

Paths of convergence for agriculture, health, and wealth

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This special feature calls for forward thinking around paths of convergence for agriculture, health, and wealth. Such convergence aims for a richer integration of smallholder farmers into national and global agricultural and food systems, health systems, value chains, and markets. The articles identify analytical innovation, where disciplines intersect, and cross-sectoral action where single, linear, and siloed approaches have traditionally dominated. The issues addressed are framed by three main themes: (i) lessons related to agricultural and food market growth since the 1960s; (ii) experiences related to the integration of smallholder agriculture into national and global business agendas; and (iii) insights into convergence-building institutional design and policy, including a review of complexity science methods that can inform such processes. In this introductory article, we first discuss the perspectives generated for more impactful policy and action when these three themes converge. We then push thematic boundaries to elaborate a roadmap for a broader, solution-oriented, and transdisciplinary approach to science, policies, and actions. As the global urban population crosses the 50% mark, both smallholder and non-smallholder agriculture are keys in forging rural–urban links, where both farm and nonfarm activities contribute to sustainable nutrition security. The roadmaps would harness the power of business to reduce hunger and poverty for millions of families, contribute to a better alignment between human biology and modern lifestyles, and stem the spread of noncommunicable chronic diseases.

In the last 50 y, there has been significant global growth in agricultural productivity, with aggregate food supply rising more than 100% and food production per capita increasing by almost 20% (1). This growth has fueled the development of national and global food systems, industrialization in many sectors of social and economic activity, intense urbanization, and improvement of health system capacities. These changes have been facilitated by the worldwide spread of information, communication, and transportation technology and the rise of global commodity and financial markets. They have translated into social and economic progress. However, with it has come a Western-biased convergence of diet, lifestyle, and environment that has had both negative and positive health outcomes and still leaves the poorest populations behind in terms of hunger and nutritional deficiency. Obesity and non-communicable chronic diseases (NCDs), such as diabetes, cardiovascular diseases, and cancer—tied to a cumulative and accelerated misalignment between human biology and conditions of modern industrial society (2)—now cause 60% of deaths globally (3); 80% of these deaths are found in low- and middle-income countries (4). They impose an ever-growing burden on health systems and threaten the economic viability of individuals, organizations, and governments worldwide.

Increasingly locked in place is a divide between agriculture, health, and wealth systems and between state, market, and civil society actors in each of these systems. Can novel paths of convergence help translate the benefits of agricultural and industrial growth, which have been at the core of wealth creation and consumption since the onset of industrial revolution, into fuller nutrition security? Can such benefits

be attained without the high toll of negative nutrition and health outcomes tied to affluence and inequity? Can smallholders still struggling in subsistence agriculture produce more food and do so in ways that sustainably contribute to nutrition security across the world? Whether they can depends on the information available, their access to markets, the technical and policy support for quality enhancement along the entire value chain, and more informed decisions by consumers around the world.

Achieving paths of convergence across agriculture, health, and wealth will require the emergence of novel forms of innovation, organization, and governance. The task is daunting, because complexity and diversity continue to increase both within and across systems. New players continue to enter the dialogue on tradeoffs and synergies, the sustainability of decisions, and incentives vs. disincentives for change. Uncertainty about current and future drivers of change plays a major role in price formation in each sphere. As such, a new transdisciplinary analysis of dynamic systems that policy makers, smallholder farmers, and business entrepreneurs can trust is needed.

This special feature seeks to promote forward thinking for a fuller and richer integration of smallholders into national and global agricultural and food systems, health systems, value chains, and markets. Nutrition security is reached “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (5). The articles identify analytical innovation where disciplines intersect and cross-sectoral action where single, linear, and siloed approaches have traditionally dominated. The issue is framed around three main themes: (i)

lessons related to agricultural and food market growth since the 1960s; (ii) experiences related to the integration of smallholder agriculture into global business agendas; and (iii) insights into convergence-building institutional design and policy, including a review of complexity science methods. In this introductory article, we discuss the perspectives framed around these three themes and elaborate on the potential benefits of the pursuit of a broad, solution-oriented, and transdisciplinary science to achieve nutrition security.

Overview

Lessons Relating to Agricultural and Food Market Growth Since the 1960s. Under the first theme, the work by Pingali (6) begins by presenting the achievements and limitations of Green Revolution approaches to increasing food supply and reducing rural poverty. The work by Pingali (6) weighs gains in farm productivity against the broader, and sometimes negative, environmental and nutritional consequences. Also, Pingali (6) recognizes a continuing need for agricultural research in its own right but sees as equally pressing the need for sophisticated knowledge on processes to support the integration of smallholders into national and global food systems. Recommendations include a renewed emphasis on agriculture as an engine of growth and poverty reduction, while reorienting research and development priorities to better face its complexity. The work by Pingali (6) reinforces the need for an

Author contributions: L.D., P.P., and P.W. wrote the paper.

Conflict of interest statement: Funding for this paper came from The Bill and Melinda Gates Foundation and the Quebec Research Fund for the Social Sciences.

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appropriate mix of private and public sector initiatives that engages smallholders in collaborative platforms in local, national, and global markets. Pingali (6) also suggests policy options to seek better complementarity between trade and domestic policy, enable income and livelihood diversification, and enhance incentives for sustainable resource use.

The work by Webb and Block (7) extends that analysis by focusing on national economic transformations that were underpinned by policy support for agriculture. The study of multiyear data for 29 developing countries confirms that economic growth rapidly raises total income and that poverty falls faster with strong support for agriculture. Reduced poverty, in turn, supports improved nutrition, especially in rural areas. However, these processes lead to several health risks associated with rising obesity rates in both rural and urban areas. These results provide additional empirical evidence to the double-edged effect of income growth; although it reduces undernutrition, it is also accompanied by increased levels of obesity, which have significant consequences in terms of chronic diseases, such as diabetes. Both effects are strongly correlated with policy support for agriculture, which poses a quandary for developing country policy makers. Webb and Block (7) conclude that, to bring about a more sustainable societal transition, policy makers must avoid assuming that other health and nutrition problems will be taken care of through economic growth. Transitional processes must be better managed if the negative consequences of obesity and NCDs are to be mitigated. Single policy actions, whether in health, trade, or agriculture, are unlikely to achieve the cross-sectoral gains that are essential to future growth, because a focus is needed on the net effects of multiple policy actions.

The work by Timmer (8) addresses the theme of nonlinear processes in relation to food price formation, highlighting price's core coordinating mechanism in market economies. Timmer (8) discusses the danger of complacency among policy makers, who see high prices as a solution to falling productivity. Focusing on rice markets and using insights from behavioral economics, Timmer (8) points out that price expectations, critical to smallholder decisions on production, storage, or consumption vs. sales, are not as rational, stable, and context-free as assumed in neoclassical welfare analysis. Risk aversion and herd behavior play key roles in food security and food price crises. Because there is little data on the formation of price expectations or their marketing consequences, the world rice market operates with imperfect information about

short-run supply and demand factors. The welfare losses from volatile food prices are, therefore, high, and more effective management and prevention of food price crises is critical. Understanding how price expectations for food are formed by farmers, traders, and consumers (in their separate domains but with interacting outcomes) and how these agents act on those expectations is critical to knowing what policy actions will stabilize food prices and keep consumers more food- and nutrition-secure.

The last paper under this theme, by Maxwell et al. (9), addresses crises more broadly, focusing on the complexity of actions needed in vulnerable environments such as Haiti, Uganda, or North Korea. The protracted crises in such locations represent a challenge to the global goal of promoting gains in agricultural output, along with good health and nutrition. Synthesizing recent research on state fragility, humanitarian principles, and institutional constraints to growth, the work by Maxwell et al. (9) suggests that new evidence-based models are needed that go beyond a food and farm focus in relief and rebuilding efforts. Attention must be given to broader livelihoods that manage risk while offering new entry points into activities that link vulnerable households to market opportunities. To date, the appropriate vehicles for intervention in such contexts remain unclear. Humanitarian agencies are called on as agents of change, but their operating principles are poorly adapted to protracted engagements. Furthermore, their motivations are often very different from the motivations of national governments, the international community, or private contractors, and civil-military partnerships are increasingly mobilized in such settings. The work by Maxwell et al. (9) states that a rethinking of intervention modalities is crucial to effective long-term actions addressing food insecurity in a volatile world.

Experiences Relating to the Integration of Smallholder Agriculture into National and Global Value Chains. The second overarching theme deals with the integration of smallholders into national and global food chains and markets. Access to markets has many aspects, including trust, long-term commitment, and transparent information about market opportunities and trends. The work by Lee et al. (10) broaches these issues using a global value chain approach to explain relationships between value chain structures and food safety/quality standards. The proliferation of food standards has fueled debate about their role as a potential entry barrier for smallholders seeking export markets. Although evidence is mixed, the literature suffers

from a focus on the relationship between private standards and smallholders, with little consideration of industry structures that may affect both groups. Lee et al. (10) propose a framework to investigate how the form of a value chain affects small-scale producers through the standards imposed on them, offering options on how they face growing burdens in complying with higher-level requirements.

The theme is elaborated on in the work by Reardon et al. (11), which examines the evolution of retail systems in Asia and the emerging strategies that seek to be more inclusive of small farmers. The work by Reardon et al. (11) offers a historical analysis of the waves of supermarket revolutions, with innovations rolling out from large cities to smaller towns, from richer to poorer consumers, from processed foods to fresh produce, and from domestic local chains to corporations. Although foreign direct investment has been important, the roles of domestic conglomerates and even state investment have been significant. Innovations include assembling companies and services that link farmers to modern markets into hubs or parks, multipronged collection cum service centers, and the creation of farmer companies that help farmers better service supermarkets. The work by Reardon et al. (11) points to the need for a closer examination of the proliferation of innovations to assess how well smallholders are profitably engaged in modern supply/value chains and whether such models are scalable.

Scale matters to value chain profitability. The work by London and Anupindi (12) takes this fact as a point of departure in their "base-of-pyramid" perspective (12). This perspective looks at initiatives led by international donors and the business sector seeking to integrate smallholders into markets by simultaneously building community capability and competitive advantages in the value chain. The work by London and Anupindi (12) argues that, regardless of their leadership, such efforts have had only modest success so far. The limitations are partly because private and public sector actors still seek to maintain independence from each other's processes and outcomes, which is typical of most private-public partnerships for development and health (13). The work by London and Anupindi (12) explores how interdependent collaboration, with partners operating under the principle of how can we help each other to achieve shared societal and economic value, can increase the sustainability and scalability of value chain initiatives. This collaboration can also serve as a catalyst for investment and community empowerment, and it can facilitate metrics and the alignment of incentives. London and Anupindi (12) point out that these approaches can result in

a rising rather than a leveling of the competitive field and the shared creation of more societal and economic value for any given investment than the status quo scenario.

Convergence-Building Institutional Design, Policy, and Complexity Sciences. The third theme deals with wider issues of institutional design and policy of weaving convergence between agriculture, health, and wealth into the social and economic fabric of societies around the world. This convergence can support smallholders in a deeper and smoother integration into national and global value chains and markets. Institutions embody the deeper norms, rules, and regularized patterns underpinning societies. In that way, they are distinct from organizations, which manifest these structural settings, and from variable policy processes and governance regimens through which specific concerns are defined and addressed (4). The work by Perez-Aleman (14) looks at multi-stakeholder networks. It explores how pro-small holder institutional design and policy can help developing countries create local capabilities and build institutions that facilitate greater informational symmetry along the value chain and foster institutional changes at multiple levels. Institutional arrangements that facilitate knowledge flows are the key to developing the capabilities of small producers, wholesalers, and retailers alike. However, the nature of global-to-local interactions beyond vertically integrated supply chains and normative guidance setting is poorly understood. One size cannot fit all when smallholder production and marketing contexts are so diverse. Tools for assessing net gains (or losses) from smallholders' engagement to more formal arrangements with value-added product chains remain to be identified.

The work by Kevane (15) also explores pro-small holder institutional design and policy with a focus on sex issues. Because globally, most farm workers are women, it is important to examine the mechanisms by which gendered discourses are deployed around decisions on investments, production, and food choices relative to other consumption requirements, such as education and health. The work by Kevane (15) examines social norms, institutional design, and policy tied to sex issues in home and market decisions around production and consumption. Acknowledgment of sex differentiation in agriculture and household decision making has begun to penetrate policy debates, because governments increasingly support programs that either target women or at least, include them equally. This acknowledgment, however, raises new questions regarding the changing roles of women as

they enter farther into salaried employment as well as national discourse and governance.

The work by Hammond and Dubé (16) reviews methods to inform the convergence-building institutional design and policy. It examines these methods, which are at the core of deep and systemic integration of smallholder and non-smallholder agriculture into national and global value chains and markets, through the lens of complexity and systems sciences. Hammond and Dubé (16) discuss the urgency of moving beyond the present metaphorical use of these approaches. To do so, Hammond and Dubé (16) propose a multilayered approach to capture the dynamic processes implicated in the world's interconnected agriculture, food, health, and environment systems. Complexity science takes a learning-based, adaptive, and diagnostic perspective that can inform policy choices as well as innovation. The work by Hammond and Dubé (16) proposes that information is the key to transformation—a recurring issue throughout this special issue. With computational power and modeling methods, it should soon be possible to weave complexity and systems sciences into organizational decision support systems of all actors involved. This approach can bridge single and collective process and outcome metrics to facilitate convergence in a fashion not possible before. The result would be that policy makers, market entrepreneurs, and smallholder producers can access that information and craft appropriate responses.

Roadmap to a Transdisciplinary Science

The articles assembled in this special issue report on science, policies, and actions directed at agricultural development for nutrition security through a richer integration of smallholders into national and global agricultural and health systems as well as into value chains and markets (6–12, 14–16). As the global urban population crosses the 50% mark and continues to grow (1), both smallholder and non-smallholder agriculture are key in forging rural–urban links, where farm and non-farm activities contribute to sustainable nutrition security for the poor and vulnerable around the world. This journey of convergence for agriculture, health, and wealth is still young. Needed now is a roadmap for a transdisciplinary science to support change of sufficient scale and scope. Such a roadmap must suggest research avenues that would (i) reflect a deep and actionable understanding of human decision making while accounting for individual and contextual diversity and intertemporal development effects; (ii) inform the design of health systems so that

they are more accessible to the most vulnerable populations and address evolving needs; (iii) foster innovation within and across agricultural, health, and wealth production and consumption systems while harnessing the creative power of grassroots engagement and local entrepreneurship; (iv) promote business engagement in multilevel collaboration with civil society and public organizations centered on the needs of the poorest and most vulnerable; (v) inspire policy convergence and novel models of governance that break down state–market bipolarity in ways that enable both cooperation and competition across sectors and levels of jurisdiction; and (vi) develop metrics and models to support integrated, near real-time decision making by all actors involved. A call for such a convergence-building and solution-oriented approach to science, policies, and actions was recently made by leading philanthropist Bill Gates: “Ultimately, the goal is to combine the world's total resources—public, private, rich, poor and in between—in ways that drive development forward” (17).

Deep and Actionable Knowledge of Human Decision Making and Behavior. With one exception [the examination by Timmer (8) of the formation of smallholders' price expectations during food price crises], the papers in this feature have only partially integrated or expanded on developments in decision sciences and behavioral economics (6, 7, 9–12, 14–16). A deeper consideration of this knowledge is needed to provide an actionable understanding of the array of rational and less rational motives and processes driving human decision making and behavior in diverse real-life contexts (2). Such pragmatic understanding runs counter to the present emphasis of policies and interventions on prescriptions for action that often ignore what is personally, culturally, economically, or politically feasible. In economics, for instance, although normative analysis focuses on comparisons of efficient and inefficient outcomes, which are defined by the Pareto frontier, there are alternative pragmatic approaches focused on real-world change outcomes (18). More emphasis is needed on courses of action that are better in line with the interests, preferences, and possibilities underlying decision making of each actor involved in nutrition security.

Integrating a more pragmatic understanding of human decision making and behaviors in policy and intervention for nutrition security is particularly critical when addressing the spread of obesity, diabetes, cardiovascular disease, and other NCDs. The complexity of prevention and control of these disorders goes well beyond traditional gene-by-environment

interactions, with individual behavior in response to given environmental conditions being the central intervening factor. Their strong neurobehavioral component is tied to the progressive misalignment between Western-biased diet, lifestyle, and environment and human biology (19, 20). Particularly for food, research shows that individual choice and behavior are rooted in a diversity of neural processes integrating biological reinforcement, environmental cues, and self-control capacity (21). These mechanisms currently serve as some of humanity's worst enemies, and their adverse impact is being fueled by a false and counterproductive dichotomy between individual and environmental approaches to their prevention and management. They are reportedly being hijacked for the marketing of nutrient-poor, calorie-rich food (22), while being neglected as powerful motivational forces by nutrition and health communities focused on education and prescription (2). Despite the significant impact that one might hope for from top-down policy intervention on either or both individual choice and environment, such powerful instincts cannot be fully regulated into submission.

In fact, public health researchers (22) and practitioners (23) have recently argued that the irresistible attraction of low costs and ubiquitous presence of processed food high in sugar, fat, salt, and calories has been the core driver of the obesity and NCD epidemics and the double burden of under- and overnutrition. Although these factors certainly have contributed to the epidemics, an alternative to this narrow account of food technology as the driver of these health conditions may very well be that food technology and marketing have been the tipping point of a progressive change through the whole of society taking place over the past 300 y. This change has reduced the need for human energy and improved nutritional efficiency—namely, through the technological innovations that have accumulated since the onset of the Industrial Revolution and transformed most aspects of agricultural, industrial, and economic development. As discussed in the work by Hammond and Dubé (16) and elsewhere (24, 25), human physiology and social entities are both complex adaptive systems with dynamics shaped by diverse systems operating on different scales. This whole-of-society transformation account of the obesity and NCD epidemics matches well with the historical analysis of 300 y of data on technological innovation, nutrition, body weight index, and disease prevalence in the works by Fogel (26) and Floud et al. (27). Empirically informed simulations are needed to test the food technology as the driver vs. whole-of-society accounts. Moving from

a narrow focus on food technology and marketing to a whole-of-society account for the emergence of diseases tied to Western-based development patterns is particularly important for the low- and middle-income countries. Not only do these countries have fragile health systems, but the transition from a traditional lifestyle and subsistence agriculture to a Western-type diet and lifestyle is occurring in the space of a few decades. Only convergence between agriculture, health, and wealth can interrupt this race to obesity- and NCD-promoting environments. Such a convergence can help build health system capacity to ensure sustainable universal access to the care needed to combat the resilient diseases of poverty and the emergent NCDs.

Research on the social dynamics underlying individual and collective decision making is also needed. Findings reported in the work by Timmer (8) about the role of herd behavior by rice farmers and market intermediaries in recent food price crises are illustrative of the many social media and network effects now available by electronic and mobile technologies. We need to know more about the underlying information diffusion, persuasion mechanisms, and contextual factors driving smallholders' decision making. As small holders become paid workers, entrepreneurs, and consumers, such an understanding would help enable them to choose courses of action that do not increasingly challenge human biology over time. Historical pattern analysis could be done to specify early detection signals of their changing decisionmaking over time, announcing emerging food, price, and/or nutrition security crises or longer-term trends. Future research on the social and cultural dimension of human decision making may also be particularly useful in delving into the various paths through which sex issues still operate. The results could guide changes in personal and societal choices more effectively than possible thus far.

In sum, research on the complexity and diversity of human motives, preferences, and experiences impacting choice will inform policies and interventions targeting nutrition security to move beyond the present one size fits all approach, better accounting for change over the course of a person's life and as a function of contextual differences over the development continuum. The value of a more differentiated and context-sensitive approach to understanding complex human problems has been shown in the environmental domain (28, 29). Recent calls have been made for research to clarify the multidimensional and changing drivers of consumer and industrial demand for food, including nutritional value, convenience, and palatability, in domestic and global

value chains and markets (30). Similar knowledge could profitably inform health policy and systems design, capacity building, and transformation.

Health Systems. Global health policy and systems research has, thus far, focused primarily on disease-specific technologies and programs. Research, capacity-building, and transformation strategies to ensure sustainable universal access to healthcare have remained focused on the resilient key killers that are infectious diseases and maternal and child mortality and undernutrition, while being relatively blind to the progressive emergence of obesity and NCDs. Health systems worldwide are ill-equipped to deal in an adaptive manner with a universal access to effective prevention and control of the diseases of both poverty and affluence in an economically sustainable manner. This finding has fueled, and is still fueling, healthcare costs to a level that may not be fully compensated by their impact on the health, wellbeing, and productivity of smallholders and other vulnerable populations around the world. Solution-oriented research that explores the power of digital communication and health technology targeted to nutrition security for the poor and vulnerable is needed.

Because many levers for change in reaching nutrition security are outside of the typical health systems purview and in agriculture, food, education, media, and other nonhealth sectors, research is needed to develop novel approaches to nutrition and public health research, policy, and practice. This research would specify key interlocking agricultural, health, and economic parameters for processes and outcomes between sectors and levels of jurisdiction, fostering convergence in decisions made by all relevant actors. It will also inform more sophisticated assessment of and balance between health and economic impacts of nutrition intervention and health system design that is better tuned to the diverse and changing needs and preferences over the course of development.

Convergent Innovation. Science, technology, and innovation pipelines from a vast array of disciplines and sectors contribute to the convergence, or lack thereof, of agriculture, health, and wealth. As development seeks transformation through the whole of society, innovation is the core engine of economic growth in industrial society (17). The private sector is not only the primary driver of economic growth, but it also accounts for as much as 75% of domestic healthcare expenses in many developing countries (31). Business can contribute the most to convergence building by mainstreaming nutrition, health, affordable and

effective disease prevention and control as a driver of innovation, and competitive advantage in core agricultural, industrial, and healthcare innovation pipelines and value-creating activities.

However, innovation has not yet achieved its full potential by fostering convergence within and across sectors and levels of investment. Innovation at the agriculture, health, and wealth nexus, thus far, had a primary focus on seeds (and other agricultural technologies, products, or processes such as biofortification), vaccines, and medicines (and other technologies and products for disease prevention, diagnostics, and control). Although these foci have resulted in critical positive outcomes from both health and economic perspectives, there is drastically much more that innovation can achieve to accelerate the pace of convergence for agriculture, health, and wealth. Innovation, on a scale that facilitates integration into the everyday life of individuals, organizations, and societies, is necessary to achieve the simultaneous shift in supply and demand drivers in all relevant sectors to ensure the social and economic sustainability of the enterprise. Convergent innovation does not need central planning and controlling of the various efforts, just the bridging of them. The power of creative chaos of distributed single and collective innovation in reaching agriculture, health, and wealth convergence can be unleashed while coordinating and collaborating on interlocking goals. The real issue is getting the right innovators together and creating an overall agenda within which everyone can innovate in the ways that they choose individually. At the same time, it is necessary to engage in collective innovation as appropriate to singly and jointly address the humanitarian and economic needs of smallholders and other vulnerable populations.

Single and collective innovation in a wide array of intermediary domains between seeds, vaccines, and medicines can proactively turn challenges associated with convergence into opportunities for shared societal and economic value creation. It will be particularly successful in this regard if it is openly collaborative and centered on the needs of the poorest and most vulnerable population (32, 33). Nutrition, health, and education interventions targeted to children, parents, and adults in developing and developed countries alike can clearly better tap into research on the full diversity of factors driving human motivation, learning, and behavior. They could also harness the power of technology in ensuring functional and economic accessibility to the poorest segments of the population through frugal and flexible innovation. The same strategy applies to business. The agricul-

ture, agrifood, computer, leisure, and sport industries, for instance, may exert the full power of their technological innovation and market capability behind health-promoting goods. Such a change could be to the benefit of local, national, and global innovators harnessing the industrial value derived from science and technology. This improvement could be the key to facilitating more meaningful and systemic integration of smallholder and non-smallholder agriculture into national and global agriculture, food, and health systems, value chains, and markets. It could, thus, pave the way for an alternative to the present shift from rural poverty to urban and periurban poverty, reducing the emergence of the double burden of under- and overnutrition.

There is a need for pragmatic scientific developments in the realm of innovation and knowledge management. Research is needed in forms of innovation that would have interconnections at vertical levels (i.e., through local to global supply/value chains) and horizontal levels (centered on comprehensive sectoral and cross-sectoral solutions to targeted problems of the poor and most vulnerable individuals, families, communities, or nations). Research is needed on the structure and dynamics of the networks of innovation and the knowledge markets. These areas link science, technology, and innovation with producers and users at local, national, and global levels within and across agriculture, health, and wealth production and consumption domains. There is a need to identify and examine best practices in open and proprietary knowledge networks and markets. These practices are required for extracting parameters and strategies for leveraging public, private sector, and philanthropic investments in science, technology, and society. There is also a need to conceive of convergence-building mechanisms that would help assemble whole-of-society solutions for sustainable nutrition security and health of smallholders and other vulnerable populations. Relevant avenues for research include but are not limited to (i) mechanism design that aligns individual- and system-level incentives driving innovation with targeted convergence goals as well as theories and models of learning and adaptation in such networks and markets; (ii) cost- and time-effective strategies to best include smallholders, microorganizations, and small and medium enterprises; (iii) embedding innovation convergence considerations into the organizational culture, farming practices, business strategies, and health policies and systems design; and (iv) national and global innovation and intellectual property strategies and policies that better provide a bridge between science, technology, and innovation.

Business Engagement in Multilevel Collaboration. Beyond innovation, business engagement is key to full and sustainable nutrition security through its strategy and investment as well as its role as catalyst in broad cross-sectoral multilevel collaboration. Many of the papers in this special feature (10–12) have examined organizational and economic parameters and models through which this collaboration can be achieved. As employers, for instance, business impacts many facets of smallholder integration into the labor force through its personnel strategies and operational practices. These actions have significant potential to impact maternal and child nutrition and health outcomes, particularly during early stages of development. In a country like India, it has been suggested that the persistence of child malnutrition despite economic growth is, in part, tied to smallholders' double workload as they pursue subsistence agriculture and enroll in the paid labor force (34). Organizational research on work–family conciliation, which has, thus far, been primarily limited to a Western context, needs to be conducted in a development context.

There is also growing interest from field practitioners and academia in business engagement through models and strategies for adding human, financial, and technological capital for addressing pressing and complex issues at the convergence of agriculture, health, and wealth. Impact investment, for instance, targets enterprises that address critical health and social issues, with a potential to pay back the invested capital with market-comparable return. This model and other innovative financing models for convergence building, as well as the diverse and enabling conditions of institutional contexts in which these models are to operate, need to get higher priority for both industry and academic research.

Additionally, illustrated in the bottom-of-pyramid approach featured in the work by London and Anupindi (12), business can act as a powerful catalyst for community involvement to achieve complex and broad collaborations for sustainable societal and economic value creation. They can go beyond traditional models of private–public partnerships to engage actors from the different sides of the many divides that have structured society since the onset of the Industrial Revolution. These engagements can be formed around focused, time-bound, and achievable goals of shared societal and economic value creation. Better harnessing the power of business as a catalyst for change for the creation of these multilevel cross-sectoral partnerships is critical to ensure sufficient scale and scope. In addition, grassroots entrepreneurial initiatives by local farmers

and other members of traditional communities are also necessary to spur community-owned development and help prevent the emergence of a double burden of disease over the course of economic transition. These initiatives can ensure the successful integration of farmers and community members into business activities in national and global value chains and markets.

Organizational and institutional studies are needed to identify key barriers, parameters of success, and metrics for complex collaboration. Collaborative mechanisms, including knowledge and competencies sharing, conflict resolution, accountability, transparency, and pragmatic trust-building processes, are to be studied in the context of real-world initiatives. Research is also needed on strategic architectural design and technological infrastructure to support sustainable collaboration and actionable interfaces with each actor's respective operations. This research would help explain how systemic development paths, observable on the aggregate level, can be traceable in space, time, and jurisdiction to individual and collective decisions.

Scaling up business engagement as a catalyst for complex collaboration through the whole of society will require changes in the underlying operating assumptions and dynamic interactions of a large number of different actors. These actors span many local, national, and global systems, and they are not represented by just a few key players and a few key systems. This engagement requires shifting mindsets from tradeoff, zero-sum games, and competition to synergy, nonzero-sum games, and cooperation (13, 34), much in line with the concept of collaborative interdependency introduced in the work by London and Anupindi (12). It also has to be systematically studied, deeply understood, and integrated into on the ground policies and actions. Existing institutional restrictions, which scale down action on the ground, have many components. These components include limited resources and funding, conflicting functional, philosophical, and/or political beliefs and goals, confidentiality concerns, issues of territoriality, and lack of trust as well as differences in decision-making styles and performance metrics (35). Research is needed on the features of institutional design that could facilitate interconnected and supportive trusting relationships. These relationships enable joint problem solving and conflict resolution.

Whole-of-Government Approaches to Policy Convergence and Whole-of-Society Governance. Many articles from this special feature (6, 7, 15) suggest that current policy

approaches do not completely account for the progressive misalignment between biological, human, and social dynamics as development unfolds. These approaches are anchored in the "virtuous spiral" of "economic development as a driver of health" and "health as a driver of agricultural and economic development" (36). They neglect the possibility that not all economic development is health-promoting and that not all health systems development and policies are economically sustainable. Disconnects exist between sectoral policy making in agriculture, trade, industry, finance, economics, health, education, and other social domains. The result is that considerations of immediate and intertemporal adverse nutrition, health, or social effects are only just now beginning to be factored into policy-making and investment decisions. The disconnect between health systems and agriculture and wealth production and consumption systems is also manifested in the observation that early health systems capacity building and policy remains focused on infectious disease and other health problems tied to extreme poverty. However, as mentioned earlier, it remains relatively blind to or unable to anticipate, prevent, and deal with the burden of obesity and NCDs. These diseases arise from present development patterns emerging for other sectoral policies and investments and are doing so at ever lower gross domestic product thresholds. Further, present policy approaches in neither health nor industrial and economic sectors sufficiently consider the central role that agriculture may play over the full development spectrum. Considering a sustained and central role for agriculture can ensure a smoother transition into industrial value chains and urban societies and more balance between traditional low-income agrarian structures and emerging farm and nonfarm activities in rural and urban communities and economies.

Research is needed to push the present boundaries of nutrition- and health-sensitive sectoral policy making in local, national, and global jurisdictions. It will allow for embrace of a convergence-based cross-sectoral, whole-of-government approach that remains rooted into the respective motives, challenges, and priorities of the diverse health and nonhealth domains involved. Insights in this regard come from recent economic analyses performed in the context of industrial policies targeted for promotion of green technologies (37, 38). Translating these analyses, in the context of nutrition security and health, suggest that policy scenarios may go beyond the pricing of externalities tied to poor societal outcomes through top-down policy such as cap-and-trade systems or user taxation. New convergence-building ap-

proaches could target competition-friendly agricultural and industrial policies and state interventions. This work also suggests that the less concentrated and more competition-compatible that policies and state interventions in this sector are, the less firms in that sector will undertake lobbying activities and the shorter that the period will be when such intervention is needed. Deep and comprehensive analyses of appropriate governance of sectoral and cross-sectoral policies under different contexts and as a function of development stages await urgent research development.

Institutional research is needed to examine how policy makers and political leaders can fully embrace the complexity of their role in the whole-of-society transformation. Like never before, governments have to learn how to be commanders in chief, which in turn, means being imposers of mandatory regulations that define boundaries and rules for consumers and all stakeholders; providers of public goods and services; stewards of public resources; and partners in various collaborative undertakings with other jurisdictions, businesses, and civil society organizations (39). Hierarchical authority is necessary but not sufficient: multiactor cross-sectoral collaboration cannot be completely by edict, and it has to be enabled, monitored, and sustained if it is to be cost-effectively impactful. Policy research must examine the full portfolio of policy instruments and specify contingencies to equip government in its many roles in moving to convergence for agriculture, health, and wealth over the full course of development.

Business engagements through innovation and multilevel cross-sectoral collaboration are increasingly important in least developed, emerging, and industrial economies alike. They call for the development of governance models that go beyond the bipolarity of traditional markets and state institutions (40). Whereas coordination mechanisms of the two institutions are price and authority, respectively, community-based institutions that can support broad-based collaboration take pragmatic trust as a relational coordinating currency. Recent developments in institutional theories suggest that hierarchy, market, and community are now core to the balancing of competition and cooperation as key components of modern capitalism (40, 41). Research is needed on the appropriate balance between trust and hierarchical rules to ensure stability, equity, and balance between trust and market competition to ensure flexibility and opportunity.

Research must also examine and support institutional entrepreneurship to move to existing and yet to be-invented whole-of-society approaches that foster full convergence for agriculture, health, and

wealth (42). Research on polycentric (43), multilevel (44), and network (45) approaches to governance are all insightful in this regards.

Polycentric models posit the importance of balancing global government and governance with positive actions underway at different scales by all actors in society, including individuals (43). Solutions require intense involvement by individual, business, and other nonstate actors throughout the whole of society. The policy solutions in polycentric governance have to reconcile two potentially contradictory imperatives. On the one hand, the process must be structured to guard against potentially distorting effects to account for the large number and diversity of nonstate actors as well as the inequalities of voice and resources among them; on the other hand, the process must also ensure that these structures are as non-bureaucratic and context-sensitive as possible to avoid eroding the passion, spontaneity, diversity, and commitment that defines a healthy civil society and a dynamic business community—qualities that add to the resources that society can put to addressing issues at the agriculture, health, and wealth nexus (46).

Models of multilevel governance (44) also see solutions to global problems, such as climate change, that originate from processes embedded in specific places. For example, these models would see the local level being the most appropriate jurisdiction for bringing about solutions with real-world impact. Transnational networks of municipal governments could then act in synergy with national, subnational, and supranational instances. General models of network governance, in turn (45), operate through nonhierarchical webs of connection among equals. These webs are held together not by force, obligation, material incentive, or social contact but shared values and the understanding that some tasks can be accomplished together that could never be accomplished separately. Research needs to examine whether new forms of network governance can weave together unstructured alliances of national agencies, international organizations, corporations, and grassroots associations so that they more effectively influence and participate in policy-making processes. Where consensus for effective policy action is a goal, such nonconventional modes of policy dialogue offer promise, although the empirical evidence of reproducibility remains limited. Research is needed to examine which governance and government model is most appropriate as a function of grassroots, community, and market-driven convergence-building initiatives. Research is also needed on embedded power structures and potential conflicts and synergies

among the diverse parties involved. Finally, research is also needed to examine how such grassroots and market-driven bottom-up initiatives can be further scaled-up and brought into policy and investment decisions made by national governments and global agencies.

Convergence Metrics and Models. Convergence efforts deployed throughout the whole of society are hampered by the current state of sectoral data and decision support in population health, human development, media, agriculture, industrial, and other economic sectors. These data are generally fragmented, out of date, unrepresentative, and unavailable at the local level. In addition, most of the levers for change in moving to more effective disease prevention and control are outside the boundaries of the healthcare system. This finding means that bridges have to be built between knowledge systems and models in health and those models used in policy making by agricultural, social, and economic actors. Public health, agriculture, business, and economics researchers and practitioners have proposed and implemented various sectoral surveillance systems and models to monitor processes and outcomes each in their respective spheres. None of them, however, fully links these areas to other relevant data that support decision and policy making across various actors in society who determine the level of direct and indirect risk factors for these diseases. The work by Hammond and Dubé (16) encourages moving from a metaphorical to a computational approach to tapping into such complexity.

Development in knowledge modeling and information systems research is needed to produce near real-time integrative architecture. In such architecture, data as well as scientific and functional knowledge embodied in models are encoded in a manner to inform policy convergence and foster the cocreation of shared health, social, and economic value by all actors of society. Such integrative architecture could bridge—within defined geographic, administrative, or political boundaries—metrics that describe nutrition, population health, disease prevalence, and healthcare expenditure status. This information could then be connected to data on key agricultural, social, industrial, and economic influences or determinants. These data could then be translated into the key risks, processes, and outcomes that are within and across domains of activity (e.g., health, education, agriculture, food, media, transportation, housing and development, etc.), sectors (e.g., academic, public, private, and civil society), and jurisdictions (e.g., community, city, province/state, countries, regional, and global).

Complementary research and technological development in analytical, statistical, and computational modeling is also required. This effort can equip governments at the global, national, and local levels with a portfolio of models, decision support, and policy simulation tools for achieving the targeted changes needed to move to convergence for agriculture, health, and wealth. Classic cost-effectiveness modeling approaches in agriculture or health need to be complemented by (and also integrated with) complex science models such as agent-based and systems dynamic approaches. Finally, macroeconomic computable general equilibrium models are required to fully account for agriculture, health, and economic convergence. The models could also incorporate microeconomic household models of demand elasticity over the natural course of development or in response to policies and interventions.

Conclusions

The articles presented in this special feature on agriculture development and nutrition security are concerned with joint value creation among key sectors (6–12, 14–16). The proposed solution-oriented transdisciplinary approach to science, policies, and actions should support smallholder and non-smallholder agriculture and forge rural–urban links where farm and nonfarm activities singly and jointly contribute to nutrition security for the poorest and most vulnerable. We hope that this special feature will serve as a catalyst to the deployment of a whole-of-society effort that bridges or leapfrogs the divides that have prevented 20th-century society from reaping the benefits of modernity without having to pay the current high tolls. The sum of innovative technology, extensive grassroots and civil society involvement, genuine business engagement, and political will promises to make possible the ambitious challenge of recalibrating a capitalism that is currently characterized by recurrent crises. Such convergence would point the way to innovation, policy, and institutions that create an alternative path from tradition to industrialization. It is a path that promotes healthy lifestyles and environments rather than undermining them, buoys farming communities rather than eroding them, and fosters capacity-building and transformation for sustainable health systems to both prevent and control diseases of poverty and affluence in the most vulnerable populations worldwide.

ACKNOWLEDGMENTS. This Special Feature is dedicated to the memory of C. K. Prahalad, who was the opening keynote in the workshop that served as the springboard to the Special Feature. C. K. Prahalad was an influential voice for the convergence of small-

holders, local entrepreneurs, and corporations throughout his brilliant career. The workshop was hosted by the McGill World Platform for Health and Economic Convergence with

substantive and financial support from The Bill and Melinda Gates Foundation: Agriculture Division. The authors thank research associates Mathew Cherian and Ebony Rose Bertorelli.

They are also grateful to journalist David Freedman for final editing. Their work was supported by the Quebec Research Fund for the Social Sciences.

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