

Farming for Health: The Future of Agriculture

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Incredibly, micronutrient malnutrition (e.g., Fe, I, Se, Zn, vitamin A, folic acid, etc.) is a massive global problem afflicting over 3 billion people worldwide (over half the world's population) mostly women, infants and children in resource-poor families in the Global South (Mason and Garcia, 1993). The consequences to human health, felicity, livelihoods, and national development are staggering resulting in increased mortality and morbidity rates, decreased worker productivity, poverty and diminished cognitive ability in children with lower educational potential born to deficient mothers (Bhaskaram, 2002; WHO, 1999; WHO, 2002). Dr. Bro Harlem Brundtland (Director General, World Health Organization, United Nations), declared at the World Economic Forum in 2000 that:

Nutrition is a key element to any strategy to reduce the global burden of disease. Hunger, malnutrition, obesity and unsafe food all cause disease, and better nutrition will translate into large improvements in health among all of us, irrespective of our wealth and home country. (WHO, 2002)

Further, the World Health Organization's 2002 World Health Report states that inadequate food and malnutrition leads to a downward spiral of increased susceptibility to illness, sickness and loss of livelihood ending in death. Current trends in micronutrient malnutrition continue to be increasing in many nations. For example, the global burden of Fe deficiency has risen from

about 35% of the world's population in 1960 to over 50% in 2000 (WHO, 2002), and Fe deficiency among poor women is increasing at an alarming rate in many developing countries and current intervention programs (i.e., food fortification and supplementation programs) to alleviate the problem have not proven to be effective or sustainable in many countries (Darnton-Hill, 1999).

This global crisis in micronutrient malnutrition is the result of dysfunctional food systems that cannot deliver enough micronutrients to meet the nutritional requirements of all. Because agriculture is the primary source of all micronutrients for human consumption, agricultural systems must be contributing to this failure to meet nutritional needs (Welch et al., 1997). How can agriculture be change in ways that will result in enough micronutrient output of farming systems to assure adequate nutrition

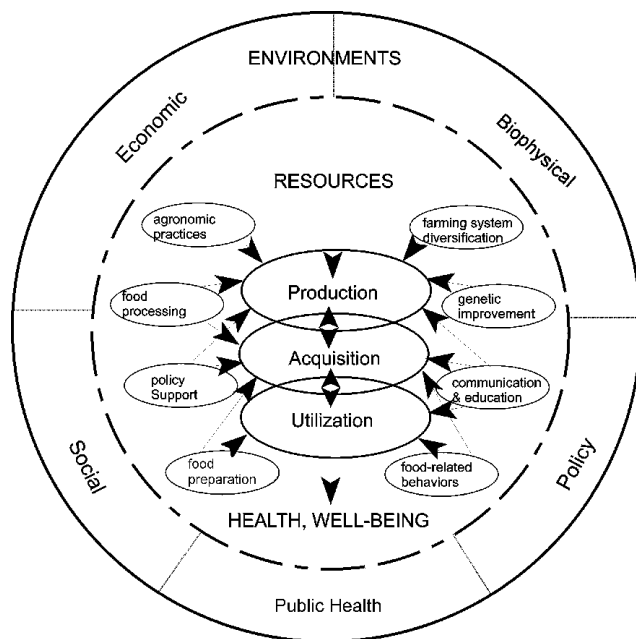


Figure 1. Holistic food system model (Combs et al., 1996).

for all? Importantly, if agricultural technologies are directed at improving the nutritional quality of food crops, they must encompass a holistic food system perspective (see Figure 1) to assure that the intervention will be sustainable, and adopted by farmers and consumers (Combs, Jr. et

al., 1996). Further, the agriculture sector must adopt a specific goal of improving human nutrition and health, and the nutrition and health sectors must adopt agricultural interventions as a primary tool to fight malnutrition.

Table 1. The known 50 essential nutrients for sustaining human life¹.

Water & Energy (2)	Protein (amino acids) (9)	Lipids (fatty acids) (2)	Macro- Minerals (7)	Micro- Elements (17)	Vitamins (13)
water carbohydrates	histidine isoleucine leucine lysine methionine phenylalanine threonine tryptophan valine	linoleic acid linolenic acid	Na K Ca Mg S P Cl	Fe Zn Cu Mn I F B Se Mo Ni Cr Si As Li Sn V Co (in B ₁₂)	A D E K C B ₁ (thiamin) B ₂ (riboflavin) B ₃ (pantothenate) B ₆ folic acid biotin niacin B ₁₂ (cobalamin)

¹Numerous other beneficial substances in foods are also known to contribute to good health.

Food systems, diet and disease

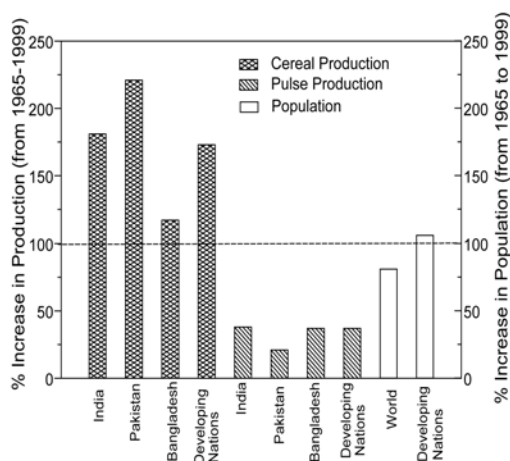


Figure 2. The percent changes in cereal and pulse production and in population between 1965 and 1999.

Humans require at least 50 known nutrients (see Table 1), in adequate amounts, consistently, to live healthy and productive lives. Unfortunately, global food systems are failing to provide adequate quantities of all of these essential nutrients to vast numbers of people. Advances in crop production, incurred during the "green revolution", were dependent mostly on improvements in cereal cropping systems (rice, wheat and maize) and resulted in greatly increased food supplies for the world preventing massive starvation. However, cereals as normally eaten, only supply needed carbohydrates for energy, a small amount of protein but few other nutrients in required amounts. This change in agricultural production to more monoculture cereal systems and away from more varied cropping systems appears to be contributing to micronutrient

malnutrition by limiting food-crop diversity (Welch et al., 1997). This has had the unforeseen consequences of reducing available micronutrient supplies to the poor formerly dependent on more diverse cropping systems which provided more traditional micronutrient-rich food crops (e.g., pulses, fruits, and certain vegetables) that are now in low supply and no longer affordable to this sector of society (see Figure 2) (Tontisirin et al., 2002; Welch et al., 1997).

Nutrition transitions are also causing increased rates of chronic diseases (e.g., cancer, heart disease, diabetes, obesity, osteoporosis, etc.) in many rapidly developing nations where people are switching from traditional diets to more calorie-rich diets derived from adopting developed nation's food systems (Clugston and Smith, 2002; Sobal, 1999). Clearly, there is an urgent need to tightly link the agricultural sector to human health to find ways to reduce the burden of diet-related diseases in the world.

From quantity to quality in the developed world

Should agriculture in developed nations be concerned about human health and nutrition issues? In 1995, the Economic Research Service published a report showing that it cost the U.S. economy over a quarter of a trillion dollars every year to treat diet related diseases (e.g., cancer, stroke, heart disease, diabetes, osteoporosis, etc.), and in lost worker productivity (Frazao, 1996). Obesity in the United States alone causes about 300,000 deaths per year and an economic cost of around \$117 million (Rouse and Davis, 2004). Clearly, the nutritional quality and "healthiness" of agricultural products is an important factor in the health of people in the United States and globally.

The future of agriculture in developed nations has been addressed in several reports. In his review of modern economic trends in agriculture a British economist, McNerney, (McNerney, 2002) listed some major economic changes that are having major impacts on agriculture in both Britain and in North America:

- Agriculture is no longer driven only by supply-side economic forces and the stimulus of support policies (i.e., "commodity" agriculture)
- Agriculture is now becoming demand-driven controlled by consumer food preferences
- These consumer demands seek distinctive elements of food value
- Quality characteristics of agricultural products can be fostered by farmers
- Profitable farms will shift from raw material producers to become genuine producers of "food" capturing some of the final value of the products consumed
- "Quality" agriculture is becoming an important part of profitable farming enterprises from an economic prospective

The agriculture community should recognize these changes in economic forces. It is not "business as usual" if many farming operations want to remain viable.

In public lectures, the futurist, Lowell Catlett (Economist, University of New Mexico State) has stated that it is the "consumer age" and healthy foods sell. According to Dr. Catlett, these facts will drive the future of agriculture in the United States. Because this nation is an aging society, interest in quality not quantity and in health and nutrition related issues are of great importance to this sector of society. There is great demand for services and agricultural product identity must be preserved from the farm to the plate (i.e., "traceability" is a new emerging driving force for farmer profitability). Catlett suggests farmers should "harvest people" by addressing consumer issues. These economic forces are causing historic shifts in the

paradigms of agriculture in North America and Europe, clearly showing the importance of consumer issues in determining successful farming operations for the future in the United States.

Agricultural tools for better health

There are numerous ways in which agriculture can contribute to improving human nutrition and health. For example, the output of micronutrients in staple food crops from farming systems to meet human needs can be accomplished in many ways (Welch, 2001). Some examples of these approaches include:

- Field site selection (e.g., identify soil types with relatively high available levels of Zn and Se)
- Agronomic practices
 - Type and rates of macronutrient fertilizers use (i.e., N, P, K, Mg, Ca, S)
 - affects levels of protein, fats, vitamins, antinutrients, etc.
 - Micronutrient fertilizers (type, application method and rates)
 - effective for Zn, Mo, Ni, Se, Cl, Li, I
 - limited effectiveness for Fe, Cu, Mn, B, Cr, and V
 - Diversity cropping systems
 - legume-cereal rotations
 - select micronutrient-dense varieties
 - increase production of fruits, vegetables, and edible legume seeds
 - Utilize micronutrient-rich indigenous food crops
 - Genetically modify food crops to improve bioavailable micronutrients and health promoting factors in food crops

For further discussions of agricultural interventions related to improving human nutrition and health refer to the following references: (Allaway, 1975; Anonymous, 1993; Chassy et al., 2003; Combs, Jr. et al., 1997; Graham et al., 2001; Grunes and Allaway, 1985; Kennedy and Bouis, 1992; Sander et al., 1987; Schneeman, 2001; Welch et al., 1997; Welch, 2001; Welch and Graham, 1999; Yip, 1997).

In 2003, the National Academy of Sciences held a workshop entitled *Exploring a Vision: Integrating Knowledge for Food and Health* (Rouse and Davis, 2004) to address issues related to agriculture, food and health. In this workshop, the need for multidisciplinary sustainable strategies to address important food related public health issues (such as obesity, diabetes, stroke, heart disease and cancer) were addressed. Interestingly, Dr. Charles Muscoplat (Dean, College of Agricultural, Food and Environmental Sciences, University of Minnesota) was quoted as saying:

It is time for the United States to shift to a new agricultural paradigm - one based on both what is good for the consumer and profitable for farmers.

Diet related health concerns in the United States were seen as a powerful driving force for changing our healthcare system to one focused on preventing chronic diseases rather than one only focused on treating the diseases. The important roles that agriculture should play in this change were recognized (see Figure 3). The participants focused on a variety of ways for linking agriculture to the healthcare infrastructures that would improve human health and nutrition. The following actions were proposed as important steps in achieving these goals:

- Form interdisciplinary (transdisciplinary) bridges between agriculture, nutrition and health
- Reevaluate reward structures and find ways to reward teamwork and investigators that empower the process
- Revise support infrastructure to invest in agriculture and health related research
- Identify a champion, either a person or organization, with high visibility and integrity that would promote the need for agricultural linkages to human health
- Integrate food-health research with behavioral studies by investing in such integrated studies
- Begin nutrition education studies in early childhood emphasizing eating habits
- Examine agricultural policies including farm subsidies and production practices as related to consumer issues and healthier food choices
- Involve leaders in government and the public, and address legislation to promote healthier food choices by the public

It was the hope of the workshop attendees that their deliberations would be a catalyst for a new paradigm for research and education in agriculture and health.

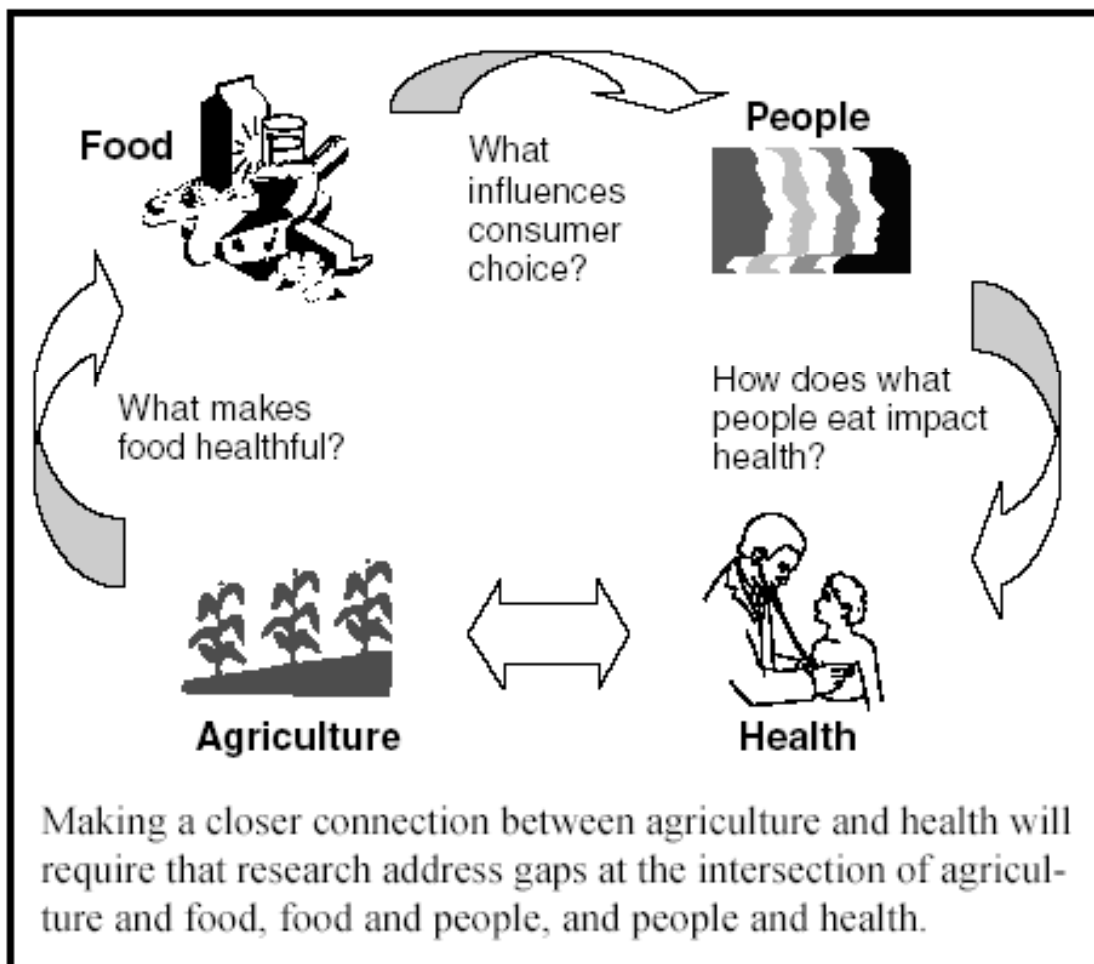


Figure 3. From farm to table, table to farm: a new agricultural paradigm (Rouse and Davis, 2004).

Conclusions

Improving human health is a key component of the future of agriculture. Food systems need to change in ways that will deliver enough affordable, health-enhancing and accessible diets for everyone in sustainable ways if we are to find sustainable solutions to malnutrition and diet-related chronic diseases globally. Domestically, consumer issues will dominate the profitability of farming enterprises in the future. Fighting chronic diseases will also be an important component of agricultural goals in the world, and much more research directed at reducing these illnesses through agricultural practices and holistic thinking will be required. Farming for health is the future of agriculture.

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