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PERSPECTIVE PAPER

Benefits and Costs of the Food Security and Nutrition Targets for the Post-2015 Development Agenda

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POST-2015 CONSENSUS

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Working Paper as of 15 January, 2015

Introduction[*#]

Food demand is poised for unprecedentedly rapid growth over the coming two generations. The world's population will grow from 7 to 9 billion by 2050 and may exceed 10 billion by the end of the century.[1] The vast majority of this growth will occur in today's low- and middle-income countries, especially in urban areas, which will be home to 70% of the world's population by 2050.[2] So there will be far more people to feed and they will live increasingly distant from the rural areas in which the overwhelming majority of food is produced, with consequences for post-harvest food loss along an elongating food marketing channel. Compounding the population growth and urbanization effects, between 2005 and 2050 today's low- and middle-income country economies are expected to grow at an average annual rate of 5.2% – versus just 1.6% in today's high-income countries – driving up their share of global output from 20 to 55%.[3] This larger, more urban, and wealthier global population will demand 70-100% more food by 2050 than the world consumes today.[4] And the vast majority of that increased demand will be in Africa and Asia, not in today's major food surplus economies. Furthermore, because 85-90% of food is consumed in the country in which it was produced, this demand growth will require comparable food supply growth on those two continents.[5]

Income growth and urbanization will also prompt a dietary transition characterized by the expansion of vegetables, fruits, semi-processed, and ready-to-eat foods and animal-sourced foods (ASFs) in the diet.[6] The relative decline of cereals, starchy staples, and pulses in the

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[*] This Perspective paper was prepared in response for the Copenhagen Consensus Center for its Post-2015 Consensus project aimed at identifying the most effective targets for the post-2015 development agenda, based on economic evidence. It was invited as a response to Mark W. Rosegrant, Eduardo Magalhaes, Rowena A. Valmonte-Santos and Daniel Mason-D'Croz, "Returns to Investment In Reducing Postharvest Food Losses And Increasing Agricultural Productivity Growth," Washington: International Food Policy Research Institute, 2014. This paper draws on the author's various prior writings and has benefitted from past conversations with Leah Bevis, Luc Christiaensen, Harry de Gorter, Miguel Gómez, John Hoddinott, Erin Lentz, Bart Minten, Rebecca Nelson, Per Pinstrup-Andersen, Prabhu Pingali, Frank Place, Terri Raney, Tom Reardon, Mark Rosegrant, Megan Sheahan and Peter Timmer, each of whom has taught me much. Any remaining errors are my sole responsibility.

[#] David J. Nolan Director and Stephen B. & Janice G. Ashley Professor of Applied Economics, Charles H. Dyson School of Applied Economics and Management, and Professor, Department of Economics, all at Cornell University, Ithaca, NY 14853-7801 USA. Email: cbb2@cornell.edu.

[1] United Nations Population Division, Department of Economic and Social Affairs. 2011. "World Population Prospects: The 2010 Revision." New York: United Nations. http://esa.un.org/unpd/wpp/Excel-Data/population.htm. Accessed January 13, 2012. There are other projections that the population level will level off between 9 and 10 billion between 2050 and 2100. For example, the United Nations' Economic and Social Affairs Division's report, "World Population to 2300," projects that world population will peak at 9.22 billion in 2075.

[2] Food and Agriculture Organization (FAO). 2009. "How to Feed the World in 2050." From the Expert Meeting on How to Feed the World in 2050, FAO, June 24-26, 2009.

[3] van der Mensbrugghe, Dominique, Israel Osorio Rodarte, Andrew Burns, and John Baffes. 2009. "How to Feed the World in 2050: Macroeconomic Environment, Commodity Markets – A Longer Term Outlook." Produced for the Expert Meeting on How to Feed the World in 2050, FAO Headquarters, Rome, June 24-26, 2009. Income growth predictions are generally imprecise and contested; this is meant as an illustrative expert conjecture only.

[4] International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). 2009. "Global report." Edited by Beverly D. McIntyre, Hans R. Herren, Judy Wakhungu, Robert T. Watson. Washington, DC: IAASTD; Tilman, David, Christian Balzer, Jason Hill, and Belinda L. Befort. 2011. "Global Food Demand and the Sustainable Intensification of Agriculture." *PNAS Early Edition*, pp. 1-5; World Bank. 2007. *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank; FAO. 2009.

[5] Christopher B. Barrett, ed., *Food Security and Sociopolitical Stability*. Oxford: Oxford University Press, 2013.

[6] FAO 2009.

diet carries significant implications. About one-third of global cereal production today becomes animal feed, which is then converted into eggs, dairy products, and meat for humans at an average protein conversion efficiency of about 10%, although animals vary in their conversion efficiency, from 18% efficiency for pork to 6% for beef, primarily driven by variations in land requirements.[7] The dietary transition observed historically and the feed conversion inefficiency of livestock imply that per capita grain, oilseed, and pulses output must rise disproportionately in spite of the human dietary transition away from cereals and pulses, and that planned post-harvest loss will necessarily grow due to the inherent inefficiency of conversion of feed crops into ASFs.

The world has faced similar demand-side pressures on food systems before. Population and incomes tripled in the decades following World War II, but food production grew even faster such that even in the face of the 'population bomb' and rapid post-war economic growth, the dramatic successes of the Green Revolution in the 1960s-70s led to falling real food prices and a steady reduction in undernutrition.[8] But those successes lulled policymakers into complacency about food security concerns. As a consequence, public investment in agricultural research and development (AR&D) and food marketing systems diminished for a quarter century beginning in the 1980s, especially relative to overall government spending.[9]

In a world in which 800-900 million people are currently undernourished, at least double that number consume insufficient minerals and vitamins (i.e., micronutrients) to lead an active and healthy life, and real food prices have risen more than 30% since the turn of the millennium – punctuated by dramatic food price spikes that prompted widespread episodes of acute malnutrition and food riots around the world from 2007-11[10] – the prospect of dramatic demand expansion in the coming decades now concerns many experts. Competition for limited land and water resources is more intense than ever and the rate of yield crop in staple crops has slowed appreciably over the past two decades.[11] Hence the renewed high-level attention to issues of global food security; policymakers are worried once again.

As the world grapples with the formidable food security challenge posed by inevitable multiplication of food demand in the coming few decades, considerable attention has turned to prospective opportunities to reduce post-harvest loss (PHL) as one way to plug part of the food availability gap. The quantity of PHL remains imprecisely estimated, especially in the developing world.[12] But a range of widely cited recent studies claim that

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[7] Reijinders, Lucas, and Sam Soret. 2003. "Quantification of the Environmental Impact of Different Dietary Protein Sources." *American Journal of Clinical Nutrition* 78(suppl):664S–8S.
[8] Evenson, R., Gollin, D., eds. 2003. *Crop variety improvement and its effect on productivity: The impact of international agricultural research*. Wallingford, UK: CABI.
[9] World Bank 2007; Barrett 2013.
[10] Barrett 2013.
[11] Alston, Julian M., Bruce B. Babcock, and Philip G. Pardey. 2010. *The Shifting Patterns of Agricultural Production and Productivity Worldwide*. Ames, IA: The Midwest Agribusiness Trade Research and Information Center, Iowa State University; Cassman, Kenneth, Patricio Grassini, and Justin van Wart. 2010. "Crop Yield Potential, Yield Trends, and Global Food Security in a Changing Climate." Chapter 3 in *Handbook of Climate Change and Agroecosystems*. Edited by Daniel Hillel and Cynthia Rosenzweig. London: Imperial College Press.
[12] National Research Council and Institute of Medicine. (2014). *Data and Research to Improve the*

the PHL volume is large, perhaps one-third of food output by weight, and larger still as a share of key micronutrients that enter diets disproportionately through perishable ASFs, fruits and vegetables.[13] Some analysts believe that PHL is so significant that halving the current loss rate could save enough food to feed perhaps another billion people on current diets.[14] Given the looming global food security challenge and the magnitude of these estimates, it is very natural to ask the question: what role might reducing PHL play in addressing the looming global food security challenge?

Rosegrant et al.'s contribution

Rosegrant et al. (2014)[15] make the most serious attempt to date at generating a reasonably rigorous answer to that question. Following a thorough and thoughtful review of the existing literature that offers a very wide range of estimates for PHL – from 10 to 50% – they undertake econometric analysis to try to establish the relationship between public infrastructure – such as paved roads, electrification, port capacity – and PHL estimates. Most of their results, which they appropriately caution should be interpreted judiciously given the mixed quality of the data they must use and the various econometric problems (e.g., unobserved heterogeneity) they face, appear reasonably intuitive. More paved roads, higher use of railroads in goods transport, and more widespread electricity access are all associated with reduced rates of PHL.

Rosegrant et al. then use their econometric estimates and secondary data on the unit costs for specific infrastructure variables to identify the infrastructure investments required in order to reduce PHL by 5, 10 and 25 percentage points. They enter those estimates into the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) – the International Food Policy Research Institute (IFPRI)'s widely-respected model for simulating alternative futures for global food supply, demand, trade, prices, and food security[16] – in order to compare the results of PHL reduction through infrastructure investment both with baseline estimates of what might happen in the absence of any concerted new effort and with the consequences of increased AR&D investment.

This sort of horse race is essential to evaluate prospective investments because resources used to improve food security through investments to reduce PHL might be used in alternative ways, with perhaps greater impacts, lower cost, or both. Exploring the food security effects of PHL reduction through infrastructure investment versus a do-nothing

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U.S. Food Availability System and Estimates of Food Loss: A Workshop Summary. Washington: National Academies Press.

[13] Ventour, Lorrayne. 2008. "The Food We Waste." Banbury, UK: Waste and Resources Action Programme; Gustavsson, Jenny, Christel Cederberg, Alexandre Meybeck, Ulf Sonesson, and Robert van Otterdijk. 2011. "Global food losses and food waste." Rome: FAO; Sergiy Zorya, Nancy Morgan, Luz Diaz Rios, Rick Hodges, Ben Bennett, Tanya Stathers, Paul Mwebaze, and John Lamb, *Missing food: the case of postharvest grain losses in sub-Saharan Africa*, Washington: World Bank, 2011; Brian Lipinski, Craig Hanson, James Lomax, Lisa Kitinoja, Richard Waite and Tim Searchinger,. "Reducing food loss and waste." *World Resources Institute Working Paper, June* 2013.

[14] M. Kummu, H. De Moel, M. Porkka, S. Siebert, O. Varis, and P. J. Ward. "Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use." *Science of the Total Environment* 438 (2012): 477-489.

[15] Rosegrant et al. 2014.

[16] Many experts consider IMPACT the best of the available models for simulating the global agricultural economy. For more details, see http://www.ifpri.org/book-751/ourwork/program/impact-model.

strategy would not be especially interesting or helpful; it would reduce to a stale assessment of whether the benefit-cost ratio of PHL reduction is greater than one. In the end, Rosegrant et al. project that both infrastructure investment to reduce PHL and AR&D investment would significantly improve food security, especially in South Asia and Sub-Saharan Africa, the regions of greatest global concern.

These projections ultimately enable Rosegrant et al. to undertake coarse benefit-cost analyses. Their conclusions are very sensible. Both infrastructure investment to reduce PHL and AR&D generate benefit-cost ratios (BCRs) well in excess of the break-even, ranging from 6 to 15 depending on assumptions. So these are high-return investments. But the AR&D investments generate 2-4 times the BCRs that the PHL reduction effects do. Put simply, infrastructure investment for PHL reduction can help, but PHL reduction offers lower returns than does AR&D as an investment in promoting food security. Rosegrant et al.' analysis is an important effort that surely arrives at the right conclusion: PHL reduction can contribute to improvements in food security globally, but it is relatively less important and less cost-effective an approach than alternative policy instruments available to policymakers.

Perhaps-exaggerated gains to post-harvest loss reduction?

For a variety of reasons, I suspect that Rosegrant et al.'s estimates even err in the direction of exaggerating the role that PHL reduction can play.

First, Rosegrant et al. motivate their focus on infrastructure improvements as an impetus to reduced PHL based in part on existing empirical studies that have found that farmers invest in improved storage and drying facilities and other PHL-reducing measures when local investments in roads and other infrastructure improve farmers' market access; the incidence and extent of on-farm losses declines as the gains to marketing one's harvest increase.[17] But infrastructure improvements likewise stimulate greater uptake of improved production technologies by farmers in Africa and Asia.[18] And by reducing marketing intermediaries' costs, infrastructure improvements also reduce local (intranational) farmgate-retail price differentials and thus consumer prices, which has an especially favorable effect on the poor's access to perishable foods. Rosegrant et al.'s simulations only consider the food security impacts of infrastructure improvements that reduce PHL and assume away the simultaneous direct impacts of those improvements due to lower prices and increased uptake of improved production technologies.

Put differently, infrastructure investments seem a good investment for any of a host of reasons, PHL reduction included. But it is unclear whether the food security benefits of

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[17] See, for example, Miguel I. Gómez and Katie D. Ricketts. "Food value chain transformations in developing countries: Selected hypotheses on nutritional implications." *Food Policy* 42 (2013): 139-150; Bart Minten, Thomas Reardon, Krishna M. Singh, and Rajib Kumar Sutradhar. "The New and Changing Roles of Cold Storages in the Potato Supply Chain in Bihar." *Economic & Political Weekly* 49, 52 (2014); Jonathan Kaminski and Luc Christiaensen, "Post-Harvest Loss in Sub-Saharan Africa: What Do Farmers Say?" Policy Research Working Paper No. 6831. Washington, DC, World Bank, 2014.
[18] Christopher B. Barrett, "Smallholder market participation: Concepts and evidence from eastern and southern Africa." *Food Policy* 33(4), 2008: 299-317; Foster, Andrew D., and Mark R. Rosenzweig. "Microeconomics of technology adoption." *Annual Review of Economics* 2 (2010).

PHL reductions surpass the benefits that would likely come from increased food production and reduced retail food prices due to the same infrastructure investments. Since those impact pathways are suppressed in Rosegrant et al.'s model, one cannot really determine PHL's relative contribution, even to food security improvements likely to arise from infrastructure improvements. So the focus on PHL may be misplaced.

Indeed, this underscores a curious feature of the modeling exercise. The PHL reduction is modeled as achieved through infrastructure investments, which really makes this more an assessment of the (truncated) estimated food security benefits from investments in infrastructure versus in AR&D. And given the incomplete modeling of those effects, we do not have a clear answer to the more interesting (and relevant) policy question: invest in infrastructure or in AR&D in order to enhance food security? I suspect that would be a closer horse race than the comparative simulation results that Rosegrant et al. present.

One very noteworthy result from their Table 5, however, is that the highest return infrastructure investments, in terms of predicted PHL reductions, are found in Africa, and by a whopping margin. To achieve the same reductions in PHL requires only 1-50% the investment in paved roads, road capacity or rail capacity in Africa as compared to Latin America and the Caribbean, which is itself an order of magnitude more cost-effective per unit PHL reduction than are infrastructure investments in Asia. This result, which unfortunately is rather buried in the paper, is potentially very important and underscores the seemingly high returns that exist to infrastructure investments in rural Africa.

A second reason why I suspect the relatively attractiveness of PHL reduction might be exaggerated is that no comparison is made with other candidate interventions with high likely returns. Consider, for example, investments in improved natural resources management (NRM). In most of Africa and Asia, PHL pales in comparison to pre-harvest losses due to pests, weeds, soils degradation, or inadequate water control that cause dramatic shortfalls relative to potential crop yields. Improved irrigation and on-farm NRM may well generate far higher gains in Africa,[19] and perhaps in Asia too. One could continue with other omitted comparisons. But that would merely belabor the point: coming in second behind AR&D in a two option competition does not make PHL reduction the second best investment opportunity for improving global food security. A host of other candidate investments were not modeled, probably for many good reasons, but would likely compete favorably with PHL in terms of the BCR for food security improvements. Is PHL reduction a good thing? *Ceteris paribus*, of course it is. But from the perspective of choosing optimal investments of scarce resources to address the looming food security challenge in Africa and Asia, PHL does not seem a high priority.

Endogenous Optimal Post-Harvest Loss

Furthermore, it is important to recognize that PHL cannot be mechanically reduced by fiat. PHL is the endogenous consequence of the actions of many disparate actors along the food value chain, from farmers who leave edible food unharvested in the field or who experience

[19]Christopher B. Barrett, Frank Place and Abdillahi A. Aboud, eds. *Natural resources management in African agriculture: Understanding and improving current practices*. Wallingford, UK: CABI, 2002.

crop spoilage or loss in storage, to transporters and processors who lose or waste product within the marketing channel, to final consumers who overpurchase and have food spoil or discard edible food for any of a host of reasons. In stark economic terms, some PHL is optimal because reducing PHL is costly.[20] So the range of instruments available to reduce PHL is limited. Moreover, "the marginal costs of public policies designed to eradicate food loss and waste rise rapidly as one reduces food loss and waste."[21]

Rosegrant et al.'s modeling strategy underscores the endogeneity of PHL. Indeed, the particular functional form they estimate nicely accommodates precisely the sort of diminishing returns to PHL rate reduction just emphasized. They identify the plausibly causal effect of exogenous improvements in infrastructure on PHL rates, reflecting how improved market access reduces the cost and increases the benefits to producers and marketing intermediaries of reducing PHL rates along the food value chain, how electrification reduces the cost of averting spoilage, etc. These are all the by-products of choices by actors along the food value chain.

That matters because optimal PHL is endogenous to other variables that have first-order effects on food security because of how those other variables affect value chain actors' choices.[22] In particular, PHL rates are endogenous to food prices and to incomes and in ways that will naturally make PHL *increase* as food security improves.

Lower food prices improve poor people's access to food. But lower food prices also reduce the opportunity cost of food waste and thereby increase the optimal rate of PHL for producers, processors, transporters, traders and consumers alike.

Poverty, not PHL, is the principal driver of food insecurity. Higher incomes are unambiguously good for food security, especially when concentrated among the poor. But PHL inevitably increases with the dietary change induced by income growth. All else held constant, as poor consumers' incomes grow and they become more food secure, they optimally waste more food, for multiple reasons. First, consumers substitute away from storable staple grains, roots and tubers toward perishable fruits and vegetables with higher rates of PHL, and especially towards ASFs that requires turning food grains into feed, with all of the conversion inefficiencies inherent to that process. Second, because the demand for food aesthetic attributes (e.g., size, shape, color) and food safety increase rapidly with income – in economists' parlance, these are 'luxury' attributes, expenditure on which increases faster than income – better-off consumers discard edible foods that they would eat were they poorer. Third, as incomes increase, the share of food consumption

[20] Harry de Gorter "Economics of Food Losses and Waste: Concepts and Practical Implications," Cornell University unpublished manuscript, 2014, offers a nice exploration of the economics of food losses and waste for those seeking far more detailed insights than those I briefly offer here.
[21] de Gorter 2014, p.2.
[22] For a more in-depth discussion of the drivers of food security, see Christopher B. Barrett, "Food Security and Food Assistance Programs," chapter 40 in Bruce L. Gardner and Gordon C. Rausser, eds., *Handbook of Agricultural Economics, volume 2B,* Amsterdam: Elsevier Science, 2002; or Christopher B. Barrett and Erin C. Lentz, "Hunger and Food Insecurity," chapter 28 in David Brady and Linda M. Burton, editors, *The Oxford Handbook of Poverty and Society,* Oxford: Oxford University Press, in press.

represented by processed foods and food-away-from-home – consumed from street vendors, restaurants and the like – grows. But processing and retail sale of prepared foods both increase food loss and waste relative to consumption of unprocessed food at home. Finally, increased real incomes raise the opportunity cost of people's time, thereby diminishing their willingness to take time to save food rather than waste it. A well-off farmer can afford to lose $100 worth of crop willfully that a very poor farmer would work feverishly to capture.

In sum, we need to be careful about paying too much attention to PHL rates if our core concern is food security. While it is surely true that technologies and policies that can costlessly and exogenously reduce PHL will enhance food availability and potentially thereby bring down food prices and boosting food security, it is unclear whether such technologies or policies exist. And if the endogenous increase in PHL due to the first-order effects of food price reductions and income growth unrelated to PHL reduction trumps exogenous decreases in PHL, then we could easily observe PHL rates covarying negatively with indicators of food insecurity and malnutrition. Since it is impossible to unpack the endogenous and exogenous components of PHL in data, the plausibility of such a relation should caution observers against reading to much into simple correlations between PHL rates and food security indicators.

Conclusions

Post-harvest loss reduction is an admirable objective. All else equal, we certainly want to reduce food loss and waste, especially in food insecure regions where PHL rates are especially high. But the problem is that things are never equal. PHL is the inevitable by-product of elongating food supply chains, changing diets and food consumption patterns, rising incomes and falling real food prices. Moreover, in Africa and Asia, the two regions where food security concerns are greatest and where food availability must grow most quickly to meet the disproportionately rapid expansion in demand anticipated in the coming decades, PHL will fall naturally as infrastructure improves. And the gains to infrastructure improvement almost surely accrue principally through pathways other than PHL reduction. So as Rosegrant et al. conclude, PHL is almost surely less important than agricultural research and development in terms of the benefit-cost ratio for advancing food security objectives. Indeed, I suspect PHL reduction is less important than any of several alternative uses of scarce investible resources.

The challenge of ensuring the food security of 9-10 billion people a few decades from now must focus primarily on three pillars. The first is agricultural productivity growth in Africa and Asia, where most income growth and virtually all population growth over the coming 50 years will happen and where agricultural yields are low by global standards, only one-third those of the highest-income nations.[23] Given inevitable and substantial demand growth, comparable supply expansion is needed and without pushing into ecologically fragile forests, drylands and wetlands not yet cultivated. Yield gaps result from a wide variety of technical and economic causes, including constrained access to land, water,

[23] Tilman et al. 2011.

nutrients, high-quality genetic material, extension services, storage facilities, transportation infrastructure, finance, and markets,[24] although access to land and water are likely to be the most limiting factors going forward. Indeed, we need to develop better methods and incentives to conserve scarce soil nutrients and water. NRM in agriculture has traditionally been underemphasized compared to the development of improved plant and animal genetic material. But as increasing natural resource scarcity starts having ever greater impacts on agricultural productivity and risk, greater thought must be given to – and more rigorous evidence developed about – prioritization among various breeding- or NRM-based approaches to stimulating productivity growth and resilience.

As Rosegrant et al. demonstrate, significant investments in AR&D – and improved NRM – offer attractive BCR for achieving such productivity growth and the ultimate food security objectives. Such investments consistently generate average annual rates of return of 30-75%,[25] although the precise return on investment is difficult to estimate due to attribution problems and temporal lags. Yet only $3 billion per year is spent annually on research on the seven major crops worldwide, and only 10% of that is targeted towards research to help small farmers in Africa and Asia, whose climate and soil conditions and pathogen and pest pressures differ markedly from those faced by farmers in higher-income, temperate zones. Renewed commitment to revitalization of food and agricultural research, education and extension institutions, especially in Africa and Asia, is essential to avert further food crises. Renewed attention is needed in research prioritization where, for example, insufficient scientific evidence exists on the relative merits of 'land sharing' strategies founded on agro-ecological approaches vs. 'land sparing' methods based on agricultural intensification.[26] We need to know more about how best to use increasingly scarce land and water to accelerate yield growth and improve resilience in the face of abiotic and biotic stresses while reducing agriculture's adverse environmental impacts.[27]

Moreover, since most of the poor in developing countries live in rural areas and derive significant income from agriculture, growth in agriculture has been shown to be two to three times as effective at reducing poverty as growth in non-agricultural sectors, making agricultural investment especially pro-poor and thereby helping with the second pillar: poverty reduction.[28] Whether through direct income growth or through social protection programs that ensure the access of the poor to a nutritionally adequate diet even when calamities strike, food access remains the biggest driver of food security today.[29]

The third pillar concerns enhancing access to and availability and utilization of micronutrients, the minerals and vitamins that are essential to good health. Although more people in the world suffer from micronutrient deficiencies than from either

[24] Godfray, H. Charles J., John R. Beddington, Ian R. Crute, Lawrence Haddad, David Lawrence, James F. Muir, Jules Pretty, Sherman Robinson, Sandy M. Thomas, and Camilla Toulmin. "Food Security: The Challenge of Feeding 9 Billion People." *Science* (February 12, 2010) 327: 812-818.
[25] FAO 2009; Alston, Babcock, and Pardey. 2010.
[26] Tilman et al. 2011.
[27] David R. Lee and Christopher B. Barrett (eds.). 2001. *Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment*. New York: CABI Publishing; Godfray et al. 2010.
[28] World Bank 2007.
[29] Barrett 2002; Erin C. Lentzand Christopher B. Barrett. "The economics and nutritional impacts of food assistance policies and programs." *Food Policy* 42 (2013): 151-163; Barrett and Lentz, in press.

undernourishment (i.e., insufficient calorie and protein intake) or obesity/overweight, much of the policy debate and foresight analysis remains focused on staple grains that contribute relatively scant micronutrients to contemporary diets. As a direct result, reductions in the prevalence of micronutrient deficiencies have been substantially smaller than in the prevalence of undernourishment.[30] This reflects the global community's longstanding emphasis on improving agricultural productivity and decreasing the real prices of staple grains, which are inferior dietary sources of most micronutrients. This matters because micronutrient deficiencies are far less amenable to resolution through increased farm-level productivity of staple crops and because the prevalence of micronutrient deficiencies also decreases far less quickly than undernourishment in response to income growth.[31] Yet we know remarkably little about the most cost-effective intervention points within food systems through which micronutrient deficiencies might be addressed, from biofortification of seed, to pre-planting mineral amendments to soils and water, to post-harvest preservation of vitamins and of minerals in processing, to fortification of food with essential minerals during processing, to consumer education and subsidies or taxes to change relative prices among food groups.

Assuring the food security of the 9-10 billion people who will inhabit the planet by the end of this century, most of them in Africa and Asia, is a major challenge. A wealth of cost-effective interventions exist that can help the world meet that challenge. Reducing post-harvest loss of food is almost certainly a cost-effective intervention. But as Rosegrant et al. convincingly demonstrate, it seems highly unlikely that PHL reduction is among the highest return options in benefit-cost terms.

[30] Miguel I. Gómez, Christopher B. Barrett, Terri Raney, Per Pinstrup-Andersen, Janice Meerman, André Croppenstedt, Brian Carisma, and Brian Thompson. "Post-green revolution food systems and the triple burden of malnutrition." *Food Policy* 42 (2013): 129-13; FAO, The State of Food and Agriculture: Food Systems for Better Nutrition. Rome: FAO, 2013.
[31] FAO 2013; Gómez et al. 2013; Christopher B. Barrett and Leah E.M. Bevis, "The Micronutrient Deficiencies Challenge in African Food Systems," in David E. Sahn, editor, *The Fight Against Hunger and Malnutrition: The Role of Food, Agriculture, and Targeted Policies.* Oxford University Press, in press.

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Copenhagen Consensus Center is a think tank that investigates and publishes the best policies and investment opportunities based on how much social good (measured in dollars, but also incorporating e.g. welfare, health and environmental protection) for every dollar spent. The Copenhagen Consensus was conceived to address a fundamental, but overlooked topic in international development: In a world with limited budgets and attention spans, we need to find effective ways to do the most good for the most people. The Copenhagen Consensus works with 100+ of the world's top economists including 7 Nobel Laureates to prioritize solutions to the world's biggest problems, on the basis of data and cost-benefit analysis.

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