutr 2002;5:223–229.

Setting New Frontiers for 21st Century Food Systems Research and Action

Agriculture for Nutrition and Health (A4NH) and Convergent Innovation (CI)

John McDermott
Director, CGIAR Research Program on Agriculture for Nutrition and Health | International Food Policy Research Institute, Washington DC, USA

Laurette Dube
Professor, James McGill Chair of Consumer and Lifestyle Psychology and Marketing, Desautels Faculty of Management, McGill University, Montreal, Quebec, Canada | Chair and Scientific Director, McGill Centre for the Convergence of Health and Economics (MCCHE), McGill University

Nii A Addy
Assistant Professor (Research), Desautels Faculty of Management, McGill University, McGill | Centre for the Convergence of Health and Economics (MCCHE), McGill University, McGill University, Montreal, Quebec, Canada

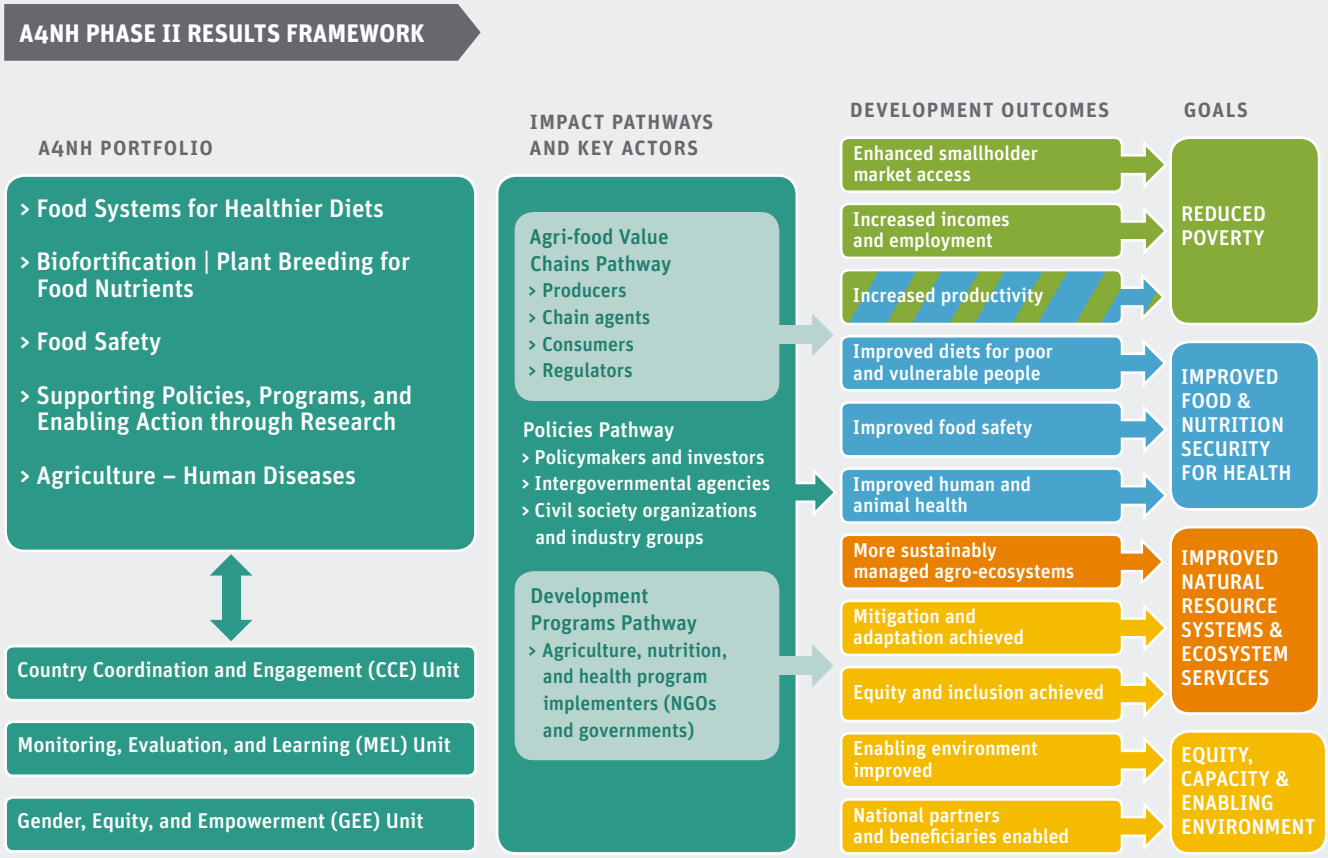
Inge Brouwer
Associate Professor, Division of Human Nutrition, Wageningen University, Netherlands

Ruerd Ruben
Professor, Impact Analysis and Research Coordinator, Food Security, Value Chains & Impact Analysis at LEI, Wageningen University and Research, Netherlands

Key messages

- Food systems are key to our ability to ensure sustainable development and well-being while arresting ballooning healthcare costs in industrialized and emerging economies alike.
- Nutrition is front and center in the global development agenda, and there is growing interest in making agriculture and other large development sectors more nutrition-sensitive.
- Low- and lower-middle-income countries are increasingly emphasizing the role of agriculture and food in their economic development plans. This requires a change in perspective – moving from a focus on agricultural production to a consideration of the entire food system.
- Since 2012, CGIAR has increased its emphasis on how to change agricultural research to improve nutrition and health through an interdisciplinary, multisectoral research program, Agriculture for Nutrition and Health (A4NH). Compared with traditional agricultural research, the A4NH program puts more emphasis on consumption and demand, and on processing, storage and other value chain elements, beyond the farm.
- A key transdisciplinary concept that expands on the implementation of inter-sectoral initiatives such as A4NH is Convergent Innovation. The CI ecosystem covers the full continuum from smallholder farms and community to local, state/provincial, national, and global markets.

FIGURE 1: A4NH research portfolio, impact pathways and key actors, development outcomes and goals



> In low-income countries and emerging economies, CI engages food businesses on two fronts: improving food security and reducing undernutrition, and shaping the food habits of the affluent population.

> It is our hope that across low-income, emerging, and industrialized economies alike, A4NH and CI will yield insights for other researchers, decision-makers from the private and public sector, and civil society, for a better convergence in human and economic development.

Food systems are at the core of our ability, as a 21st century society, to ensure sustainable development and well-being while arresting ballooning healthcare costs in industrialized and emerging economies alike. Food is at the nexus of the positive and negative externalities that agricultural, health, and other related systems have had on rural and urban communities worldwide since the onset of the industrial revolution. To go beyond what has been possible thus far, there is a need to reinvent food systems research and action so as to accelerate the scope and impact of significant sectoral and inter-sectoral investments made by governments, the private sector, civil society, and academia, for better convergence in efforts. This perspective features two pioneering initiatives in the nutrition research landscape: the CGIAR's Agriculture for Nutrition and Health (A4NH) program, and the development and implementation of Convergent Innovation (CI) platforms.

CGIAR's Agriculture for Nutrition and Health (A4NH) Program

Nutrition is front and center in the global development agenda in low-income countries and emerging economies. Although commitments to prioritize and invest in improving nutrition have soared, intent needs to be translated into successful action. Additionally, while nutrition-specific interventions, usually delivered by the health sector, have well documented efficacy, they will only reduce undernutrition by about 20%, even if implemented at scale.[1] Thus, there is growing interest in inter-sectoral approaches, including through making agriculture and other large development sectors more nutrition-sensitive.

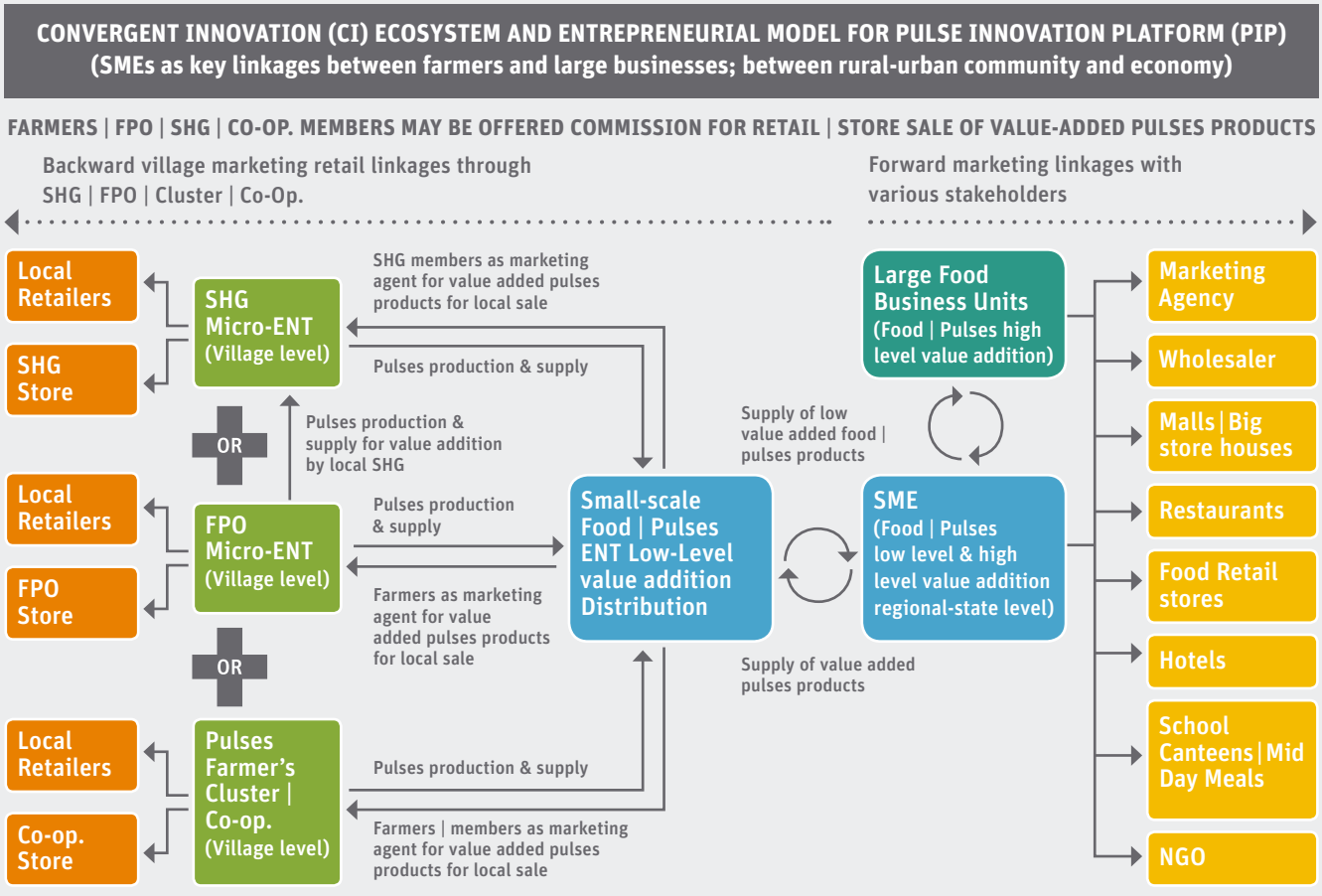
Agriculture is particularly important in low-income countries, as the majority of people (typically 60–80%) and a large share

of GDP (25–40%) come from agriculture.[2] Agriculture is charged with providing safe, healthy, diversified, and nutritious foods at affordable prices. The diets of many people in low-income countries, especially mothers and children who are most vulnerable, often lack fruits, leafy green vegetables, pulses, seeds and nuts, and animal-sourced foods. In addition to food, agriculture contributes to nutrition through improved incomes. Attention to gender, both the role of women and of men, is critical. With a gender focus, benefits multiply, particularly where empowered mothers are more capable of raising healthy children.

"There is growing interest in making agriculture more nutrition-sensitive"

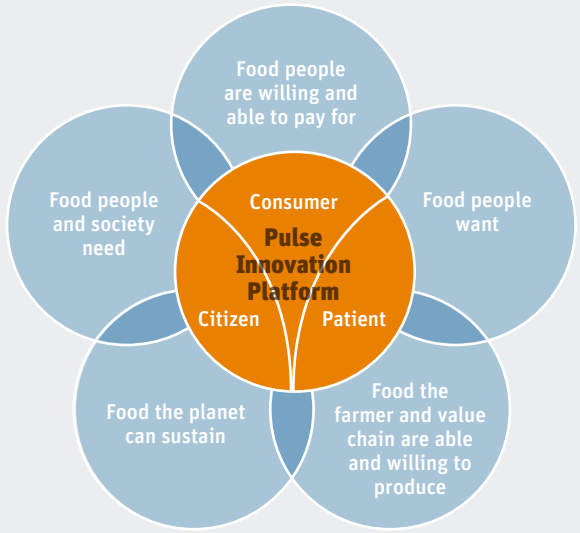
Low- and lower-middle-income countries are increasingly emphasizing the role of agriculture and food in their economic development plans. As economies develop, more people are involved, and greater economic value is added beyond the farm. This requires a change in perspective – moving from a focus on agricultural production to a consideration of the entire food system. In low-income, agrarian countries, an obvious starting place is to invest in more efficient ways of supplying nutritious foods, such as milk, fish, and vegetables, to households, whether through their own production, or through markets. With economic growth and urbanization, agri-food systems become more complex, and investments beyond the farm, such as storage facilities and cold chains, become more important. There have been major transformations in food systems in middle-income countries in recent decades.[3] These transformations include changes in food supply chains, which have grown longer and more capital-intensive, with much additional processing of food products.[4] Even in low-income countries, there have also been dramatic changes in food consumption patterns, often driven by the rapid urbanization and improved domestic markets and some increased trade.[5]

FIGURE 2: Key ecosystem and enterprise considerations for pulse innovation



Terminology: FPO Farmer Producing Organization, **SHG** Self-Help Group, **ENT** Entrepreneur, **SME** Small and Medium-sized Enterprises, **NGO** Non-Governmental Organization, **PIP** Pulse Innovation Platform

FIGURE 3: Convergent Innovation "sweet spot"



We note, however, that most changes in food systems have been ad-hoc and opportunistic. If food systems are to provide healthier food both sustainably and equitably, a more systematic approach will be needed. Such an approach establishes national consensus on objectives, and considers key actors and the drivers and enablers of food system transformation. This is a major challenge for countries, as food systems must balance and resolve trade-offs between health, socioeconomic and environmental objectives, and endowments and constraints. Thus food systems research and thinking must embrace multiple technical disciplines within an overall national, socioeconomic and political economy context.

Since 2012, CGIAR has increased its emphasis on how to change agricultural research to improve nutrition and health through an interdisciplinary, multisectoral research program, Agriculture for Nutrition and Health (A4NH). Hosted by the International Food Policy Research Institute (IFPRI), the program includes reducing stunting and micronutrient deficiency on the one hand, while controlling alarming increases in obesity and non-communicable diseases on the other. **Figure 1** describes A4NH's research portfolio, impact pathways and key actors, development outcomes and goals. Classically, the research for development pathway focuses on: identifying and developing nutrition-enhancing production technologies, knowledge and evidence; the institutional innovations that support sustainable access to and/or application of these technologies and knowledge; and policy and investment options that can increase the contribution of agri-food systems to nutrition and health. Compared with traditional agricultural research, the A4NH program puts more emphasis on consumption and demand, and on processing, storage and other value chain elements, beyond the farm. Given the scale of nutrition and health challenges, and of urgent needs, there is also emphasis on how proven approaches to improving nutrition and health can be scaled up and sustained in specific countries and contexts.

> "Most low- and middle-income countries are undergoing unbalanced diet transitions"

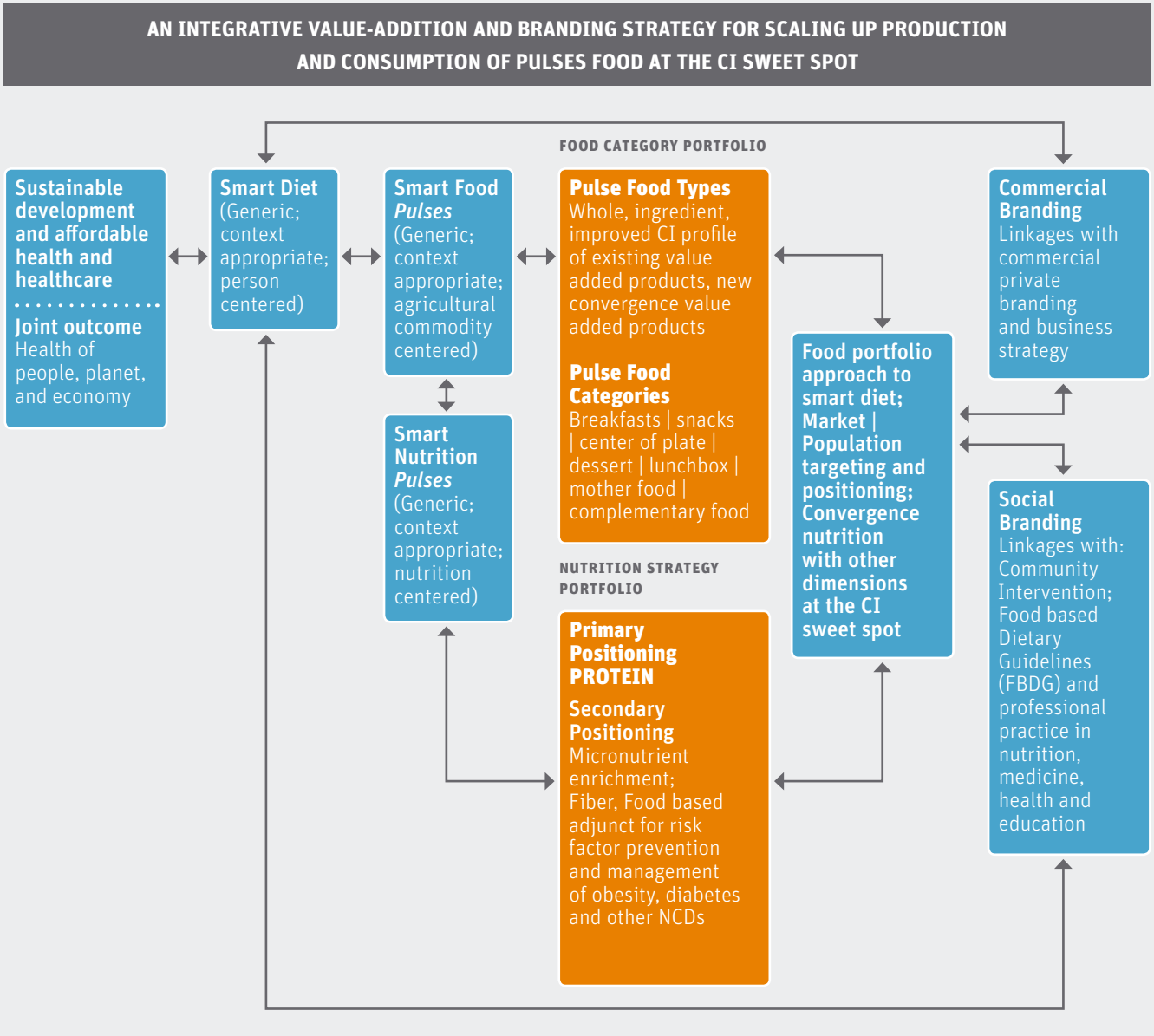
Most low- and middle-income countries are undergoing unbalanced diet transitions – too slow improvements in chronic undernutrition and micronutrient deficiencies, and rapid increases in overweight and obesity. Such countries also have strategies and plans for agri-food transformation as a key element of their economic development. For these reasons, A4NH plans much greater emphasis on food systems research through its "Food System for Healthier Diet" program. This program brings together a new partnership, led by Wageningen University Research, bringing together CGIAR Centers, national research and development partners, and private sector companies, facilitated by the Global Alliance for Improved Nutrition (GAIN), and business schools, coordinated by McGill University. The program builds on current capacities in agricultural production and value-chain innovations for nutritional quality and food safety, with greater emphasis on assessment of consumption and diet quality and on multi-chain food systems innovations and analysis. The research program will be organized in three main components:

- Assessing regional and sub-regional drivers of food system transformation, and options and constraints for dietary change (**diagnosis and foresight**);
- Testing concrete agri-food value chain innovations and interventions for improving diet quality and diversity (**food system innovations**); and
- Supporting the scaling-up of successful actions through effective engagement of multi-stakeholder platforms and multisectoral mechanisms (**scaling up and anchoring**).

Convergent Innovation (CI)

A key transdisciplinary concept that expands on the implementation of inter-sectoral initiatives such as A4NH is Convergent Innovation. The development and deployment of CI has benefited from the support of the International Development Research Centre and the Social Sciences and Humanities Research Council of Canada. CI fosters behavior change and societal transformation through instilling social and environ-

FIGURE 4: Scaling linkages between core business activity and solutions to nutrition



mental objectives of agriculture, food product development, nutrition, and health into business strategies, while improving the economic viability of efforts focused on social benefit. CI intertwines technological innovation, social innovation, and institutional innovation to simultaneously derive measurable economic and social benefits.

"CI takes food as the transformational layer between agriculture and the health of people, economy, and planet"

CI takes food as the transformational layer between agriculture and the health of people, economy, and planet. Research and practice based on CI focus on agricultural commodities of high strategic significance at local, state/provincial, country or global levels. The CI ecosystem covers the full continuum from smallholder farms and community to local, state/provincial, national, and global markets, with small start-ups, small and medium-sized enterprises (SMEs), and large businesses competing and collaborating in novel ways for better distributed value addition.

Pulses have served as the test bed for CI's operational deployment through global and national innovation platforms. Over the last four years, academic, civil society, private, and public-sector partners in the Global Pulse Innovation Platform (PIP) have spearheaded a social movement that led to the UN's

declaration of 2016 as the International Year of Pulses (IYP). The Global PIP, launched in March 2016 in Montreal, is the core food convergent innovation hub of the sector, with national platforms in development in Canada, India and Ethiopia. Some key ecosystem and enterprise considerations for pulse innovation are illustrated in **Figure 2**.

A "sweet spot" for CI is illustrated in **Figure 3** by the overlap between characteristics of safe and nutritious food that people and society need, food they want, food people are able and willing to pay for, food farmers and the value chain are able and willing to produce, and food the planet can sustain. The characteristics of food at the CI sweet spot – be they in people's minds or in terms of actual physical characteristics – are likely to present both conflict and convergence in their contribution to the health of people, economy, and planet. CI therefore considers the diverse and dynamic nature of individual food choices, and diet, from the joint perspective of consumer, patient, and citizen. Successful 21st century food systems from this perspective are ones that can produce a rich portfolio of food at the CI sweet spot for domestic and/or international markets.

For food businesses in both traditional and industrialized contexts, scaling the linkages between core business activity and solutions to nutrition is non-trivial, and presents several challenges (see **Figure 4**). First, placing nutrition and health sensitivity as a core driver of technological innovation, product category transformation, and commercialization requires a strategic shift in mindset and activities. Second, to change product and brand portfolio in a nutrition- and health-sensitive direction, businesses have to be able to produce an appealing product that balances immediate desires (e.g. tastiness) and long-term benefits (e.g. healthiness), and can be produced at a price point that the consumer can afford and is willing to pay, without losing out on profitability.

> "CI fosters health promotion and nutrition transformation as economic development occurs"

Thus, in low-income countries and emerging economies, CI engages food businesses on two fronts: improving food security and reducing undernutrition by seeding business entrepreneurship and innovation in resource-poor communities, and shaping the food habits of the affluent population. CI fosters health promotion and nutrition transformation as economic development occurs, and sets the agri-food sector on a path to prosperity that balances tradition and modernity, and builds more rural-urban continuity. In industrialized countries, business engagement is about mainstreaming CI in innovation pipelines, business strategies, and investment. CI acceleration processes combine principles and methods from multiple domains, including behavioral insights from consumer research, entrepreneurship training, and Big Data analytics. These principles and methods are applied in providing support, through training and mentorship, for small start-ups, SMEs, and large businesses, with incubation facilities being available as needed for SMEs.

Conclusion

Research that informs, and emerges from, the CGIAR's Agriculture for Nutrition and Health (A4NH) program and partnerships around Convergent Innovation (CI) provides opportunities for engaging agriculture, nutrition, and health researchers for sustainable development and improvements in well-being. It is our hope that across low-income, emerging, and industrialized economies alike, A4NH and CI will yield insights for other researchers, decision-makers from the private and public sector, and civil society at local, state/provincial, national, and global levels, for a better convergence in human and economic development.

Correspondence: ***John McDermott,*** *Director,*
CGIAR Research Program on Agriculture for Nutrition and Health, International Food Policy Research Institute, 2033 K St, NW, Washington, DC 20006-1002 USA ***Email:*** *j.mcdermott@cgiar.org*

Laurette Dube, *Professor,*
James McGill Chair of Consumer and Lifestyle Psychology and Marketing, Desautels Faculty of Management, McGill University, 1001 Sherbrooke Street West, Montreal, Quebec, Canada H3A 0G4
Email: *laurette.dube@mcgill.ca*

References

01. Black RE, Victora CG, Walker SP et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013;382: 427–451.
02. FAO. State of Food and Agriculture, 2015. Technical Annex Table A2, 2015, pp. 96–101.
03. Reardon T, Chen K, Minten B et al. The Quiet Revolution in Staple Food Value Chains: Enter the Dragon, the Elephant and the Tiger. Mandaluyong City, Philippines: Asian Development Bank, 2012.
04. Hawkes C, Friel S, Lobstein T et al. Linking agricultural policies with obesity and noncommunicable diseases: A new perspective for a globalising world. Food Policy 2012;37:343–353.
05. Tschirley D, Snyder J, Dolislager M et al. Africa's Unfolding Diet Transformation: Implications for Agrifood System Employment. JADEE 2015;5: 0-48. doi:10.1108/JADEE-1101-2015-0003.