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Food systems and human health and nutrition:

An economic policy perspective with a focus on Africa

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Abstract

Food systems and human health and nutrition are closely linked in Africa and elsewhere. Changes in food systems caused by policy interventions and other drivers of food systems may result in positive or negative health and nutrition effects and changes in health and nutrition may influence food systems. These two-way causal relationships offer important opportunities for improving health and nutrition through policy interventions in food systems. Unfortunately, such opportunities have not been exploited. While policies and projects aimed at the food system may be justified by the existence of hunger, malnutrition and poor health, they are not usually designed in such a way as to seek the greatest possible positive health and nutrition effects. Food systems and health are treated as two isolated sectors and the need for broad-based integration called for by many remains an illusion.

Clearly identified pathways between the two sectors are essential to help design food and health policies with mutual benefits. This paper addresses such pathways from food systems to health and nutrition. While increased availability of food, clean water, good sanitation and health care are essential, they are not sufficient to assure positive health and nutrition effects. Lack of money and gender-specific lack of time as well as prices of these basic necessities may preclude access. Furthermore, the behavior of the various agents in the food and health systems, including but not limited to consumers, may stand in the way of capturing potential positive health and nutrition effects. Health-sensitive policy interventions in the food system should include not only the producers of food and health care but the complete value system from producers to the final consumer. This paper suggests a set of such policies and discusses how a set of key drivers of food systems affect health and nutrition.

Food systems and human health and nutrition: An economic policy perspective with a focus on Africa

Introduction

Most human health and nutrition problems, including obesity and related chronic diseases, in Africa and globally originate in the food system. Zoonotic microbes alone account for more than 50 percent of all human diseases. "Agricultural production, food systems and population health are intimately linked" (Hawkesworth et al. 2010, p. 3083). Interventions to influence the pathways through which the adverse health and nutrition factors flow would seem to offer very promising opportunities for improving human health and nutrition. "A clearer understanding of the links between the agriculture and food system and population health will ensure that health becomes a critical driver of agricultural change" (Hawkesworth et al. 2010, p. 3083).

Unfortunately, this prediction may be too optimistic. As stated by Lock et al. (2010, p. 1699) "agriculture and health sectors are largely disconnected in their priorities, policy, and analysis". Research and policy interventions tend to be sector-specific. Health problems are addressed through health policies and programs while the design and implementation of food system policies rarely consider health and nutrition goals; except in very general terms when the prevalence of poor health, hunger and malnutrition is used to justify food system policies. There are many examples of proposals and plans that blatantly and unashamedly use the existence of poor health and malnutrition to argue for intervention in the food system without ever suggesting how the intervention would improve health and nutrition or explicitly incorporating action to try to achieve improvements.

Explicit attempts to design and implement food system policies for the greatest possible positive health and/or nutrition effect and avoidance of negative ones are few and far between. There are at least two plausible explanations for that: Either it is assumed that the proposed changes in the food system will automatically result in improved health and nutrition without any explicit consideration of these outcomes or the existence of human misery is used as a means of getting the desired action irrespective of the impact on such misery. The former is usually wrong and the latter is unethical. My argument is not that improved health and nutrition should be the only or even the primary goal of all policy interventions. Instead my point is that if the need to improve health and nutrition is used as a justification for doing something, that something should incorporate explicit attempts to achieve such improvements.

Increasing and more volatile food prices and widespread concerns about future food supplies and unsustainable management of natural resources have drawn the attention of the news media and policymakers. Although most recent policy responses have been of a short-run nature, a consensus is developing – at least rhetorically - among national policymakers and international organizations that investments in agricultural development must be accelerated. Thus, members of the G8 and G20 have committed large increases in international economic support for such investments and some developing countries such as Ethiopia and Ghana are planning large new investments. While most of these recent initiatives focus on expanding food supplies, there is an increasing understanding that merely making more food available will not assure better food security, nutrition and health at the household and individual levels (Herforth, Jones and Pinstrup-Andersen forthcoming; Pinstrup-Andersen 2012; Hawkes and Ruel 2006). The International Obesity Task Force suggests a three-pronged strategy: include nutritional criteria in

agricultural policies, undertake health impact assessment of such policies, and provide support for agricultural programs aimed at meeting WHO's dietary guidelines (Hawkes 2007). It matters for health and nutrition how the increasing food supplies are brought about and of what it consists.

While this is not a new argument (Pinstrup-Andersen, de Londono and Hoover 1976; Pinstrup-Andersen 1981; WHO 2004), its application in the design and implementation of food system policies and investments, including agricultural development investments, has been very limited. Unfortunately that is still the case, but a renewed attention to the importance of guiding food system activities towards improved health and nutrition is visible in recently developed plans and proposals. For example, the Global Agriculture and Food Security Program (GAFSP), which facilitates the distribution of some of the G8 and G20 $20 billion commitments, prescribes that country proposals for funding of agricultural development projects must show a clear pathway from the proposed agricultural changes to human nutrition (GAFSP N.d.).

The recently established Scaling-up Nutrition (SUN) Framework and Roadmap – endorsed by over 100 partners, including Chief Science Officers (CSOs), academia, bilateral partners, UN agencies, the private sector, foundations and the World Bank – identify the need for action to address malnutrition through agriculture and other sectors. Several recent documents by the Department of International Development (DFID), the European Commission, USAID's Feed the Future Guide and World Vision have focused on how to strengthen the nutrition effects of agricultural development projects and policies (Herforth 2012 and SUN Framework for Action 2010). An international conference hosted by the International Food Policy Research Institute (IFPRI) on "Leveraging Agriculture For Improving Nutrition and Health" in 2011 brought together a large number of people to discuss how best to proceed on this matter. The output from the conference includes a large number of publications and follow-up activities (IFPRI N.d.).

The increasing attention to the link between the food system and human nutrition is also an outcome of the failure of past nutrition interventions to significantly reduce the widespread household food insecurity and nutritional deficiencies as well as the rapidly increasing prevalence of overweight, obesity and resulting chronic diseases (Hawkes et al. 2012; Nugent 2011). In fact, the world outside China now has more food insecure and nutrient deficient people than it had a decade ago, and the prevalence of obesity-related diabetes, high blood pressure and cardio-vascular diseases is increasing at very rapid rates. With only three years away from the Millennium Development Goals (MDGs) deadline this is a terrible track record, and has led researchers, advisors, policymakers and the news media to look for scapegoats and seek alternative approaches. Scapegoats include the OECD whose agricultural subsidies have been held accountable for the obesity epidemic (Elinder 2005), the Green Revolution which is accused of not having eliminated malnutrition (Food First 2000), the promotion of organic food production methods that result in low yields (Seufert et al. 2012), large-scale industrialized agriculture accused of pursuing profit motives instead of health and nutrition goals (Horrigon et al. 2002), heavy agri-business concentration generating excessive profits and a food processing sector accused of promoting unhealthy foods, obesity and chronic diseases (Nestle and Nesheim 2012).

Some or all of these accusations may be justified. While beating up on them and other postulated contributors or causes of poor health and nutrition makes for good media – it is ideal blog fodder – these accusations may lead to quick, but wrong conclusions and policy advice. A more

constructive way to proceed, now pursued by some national governments and international organizations, is to identify the pathways between food systems and human health and nutrition, and look for interventions that would eliminate negative and strengthen positive effects.

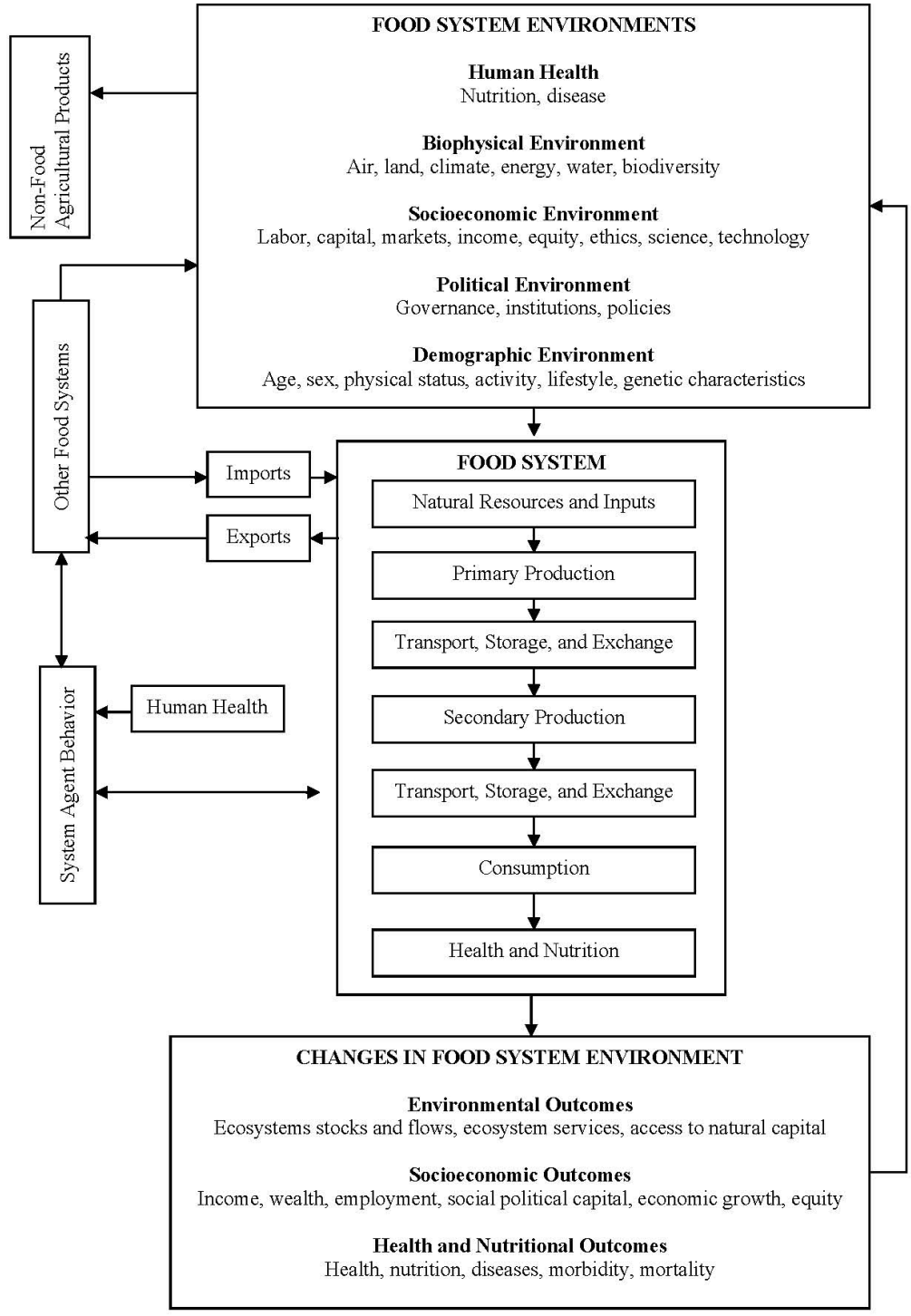
This paper attempts to identify the most important health and nutrition related drivers of food systems and the principal pathways through which food systems affect health and nutrition as well as policy and program interventions that may strengthen the positive health and nutrition effects of food systems and reduce or eliminate negative ones. The next section provides a brief description of food systems and their explicit and implicit goals. The importance of health and nutrition goals relative to other goals pursued by decision-makers and facilitated by the market is discussed along with trade-offs and win-wins. Can health and nutrition goals be achieved without giving up the achievement of other goals considered by the decision-makers to be more important? Can policy interventions be designed and implemented that will be compatible with market signals or will the needed interventions conflict with the signals sent by the market? Widespread health and nutrition problems are undoubtedly a market failure that requires intervention by society. The question is whether such interventions should work with or against the market.

The third section discusses the main food system drivers related to health and nutrition and the potential policy interventions. The fourth section presents magnitudes and nature of the health and nutrition challenges globally and for Africa that relate to food systems, and suggests the main pathways through which the challenges are transferred from the food system to human health and nutrition. The fifth section summarizes the current gaps in the evidence relevant to the topic of the paper and research needs followed by suggestions about how food systems can be designed to strengthen human health and nutrition. A short conclusion ends the paper.

Food systems and their goals

A food system, as defined here, is a system that includes all food-related activities, the health, biophysical, socioeconomic and demographic environments within which these activities occur, and the socioeconomic, environmental, and health and nutrition outcomes (Figure 1). Each of the environments and activities may be affected by government policy and action taken by various stakeholder groups including farmers, consumers, traders, processors and non-governmental organizations. Understanding the behavior of these actors and stakeholder groups and what motivates them is essential to understand how the food system functions and how it may be modified. Thus, rather than a linear, one-dimensional model, the food system should be seen as a dynamic, behavioral system that can be influenced by internal and external factors including deliberate action to achieve specific goals (Pinstrup-Andersen and Watson 2011). This dynamism is an important consideration because even though the food system may appear to consist of a neutral supply chain, it is in fact shaped by a set of actions by the public and private sectors and civil society. Food systems may be explicitly tailored to meet health and nutrition goals or such goals may be implicit, assumed or, most often, ignored. A food system has many feedback loops and, although it is frequently presented as a supply chain that begins with land, water, labor, sunshine and plant nutrients and ends when the food is on the consumer's table (the farm to fork notion), it is not linear and has no beginning or end. This is illustrated by the role of health and nutrition which is both an outcome and an input to the food system.

Figure 1: A conceptual framework of a food system



Source: Pinstrup-Andersen and Watson 2011.

A poorly functioning food system contributes to malnourishment in children who grow up to be poor, low productivity adults (Victora et al. 2008). Most of them end up working in the food system, thus creating a self-enforcing relationship between poor nutrition and a poorly functioning food system.

Food systems, whether local, national or global, are expected to achieve a multitude of goals. The prioritization among these goals will depend on the environments within which the food system operates and the relative power of the stakeholder groups. Strong political power held by farmers in the United States, the European Union member countries and Japan has resulted in large government subsidies to support farmer incomes in these countries at the expense of taxpayers and consumers. Consumer groups have been influential in improving food safety and – in some countries – convincing governments not to permit the use of genetic engineering, irradiation and other technology in food and agriculture. Thus foregoing potential nutrition and other benefits while avoiding potential or perceived risks. In a few cases, such as the United States Farm Bills, support for farmers and consumers, the latter in the form of food stamps (the SNAP Program) have been combined through political negotiations.

However, such outcomes are rare in developing countries. Governments in many developing countries have kept food prices low to farmers, while benefitting consumers and expanding government revenues. Although such implicit taxation of farmers is much less prevalent now than in the past, the response by most governments to the recent food price increases was to protect urban consumers, in part by keeping domestic prices artificially low, to the detriment of farmers' incomes. Although nutrition and health goals played only a minor role or maybe no role, such policies can in fact have significant positive or negative nutrition impact. Other goals include the protection of natural resources, animal welfare, promotion of organic production methods and support of the consumption of locally produced foods. Some of these goals are complementary while others compete. Where trade-offs have to be made, health and nutrition goals are usually in a very weak position because health and nutrition generally do not have a powerful vested interest group either within or outside the food system or for that matter within governments. Ministries of health are notoriously weak and usually ignore opportunities for health and nutrition improvement found in the food system.

As mentioned above, health and nutrition goals are frequently mentioned in plans and strategies for the food system, but they are usually not taken into account in the actual execution of the plans. Malnutrition may be used as a justification for undertaking certain food system action but little or no attempt is made to explicitly guide the action to optimize the nutrition impact. Although the intensions may be laudable, the ethics of using malnourished children or poor health conditions as a justification for recommending policy action or obtaining funding for food system initiatives that are not designed to improve child nutrition or health is questionable. Yet, such behavior is common.

The first two reports of the recently created High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE 2011a and HLPE 2011b) fall into that trap. Report No. 1 states on the very first line of the summary and recommendations that "Food price volatility over the last four years has hurt millions of people, undermining nutritional status and food security" (p. 9). Yet there is no discussion about how food price volatility undermines nutrition or how such negative nutrition effects could be alleviated. Efforts to improve nutrition are not mentioned in any of the recommendations or, for that matter,

anywhere else in the report. Similarly, in the first mentioned "principal observation", Report No. 2 states that "close to one billion people are short of food and another billion suffer from various forms of malnutrition in middle and low income countries" (p. 8) without ever returning to efforts to improve nutrition in any of the recommendations. Such findings are particularly worrisome given the name and objectives of the panel.

Key health and nutrition-related drivers of contemporary food systems

Food systems are dynamic and respond to policy changes and changes in the behavior of farmers, consumers, processors, traders and other agents operating within the system. Food systems are also influenced by factors fully or partially external to them, but which may be modified by policy, such as the impact of recent increases in food prices and more volatile prices. Many other health and nutrition related factors are driving or influencing food systems including economic growth and its distribution, globalization of the food system and related market concentration, urbanization, technological change, population growth and demographic shifts, degradation of natural resources, climate change, land grabbing, rising energy prices and increasing emphasis on the production of biofuel. The way in which these factors may influence the interaction between the food system and human health and nutrition is discussed below.

Food price changes

To the extent that they were transmitted to poor consumers in developing countries, increases in international food prices during 2007-08, 2010-11 and the first half of 2012 reduced purchasing power and access to food by low-income net food buyers. The impact on diets was two-fold: A shift from more expensive calories to less expensive ones and a net reduction in the intake of dietary energy and nutrients (Iannotti and Robles 2011, Robles 2010, and von Grebmer et al. 2011). Although the empirical evidence is scarce, it is likely that the former reduced diet diversity and increased micronutrient deficiencies. The latter would be harmful to those consuming too little and helpful for those at risk of overweight or obesity. Attempts by many governments to control food prices generally failed unless they were accompanied by interventions in supply and/or demand such as trade policies or rationing. Export bans, such as Indian and Vietnamese bans on rice export in 2007-08 were effective in reducing or avoiding the transmission of international food prices to national markets in traditional export countries, while placing upward pressures on prices in the international market to the detriment of net-importing countries such as the Philippines. Social safety nets, including cash or food transfers and targeted consumer food subsidies, were implemented by several developing countries. However, even though a large share of the malnourished were net-buying rural poor, most of these programs were targeted to the urban population, including the non-poor, who threatened government legitimacy. Investments in public goods such as rural infrastructure, market information and certain kinds of research and technology dissemination could help smallholders to become net sellers while facilitating private sector investments and reduced price and production fluctuations at the local levels.

It is unlikely that real food prices will continue to increase. There was a need for a food price adjustment in the beginning of this century. This has now taken place and the long-run real food price trend is likely to be slightly falling. It is very likely that the high degree of food price volatility will continue and possibly increase in the future due to continued extreme weather events caused by climate change and the reactions by governments and speculators to amplify price fluctuations as experienced during 2007-08, 2010-11 and the first half of 2012.

Enforcement of World Trade Organization (WTO) rules against unjustified and abrupt changes in food exports resulting in large changes in international food prices and consideration of new rules might reduce the temptation faced by exporting countries to alter trade policies at the expense of the rest of the world. A new set of rules of behavior for speculators in futures markets could also reduce the severity of future price volatility. Public and privately funded research to develop new food crop varieties tolerant to drought, floods, strong winds, and new biotic risks associated with climate change would be useful to reduce production fluctuations.

Economic growth, urbanization and globalization

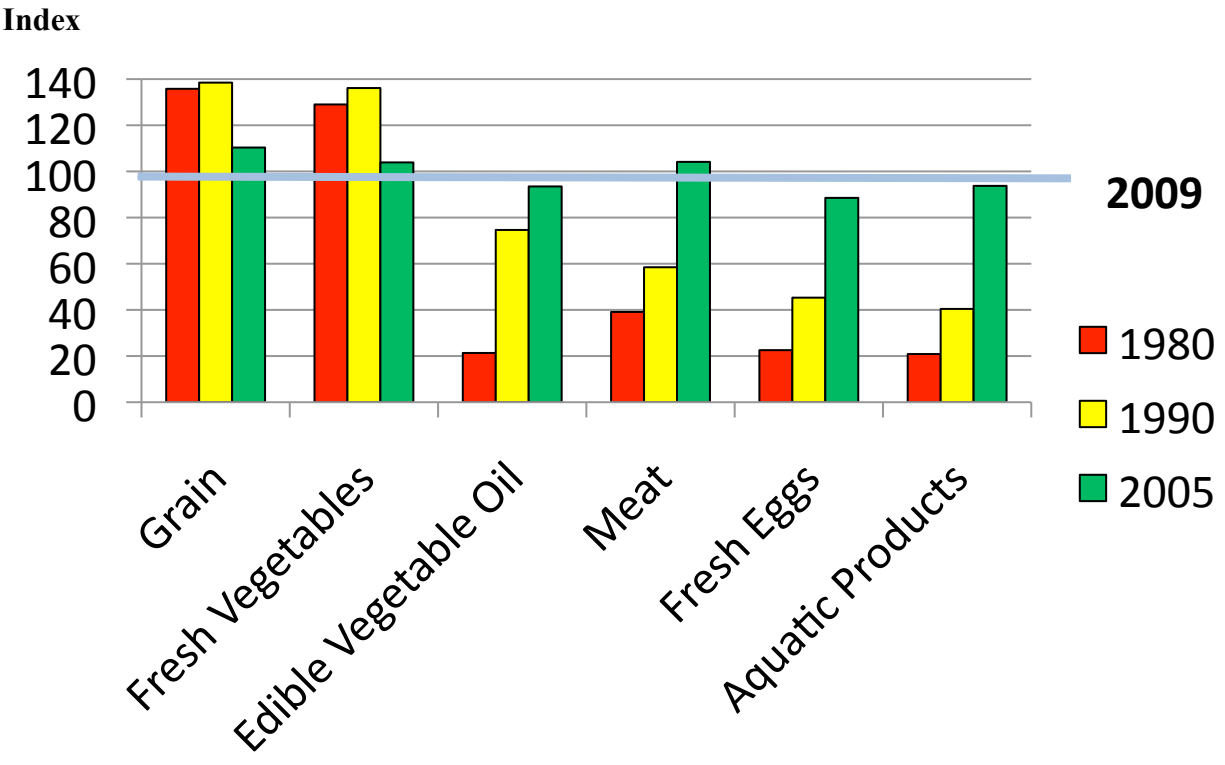
Economic growth, urbanization and globalization contribute to the diet transition, enlarge the supply chain and place new demands on the food system likely to result in changes in relative food prices. Fruits, vegetables and animal source foods are likely to be more expensive relative to staples such as maize and cassava although staple prices will be supported by the demand for animal feed and raw material for biofuel. If these relative price changes are driven by dietary changes among the non-poor, the poor and malnourished will respond by consuming more staples and less fruits, vegetables and foods of animal origin. The result may be further increases in micronutrient deficiencies, overweight and obesity resulting from excessive energy intake and reductions in diet diversity.

Economic growth and urbanization move consumer demand towards higher quality food, an increasing concern for food safety, a more diverse diet shifting from grains to animal source foods and more convenience foods. This demand change is paralleled by the expansion of supermarkets in most developing countries (Reardon et al. 2003 and 2007). The share of the consumer outlay that is captured by the farmer decreases and the post-harvest portion of the food value chain, e.g., processing, fortification and storage, becomes more important. The supply chain becomes longer and the effect of agricultural policies, such as price policies, on consumers and their nutrition becomes less pronounced, while policies focused on food processing gain importance (Hawkes et al. 2012). Promotion of value chains in which health and nutrition goals play a major role offers new opportunities for strengthening the health and nutrition effects of the food system (Gomez and Ricketts 2012). A potential conflict between food safety standards and food security may develop when the former results in higher food prices (Caswell and Friis Bach 2007).

Although the diet transition will differ across countries, the diet transition in China provides a rough illustration of the global transition (Figures 2 and 3). The diet up to 1980-81 consisted primarily of grains and vegetables. Energy and nutrient deficiencies as well as infectious diseases were widespread. This pattern is characteristic of very low-income countries. By 1990, the consumption of vegetable oil and foods of animal origin had increased very significantly while

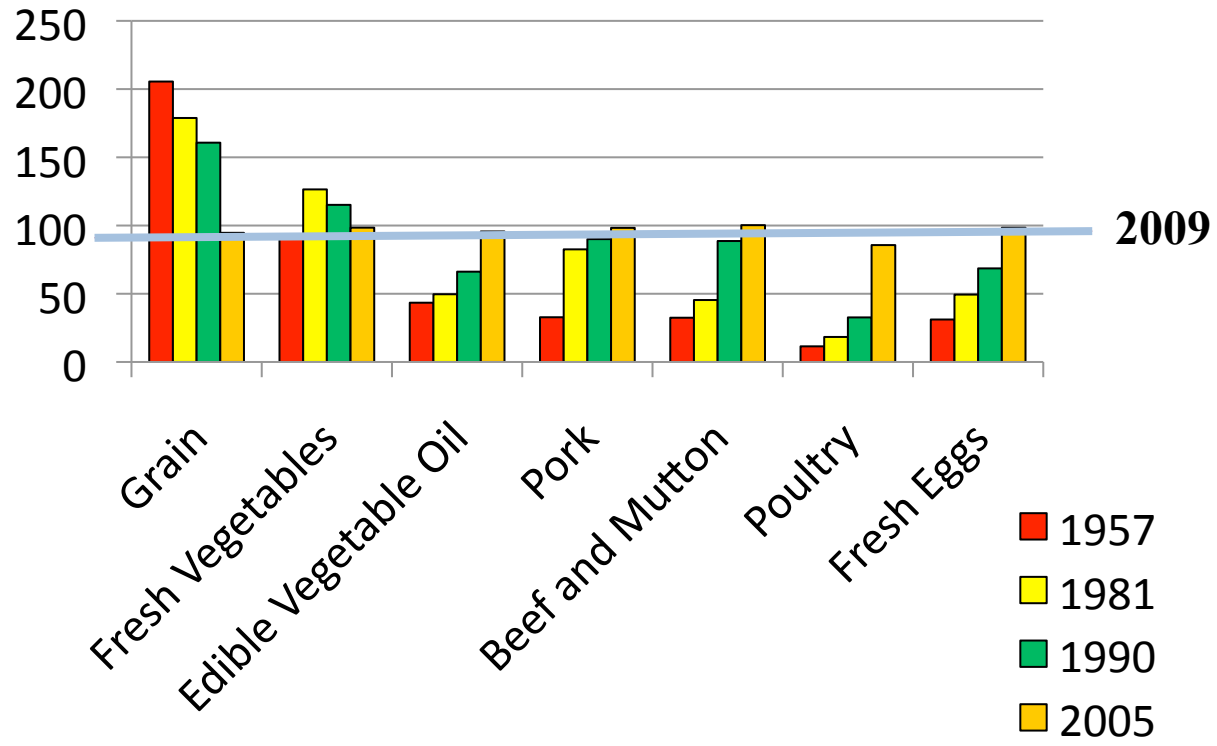
the consumption of cereals and vegetables stayed constant. Thus increasing both calorie and nutrient intake, characteristics of many lower middle-income countries. Poverty and energy deficiencies decreased dramatically due in large measure to changing agricultural policies and related rural development. As the consumption of vegetable oil and foods of animal origin jumped to new highs, grain and vegetable consumption dropped. The prevalence of overweight and obesity increased, a common development for middle-to-high income countries. Projections are that the trend towards excessive intake of dietary energy, a higher prevalence of obesity and a larger burden of chronic diseases will continue for the foreseeable future. An understanding of where a particular country or community is in the diet transition is important to identify the most appropriate policy interventions. Given the large variation among communities and cohorts of people in a given country, policies may have to be targeted.

Figure 2: Per capita annual consumption of selected food groups by Chinese rural households (Index, 2009=100)



Source: NBS China Statistical Year Book 1987 and 2010.

Figure 3: Per capita annual consumption of selected food groups by Chinese urban households (Index, 2009=100)



Source: NBS China Statistical Year Book 1987 and 2010.

While food supply chains are becoming longer in most African countries, campaigns to prioritize the consumption of locally produced food are attempting to shorten supply chains in higher-income countries by bringing farmers and consumers together at farmers markets and reducing or eliminating the input from other market agents. It is interesting to note that both the lengthening of the supply chain driven by supermarkets and better storage and transportation facilities in developing countries and the shortening in higher-income countries may reduce nutrient losses and food safety risks from mycotoxins found in inappropriate storage and transportation activities. A shortening of the food supply chain may also result from urban agriculture and kitchen gardens.

The demand for organically produced food is increasing rapidly in higher-income countries. Organic production methods may have positive health effects due to reductions in the use of pesticides, antibiotic and other inorganic chemical agents, and smallholder farmers may gain from a price premium. In a recent review of available evidence Smith-Spangler et al. (2012, p. 348) concluded that "consumption of organic food may reduce exposure to pesticide residues and antibiotic-resistant bacteria." The same review concluded that "the published literature lacks strong evidence that organic foods are significantly more nutritious than conventional food" (p. 348). The findings have been hotly contested in the news media, e.g., Bittman (2012). An earlier systematic review of the evidence concluded that "evidence is lacking for nutrition-related health effects that result from the consumption of organically produced foodstuffs" (Dangour et al. 2010, p. 203), while Worthington (2001) found that organic crops contained significantly more

vitamin C, iron, magnesium, and phosphorus and less nitrates than conventional crops, and she concluded that "there appear to be genuine differences in the nutrient content of organic and conventional crops" (p. 161).

As developing countries liberalize their food and agricultural markets and open up for food import, processed energy-dense food products become more readily available (Hawkes 2006, Young 2012). Both energy intake and diet diversity are likely to increase and the higher content of refined sugar, sweeteners, fats, oils and salt and the lower content of fiber and nutrients will likely cause obesity, increasing health risks and diet deterioration. Diet diversity is critically important for nutrition but diet diversity resulting from a shift towards more processed energy-dense foods is not what improved nutrition calls for. Globalization is also correlated with increasing concentration of wholesale food and retail, including a rapid increase in supermarket chains. Smallholder farmers may find it difficult to meet the supermarkets' demands for higher levels of food safety, uniformity, quality and appearance. Government policy to facilitate contract farming and reduce post-harvest costs for smallholders such as legislation to enforce contracts, set standards and measures, and investments in rural infrastructure and domestic markets would be options to consider (Minot 2009, Birthal and Joshi 2009).

Research and technological change

Research and technological change in agriculture and the post harvest value chain deserve much credit for the current ample food supply. Modern scientific methods, including that based on molecular biology and nanotechnology together with technological innovations in information and communication technology offer tremendous opportunities for meeting future food demand at reasonable prices. However, to achieve sustainable food security and improved health and nutrition, research and technological change should be focused on sustainable productivity increase of a diverse portfolio of foods with a bias in favor of smallholders and reduced unit-costs of production and marketing. Research to improve the nutritional quality of food through biofortification, post harvest fortification, processing, storage and transportation should be expanded. Low et al. (2007) describes a successful effort to increase vitamin-A intake through biofortification of sweet potato, and research is under way to enhance the content of vitamin-A, iron and zinc in several other staple crops (Bouis et al. 2011). A shift from processing to create foods with a high content of refined sugar, sweeteners, fats and oils to foods with high contents of micronutrients could be promoted through taxes on sugar, sweeteners, fats and oils; government financial support of fortification; research and technology development for nutrient-dense foods such as fruits and vegetables; and educational and promotional programs to alter consumer demand. Inexpensive designer foods for low-income people suffering from nutrient deficiencies, health problems or obesity and diabetes are a dream whose time has come.

Biofuel and competition for resources

Biofuel production based on maize, soybeans, rapeseed, jatropha and oil palm competes with food production for land and water resources while generating incomes for producers. The profitability of biofuel production is closely related to government policies and oil prices, and

future fluctuations in the latter are likely to cause food price fluctuations. Although estimates vary, it appears that the expansion of biofuel production contributed significantly to the food price increases during 2007-08. The nutrition and livelihood impact will depend on the extent of price increase and the proportion of the income increase captured by smallholder farmers with malnourished members. As the production of biofuel on the basis of cellulose becomes more economical, the competition for resources, which reduces food production and increases food prices may be less pronounced. Current blending mandates together with high maize prices and low oil prices in the United States have perverse effects on the availability of maize for human and animal consumption. The mandate removes a fixed quantity of maize from the market, currently about 40 percent of total production, irrespective of the maize and oil prices, thus increasing the fluctuations in the maize price in the rest of the market.

Land grabbing

Land grabbing, i.e., acquisition of control over large extensions of land by multinational corporations or foreign government agencies through agreements with governments in countries where the land is found, may increase agricultural production of foods and non-foods including raw material for biofuel. It may also contribute to economic growth in the communities where the land is located. Employment of landless labor and farmers who previously cultivated the land may reduce rural poverty and improve food security and nutrition. If the additional food produced is sold in the country where it is produced it may lower food prices for the benefit of net buyers. Unfortunately, although solid evidence is limited, it appears that land grabbing tends to push smallholder families off the land they have cultivated providing little or no alternative sources of income. The number of farmers and landless workers that gain employment is small and the destiny of the foods and non-foods produced is usually export (Robertson and Pinstrup-Andersen 2010, Deininger and Byerlee 2011, German et al. 2011, Oxfam 2011, Cotula et al. 2009). While international guidelines for land grabbing exist, there is no indication they are being followed (World Bank 2010, Robertson and Pinstrup-Andersen 2010). Regulatory policies are urgently needed to protect the rural poor from adverse effects of the land grabbing agreements entered into by several developing country governments with little or no consultation with the affected rural poor.

Climate change

Climate change and unsustainable management of natural resources make the achievement of good nutrition difficult. Extreme weather events cause fluctuations in food production and food prices and increasing temperature and changing rainfall patterns make rainfed agriculture in tropical areas more risky and less productive. Unsustainable management of land and water resources will make it more difficult for future generations to produce the food needed. Policies to assist farmers to adapt to climate change and related extreme weather events may be very important means to protect the nutrition and livelihood of the rural poor, notably those in the lowest-income countries (Pinstrup-Andersen and Watson 2011).

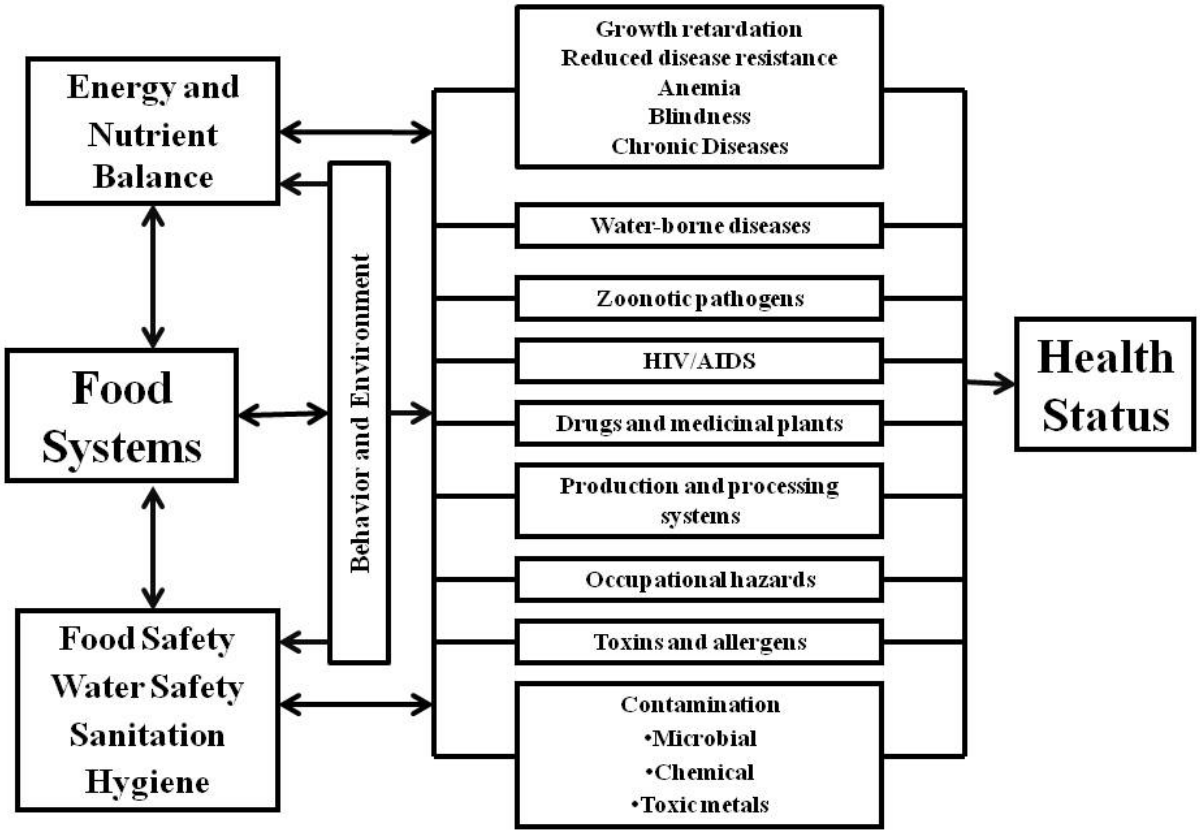
Demographic change

The global population is expected to grow to about 9 billion by 2050 and by another 1-2 billion before stabilizing around the end of the century. Population growth together with increasing incomes and the dietary change towards more animal sourced food is expected to call for a 70 percent increase in food demand by 2050, corresponding to about a 1.4 percent annual increase. This is doable without increasing real food prices if appropriate policies are implemented. From a nutritional perspective, the composition of the food produced and who produces it are critically important. Large-scale, capital-intensive mono-crop production of the kind expected to result from land grabbing exported to middle-income countries may meet production goals but at the expense of food security and nutrition. Policy interventions are needed to guide private investment towards the production of a diverse portfolio of foods that generates income and food security in households with malnourished members and lowers unit-costs of production and food prices. While such a priority by itself does not assure good nutrition, it provides an essential building block.

Magnitudes and nature of the health and nutrition challenges and the main pathways

Imbalances in the intake of dietary energy and nutrients have resulted in a triple burden of malnutrition and related health problems: 1) insufficient intake of dietary energy and protein combined with infectious diseases result in hunger, reduced learning ability, diseases and premature death, and affect close to one in seven people worldwide, one in four Africans and one in three in Sub-Saharan Africa; 2) micronutrient deficiencies cause physical and cognitive deficits, anemia, blindness and reduced resistance to a variety of health risks, affecting around one in four people worldwide; and 3) excess intake of dietary energy result in overweight, obesity and chronic diseases affecting about one in five people worldwide, including both developing and developed countries (Figure 4). Although reliable statistics are scarce, casual observation shows that there is considerable overlap among the three burdens with many people suffering from any combination of two of them.

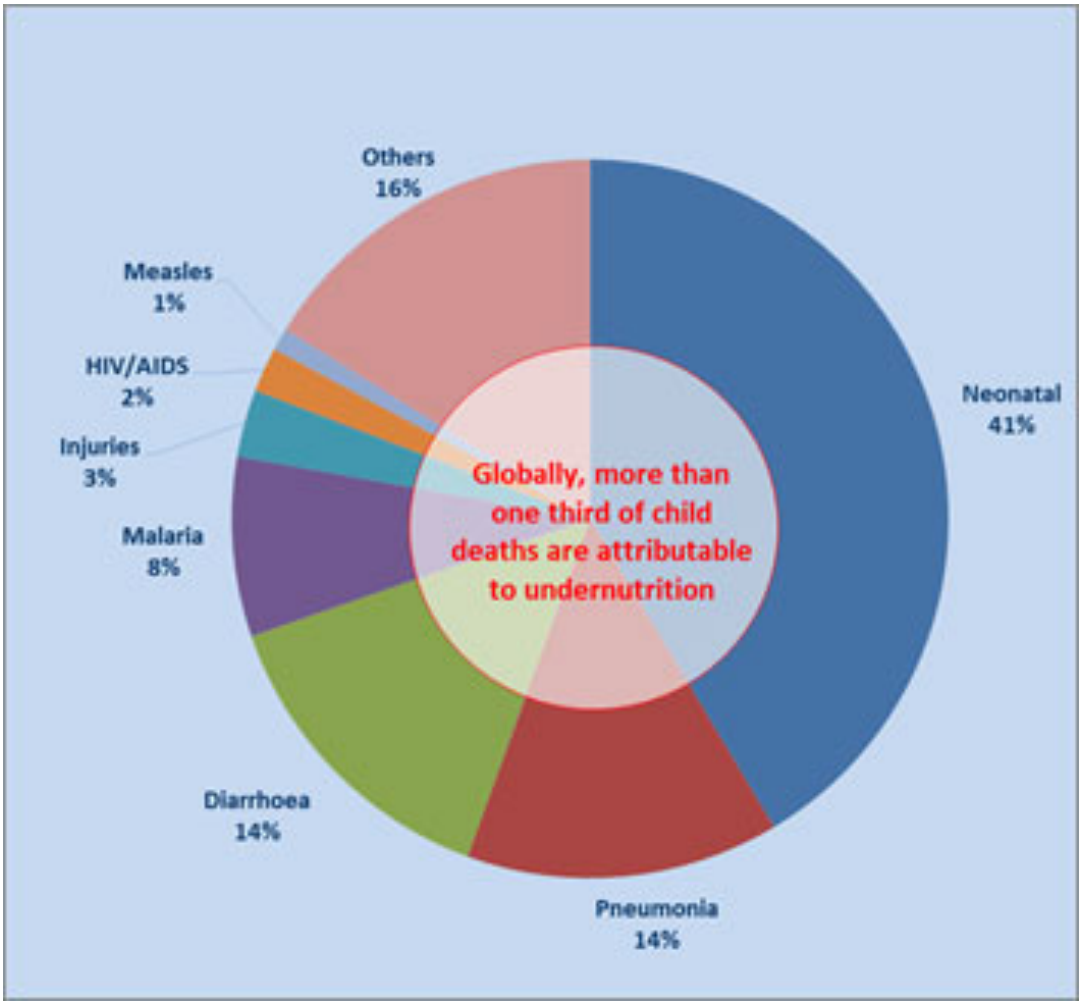
Figure 4: Interactions between food systems and human health and nutrition



Source: Pinstrup-Andersen and Watson 2011.

The prevalence of overweight and obesity is higher among the poor in high and middle-income countries and among the non-poor in low-income countries. The prevalence of energy and nutrient deficiencies is generally higher among rural households while overweight and obesity is more prevalent in the urban population. The triple burden is a very serious global public health problem and an important contributor to slow economic growth, widespread poverty and high rates of morbidity and mortality. Undernutrition is an important contribution to child deaths as it interacts with other health problems (Figure 5).

Figure 5: Causes of under-five deaths in 2008



Source: UNICEF 2012.

About 40 percent of all children in sub-Saharan Africa below the age of five are stunted and 21 percent are underweight compared to a global prevalence of 26 percent and 16 percent respectively. The prevalence of preschool child wasting and overweight in sub-Saharan Africa is about the same as the global prevalence (Table 1).

Table 1: Percent of preschool children who are stunted, underweight, wasted or overweight globally and in Sub-Saharan Africa 2011.

	SSA	Globally
Stunted	40	26
Underweight	21	16
Wasted	9	8
Overweight	7	7

Source: UNICEF-WHO-World Bank 2012.

Table 2 presents a few selected health statistics of relevance to the food system-health interactions. The maternal mortality rate and mortality due to HIV/AIDS and malaria are high relative to the global rates. The prevalence of overweight and obesity in African women is higher that the global prevalence while the prevalence for men is virtually the same for Africa and the world. The African population growth rate is twice the global rate. Access to improved drinking water and sanitation is lower for Africa.

Table 2: Selected health statistics

	Africa	**Globally**
Maternal mortality (per 100,000 live births)	480	210
HIV/AIDS mortality (per 100,000 live births)	160	27
Malaria mortality (per 100,000 live births)	94	12
Obesity prevalence in adults – Males (%)	5	10
Obesity prevalence in adults – Females (%)	11	14
Overweight prevalence in adults – Males (%)	23	24
Overweight prevalence in adults – Females (%)	30	22
Improved drinking water (%)	63	89
Improved sanitation (%)	34	63
Exclusive breastfeeding	33	37
Population growth rate (%/year 2000-2010)	2.4	1.2

Source: WHO 2012 and Kelly et al. 2008.

Overweight, obesity and non-communicable diseases such as diabetes, cardiovascular diseases and cancer cause 60 percent of global deaths. 80 percent of these deaths occur in low- and middle-income countries (Dube et al. 2012). The number of overweight and obese people worldwide has doubled during the last 30 years to the current 1.4 billion or about one in five people. About one-half billion of them are obese. One in 10 adults has diabetes and one in three has raised blood pressure. Is this all the fault of the food system? Certainly not, but changes in the system might make a significant difference.

Malnutrition is a life cycle phenomenon (Benson 2004). Deficiencies during pregnancy and the first two years of a child's life are of greatest concern. The first 1000 days following conception are a very critical period for a child's health and nutrition because damage done during that period tends to be irreversible. Contrary to common beliefs, agriculture and agricultural policy can play a major role in assuring good nutrition during that period partly by assuring that low-income women have access to good nutrition during pregnancy and lactation and the necessary time for check-ups during pregnancy, breastfeeding, child care and food preparation, and partly by producing the energy and nutrient-dense complementary food needed by the children below the age of two years. Local agricultural production to make therapeutic foods for extremely undernourished children, and thereby replacing imported therapeutic food such as Plumpy'nut, is an opportunity that has not been fully utilized. Thus, the commonly expressed argument that the solutions to nutrition problems during the first 1000 days are to be found exclusively in narrowly focused health and nutrition interventions with no role for agriculture and the broader food system is incorrect. A focus on pregnant and lactating women and children below the age of two

years does not imply the exclusion of other population groups. It is a matter of relative rather than absolute priority.

Main pathways

Several pathways through which food system interventions can affect nutrition have been suggested in recent literature. A few are mentioned below.

Hoddinott (2012) suggests the following six pathway components: 1) changes in incomes; 2) changes in crops, farm practices, and markets; 3) changes in crop varieties and production methods; 4) changes in the use of time; 5) change in savings; and 6) changes in intra household resource allocation. Arimond et al. (2011) suggest five pathway elements: 1) increased food for own consumption; 2) increased incomes; 3) reductions in market prices; 4) shifts in preferences; and 5) shifts in control of resources within households. Gillespie and Kadiyala (2012) suggest five pathways between agriculture and nutrition: 1) agriculture as a source of food; 2) agriculture as a source of income; 3) the link between agricultural policy and food prices; 4) income derived from agriculture and how it is actually spent; and 5) the increasing feminization of the agricultural labor force. The latter has the following implications for: women's socioeconomic status, their control of resources, and their ability to influence household decision making and intra household allocation of food, health, and care; their ability to manage the care, feeding, and health of young children; and their own nutritional status, when their work-related energy expenditures exceed their intakes, their dietary diversity is compromised, or their agricultural practices become hazardous to their health.

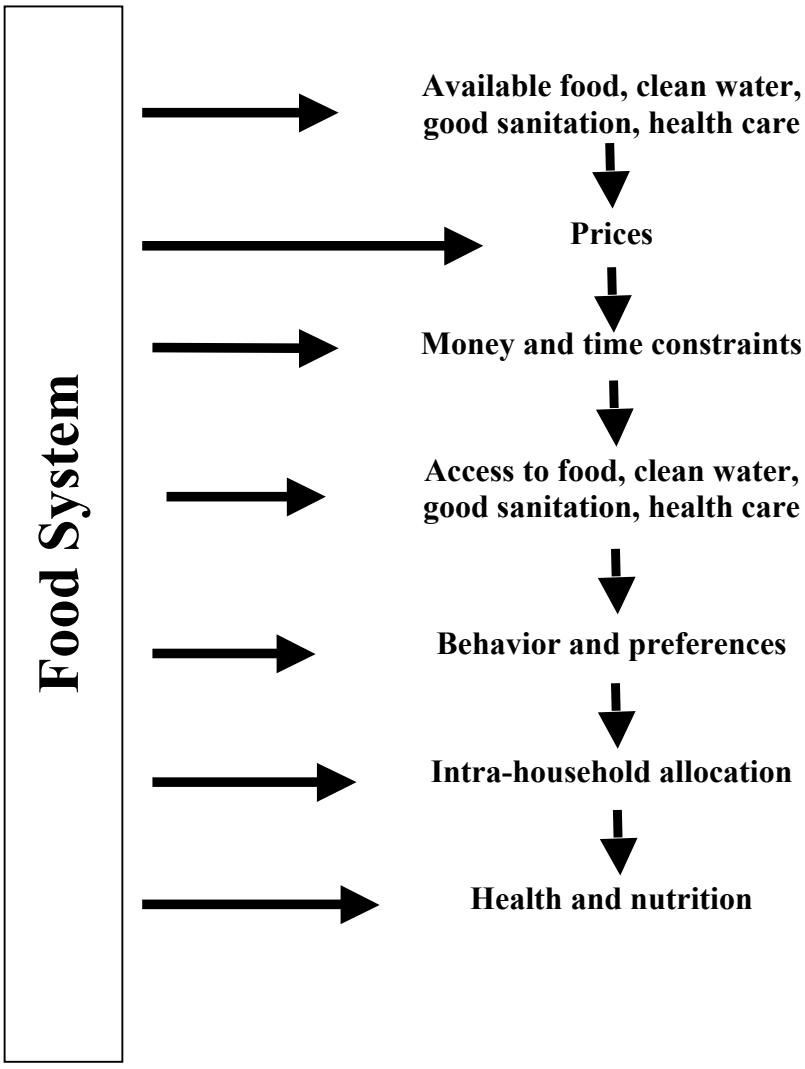
The World Bank (2007) suggests the following five pathways: 1) production for the household's own consumption; 2) production for household income generation; 3) reduction in real food prices associated with increased agricultural production; 4) empowerment of women as agents instrumental to household food security and health outcomes; and 5) the indirect relationship between increasing agricultural productivity and nutrition outcomes through the agriculture sector's contribution to national income and macroeconomic growth. Finally, Jones (2011) has developed a more complete conceptual framework for the interaction between agriculture and child nutrition based on a main pathway consisting of the following five steps: 1) household productive assets; 2) household agricultural production; 3) household food access; 4) child dietary intake; and 5) child nutritional status.

The authors cited above seem to agree that production for own consumption, incomes, prices, gender-specific time allocation, food availability and household behavior provide important links between the food system, household access to food and nutrition. They clearly reject the commonly held notion that the quantity of food produced is the food system's sole link to human nutrition. They also indicate that the nutrition effect of food and agricultural interventions may depend on the presence or absence of other interventions such as interventions to improve sanitation, water quality and hygiene. The World Bank (2007, p. 31) concludes that "agricultural interventions thus cannot be expected to achieve impacts on nutrition outcomes unless they are integrated with complementary efforts to address other issues such as high levels of morbidity and inappropriate child-feeding practices." There is evidence that the effect of food system interventions such as the promotion of export crop production may increase household incomes

and household food security without having any effect on child nutrition (Kennedy et al.1992; von Braun and Kennedy 1994). Such an outcome would be expected where diarrhea or other infectious diseases, or low quality diets rather than lack of food quantity are the most limiting factors in efforts to improve child nutrition.

By being the entry points, the six factors are key components of the pathways through which food systems may affect nutrition. From the perspective of the household, the pathway may be perceived as shown in Figure 6. However, as shown in Figure 4, the nutrition effect of changes in any of these factors will depend on several other components of the pathways. Thus, merely pursuing changes in food availability, incomes, food prices, knowledge, time allocation or behavior will not assure the desired nutrition effects. The complete pathway must be understood to help guide the food system for nutritional benefits. Each of the pathways associated with the five entry points is discussed below.

Figure 6: A generic pathway



Food availability

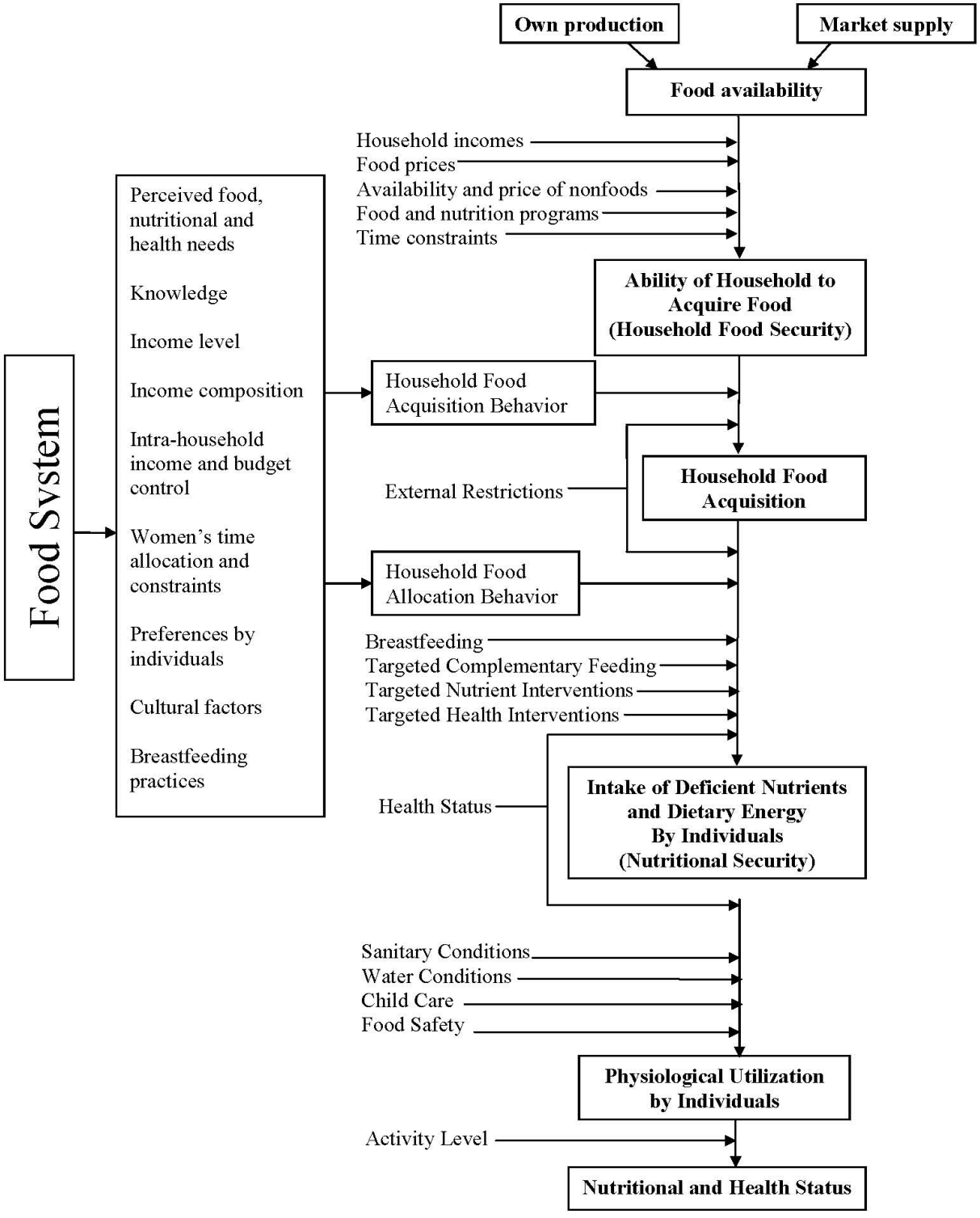
The availability of food is necessary but not sufficient to assure good nutrition. Availability depends on the private sector and government policies. For example, trade liberalization may increase the availability of imported foods with undesirable characteristics such as processed foods with a high content of fats and sweeteners. Investments in research and processing by the private sector may develop new products beneficial or harmful to nutrition. Public and private investments in the food marketing sector may improve food safety and quality. Availability of meat, dairy products, fruits and vegetables may reduce micronutrient deficiencies while availability of fats, oils, sugar, sweeteners and energy-dense, nutrient-poor foods may contribute to overweight, obesity and chronic diseases. A high degree of diversity in the food supply, whether from own production or the market may facilitate consumption diversity and better nutrition.

Opportunities for enhancing consumption diversity, and in that way reducing micronutrient deficiencies, may be pursued on semi-subsistence farms and isolated local wet markets where the diet may consist of one of two basic staples. Research and policy interventions to promote the production, marketing and consumption of so-called "orphan crops", i.e. food crops for which little or no attention has been paid by researchers and policy-makers, offer such an opportunity. Support of home gardens and the promotion of the production, marketing and consumption of animal products such as beef, poultry, pork, goat and sheep meat, and milk would be other initiatives to consider. In locations where water resources are available, the promotion of aquaculture may help improve diet diversity and improve nutrition both through fish and seafood consumption and income-generating sales. The nutritional value of foods may be improved by industrial fortification and biofortification. Industrial fortification may increase the price of food and would not be relevant for food that does not pass through processing. Thus, it would not work for farm families that consume what they produce or buy in the local wet market. To be successful, biofortification depends on farmers' adoption of the fortified seed, and consumers' acceptance, ability and willingness to pay a higher price if necessary.

In addition to processing and fortification, the nutritional quality and safety of foods may be improved or deteriorated by action or lack of action in storage, transportation and other food system activities. Finally, waste and losses in the food supply and consumption chain are large. A recent assessment found that about one-third of the food supply is wasted or lost (Gustavsson et al. 2011). Adding production lost to plant and animal diseases and pest attacks in farmers' fields, the large opportunities for expanding the food available for actual consumption become obvious. Gustavsson et al. (2011) estimate that 1.3 billion tons of food is lost or wasted annually. That corresponds to the calorie needs of 3-3.5 billion people, or about half of the current world population.

While food availability is necessary for good nutrition, changes in food availability will not have any impact on nutrition unless the actual or potentially malnourished people have access. As shown in Figure 7, access, or the ability of households to acquire the food available, is influenced by incomes, own production, food prices, availability and prices of nonfoods and social safety nets. These factors and the related behavioral aspects are discussed below.

Figure 7: A simplified conceptual framework linking food availability, food security, health and nutrition



Source: Pinstrup-Andersen and Watson 2011.

Incomes

Reducing poverty is important but insufficient to eliminate deficiencies and may contribute to obesity (Ecker et al. 2012; Rajkumar et al. 2012). Changes in the food system may affect incomes of the actual or potentially malnourished people in several ways. First, research and technology may generate an economic surplus by improving productivity of land, water or labor, not only in agriculture but in other parts of the food system. Depending on supply and demand, relative demand and supply elasticities and market structure, conduct and performance, the surplus may result in higher incomes (in cash or kind) for farmers, traders and other food system agents, lower prices for consumers or, most likely, a combination of the two. This was exemplified by the effects of the Green Revolution, which lowered unit-costs of production of wheat and rice, increased farmers' incomes and lowered consumer prices. Research and technology may also improve the nutritional quality of foods, e.g. through biofortification. A second pathway through incomes that will change access relates to changes in labor demand, wages and access to productive resources, e.g., land and water, labor-using technology, investments in rural infrastructure, changes in land tenure and water policies, and other fiscal and monetary policies. Third, changes in the food system may change the gender-specific income control as well as the composition of household incomes (cash or production for own consumption), and cash flow over time. Those changes will, in turn, influence household food acquisition behavior and the extent to which access is converted to acquisition. It is also likely to influence the allocation of food within the household. Increasing income and budget control by women is likely to increase the portion of household incomes dedicated to food, particularly as it relates to child feeding.

Prices

Changes in food and non-food prices will influence a household's purchasing power and as such its access to food. Changes in relative prices are also important. Lower prices for one food commodity relative to the price of another will usually increase consumption of the former and reduce the consumption of the latter. Unit-cost reducing technological change in food production, processing and marketing as well as commodity-specific taxes and subsidies and trade restrictions such as export restrictions and import duties are examples of policy interventions that may change relative prices. Before such commodity-specific policies are proposed, it is important to clearly specify the nutrition problem to be solved: is it dietary energy deficiencies, micronutrient deficiencies or obesity-related chronic diseases? Can changing relative prices reduce the importance of one problem without contributing to another?

Most developing countries experience all three of these problems. This makes the choice of price-related policies difficult. For example, taxes on meat, vegetable oil, sugar and sweeteners may reduce the risks of chronic disease among low- and high-income people while increasing the deficiency of iron, essential fatty acids and dietary energy in low-income population groups. If these foods are highly preferred by low-income households, such taxes may also reduce purchasing power and the consumption of other foods which are beneficial for nutrition such as fruits and vegetables. Subsidies on fruits and vegetables may release purchasing power that could be used to acquire foods of lesser or negative nutrient value such as drinks high in sweeteners. Increasing productivity and lower unit-costs of production and marketing as well as price

subsidies for foods such as fruits, vegetables and animal source foods may reduce micronutrient deficiencies.

As already mentioned, food price fluctuations may be harmful to nutrition. Policies to strengthen price information for all food system agents would reduce fluctuations caused by poor market information. Farmer, consumer and trader associations may be useful to facilitate sound competition and avoid hoarding in the food supply chain. Social safety nets are needed to protect low-income people's nutritional status and general wellbeing.

Knowledge

Improved knowledge regarding nutrition and its relations to the food system is needed for all food system agents, including consumers, farmers, traders and policy-makers. Nutrition education and dissemination of information through labeling and social marketing for consumers has been a commonly used tool to improve nutrition with limited success. As might be expected, free-standing nutrition education programs will only be successful where lack of knowledge is the most limiting factor for good nutrition. Labeling, in turn, will only be useful to consumers if they have the necessary knowledge to interpret the label. Labeling can communicate misinformation by making unsubstantiated claims or claims that are clearly incorrect. The Smart Choices Program was accused by some of doing that (Smart Choices Program 2009). Similarly, since there is no reliable evidence that the health risk associated with the consumption of approved foods that contain transgenic elements – the so-called GMOs – is higher than that for foods that do not contain such elements, GMO labeling claiming a higher health risk would not be evidence-based. There may, of course, be reasons other than health risk that motivate countries to label foods. In fact, labeling may be seen as a means to differentiate foods, a goal similar to private branding. However, it is important that neither private branding nor public labeling makes unsubstantiated health claims.

Educational efforts with all the right messages may be of no value if the new knowledge cannot be implemented because of time or income constraints. On the other hand, increased incomes, improved production diversity or reduced pressures on time may be of little or no nutrition value in the absence of the relevant knowledge. Therefore, nutrition education should in most cases be combined with other efforts to remove constraints to good nutrition. Improved knowledge regarding food storage, processing and transportation may be effective in improving nutrition and food safety if the necessary resources are available to implement changes. In some cases, the achievements of nutrition goals may imply trade-offs with other goals but win-wins are common and often overlooked. Examples of win-wins include investments in rural infrastructure (e.g., feeder roads and irrigation facilities), agricultural research, food processing technology, nutrition education and market information, which may increase food production, reduce unit-costs of production and marketing, reduce consumer prices, increase farmer incomes and improve nutrition. Having nutritional improvements as one of the goals of interventions in the food system is preferable to the relegation of nutrition improvements to narrowly-focused food system interventions with the sole objective of nutrition improvement. As discussed later, this poses serious challenges for the evaluation of impact.

Time allocation

Opportunities in the food system for improving – and potentially harming – the nutritional status of pregnant and lactating women and children during the first two years of life are often related to how the food system affects women's time allocation. Projects and policies often seek to empower women and improve their wellbeing as well as that of children by attempting to generate employment. However, some food system practices make breastfeeding, which is critically important during the first six months of life and beyond, very difficult either because employment takes the lactating mother away from the baby for long periods or because the employment activities are otherwise incompatible with breastfeeding. Furthermore, employment creation by women may harm nutrition by reducing their time available for other important nutrition-related activities such as care, cooking, fetching water and firewood and agricultural work. Thus, changes in the food system should consider the net effect of changes in women's time before introducing new demands for women's work. Ideally, ex ante estimates would be based on total household time and efforts should be made to facilitate substitution among adults, e.g., between women and men. There is a general perception that women in poor households are overworked while men have time to spare. While this so in many (most?) cases, it is important to assess this as well as substitution possibilities in each specific situation before making assumptions or introducing policies aimed at the increase of gender-specific labor demand.

Introduction of labor-saving and productivity-enhancing technologies for the work traditionally done by women, such as herbicides to replace weeding, improved equipment for food processing, better access to water and fuel and rural infrastructure to improve food marketing, and the time needed to bring food to the market as well as child care facilities appropriate for the particular situation, are examples of actions that could be considered.

An additional behavioral issue

The critical importance for the impact of policy interventions – the extent to which decisions are made on the basis of rationality – is briefly discussed here. The five factors: food availability, prices, incomes, time availability, and knowledge may be perceived as providing the boundaries within which households make their food and health-related decisions. In an ideal world, health and nutrition needs would be represented in household and individual wants which in turn would be represented in demand. In the absence of the above constraints, the market would be expected to fulfill these demands. In the real world, the constraints exist and the demand is likely to be influenced by a list of factors some of which are mentioned above. Assuming rationality, the consumer would seek to meet perceived (but not necessarily real) needs subject to the constraints, other goals and the cost of achieving them as well as preferences and cultural issues. In addition to removing or reducing the impact of the constraints, government intervention might attempt to change consumer behavior to reduce the gap between perceived and real needs, as well as the gap between needs and wants and the gap between wants and demand. Nutrition education comes to mind.

Recent behavioral research suggests that "the potential for information-based interventions is fundamentally limited, given that it is based on a view of human behavior that is at odds with psychological and neuroscientific evidence that much human behavior is not actually driven by

deliberations upon the consequences of action, but is automatic, cued by stimuli in the environment" (Marteau et al. 2012). In other words, utilitarianism, on which economics and the policy suggestions in this paper is based, is at odds with how people make decisions. If this is so, the way out for policy advisors seems to be to focus on re-arranging the environment to produce the cues needed to achieve health and nutrition goals. A large number of experiments by Wansink (2006) would support that conclusion. If these new findings are interpreted to mean that utilitarianism plays an important role in some but not all decisions, the question becomes how to design activities such as nutrition education for maximum effect. That is not a new question.

Water-borne diseases

Returning to Figure 4, the food system influences health and nutrition through water-borne diseases, bacteria, viruses and parasites associated with poorly functioning irrigation systems and other water management problems in the food system. These system and management problems may cause malaria, diarrhea and other water-borne diseases and reduce labor productivity with negative implications for the food system. Water contaminated with arsenic, cadmium, or other poisonous metals may cause illness through drinking water or the consumption of contaminated fish and plants. Arsenic poisoning is particularly problematic in South Asia where irrigation has reduced groundwater levels.

Zoonotic pathogens

"Animals and humans are intimately connected by diseases" (Torrey 2010, p.58). Most of the microbes causing human diseases originated in animals (Torrey and Yolken 2005; Torrey 2010). HIV/AIDS, avian influenza (H5N1), swine flu (H1N1), Mad Cow Disease and related Cruzfeldt-Jacob disease, Lyme disease carried by ticks from wildlife to humans, measles, tuberculosis, West Nile virus, Hendra virus, Nipah virus, Ebola, and SARS, as well as microbial contamination of food by E. coli, salmonella and other microbes causing diarrhea and other diseases, are examples. The International Livestock Research Institute (ILRI) estimated that more than 2 million people die from diseases that spread from wild and domesticated animals to humans (Grace et al. 2012). Though rarely prioritized and often ignored, policies that would change the interactions between humans and animals, develop resistance in animals to certain diseases, and reduce the population of disease-carrying rodents and other wildlife could reduce the health risks associated with zoonotic diseases. One of the important policy questions related to the intensification of animal production is whether the risk of zoonotic diseases in humans increases or decreases with increasing concentration of domestic animals and associated technological and environmental changes.

HIV/AIDS

HIV/AIDS influences the food system through reduced labor productivity – and resulting poverty – and through an impaired immune system, increased vulnerability to infections, increased nutritional needs, and malnutrition (Gillespie and Kadiyala 2005). The interaction

between food security and HIV/AIDS is particularly important in rural areas of developing countries because of the debilitating effects on agricultural production. In response to death or sickness among adults, farming households may reduce the area cultivated, shift from high-value, labor-intensive crops to crops requiring less labor, such as cassava and sweet potatoes, and spend less time weeding, all of which tend to reduce incomes and increase the risk of poverty and malnutrition. HIV/AIDS is also likely to reduce off-farm incomes and increase expenditures for health care and funerals, leaving less money for the purchase of agricultural inputs (Jayne et al. 2006). On the basis of a review of available evidence, Gillespie (2006, p. 15) concludes that "decapitalization of highly afflicted rural communities, meaning a loss of savings, cattle assets, draft equipment, and other assets, may pose the greatest limits on rural productivity and livelihood for these communities." This is an important consideration for policy design because, instead of a sole focus on labor productivity, it implies a greater emphasis on making capital available to communities with a high incidence of HIV/AIDS.

Drugs and medicinal plants

The food and agricultural system is an important supplier of medicinal plants used in both traditional and modern medicine to treat health problems (Herforth 2010). Such production may be important sources of income among farmers and others in food systems and thus contribute to better diets, nutrition, and health. Although illicit drugs (e.g., marijuana and cocaine) are not foods, they are an important link between the food and agricultural systems and human health, partly because their production generates incomes among the rural poor in producing countries, which in turn may help them improve their health status, and partly because of the negative health effects among users. Like other non-food agricultural commodities such as cotton and crops for biofuel, production of illicit drugs also influences the food system through the competition with food crops for land and water. Supporting alternative remunerative agricultural livelihoods, including through improved infrastructure and agricultural research, can be one method of combating illicit drug use, drug trafficking, and drug-related violence and conflict.

The food system is also a large consumer of drugs such as antibiotics, growth promoters and synthetic hormones. Use of antibiotics in animals has been shown to create antibiotic-resistant bacteria (Science Daily 2007). A drug-resistant form of the bacterium S. aureus (MRSA) found in pigs has recently been shown to jump to humans (Science 2010). Sapkota et al. (2011) found that organic poultry farms have significantly fewer antibiotic-resistant bacteria.

Food production and processing systems

Consumer demand is influenced by preferences, household decision making patterns, incomes and their sources, relative prices, advertizing and promotion, and available food choices. Demand for cotton, coffee, biofuels, and other non-food agricultural production may change health and nutrition among farm families, consumers, and others involved in agricultural production as incomes, relative prices, and available food choices change. Rapid increases in sugar and sweetener consumption are of particular concern because of the high-energy content and lack of nutrients, leading to overweight, obesity, diabetes, and micro-nutrient deficiencies.

Fraudulent or irresponsible practices by farmers and feed producers may result in negative health effects. Two examples illustrate this point. The 2008 Chinese milk scandals which involved the addition of melamine to milk caused urinary tract stones in around 300,000 children, some of whom died (WHO 2009; Wu et al. 2009). In an analysis of the content of meal from chicken feather, a recent study found a class of antibiotics (fluoroquinolones) that are banned in poultry production because they are suspected of contributing to antibiotic-resistant bacteria. The analysis also found antibiotic-resistant bacteria, arsenic, caffeine and active ingredients of Tylenol, Prozac and Benadryl (Love et al. 2012). The study did not analyze whether any of these items were present in the poultry meat. The items re-enter the food system through the use of feather meal in animal feed. Whether and to what extent they will be found in food is not known. The study did not analyze the source of the items but many and possibly all are mixed into poultry feed to improve productivity. Delivery of feed is frequently included in poultry production contracts and farmers may not know the content of the feed.

Excessive consumption of foods of animal origin may lead to various chronic diseases while lack of access to such foods may contribute to risks of micronutrient deficiencies. Chan et al. (2011, p. 1) found that "high intake of red and processed meat is associated with significant increased risk of colorectal, colon and rectal cancers." Pan et al. (2012) found that replacing one serving per day of red meat was associated with a seven to 19 percent reduction in mortality risks. Similar findings are reported by Sinha et al. (2009) and Cross et al. (2007). Pan et al. (2011) found that replacing one serving of red meat with another food would result in a 16-35 percent lower risk of type 2 diabetes.

Agro-ecological or organic production processes may reduce health risks associated with the use of inorganic pesticides but may, at the same time, have negative nutrition effects among low-income consumers because of higher production costs and prices. On the basis of a survey of existing literature Smith-Spangler et al. (2012, p. 348) conclude that "consumption of organic food may reduce exposure to pesticide residues and antibiotic-resistant bacteria".

A key policy question is to what extent food systems (supply factors) influence household and individual food consumption (demand factors) because the answer to that question will help design and implement effective policies. At the one extreme it can be argued that the food system responds to what the consumers want. Thus, policies to change diets to improve nutrition should be focused on demand behavior. At the other extreme, some argue that supply decisions, particularly advertizing and promotion by the food system and the design of processed food, determine what is being consumed. If this is true, policies should try to change supply behavior. The answer is context-specific but in most cases it is the interaction between supply and demand factors that determine what people eat and the related health implications.

Occupational hazards

Occupational hazards are another source of health risks in the food system. According to the Food and Agriculture Organization (FAO) and the International Labour Organization (ILO) (FAO 2010), agriculture causes slightly more than half of all fatal workplace accidents and "is one of the three most dangerous sectors in which to work." "Agricultural work possesses several characteristics that are risky for health: exposure to the weather, close contact with animals and

plants, extensive use of chemical and biological products, difficult working postures and lengthy hours, and use of hazardous agricultural tools and machinery" (Cole, 2006, p. 1). Other parts of the food system, including processing and transportation, also exhibit health risks.

Health risks associated with the application of pesticides and other agrochemicals and the risks associated with pesticide residues in food have received considerable attention, and a series of policy interventions are in place to reduce such health risks. FAO has developed an international code of conduct for the distribution and use of pesticides (FAO 2003). Unfortunately, many developing countries do not follow these guidelines, and where regulations exist they are frequently not enforced. Agrochemicals outlawed in most developed countries are used in many developing countries and sound application methods are not followed. Trade-offs between yield losses due to pests and health risks associated with the application of pesticides are a key issue in policy decisions and farmers' compliance with existing regulations.

Toxins and allergens

Toxins and allergens found in foods may be naturally occurring, e.g., mycotoxins in grains and nuts, or they may be introduced through the application of chemical pesticides or plant breeding. Aflatoxin is a very potent liver carcinogen and is particularly damaging when combined with Hepatitis B or C (Miller and Marasas 2002). Arsenic is a potent human carcinogen found in water, rice, fruit and fruit juice (Consumer Report 2012). It is naturally occurring in soil and water, and added to soil and water through its use in agriculture and industry. Residues from past use of lead arsenate insecticides, use of arsenic in animal feed to prevent disease and promote growth, and application of animal manure as fertilizers are sources of arsenic in food. Production and processing research may remove toxins and allergens or introduce new ones. Testing of modified foods is critical before they are approved for commercial use. Traditional plant breeding and genetic engineering can be used to develop pest resistance in plants to reduce the need for pesticides without yield losses. Much progress has already been made, for example in rice production, where the use of chemical pesticides has decreased significantly (Nelson 2010). The potential of genetic engineering to reduce the need for chemical pesticides to protect plants should be exploited to its fullest.

A large number of acute pesticide poisonings occur worldwide every year. Some pesticides contaminate water and soil. Research is needed to replace pesticides and where that is not possible to permit only those pesticides with very low human health risks.

Price policies may partially determine pesticide usage. Large price subsidies on pesticides in several Asian countries during the first phase of the Green Revolution resulted in significant overuse. In addition to reducing pesticide subsidies, policies that regulate the use of pesticides considered of greatest risk to humans would also help reduce the negative health effects. Organic and other agro-ecological production methods (e.g., integrated pest management) attempt to reduce health risks by only using organic pesticides and by using biological pest control and crop rotation. Some sources of toxins such as Aflatoxin and other Mycotoxins may be difficult to avoid under adverse production and storage facilities and may cause higher health risks than appropriate application of pesticides. The choice of government interventions to reduce health risks associated with toxins and allergens in food is context-specific. Agro-ecologically sound

production systems that draw on science to develop host-plant pest resistance, biological pest control, and deliberate use of pesticides when no other option is available to avoid crop losses provide a starting point for policy design and implementation. Enhanced testing, incentives, and regulations of new foods complemented with certain chemical agents would also be useful to protect consumer health.

Contamination and food safety

Food safety hazards include food-borne pathogens (bacteria, parasites, viruses, and prions), chemical and medicinal residuals in food, growth hormones, and improper antibiotic use that supports the evolution of resistant bacteria. In addition to food safety, the impact of food systems on human health is heavily influenced by the degree of water safety, sanitation, and hygiene. Food contamination may be caused by deficiencies in any of the four in interaction with adverse production, processing, storage and transportation facilities and activities. The outcome may be microbial, chemical and/or toxic metals contamination

Food safety standards tend to be more stringent in high-income than low-income countries (Caswell and Friis Bach 2007). Assuming that higher food safety standards increase food prices, governments may face a trade-off between higher priced, safer foods that high-income consumers want but low-income people cannot afford and less safe, lower-priced food. A segmented food system with dual safety standards may develop with safer food exported and less safe food used for domestic consumption. Food-borne diseases may cause diarrhea, fever, long-term health complications and death (Nakimbugwe and Boor 2010). Diarrhea is a major cause of death in children (Lopez et al. 2006). WHO (2011) reports that about 1.8 million people died from diarrheal diseases in 2005, mostly caused by contaminated food and water.

Evidence gaps and research needs

The impact of food system policies on nutrition and health has not been rigorously evaluated and compiled in the same manner as health interventions. The main reason was given by Bhutta et al. (2008) in a recent *Lancet* article in which they concluded that "interventions to diversify diets by enhancement of agriculture and small-animal production…are potentially promising and culturally relevant, but in general, have only been implemented at a small scale, and have not been adequately assessed…dietary diversification strategies have not been proven to affect nutritional status or micronutrient indicators on a large scale. In view of the weak evidence for the effects of these interventions on human nutrition, we did not attempt to estimate their effects." The problem is that evaluation methods based on controlled experiments – the gold standard and often the only methods perceived to provide reliable results in the health sector – are generally impossible to apply to the food system except for small, usually insignificant projects. Health and nutrition effects resulting from agricultural and other food system policies are very difficult to assess because of the lack of a "control group" as well as the long chain of activities between the policy implementation and the health outcome, the many intervening factors and the impact of uncontrollable behavior by system agents involved. Yet, the big and promising opportunities for health and nutrition improvements are undoubtedly found in such

policies and not in home gardens and other minor projects where a controlled experimental methodology can be used. This is borne out by several recent reports that reviewed the available literature and summarized outcomes of agricultural policies on nutrition. The reports conclude that most available evidence is hampered by methodological problems. A new DFID-commissioned review of nutrition-targeted agricultural interventions over the last 20 years (Masset et al. 2011) found very little impact on child nutritional status, but concluded that the lack of impact might be due to weaknesses in the evaluations rather than inherent weaknesses of the interventions themselves.

A related problem is the small number of studies that make up the evidence base. For example, the DFID review of the available well-designed home gardens evaluations shows an overall significant increase in vitamin A intake attributable to the home gardens; yet the authors conclude that because there are so few studies available, the evidence of home gardens (or any other agricultural intervention) on vitamin A intake is not robust. A greater number of rigorous evaluations of large-scale changes in the food systems are urgently needed.

The DFID review identifies common gaps in available studies, which include poor description and control of selection bias, no analysis of program adoption determinants, and virtually no disaggregation of results by wealth or gender. Of the evaluations reviewed, only two had sample sizes large enough to see a 20 percent change in underweight or stunting, and none had the power to see more modest improvements.

Furthermore, to date there has been little consideration of the impact of food system policies on overweight, obesity and chronic diseases. Given the nutrition transition leading to rapidly increasing rates of obesity and chronic disease worldwide, it is important that potential consequences on overnutrition are considered during the planning of agricultural policy. Yet few evaluations and no literature review have been done on how agricultural policies affect obesity and chronic diseases. An exception is a study of the obesity impact of U.S. agricultural policies (Alston et al. 2010). The study's conclusion that the policies, when taken together, have not contributed to obesity, has been challenged by the Physicians Committee for Responsible Medicine which, under the headlines of "Agriculture and Health Policies in Conflict, How Food Subsidies Tax Our Health" concluded that U. S. agricultural subsidies have very large negative health effects (PCRM 2012). The main reason for the different findings most likely is that Alston et al. (2010) assess the whole U. S. agricultural policy while PCRM focus on parts.

Finally, food system policies typically affect multiple aspects of food systems simultaneously and are deeply rooted in the local context (e.g., the availability of local foods, cultural beliefs, gender norms and divisions of labor, and the policy environment). Therefore, much of the evidence is likely to be context specific and there is a need to undertake syntheses of what is available.

Designing the food system to support human health and nutrition.

Any government policy that affects low-income, food insecure and malnourished people is likely to affect health and nutrition, whether such an effect is intended or not. Nutrition sensitive policy interventions may aim to change factors external or internal to food systems. The former

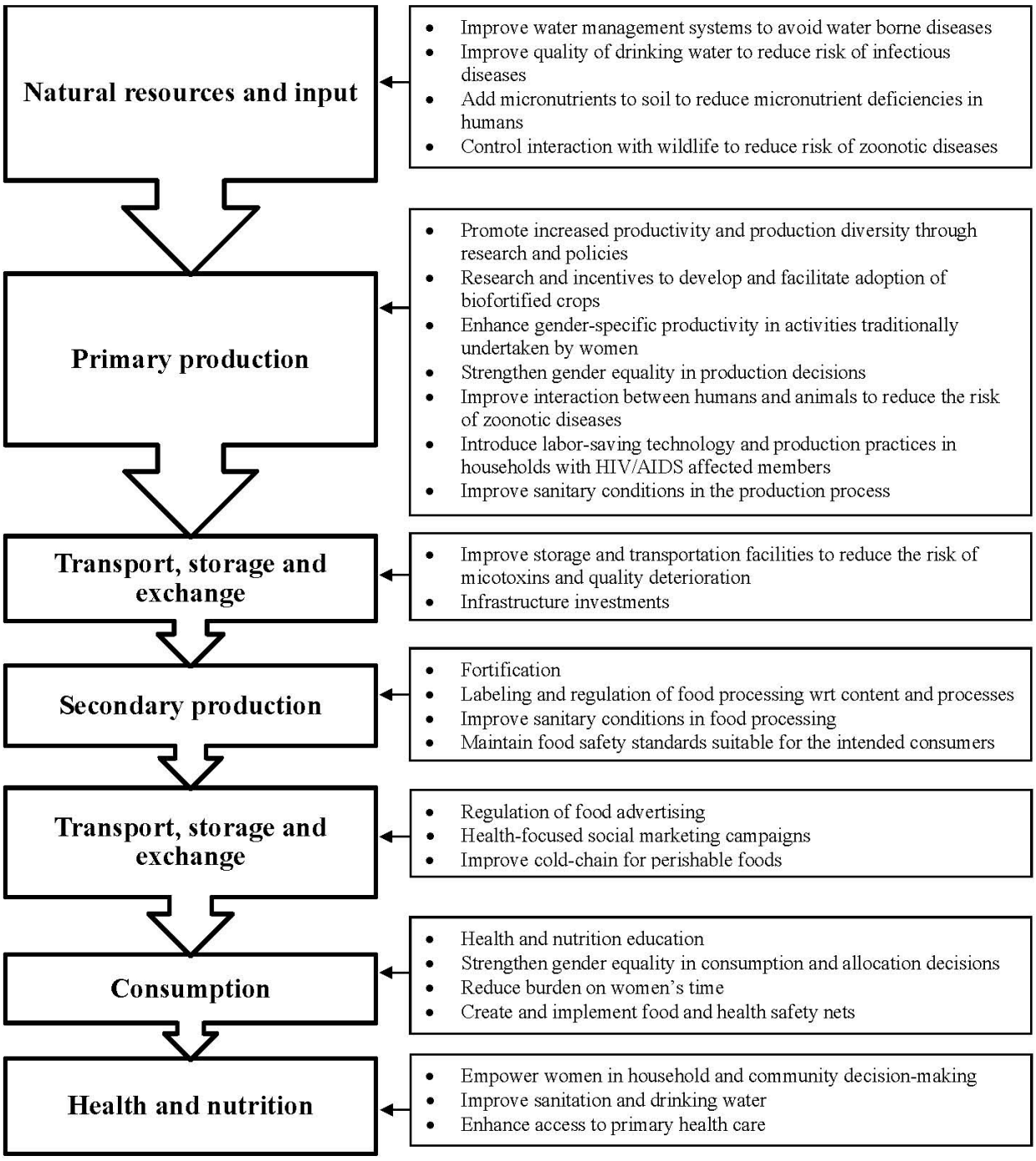
attempts to change the environment within which the system operates while the latter is focused on changing the behavior of food system agents.

Government policy to promote economic growth and employment in low-income countries is likely to have a more positive health and nutrition effect if focused on pro-poor economic growth in rural areas. Macroeconomic and trade policies with no direct aim at the food system or nutrition may have very significant impact on food prices for farmers and/or consumers. Policies to enhance globalization through trade liberalization may create new opportunities for farmers to earn incomes from agricultural exports and at the same time open up food imports which might lower domestic food prices and expand the availability of energy-dense processed foods. Relative prices among foods are likely to change and the nutrition effect may be positive for some population groups and negative for others.

Policies to promote the availability of sufficient food to meet economic demand are plentiful. Many of them are mentioned in previous sections of this paper and include trade policies, regulations of globalization-related inflow of processed food, food systems research and technology dissemination, food fortification, infrastructure investments, risk management and price policy that facilitate a diversified diet. Key in these policies is that they aim to change the behavior of farmers, processors and other suppliers of food to meet economic demand instead of nutrition needs not reflected in demand. The reason is obvious. Farmers and processors producing foods for which there is no market demand at prices that cover costs of production go broke. Therefore, to meet nutrition needs in a market economy, interventions are needed to help assure that nutrition needs are reflected in market demand. Poverty, lack of time, lack of knowledge, uneven distribution of decision-making power within the household, and tastes and preferences, are five reasons why demand and needs may differ. Removing these reasons should be a main goal of nutrition-sensitive policy intervention. Income generation policies and projects and food and cash transfer programs, gender-specific time-saving productivity increases, education and knowledge dissemination, and policies to empower women and protect the rights of children are examples of interventions that may help households match demand to needs.

Although the emphasis of much of the current debate is on the nutrition effects of changes in agriculture this paper has tried to expand the discussion to the health and nutrition effects of food systems incorporating each of the system components. For this purpose a health and nutrition value chain analysis is appropriate (Hawkes and Ruel 2011 and 2012). Policies and other action, including action by the private sector in, for example, processing, storage and transportation may change the nutrition value chain whether intended or not. Figure 8 presents a list of areas for health-sensitive policy interventions along the food value chain.

Figure 8: Illustrations of areas for health-sensitive policy interventions along the food value chain



Source: A revised and expanded version of Table 2 in Herforth et al.forthcoming.

Policy implementation

Nutrition presents very interesting institutional challenges because, contrary to agriculture and health, it is not a sector and it does not have a ministerial home in governments. It is, in the words of Mwadime (2012, p. 153) "a cross-cutting development problem that needs to be integrated into the activities and policies of the agriculture, health, education, and sanitation and water sectors (among others), and featured in the priorities of broader agencies such as ministries of finance and gender." This has turned out to be extremely difficult (Garrett and Natalicchio 2011; Hill et al. 2011), but not impossible. Examples of successful integration of nutrition into several existing ministries and programs include Brazil's Zero Hunger program, Bolivia's Zero Malnutrition program, the nutrition program in Thailand and the REACH program in Lao PDR and Mauritania (Kepple et al. 2012; Hoey and Pelletier 2011; and Pearson and Ljungqvist 2011). Recent initiatives by international organizations including the World Bank, FAO, CAADP and UNICEF, to mainstream nutrition in national and international strategies are expected to further promote successful institutional developments.

While lack of awareness – and a very weak evidence base – of potential benefits from incorporating nutrition goals into food systems policies undoubtedly plays a role, the biggest barrier to the mainstreaming of nutrition in agriculture and the rest of the food system is of a political economy nature (Pinstrup-Andersen and Watson 2011). Each sector develops and protects its priorities and funding. Large potential nutrition benefits may be of little interest to the minister of agriculture if it conflicts with other agricultural goals. One of the context questions to be addressed is whether integration should take place at the national or community level. Identifying win-win propositions in which both food system and nutrition goals can be achieved is an important role for research. Policy interventions may be needed to match nutrition goals with other goals of the food system agents, such as farmers, agri-businesses and consumers, including those suffering from malnutrition who are unable or unwilling to prioritize nutrition improvement.

Concluding comments

As defined in this paper, the food system is the sole provider of food. Given that food is essential for nutrition which in turn is essential for good health and survival, the question is not whether the food system contributes to health and nutrition but whether the contribution could be greater if taken into account in the design and implementation of policy interventions and other changes in the food system. Similarly, the food system influences human health through pathways other than those going through nutrition. A related question is whether explicit incorporation of health and nutrition goals into food system action by government and other stakeholders will force out other goals with greater welfare effects, resulting in a negative net outcome.

Those of us who have worked on nutrition policy issues over a lifetime may feel that improved health and nutrition is more important than the achievement of other goals but that is a bias not necessarily shared by others, including the malnourished. Furthermore, the malnourished and unhealthy are usually poorly represented in the policy-making process and are easily overridden by more powerful interest groups, including sectorial departments, ministries and lobbying groups. Low-income households may prioritize economic survival of the household over the

health and nutritional status of its children by investing whatever meager incomes it has available into its agricultural production, off-farm employment, school fees and non-food consumer goods.

Available empirical evidence supports the conceptual argument that much can be done to improve the health and nutrition effects of food systems, both by strengthening positive effects and reducing negative ones. However, the empirical evidence is weak and suffering from a focus on small food systems projects that by themselves may have little impact which, even when real, may not be easily found with the evaluation tools used. The major nutrition impact of the food system, positive or negative, is associated with large-scale changes in the environments, activities and behavior and not small-scale kitchen gardens. The choice of commodities to receive agricultural subsidies, the market concentration of the agri-food sector, the behavior of advocacy groups, food price volatility and changes in gender-specific employment opportunities and time demands are examples of such large-scale changes.

Unfortunately, the commonly used evaluation methodology, particularly that borrowed from the health sciences, where double-blind randomized experimental designs reign, is more appropriate for small-scale projects. The result has been a body of evidence that is inconclusive, while common sense based on conceptual thinking and field observations would conclude that large unexploited opportunities exists for improving the health and nutrition effects through changes in the food system. There is an urgent need for more research to estimate the health and nutrition impact of large-scale changes in the food system.

While waiting for such research, a number of policy interventions can be proposed that are likely to benefit health and nutrition. It is critically important that such interventions be based on a solution-free specification of the particular health and nutrition challenge, that the relevant pathways and intervention points are identified and that the environment within which the challenge exists is fully understood. A political economy approach, in which the policy process and the relevant stakeholder groups, their objectives and relative power are understood, is most likely to succeed. Merely assuming that improved nutrition overrides all other food system goals, even if the head of state or some other high-level decision-maker declare that it is so, will lead to disappointing results. Instead, efforts should be made to identify multiple-win strategies in which nutrition goals can be achieved along with other goals of importance to the constellation of stakeholder groups, including households and individual household members.

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Core literature on Food Systems and Human Health and Nutrition: An economic policy perspective with a focus on Africa

Hawkes, C., Friel, S., Lobstein, T., and Lang, T. 2012. Linking agricultural policies with obesity and noncommunicable diseases: A new perspective for a globalizing world. *Food Policy* 37(3): 343-353.

This paper develops a series of hypotheses on the relationship between agricultural policies and consumer diets. The first hypothesis is that a paradigm shift has led to greater specialization of production, so changing the ability and incentive for producers to supply certain foods relative to others. Second, the shift has affected farmgate prices, creating opportunities for the industries which purchase farm commodities to substitute lower priced ingredients, thereby influencing the nutritional quality and content of foods available in the marketplace. Third, it has increased the ability of the food industry to "add value" through product innovation and marketing, creating a market characterized by highly differentiated products targeted to individualized preferences, thus increasing the acceptability of a wider variety and quantity of food products.

Herforth, A., Jones, A., and Pinstrup-Andersen, P. (Forthcoming). *Prioritizing nutrition in agriculture and rural development: Guiding principles for operational investments*. Washington, DC: World Bank.

Agricultural and rural development provides a critically important opportunity for reducing malnutrition. The purpose of this paper is to provide a set of guiding principles for incorporating nutrition goals into the design and implementation of agricultural and rural development projects, and to provide examples of current best-evidence options for operational investments. Several principles are likely to be important in all or most cases for nutrition-sensitive agriculture, which can be adapted to individual contexts. These include:

1. Incorporate nutritional concerns into the design and implementation of agricultural policies, projects and investments
2. Target nutritionally-vulnerable groups
3. Invest in women
4. Increase year-round access to diverse, nutrient-dense foods
5. Protect health through water management
6. Design poverty-reduction strategies explicitly to benefit nutrition
7. Create enabling environments for good nutrition through knowledge and incentives
8. Seek opportunities to work across sectors.

To help assess which actions are most relevant for a specific situation, a set of key questions are included after each broad principle. The paper also highlights areas where agricultural investments may be in danger of causing harm, and provides options for improving policy coherence.

The principles underscore investments in people and systems that have the potential to transform underlying conditions and positively influence the multiple, proximal determinants of proper nutrition. Further research and evaluation priorities include tracking impact on multiple outcomes at once (such as diet, nutritional status, productivity and income); better designing

studies to attribute impact to specific approaches; and collecting information on costs and cost-effectiveness. Although there is a need to strengthen knowledge around design and implementation strategies, there is good evidence that well-planned investments are likely to reach at least targeted income and dietary outcomes. Existing knowledge around the recommended principles is sufficient to move ahead with designing nutrition-sensitive agricultural interventions.

Lock, K., Smith, R.D., Dangour, A.D., Keogh-Brown, M., Pigatto, G., Hawkes, C., Fisberg, R.M., and Chalabi, Z. 2010. Health, agricultural, and economic effects of adoption of health diet recommendations. ***The Lancet*** **376(9753): 1699-1709.**

Transition to diets that are high in saturated fat and sugar has caused a global public health concern, as the pattern of food consumption is a major modifiable risk factor for chronic non-communicable diseases. Although agri-food systems are intimately associated with this transition, agriculture and health sectors are largely disconnected in their priorities, policy, and analysis, with neither side considering the complex inter-relation between agri-trade, patterns of food consumption, health, and development. This article shows the importance of connection of these perspectives through estimation of the effect of adopting a healthy diet on population health, agricultural production, trade, the economy, and livelihoods, with a computable general equilibrium approach. On the basis of case-studies from the UK and Brazil, the article suggests that benefits of a healthy diet policy will vary substantially between different populations, not only because of population dietary intake but also because of agricultural production, trade, and other economic factors.

Masset, E., Haddad, L., Cornelius, A., and Isaza-Castro, J. 2011. ***A systematic review of agricultural interventions that aim to improve nutritional status of children*****. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.**

This report is a systematic review of the impact of potential "win-win" agricultural interventions that aim to improve children's nutritional status by improving the incomes and the diet of the rural poor. Previous reviews on the same subject found mixed results or no impact of agricultural interventions on nutritional status. The differences in results across these reviews are the result of the different timeframes and methodologies adopted, and of the different types of agricultural interventions reviewed. This report builds on and expands previous reviews by covering the period 1990-2010 and finds results similar to those of previous reviews, but attributes the lack of impact of agricultural interventions on child nutrition to methodological weaknesses of the studies reviewed rather than to specific characteristics of these interventions.

The review is based on a systematic search of the published and unpublished literature. The search was broken down by interventions of the following types: biofortification interventions; home gardens; aquaculture and small fisheries; dairy development; and animal source food promotion. More were found, but only 23 qualified for final inclusion based on the exclusion criteria set.

None of the studies assessed whether the interventions improved the quality of the whole diet. Five studies undertook tests for impacts on iron intake. Four tests showed no statistically significant difference at the 5 percent level and one showed a positive impact at the 5 percent

level. Nine studies tested for program impact on vitamin A intake, but only four reported data to be able to verify whether there was indeed an impact. The summary effect, assessed by meta-analysis, of these four studies reveals a positive difference in vitamin A intake between project and control groups.

No evidence of impact on prevalence rates of stunting, wasting and underweight among children under five was found. Eight studies examined the impact on childrens' nutritional status. Of these, only one found a positive and significant impact on stunting prevalence, three found a positive and significant impact on underweight and two found a positive and significant impact on wasting. Five of the eight studies showed no impact on any of the three indicators.

Nakimbugwe, D. and K. J. Boor. 2010. Food safety as a bridge between the food system and human health in Sub-Saharan Africa. In *The African food system and its interaction with human health and nutrition,* P. Pinstrup-Andersen, ed. Ithaca, NY: Cornell University Press.

The safety and wholesomeness of foods within a food system are an important reflection of the adequacy of the system for the population that depends on that food supply. A high prevalence of unsafe foods is as undesirable as an inadequate food supply, because both ultimately result in poor human nutrition and health. Diseases transmitted through foods interact in a vicious circle with malnutrition, each compounding the public health burden of the other. The predominant causes of food-borne illnesses are biological disease agents (bacteria, viruses, fungi, and gastrointestinal parasites), but chemical and physical contaminants are also a concern. In Sub-Saharan Africa, food-borne illnesses frequently go unrecognized, unreported, and uninvestigated because of limited access to medical facilities, limited diagnostic facilities at the available medical establishments, lack of national surveillance systems, and limited resources for investigation of food-borne illnesses in these countries. It is clear, however, that diarrhea continues to be a major cause of morbidity and mortality among Sub-Saharan African children. One key strategy for strengthening food safety systems and reducing food-borne illnesses is to develop effective food-borne illness surveillance systems to collect, analyze, and share epidemiological data. These data must then be used as a basis for setting priorities on the most critical food-borne risks that need to be addressed in order to realize the highest impact. Other critical needs include development of basic infrastructure for hygiene, such as access to toilet and hand-washing facilities, as well as delivery of potable water for food-related businesses and for domestic use. Education and communication with consumers is a critical component of a well functioning food system. Food system developments must be appropriate and sustainable for the local community, region, and country. Ultimately, because the safety of foods in a given food system is a critical factor affecting public health, strategies that effectively reduce food-borne illnesses by enhancing the safety of local, national, and international food systems will yield tangible improvements in the global public health profile.

Nelson, R. 2010. Pest management, farmer incomes, and health risks in Sub-Saharan Africa: Pesticides, host plant resistance, and other measures. In *The African food system and its interaction with human health and nutrition,* P. Pinstrup-Andersen, ed. Ithaca, NY: Cornell University Press.

In the African context, crop pests affect human health through multiple pathways. "Pests" include the diverse mammals, birds, insects, weeds, mollusks and microbes that compete with humans for utilization of agricultural products. Available crop loss estimates are impressive (and dubious), suggesting that biotic stresses significantly reduce food security for African smallholders. Reduced food supplies contribute to malnutrition, and reduced incomes lead to inadequate access to purchased food and medical care. In addition to reducing crop yields and value, pests can reduce food quality and safety. The use of pesticides has direct health implications as well. Pest complexes and related health challenges vary among production systems. Traditional cropping systems are oriented to the production of diverse crops without favoring massive pest outbreaks. Increasing population pressure can lead to system degradation, input-intensive production and/or agroecological intensification. On degraded soils, the parasitic weed *Striga* is a severe problem. Stressed systems also favor the accumulation of mycotoxins such as aflatoxin, which are a huge health burden in Africa. Intensification can lead to pest outbreaks as well, provoking the heavy use of pesticides. Heavy pesticide use can lead to the loss of natural biological control mechanisms, causing further losses as well as toxicity to humans. Agroecological intensification implies increasing and diversifying crop production through methods that improve soil and crop health. Improving farmers' access to well-adapted, pest-resistant crop varieties and facilitating their agroecological intensification will have positive effects on human as well as ecosystem health.

Torrey, E. F. 2010. Animals as a source of human diseases: Historical perspective and future health risks for the African population. In *The African food system and its interaction with human health and nutrition,* P. Pinstrup-Andersen, ed. Ithaca, NY: Cornell University Press.

Animals and humans are intimately connected by diseases. Many of the earliest diseases affecting humans, such as hepatitis and malaria, are thought to have been passed down as humans evolved in Africa from primate ancestors. Other diseases, such as anthrax and brucellosis, spread from animals to *Archaic Homo sapiens* when these hominids began to systematically hunt the animals. The greatest number of human diseases, including measles and tuberculosis, originally came from animals domesticated by *Homo sapiens*. The transmission of diseases from animals to humans continues to occur, as AIDS tragically illustrates.

Africa has the world's largest number of mammalian species and thus the greatest potential reservoir of new microbes to infect humans. It also has a large number of disease-transmitting arthropods, contaminated water supplies, and a major problem with malnutrition, all of which favor disease transmission. Minimizing such transmission will require attention to four factors: (1) changes in the relationship between animals and humans, such as the greater intimacy that comes when animals and humans share living space; (2) changes in modes of travel, such as paved roads and new airports, which facilitate the rapid transmission of infectious diseases; (3) changes in food production and processing, such as the change from the slaughter of individual animals to the simultaneous slaughter of hundreds; and (4) changes in ecology and environment, such as urbanization, deforestation, and global warming, all of which may increase disease transmission.

The largest impediment to controlling the transmission of animal diseases, both in Africa and elsewhere, is the lack of coordination between national and international agencies that have

responsibility for animal health and those that have responsibility for human health. By coordinating such agencies, African nations could provide a model for the rest of the world.

World Bank. 2007. *From agriculture to nutrition: Pathways, synergies and outcomes*. Report No. 40196-GLB. Washington, DC: World Bank.

The report seeks to analyze what has been learned about how agricultural interventions influence nutrition outcomes in low- and middle-income countries, focusing on the target populations of the Millennium Development Goals—people living on less than a dollar a day. It also sets out to synthesize lessons from past efforts to improve the synergies between agriculture and nutrition outcomes. The report identifies a number of developments in agriculture and nutrition that have transformed the context in which nutrition is affected by agriculture. These developments have considerable practical significance for nutrition-related agricultural programs including the design of those programs that aim to improve nutritional outcomes. Finally, the report draws a number of practical conclusions that shed light on how agricultural interventions and investments may improve nutrition outcomes in low- and middle-income countries.

Discussant comments on "Food systems and human health and nutrition: An economic policy perspective with a focus on Africa"

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I want to thank Wally Falcon and Roz Naylor for inviting me to discuss Professor Pinstrup-Andersen's presentation. I also want to thank Professor Pinstrup-Andersen for an eye-opening discussion. His breadth of knowledge and experience in the field of food policy is remarkable, and his accomplishments, spread thin, would make the parents of an entire Stanford class very proud.

Few people have thought as deeply about food systems and how they do – or do not – achieve their goals. Professor Pinstrup-Andersen's thesis addresses the relationships between food, nutrition, and health, with a particular emphasis on the African context and on the triple *global* threats of malnutrition, micronutrient deficiencies, and, at the other end of the spectrum, obesity. We heard about the gap between the stated importance of nutrition and health in the justification of food systems activities, and the *revealed* preferences of actual policies. While the alleviation of hunger and malnutrition is frequently used in justifying the design of food system policies, the pathway from the policies to improved nutrition is often vague and incompletely understood at best, or ignored and undermined at worse. We heard a dizzying exposition of the complex dynamics of food systems and their interaction with health and nutrition, through economic, social and demographic, and environmental forces. Much of what we heard serves to illustrate the poor alignment of food systems with adequate nutrition and health, and the potential contribution of such poorly aligned systems to the burden of poor nutrition and other health burdens. Professor Pinstrup-Andersen also makes the point that despite the thin evidence, the design of future policy that is better aligned with health and nutrition goals is possible through careful understanding of the complex dynamics of food systems. For example, the control of human interaction with livestock and enhancing gender-specific productivity.

I would like to expand on a few points that Professor Pinstrup-Andersen made. My hope is to highlight some areas with lingering questions that can be further addressed in the discussion. I am a physician, and when you give a kid a hammer, everything looks like a nail, so in addressing these points, I will start from a medical/biological perspective.

The first point I would like to expand on is the link between nutrition and health. The terms nutrition and health often come out in the same breath, and they *are* intimately related, but they are not the same. To say that my nutritional status is adequate means that all the component parts that make me up, including my human and non-human cells, are getting the necessary materials to sustain the biologic activities of life. My brain cells are getting glucose so my neurons can fire and make barely intelligible arguments, my muscle cells are getting protein to allow me to escape the bicycle stampede on Serra mall, and every cell in my body has enough building blocks to repair the damage of watching the vice-presidential debates. Adequate nourishment may be necessary, but it is not sufficient for being "healthy." For example, the global burden of cancer, heart disease, and lung disease is rising even in populations with perfectly fine nutritional status. In a sense, nutrition sits between food and health, and my question is whether policies can target both at the same time.

This brings me to my second point about the complexity of the interaction of nutrition and health. Robert Fogel, the Nobel-prize winning economic historian, argues that perhaps the single most important factor contributing to the rising human longevity over the past 200-300 years is more and better food. Now, nutrition and health are not a perfect match. Here is an example: a critical mechanism by which foodstuffs we put in our mouths is then churned into longer and healthier life involves human immunity and the resilience that comes with a well-tuned system. When healthy, we do not usually pay it much attention, but every single moment of every single day it works to isolate and destroy threatening viruses, bacteria, and fungi. For example, we do not think of the common bread mold as a major health risk, but people with a weakened immune system – think of HIV or chemotherapy as extreme examples – commonly get overwhelming bread mold infections. Vaccinations, perhaps the most important life-saving innovation of all times, work through the immune system as well.

But here is what I want to say about the immune system: it is a highly adaptive and flexible system with enormous nutritional and energy requirements, and there is evidence to suggest that it continues to improve with food well into the zone we associate with overconsumption of food and associated health risks such as obesity and diabetes. When Fogel did his historical analyses, he estimated that mortality is lowest at a BMI – body-mass index – around 23. By most definitions, ideal BMI is between 20 and 25, while underweight or malnourished is below 20, overweight is 25 to 30, and obesity is a BMI upwards of 30.

But is slim really healthy? Historically, plump was considered healthy. My grandmother used to worry about what a skinny little boy I was. Not that I am a leviathan now, except in the eyes of my five-year-old, but now lean is in and I do not think even my grandmother would try to stuff me with chopped liver anymore. The epidemiological evidence now suggests that the bottom of the u-shaped BMI & mortality curve is creeping up, and people with a BMI of 26 or even 27 have the lowest mortality in many populations. And human longevity continues to creep up, despite, and alongside, our collectively increasing caloric consumption and waist size. So as we consider Professor Pinstrup-Andersen's important ideas about threading the needle of food policy to promote health while balancing malnutrition and obesity, this link between nutrition and health calls for more answers.

This is a good segue to another important point raised by Professor Pinstrup-Andersen: the evidence gap. Professor Pinstrup-Andersen brings up important points about the limitations of small-scale evaluations and the dearth of large-scale evaluations. In the medical world, for better or worse, randomized trials are at the top of the evidence hierarchy, but randomized trials are no longer the sole property of medicine. Over the past few years their use has exploded in such diverse areas as education, microfinance, democratic voter participation, and health insurance. The Mexican government subjected the entire country to a randomized evaluation with the expanded national health insurance program for the poor, Seguro Popular. These trials are complex, lengthy, and costly, but the larger the program, the greater the value that comes from having evidence to guide policy. In the development, health and education world, the initial trials were largely serendipitous: the confluence of a skilled investigator, a program that was about to be implemented, and decision-makers with the foresight and vision to see the value of a rigorous evaluation. Random assignment of textbooks to Kenyan children was used to evaluate the effect on test scores. Randomized treatment of intestinal worms in rural Kenya was used to test the effect on rates of anemia and school achievement. Such small but solid empirical foundations

expanded the frontier of what was known, and then led to a daisy chain of experiments that dramatically altered the process and content of policy design.

This brings me to the last issue I would like to bring up. Professor Pinstrup-Andersen makes many excellent policy suggestions that could improve health and nutrition, especially in Africa where too little food remains the dominant form of the food security issue. These policy suggestions include up-the-food-chain interventions such as infrastructure improvements, community-level interventions such as social marketing, and person-level interventions such as empowerment of women and girls. An important question, however, is *how* to implement these policies? In the health domain, policies aiming to directly improve health in Africa often face serious implementation challenges and have unforeseen and unintended consequences. In my area of expertise, HIV policy, some of the most ardent criticisms have been leveled at the best of intentions. Support for the control of HIV is said to crowd out other health priorities and funnel health care workers and resources away from the public health system towards better-paying aid-financed priorities. I am not a food policy expert, but I imagine that well-designed food policies in any country or community will need to work with local institutions, a complicated task even where governance systems are relatively transparent and functional. Here again I would ask whether rigorous evidence and trials have a role to play in the *advocacy* for policy implementation. With all the skepticism over the veracity of the scientific endeavor, good evidence and new knowledge have a way of changing our world, bit by bit. So any graduate students out there, consider this a call to action.

Preserving and improving human health and nutrition <u>should</u> be real goals of well-designed food systems. This is particularly true for improving under- and mal-nutrition, especially in Africa. But when it comes to human health, we do not really understand how food systems work their way under the skin. Real trials to illuminate such policy areas can provide knowledge, and the impetus, for future change. I will end here, but not before thanking Professor Pinstrup-Andersen once more for coming to Stanford and for his long-standing leadership and commitment to improving the health and well-being of the world's poor.