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Toward a Constructive Engagement: Agricultural Biotechnology as a Public Health Incentive in Less-developed Countries

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Abstract

Concerns over global public health crises, especially as they relate to less-developed countries are dominated by the issue of access-freeze to life-saving drugs. Without discounting the problem of access to essential drugs, this article shifts attention from that conventional discourse and focuses on the relationship between biotechnology, specifically agro-biotech, and nutritional health. It argues that despite the traditional reservations against agro-biotech, in some quarters, and various inchoate claims made on its behalf, it is a practical tool for public health intervention. The article examines the concept of bio-fortification or functional food as a viable public health strategy against the scourge of malnutrition said to be the greatest risk factor contributing to global burden of disease. Analogizing access to bio-fortified foods to access to essential medicines, the article argues for a public goods approach to bio-fortified foods as a public health incentive in the less-developed world.

> "Do we change the food supply or do we change the consumer to meet health needs? One involves evolution within the food industry and the other involves a revolution in nutrition education" –Milly Ryan-Harshman, 2007

Introduction

Discourses on global public health crises, especially as they impact the less-developed world, focus mostly on the issue of access to life-saving drugs for needy populations.[1] Also, they implicate the misalignment of global pharmaceutical R&D agenda with the health needs of the poor.[2] Equally attracting significant attention is the role of intellectual property in driving up the cost of drugs and exacerbating the drug access freeze to needy populations.[3] More often, the conceptual strings of these discussions are woven around complex interaction of themes, including those of globalization, the development narrative, and strategic changes in international law making, especially in the areas of intellectual property, international trade, etc., and the correlating supervisory international institutional and global governance regimes.[4]

The emphasis on access to drugs as a panacea for global public health crises accounts for only one response to a complex situation. It is a response that focuses mainly on therapeutic intervention, which is often a crisis-driven initiative. A more strategic

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** Author Information to be supplied

[1] See, for example, Michael Zisuh Ngoasong, *The Emergence of Global Health Partnerships as Facilitators of Access to Medication in Africa: A Narrative Policy Analysis*, 68 SOC. SCI. & MED. 949 (2009); NEGOTIATING HEALTH: INTELLECTUAL PROPERTY AND ACCESS TO MEDICINE (Pedro Roffe, Geoff Tansey & David Vivas-Eugui, eds., 2005); HOLGER P. HESTERMEYER, HUMAN RIGHTS AND THE WTO: THE CASE OF PATENTS AND ACCESS TO MEDICINES (Oxford University Press 2007); see also Stephen Barnes, *Pharmaceutical Patents and TRIPS: A Comparison of India and South Africa* 91 KY. L.J. 911 (2003); Christopher K. Eppich, *Patenting Dilemma: Drugs for Profit Versus Drugs for Health*, 43 SANTA CLARA L. REV. 289 (2002); Frederick M. Abbott, *The Doha Declaration on the TRIPS Agreement and Public Health: Lightening a Dark Corner at the WTO*, 5 J. INT'L ECON. L. 469 (2002); Susan K. Sell, *TRIPS-Plus, Free Trade and Agents and Access to Medicines*, 28 LIVERPOOL L. REV. 41 (2007).

[2] See Chidi Oguamanam, *Patents and Pharmaceutical R&D: Consolidating Private-Public Partnership Approach to Global Public Health Crises*, 13 J. WORLD INTELL. PROP. 556 (2010); Taiwo A. Oriola, *Strong Medicine: Patents, Market, and Policy Challenges for Managing Neglected Diseases and Affordable Prescription Drugs*, 7 CAN. J. L. & TECH. 57 (2009); OXFAM, *Ending the R&D Crisis in Public Health*, in OXFAM INTERNATIONAL BRIEFING PAPER NO. 22 (2008); Anup Shah, *The Pharmaceutical Corporations and Medicinal Research*, GLOBALISSUES.ORG, http://www.globalissues.org/article/52/pharmaceutical-corporations-and-medical-research (last visited Jan. 31, 2011).

[3] See Thomas K. Mirabile, *AIDS, Africa and Access to Medicines*, 11 DETROIT COLL. L. J. INT'L L. 175 (2002); see also Eppich, Sell (2007), Barnes, Abbott, *supra* note 1, and Shah, Oguamanam, Oriola, OXFAM, *supra* note 2.

[4] SUSAN K. SELL, PRIVATE POWER, PUBLIC LAW AND THE GLOBALIZATION OF INTELLECTUAL PROPERTY RIGHTS (2003); PETER DRAHOS & JOHN BRAITHWAITE, INFORMATION FEUDALISM: WHO OWNS THE KNOWLEDGE ECONOMY? (2002); INTELLECTUAL PROPERTY, TRADE AND DEVELOPMENT (Daniel Gervais, ed., 2007); Susan K. Sell, *The Quest for Global Governance in Intellectual Property and Public Health: Structural Discursive and Institutional*, 77 Temple L.R. 363 (2004). See generally PETER DRAHOS & JOHN BRAITHWAITE, GLOBAL BUSINESS REGULATION (2000); CHIDI OGUAMANAM, INTELLECTUAL PROPERTY IN GLOBAL GOVERNANCE (forthcoming 2011).

response to global public health crises would be a preventive one.[5] Public health crisis intervention essentially involves both therapeutic and preventive strategies.[6] These strategies are not necessarily mutually exclusive. However, in some cases, a good preventive intervention is more cost-effective, socially and economically,[7] in part, because it radically reduces the burden and general cost of therapeutic intervention in the long run. For example, on a cumulative scale, the high rate of infant and maternal mortality in less-developed countries can be more effectively tackled by strategic investment in the promotion of sanitary, nutritional and generallifestyle education for mothers and mothers-to-be.[8] The result of such an approach would be more enduring than an ad hoc supply of donor-sponsored patented drugs or dietary supplements at critical stages of pregnancy or postpartum.

Without underrating the subject of access to drugs for needy populations, this article aims at shifting the focus on the traditional sites of discussion of global public health crises, especially in the legal literature. It explores how the relationship between biotechnologies, specifically agricultural biotechnology, and nutritional health could constitute a tool for positive public health impact for less-developed countries. As its core objective, the paper aspires to call attention to a preventive rather than a therapeutic

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[5] See PUBLIC HEALTH ETHICS: THEORY, POLICY, AND PRACTICE 28–29 (Ronald Bayer et al., eds., 2007).
[6] *Id*.
[7] See LAURIE GARRETT, BETRAYAL OF TRUST: THE COLLAPSE OF GLOBAL PUBLIC HEALTH (2000), which argues for a concerted internal global strategy for public health based on preventative measures, including lifestyle changes, monitoring, equitable access and more objective approaches to understanding of diseases and appropriative therapeutic interventions.
[8] See Jerker Liljestrand, *Strategies to Reduce Maternal Mortality Worldwide*, WORLD BANK, HEALTH NUTRITION AND POPULATION, http://info.worldbank.org/etools/docs/library/48578/Strategies%20to%20reduce%20MMR.doc (last visited Dec. 31, 2009); see also Jerke Liljestrand, "Reducing Perinatal and Maternal Mortality in the World: The Major Challenges" 106 BR. J OBSTET. GYNAECOL. 877 (1999).

approach to global health crises, by focusing on public health aspects of agricultural biotechnology.[9]

Mindful of the controversies, reservations and high-stakes debates surrounding agricultural biotechnology in particular, and the political economics of global agriculture in general,[10] the paper attempts to rise above the two extremes of often-uninformed skepticism and uncritical enthusiasm, and sentiments over agricultural biotechnology. I explore how aspects of advances in agricultural biotechnology could be made accessible, in a sustainable way, to less-developed countries as a tool to mitigate, in a deliberate and targeted fashion, nutritional lapses that constitute significant aspects of public health crises in those countries. I examine the potential and real obstacles that assail a selective or targeted deployment of agricultural biotechnology to mitigate the public health challenges in less-developed countries. Finally, I consider ways around the identified challenges.

1. Agricultural Biotechnology

The Convention on Biological Diversity defines "Biotechnology" as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make

[9] The link between public health and agricultural biotechnology is approached, for the most part, within the rubric of broader public policy debates around the reception and acceptability of biotechnology and associated products, including the debate over the appropriate method of public education and information (e.g. through disclosure and labelling) of genetically engineered products. See, for example, Mitchell Berger, Public Health and Agricultural Biotechnology: A Review of Legal, Ethical and Scientific Controversies Presented by Genetically Altered Foods (unpublished MPH Dissertation, Emory University), *available at* http://www.dissertation.com/book.php?method=ISBN&book=1581120931 (last visited Jan. 31, 2011).

[10] See Berger, *supra* note 9; see also GENE TRADERS: BIOTECHNOLOGY, WORLD TRADE, AND THE GLOBALIZATION OF HUNGER (Brian Tokar, ed., 2004); Carmen G. Gonzalez, *Trade Liberalization, Food Security and the Environment: The Neoliberal Threat to Sustainable Rural Development*, 14 TRANSNAT'L L. & CONTEMP. PROBS. 419 (2004); ROBERT E. EVENSON, V. SANTANIELLO, & DAVID ZILBERMAN, ECONOMIC AND SOCIAL ISSUES IN AGRICULTURAL BIOTECHNOLOGY (2002); Carmen G. Gonzalez, *Institutionalizing Inequity: The WTO Agreement and Agriculture*, 27 COLUM. J. ENVTL. L. 433 (2002); JOHN D. SHAW, GLOBAL FOOD AND AGRICULTURAL INSTITUTIONS (2009).

or modify products or processes for specific use."[11] Literarily, "bio" technology presupposes the application of technological knowledge, insight and practices to life forms. In terms of its practical applications, biotechnology embraces a very wide scope, as "a mélange of scientific techniques, which can be applied to alter the genetic composition or genetic structure of an organism."[12] It is inherently an interdisciplinary endeavor.[13] When biotechnological methods are applied to a specific subject area, the latter becomes an object of the "biotechnology suffix." Agricultural and health R&D are currently the two most prominent sites for the application of biotechnology. Specifically, when biotechnology is deployed for the purpose of R&D in agriculture/food, or health production and delivery, it is often referred to as health or agricultural biotechnology, respectively. The concept of agricultural biotechnology includes other applications of biotechnology in the context of agriculture and food; hence in terms of specificity, references are made to some open-ended but related fields, including food, nutrition, environmental, crop or plant biotechnologies. Thus, the interrelatedness of agriculture, food, nutrition and diet allows for a fluid conceptualization of the concept of agricultural biotechnology to accommodate all these associations and more as the case may permit.

a) Genetic Engineering

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[11] See Article 2 of United Nations Convention on Biological Diversity (CBD) June 5, 1992 1762 U.N.T.S. 79, *available at* http://www.cbd.int/convention/text/ (last visited Jan. 31, 2011).

[12] See John Adeoti & Adetola Adeoti, *Biotechnology R & D Partnership for Industrial Innovation in Nigeria*, 25 TECHNOVISION 349, 352 (2005) (citing Rohini Acharya, The Impact of New Technologies on Economic Growth, unpublished PhD Dissertation, Faculty of Economics and Business Administration, Maastricht University, Netherlands, 1995).

[13] Some of the disciplines implicated in the exploration of biotechnological activities include genetics, genomics, proteomics, biology, molecular biotechnology, bioinformatics, food science & technology, medicine, cell and tissue culture.

At the core of biotechnology and, to a large extent, agricultural biotechnology is the phenomenon of genetic engineering. Genetic engineering is the practice of using molecular information and other techniques to deliberately modify or manipulate life forms for various human needs, especially in health and agriculture, including for desirable and non-desirable or other experimental outcomes.[14] It is a critical aspect of agricultural biotechnology. However, its utility and applications are not limited to agriculture and food. Genetic engineering is a crucial industrial tool or model for R&D, especially in pharmaceutical, chemical, environmental and allied sciences, just to mention a few. In the 21st century, genetic engineering has radically redefined the face of modern agricultural, as well as R&D and aspects of service delivery.

b) Competing forms of Agricultural Practice

The advent of genetic engineering, including industrial use of recombinant DNA, cell fusion and various new bioprocessing techniques, as the key features of modern biotechnology in the agricultural arena, has led to the present, albeit inchoate, attempt at re-categorization of the forms of prevailing agricultural practices. Genetic engineering techniques have not only broadened the scope of agricultural production, they also have yielded perhaps the most encompassing definition of biotechnology, "to include the application of scientific and engineering principles to the processing of materials by biological agents (e.g. microorganisms) or any technique that uses living organisms (or parts thereof), to make or modify products, to improve plants or animals, or to develop

[14] See Chidi Oguamanam, *Agro-Biodiversity and Food Security*, MICH. ST. L. REV. 215, 222 (2007)[hereinafter *Agro-Biodiversity*].

microorganisms for specific uses."[15] Perhaps the encompassing and increasingly central nature of biotechnology in agriculture contributes to lack of clarity or consensus on what now qualifies as conventional farming or agriculture.

Analysts readily make a distinction between "organic" or "biological agriculture", and "conventional" or "industrial" agriculture.[16] According to a report by the United Nation's University's Institute of Advanced Studies (UNU-IAS), "'organic or biological agriculture' designates an agricultural mode of production that does not rely on the use of chemicals, e.g., fertilizers and chemical pesticides. It also excludes any genetically modified organism, and is labor intensive."[17] On the other hand, conventional agriculture essentially depicts the mechanization of agricultural production through emphasis on monocultures, synthetic inputs, applications of chemical fertilizers, pesticides and various techniques for the optimization of agricultural production in the short run. The ample flexibilities and variations in the applications of agricultural biotechnology place it at the intersection of conventional and industrial agriculture, especially given regard to the convergence of the two concepts.[18]

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[15] Adeoti & Adeoti, *supra* note 12, at 352. In its various established forms such as cell and tissue culture, recombinant DNA/genetic engineering, bioprocessing and bioinformatics, biotechnology is central to modern agricultural production and health services delivery, production, as well as R &D in the two sectors.

[16] This form of inchoate or arbitrary classification is problematic in many respects. At best they serve analytical convenience. For example, it is hard to think of an agricultural practice that is not fundamentally biological in nature.

[17] See ALBERT SASSON, FOOD AND NUTRITION BIOTECHNOLOGY: ACHIEVEMENTS, PROSPECTS, AND PERCEPTIONS 24, UNU-IAS Report, (2004).

[18] Conventional agriculture, simply, is a reference to an intensive approach to farming, especially at a time when agricultural production was essentially a labour intensive exercise with little mechanical support. According to Annie Eicher, Organic Farming Program Coordinator for the University of California Cooperative Extension, conventional and industrialized agriculture have melded in the last 60 years following the World War II. Consequently, the terms appear to be used interchangeably. See Annie Eicher, *Organic Agriculture: A Glossary of Terms for Framers and Gardeners* (2003), http://ucce.ucdavis.edu/files/filelibrary/1068/8286.pdf (last visited Dec. 28, 2009).

Contrary to the impression by the UNU-IAS, it may be inaccurate to assume that any form of agricultural practice that does not involve genetic engineering or genetic modification qualifies as "organic" or so-called biological agriculture, which classification also conveniently fits traditional agricultural practices in the indigenous and rural communities.[19] In reality, entitlement to the often contested "organic" certification in the agricultural sectors is not necessarily premised on zero tolerance of the presence of transgenic components. Rather, for the most part, it is now a matter of marketing and branding. On a more serious, practical and less-delusional note, organic status is determined more by what constitutes an acceptable level than the total absence of transgenic material.[20]

Today, genetic engineering is at the core of modern agricultural biotechnology, which constitutes an important feature of 21st century technological advancements. All other agricultural practices, including traditional, non-industrial, labor-intensive or "folk" agricultural practices in indigenous and local communities, whether they qualify as organic or biological farming are often evaluated *vis á vis* genetic engineering or

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[19] See Chidi Oguamanam, *Tension on the Farm Fields: The Death of Traditional Agriculture?* 27 BULL. SCI. TECH. & SOC. 260 (2007) [hereinafter *Tension on the Farm Fields*].

[20] See Maria Lee & Robert Burrell, *Liability for Escape of GM Seeds: Pursuing the 'Victim'?* 65 MOD. L. REV. 517, 518 (2002) (wherein the authors argue that "GM-free will no longer mean 'no GMOs present'; 'organic' will not mean GM-free"); see also Article 23 of European Commission Regulation No. 1804/99/EC (June 19, 1999)–Supplement to Council Regulation (EEC) No. 2029/91 (June 24, 1991) on Organic Production of Agricultural Products (providing for a maximum threshold of inadvertent contamination without loss of certified organic status); see also *Tension on the Farm Fields, supra* note 19 at 269 (where the author observes that "[r]ealistically, many organic farmers are concerned with determining what amount of transgenic material would be unacceptable for organic certification. Indeed, for consumers, the "organic label" poses a semiotic quandary rather than being a safety or quality assurance alternative to transgenic food products").

agricultural biotechnology.[21] The latter constitutes, now, a permanent comparator in relation to other modes of agricultural production and practices.[22] Thus, it would appear that biotechnology or genetic engineering and its historical precursor, namely the modification of living organisms (especially plants and animals) through hybridization and artificial selection currently constitute the so-called conventional agriculture.

In underscoring the evolution and significance of modern biotechnology in the agricultural arena, it has been observed that:

> In the last two hundred years, mechanization, scientific plant breeding, hybridization, and chemicalization, in terms of the use of pesticides, herbicides, and fertilizers, have become the key features of agricultural practices in the industrialized world. 'The discovery of recombinant DNA in the early 1970s rapidly opened new frontiers' in the agricultural revolution. Essentially, they involve the applications of molecular genetics or biological processes in agriculture through the selection of natural strains (gene splicing) associated with desirable traits and other molecular or scientific devices for the manipulation of plant and animal life forms.[23]

Accordingly, the art and science of "gene splicing" or genetic manipulation is a crucial feature of agricultural biotechnology, "[a] subset of biotechnology steeped in diverse techniques for manipulating the genetic material of living organisms and for exploring and exploiting the complex chemistry of biological systems for food production and other

[21] See *Agro-Biodiversity*, *supra* note 14; see also *Tension on the Farm Fields*, *supra* note 19.
[22] *Id*.
[23] See *Agro-Biodiversity*, *supra* note 14, at 221–222 (footnotes omitted).

industrials ends."[24] In terms of its significance, "[t]he advent of agricultural biotechnology (as an offshoot of biotechnology) shifts agriculture from land-based farming and opens it up to trans-disciplinary convergences in therapeutics, chemicals and marketing in complex industrial economics of globalization,"[25] transforming it from a model of life to barely a mode of production.[26]

The manipulation of plant and animal genes for food production opens the practice of agriculture to possibilities that transcend addressing global hunger. In other ways, this approach to agricultural production provides concrete basis for reflective critique or understanding of the limitations of organic/biological and other non-conventional agricultural practices. Nonetheless, the advent of agricultural biotechnology and its *modus operandi* are as controversial as its real, perceived or potential benefits. Resistance or opposition to agricultural biotechnology is more often premised on the disputation over most of the benefits claimed by its proponents.[27] In some ways, the ongoing debate between proponents and opponents of agricultural biotechnology assist to unravel the gaps in competing models of agricultural endeavor. As well, such conversation provides an opportunity for the exploration of the potential for complementary engagement and application of the benefits of agricultural biotechnologies along side other models of agricultural production for optimal ends. Without being exhaustive, the following few examples illustrate the polarizing claims, counter claims and resistances that undergird

[24] *Id.*, at 222.
[25] *Id*.
[26] See SHELDON KRIMSKY & ROGER P. WRUBEL, AGRICULTURAL BIOTECHNOLOGY AND THE ENVIRONMENT: SCIENCE, POLICY AND SOCIAL ISSUES 213 (1996).
[27] See Jeffrey Burkhardt, *Agricultural Biotechnology and Future Benefits Argument*, 14 J. AG. & ENVTL. ETHICS 135 (2001) for general review of the philosophical basis/justification for agricultural biotechnology and an exploration the future benefit analysis (FBA) in regard to prevailing objections to genetically modified organisms.

the tension between agricultural biotechnology, especially genetic engineering, and other modes of agricultural production.

2. Agro-Biotech vs. Others: Claims and Counter Claims

a) Sustainability, Cost, Efficiency and Environmental Arguments

Promoters of organic or non-conventional agriculture are quick to claim that, in comparison to conventional or industrial agriculture (including agricultural biotechnology) their approach is more natural, more environmentally friendly and more sustainable in the long run.[28] For a number of reasons, this would seem self-evident. Organic or biological agriculture – hardly precise terms – is labor-intensive, diversity-sensitive, and mostly subsistent, involving the use of little or no chemicals, and mainly engages in natural selection, shifting cultivation and other environment regarding practices. In contrast, conventional agricultural practices, especially agricultural biotechnology, are industry-driven; involve full-scale, energy-intensive industrial monocultural production and direct manipulation of genetic compositions of life forms.

When all these claims are unpacked, they do not seem as settled as they are presented. For instance, claims to sustainability are as contested as those for environmental friendliness made in favour of organic or biological agriculture. Interestingly, the same claims are also made in support of agricultural biotechnology. Organic agriculture is said

[28] This is often in contrast to the process of gene splicing or genetic engineering, which involves direct artificial manipulation or tinkering with the genetic compositions of living organisms. Ironically, biotechnology is also represented as hardly at odds with the natural process and as indeed based on "nature's own methods." For perspectives on the contested ideology of nature and natural process in agricultural context, see Krimsky & Wrubel, *supra* note 26, at 227; see also *Agro-Biotechnology*, *supra* note 14, at 222.

to amass too much pressure on agricultural lands.[29] The amount of agricultural land required for sustainable organic farming far exceeds land use for conventional agriculture.[30] Also, organic or forms of non-conventional agriculture do not adequately or readily adjust to radical changes in the natural environment such as drought, soil erosion, severe changes in weather patterns, etc.

Agricultural biotechnology is associated with the potential to cut back on the amount of land required for agricultural production, for example, through no-till farming practices. No-till farming is "an agriculturally-sustainable method of preventing soil erosion"[31] and other forms of agriculture-induced environmental degradation. Also, in some cases agricultural biotechnology makes it possible to genetically predispose crops to consume less water or other agricultural nutrients, thus mitigating the pressure on the natural environment, including land, which is historically associated with agriculture. Cumulatively, these and other related benefits of agricultural biotechnology provide empirical bases for the claim by its proponents that agro-biotechnology is sustainable agricultural practice. For example, limiting water consumption for agriculture assumes a compelling imperative in the light of dire apprehensions over global water crises to which many less-developed countries, especially in sub-Sahara Africa, are vulnerable.[32] In

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[29] See Milly Ryan-Harshman, *Food Biotechnology: Food Industry, Nutrition and Public Health* (UNU-IAS Research Paper) 56 PROC. NUTRITION SOC. 845 (1997).
[30] *Id*.
[31] *Id.* at 846.
[32] According to the UNESCO's International Hydrological Program, "water withdrawals for irrigation represent 66 % of the total withdrawals and up to 90 % in arid regions." Globally, per capita water use reflects the dichotomous difference in lifestyle between rich and poor societies. Consequently, given the spatial, geographical, ecological, even temporal variations in the availability of water, there is an increasing scarcity of water for human needs, especially in agricultural production in Sub-Saharan Africa and other vulnerable regions of the globe. This state of affairs is a recipe for food insecurity. See Igor A. Shiklomanov, *World Water Resources and their Use*, UNESCO (1999),

drawing attention to the importance of agricultural biotechnology for global water crisis, G.J. Persley remarks that "[b]ecause land and water for agriculture are diminishing resources, there is no option but to produce more food and other agricultural commodities from less arable land and irrigation water. The need for more food has to be met through higher yields per units of land, water, energy and time."[33] Generally, ongoing concerns about global water supply and rapidly creeping effects of global climate change require a more creative agricultural strategy, one now within the purview of agricultural biotechnology.[34] Despite its advantage in regard to water and land use, there are reservations about the negative environmental ramifications of agricultural biotechnology, especially those that stem from its direct or so-called non-natural manipulation of genetic compositions of plants and animals. The result of these interventions is the introduction, by raw ingenuity of human intervention, of what analysts call strangers or non-naturally occurring entities to the ecosystem.[35] The presence of these genetically modified organisms (GMOs) is associated with

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http://webworld.unesco.org/water/ihp/db/shiklomanov/index.shtml; see also World Water Council, *Water Crisis* (2009), http://www.worldwatercouncil.org/index.php?id=25 (last visited Jan. 1, 2010).

[33] See G.J. Persley, *Biotechnology and the Poor: Promethean Science*, in BIOTECHNOLOGY AND THE POOR 3–21, 3 (G.J Persley & L.M. Lantin, eds., 2000).

[34] For example, agricultural biotechnology is a tool of intervention in crop production systems, including the development of genetically engineered crops capable of adapting and better responding to change in climate. See Rachel Chikwamba, Advanced Biosciences in Crop Adaptation to Climate Change, Presentation at the 2009 Bio2Biz Conference, Durban International Conference Centre, South Africa, (September 20-23, 2009). For conference proceedings, see online: http://www.bio2biz.org/Programme.aspx#selection. See also M.S. Swaminathan, *Global Climate Change and the Role of Agricultural Biotechnology*, http://www.pub.ac.za/docs/bio2biz2009_agribio_climate.pdf (last visited Feb. 16, 2011). See also The European Association of Biodindustries, Green Biotechnology and Climate Change, http://www.europabio.org/positions/GBE/PP_090619_Climate_Change.pdf (last visited Feb. 16, 2011).

[35] See *supra* note 28 and accompanying text.

environmental and ecological distortions, the full impact of which are hard to measure both in the long and short runs.[36]

Notwithstanding attempts to downplay problems around GMOs from health, environmental, safety, cultural, philosophical and other perspectives, these anxieties have yet to abate.[37] Opposition to GMOs and the processes of their production has continued to galvanize environmentalist rhetoric that appears to have defined agricultural biotechnology in the court of public opinion. The environmentalist critiques of GMOs seem to overshadow (or at best compete with) other more tenable arguments in support of the potential or real contributions of agricultural biotechnology to sustainable agriculture. The short point is that as between organic or non-conventional agricultural practices, and agricultural biotechnology, especially the practice of genetic engineering, claims to environmental friendliness and sustainability of their endeavors are contested and do not lend themselves to easy resolution.

b) Boost in Global Food Production and Panacea to Global Hunger

The second aspect of these contested claims is one that appears obvious on its face value. Agricultural biotechnology boosts global food production and constitutes a panacea to

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[36] Analysts readily point to a 1999 research finding suggesting that pollen from genetically modified Bt corn was harmful to the larvae of monarch butterflies. See John E Losey, Lynda S. Rayor & Maureen E. Carter, *Transgenic Pollen Harms Monarch Larvae*, 399 NATURE 214 (1999). This and similar research has been disputed in some quarters, including at the USDA, a situation that further fosters the controversy over agricultural biotechnology. Like most claims over agricultural biotechnology, research on the effect or impact BT corn pollen on monarch butterfly remains inconclusive and is hardly resolved with any clarity. For general overview of the state of literature on Bt corn and the monarch butterfly, see Richard L. Hellmich, *Monarch Butterflies and Bt Corn*, http://agribiotech.info/details/Hellmich-Monarch%20Mar%208%20-%2003.pdf (last visited Feb. 16, 2011).

[37] For a general articulation of arguments against agricultural biotechnology from diverse perspectives, see Miguel A. Altieri, *The Case Against Agricultural Biotechnology*, CORPWATCH.COM (2003), http://www.corpwatch.org/article.php?id=7030 (last visited Feb. 16, 2011).

global food insecurity.[38] Increased food production at mindboggling industrial scale is facilitated by diverse techniques of agricultural biotechnology. This would appear to be a palpable contention. However, whether that translates into any significant impact on reduction of hunger and promotion of food security is another matter entirely. Some analysts do not find a corollary between increased food production in the present era of agricultural biotechnology and any significant reduction of hunger, especially among the global population in dire need.[39] Also, there is no compelling correlation between advances in agricultural biotechnology and food security. More critical policy introspection around agricultural biotechnology suggests that the technological approach is not indispensable to tackling global hunger. Put differently, without agricultural biotechnology, the world is capable of feeding itself.[40] For many, global hunger is less a consequence less of food production than of food distribution and the global political economics of agriculture.[41]

The dubious impact of agricultural biotechnology or industrial agriculture in general on both the eradication of hunger and food insecurity, is tied to the global political

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[38] See the Food and Agricultural Organization, *Biotechnology in Food and Agriculture: FAO Statement on Biotechnology* (2000), http://www.fao.org/biotech/stat.asp (last visited Feb. 16, 2011).
[39] Carmen G. Gonzalez, *Markets, Monocultures and Malnutrition: Agricultural Trade Policy through an Environmental Justice Lens*, 14 MICH. ST. J. INT'L L. 345 (2006); see also Gonzalez (2002), *supra* note 10.
[40] In Norway and other Scandinavian countries where a more deliberative and critical policy approach is the norm for evaluating agricultural biotechnology, policy makers recognize that agricultural biotechnology is not *sine qua non* for addressing hunger and food supply. See Margareta Wandel, *Genetically Modified Foods in Norway: A Consumer Perspective* in BIOTECHNOLOGY UNGLUED: SCIENCE, SOCIETY AND SOCIAL COHESION 70 (Michael D. Mehta, ed., 2006); see generally Altieri, *supra* note 37.
[41] See generally Gonzalez (2004) and Tokar, *supra* note 10. See specifically Brian Tokar, *The World Bank, Biotechnology and the 'Next Green Revolution'*, and Devinder Sharma, *The Great Trade Robbery: World Hunger and the Myths of Industrial Agriculture*, in Tokar, *supra* note 10. See also GORDON CONWAY, THE DOUBLY GREEN REVOLUTION: FOOD FOR ALL IN THE TWENTY-FIRST CENTURY (1997); FRANK ELLIS, AGRICULTURAL POLICIES IN LESS-DEVELOPED COUNTRIES (1992); E.M. YOUNG, WORLD HUNGER (1997); and FAO, *Food Security Statistics* (2008), http://www.fao.org/economic/ess/food-security-statistics/en/.

economics of agriculture.[42] This phenomenon has been dealt with elsewhere and is outside the scope of this paper.[43] The global political economics of agriculture is driven in part by international historical division of labour.[44] In that matrix, less-developed countries and centres of agricultural biodiversity serve as producers of raw materials and feeders of global commodity markets under inequitable bargains.[45] Coupled with the globalizations in legal and regulatory frameworks of the new international trade and intellectual property order, there is unprecedented tightening of corporate proprietary control of new technological innovations in agriculture and allied sectors.[46] Consequently, access to the benefits of increased food production in the wake of advances in agricultural biotechnology remains a challenge.[47] Rather, there is an exacerbation in unidirectional transfer of resources and knowledge from less-developed countries to the Western agro-industrial complexes.[48]

c) Food Security and Food Safety

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[42] Young, *supra* note 41; Gonzalez (2004), *supra* note 10; Conway, *supra* note 41.
[43] See *supra* note 39.
[44] *Id.*
[45] Gonzalez (2004), *supra* note 10.
[46] See Altieri, *supra* note 37; Carmen Gonzalez, *Genetically Modified Organisms and Justice: the International Environmental Justice Implications of Biotechnology*, 19 GEO. INT'L ENVTL. L. REV. 580 (2007); see also Keith Aoki & Kennedy Luvai, *Reclaiming 'Common Heritage' Treatment in International Plant Genetic Resources Regime Complex*, MICH. ST. L. REV. 35 (2007).
[47] See J.G. PERSLEY & L.M. LANTIN, AGRICULTURAL BIOTECHNOLOGY AND THE POOR (2000).
[48] According to Altieri, *supra* note 37, "Biotechnology is a technology under corporate control, protected by patents and IPR, and contrary to famers' millenary traditions of saving and exchanging seeds." There is a relationship of dependence between biotechnology and traditional agricultural, medicinal, genetic resources, practices and associated knowledge systems in indigenous and local communities and centers of biological diversity. As a consequence of this epistemic dynamic, biotechnology is a site for appropriation of local knowledge systems through the incorporation or use of insights from local knowledge custodians in biotechnology R & D. While the latter is easily a subject of intellectual property protection, the extent to which intellectual property accommodates local knowledge is open to politico-legal negotiations. This state of affairs is at the basis of discourses around the concept of biopiracy. See generally, IKECHI MGBEOJI, GLOBAL BIOPIRACY: PATENTS, PLANTS AND INDIGENOUS KNOWLEDGE (2006); VANDANA SHIVA, MONOCULTURES OF THE MIND: PERSPECTIVES ON BIODIVERSITY AND BIOTECHNOLOGY (1993).

Even if agricultural biotechnology results in increased food supply to feed the world's poor, such does not necessary translate to improvement in food security. The misalignment of agricultural biotechnology with food security is rooted in complex dynamics. A few factors assist to illustrate this point. Most of the technologies, including agricultural biotechnologies, are concentrated in industrialized and rich countries of the globe.[49] These countries have championed recent strategic changes that have resulted in the tightening of intellectual property law in a manner that guarantees for them firm control of innovations in the agricultural and other technological sectors.[50] In addition, continued convergences in agricultural biotechnology, chemical, pharmaceutical and allied industries and the relaxation of anti-trust laws help to consolidate monopolistic tendencies in these sectors.[51] A combination of these and other factors invigorated by globalization's neo-liberal economic and trade liberalization policies demonstrate that advances in agricultural biotechnology may not be a panacea for food insecurity, especially in less-developed countries.

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[49] This trend is not necessarily sustainable as it has potential for transformation. For example, the two interrelated and paradigmatic technologies of the last and present centuries, namely information and communications technology, and biotechnology, are critical in the ongoing exponential developmental progress and transitions in three key less-developed countries of Brazil, India and China (analysts have joined Russia to the three under the so-called BRIC bloc of countries). These countries have the potential to rival the United States, Canada and Argentina, now the current global leaders in agricultural biotechnology. For perspectives on the BRICs, which recently admitted South Africa into their exclusive group, see Dominic Wilson and Roopa Purushothaman, *Dreaming the BRICs: The Path to 2020*, Global Economics Paper No. 99, Goldman Sachs, New York (1 October 2003), http://antonioguilherme.web.br.com/artigos/Brics.pdf (last visited Feb. 2, 2011).

[50] The TRIPS Agreement is the symbolic depiction of new changes in intellectual property. In a way, TRIPS is a global imposition of the US's all-inclusive and permissive intellectual property regime into the realm of life forms, specifically incorporating innovations around genetic resources. In addition, the US's continued negotiation of bilateral trade agreements after TRIPS and its support for the WIPO Patent Agenda gradually prods the international intellectual property order onto a TRIP-plus regime. See SUSULE F. MUSUNGU & GRAHAM DUTFIELD, MULTILATERAL AGREEMENTS IN A TRIPS-PLUS WORLD: THE WORLD INTELLECTUAL PROPERTY ORGANIZATION (WIPO) (2003), which explores how recent intellectual property reforms at the WIPO, especially the patent and digital agenda promote and co-opt less-developed countries into standard of intellectual property protection that transcend those of the TRIPS Agreement; see also Jean-Frédéric Morin, *Multilateralising the TRIPS-Plus Agreement: Is the US Strategy a Failure?* 12 J. WORLD INTELL. PROP. 175 (2009).

[51] See Susan K. Sell (2004), *supra* note 4.

Food security is a concept with multiple perspectives.[52] Overall, virtually all perspectives on food security denote physical and economic accessibility by all peoples at all times to adequate, safe, nutritionally suitable, culturally and personally acceptable food in manner that is sensitive to their human dignity and for their overall active and healthy life style.[53] It follows that food security and food safety, nutrition and public health have a symbiotic relationship. Forms of agricultural production, including so-called conventional and non-conventional agriculture, are practices at critical intersection of food security and food safety. We shall explore that intersection in the next section.

From the above overview of food security, it is possible that agricultural biotechnology has real and practical potential to advance or undermine food security. In regard to advancing food security, agricultural biotechnology may not, however, be a magic bullet. Its role could be complemented by other modes of agricultural production and practices in order to factor in the cultural and human dignity aspects of food security. As for the second potential, there are many ways in which agricultural biotechnology could undermine food security. For instance, the industrial and commercial focus of agricultural biotechnology accounts for the concentration of research, innovative and development endeavors on a few monocrops.[54] Because agricultural biotechnology is industrially and commercially driven, it targets crops and plants on the basis of their commercial

[52] See TRADE REFORMS AND FOOD SECURITY: CONCEPTUALIZING THE LINKAGES 25–26(FAO, 2003).
[53] *Agro-Biodiversity*, *supra* note 14, at 230; Ryan-Harshman, *supra* note 29, at 845.
[54] See Persley & Lantin, *supra* note 47; see also Altieri, *supra* note 37; see generally Shiva (1993), *supra* note 48.

viability.[55] That priority is hardly the driving factor in indigenous and rural communities where agriculture is first a cultural process and a factor of cultural and ecological diversities of people and their environment.

Consequently, in some ways, agricultural biotechnology appears to be antithetical to agro-biodiversity. The idea of agro-biodiversity refers for the most part to diverse ways in which "farmers use the natural diversity of the environment for production, including not only their choice of crops but also their management of land, water and biota as whole."[56] Because agricultural and food production are culturally located and culturally driven practices, they correlate with diversities in the ecological features of peoples and civilizations.[57] That way, agricultural biodiversity guarantees aspects of food security, especially in regard to access to culturally/personally acceptable foods, reflective of the human dignities of peoples.

In contrast, biotechnology's tendency to promote monocultures shortchanges a crucial aspect of food security for a critical segment of the population that relies on the diversity in traditional landraces and animal resources. Also, the political economics of agriculture tightens proprietary control of the end products of innovations in agricultural

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[55] See Jay P. Kesan, *Intellectual Property Protection and Agricultural Biotechnology: A Multi Disciplinary Perspective*, 44 AM. BEHAV. SCI. 464 (2000); see also Bongo Adi, *Intellectual Property in Biotechnology and the Fate of Poor Farmers* 9 J. WORLD INTELL. PROP. 91 (2006); *Tension on the Farm Fields*, *supra* note 19.

[56] *Agro-Biodiversity*, *supra* note 14, at 220 (quoting Harold Brookfield and Christine Padoch, *Appreciating Diversity: A Look at the Dynamism and Diversity of Indigenous Farming Practices*, 36 ENVIRONMENT 6, 9, 1994).

[57] See Assya Pascalev, *You Are What You Eat: Genetically Modified Food, Integrity and Society* 16 J. AGRIC. ENVTL. ETHICS 583 (2003); see also HARRIET J. KUHNLEIN & NANCY J. TURNER, TRADITIONAL PLANT FOOD OF CANADA'S INDIGENOUS PEOPLE: NUTRITION, BOTANY AND USE (1991), *available at* http://www.fao.org/wairdocs/other/ai215e/ai215e00.htm (last visited Feb. 4, 2011).

biotechnology and creates a culture of dependence on technologically endowed countries by many in the less-developed world. Physical access to agricultural biotechnology or GM foods presents considerable challenges for needy populations[58] akin to those posed by access to essential drugs. Because of cost or affordability and distribution constraints, agricultural biotechnology end products are often delivered to needy populations in less-developed countries as food aid.[59] Often, like high-end patented drugs, GM foods are fast becoming part of *ad hoc* crisis intervention relief packages. For the recipients in less-developed countries, this phenomenon detracts from physical accessibility, cultural suitability and human dignity, which are necessary elements of food security.

The reluctance of some to embrace GM foods and other products of agricultural biotechnology, in a way, demonstrates the latter's inability to satisfy aspect of cultural and human dignity elements of food security. For many who resist these products due to cultural, philosophical, religious, environmental and other considerations, the question, however, is not whether they are physically available, affordable, or nutritionally safe. Rather, it is whether they are acceptable.[60] The short point here is that the relationship between agricultural biotechnology and food security unravels as a more complex analytical morass than what appears obvious at first glance.

[58] See Conway, *supra* note 41; see also Altieri, *supra* note 37, who argues that most rural populations in the tropics live in very challenging environmental condition and are threatened by global warming while hardly being impacted by modern agricultural science.

[59] See Shaw, *supra* note 10, at 201, where the author notes that contrary to the preference of global food aid agencies such as the UN World Food Program to source food aid locally to support local economies, donor countries, especially the US, tie food aid to their interest. The US requires, for example, that donations be sourced from their surplus stocks and that three-quarters of which be bagged, fortified or processed products.

[60] Chidi Oguamanam, *Intellectual Property Rights in Plant Genetic Resources: Farmers' Rights and Food Security in Indigenous and Local Communities* 11 DRAKE J. AGRIC. L. 273 (2006).

Finally, in regard to the safety component of the food security discourse, the role of agricultural biotechnology takes an explosive and sometime passionate turn. Perhaps there is as much case to be made in favour of agricultural biotechnology's ability to promote food safety as can be made for its converse impact on food safety. Arguably, most of the objections to agricultural biotechnology, especially those stemming from environmental, health and sustainability are aspects of the reservations over the safety of products of agricultural biotechnology. In short, oppositions to agriculture biotechnology are woven around inter-connected and yet emerging themes.[61]

In many quarters, the benefits of agricultural biotechnology are presented as constituting critical strategy for the advancement of public health.[62] On other fronts, agricultural biotechnology products and processes are represented as sources of significant threat to public health and myriad economic and social issues.[63] This ironic twist underscores the contentious nature of policy debate around biotechnology in general and agricultural biotechnology in particular. Safety concerns over the products of agricultural biotechnology are more hotly debated in the specific and interrelated contexts of food, medicine and nutritional health. This is hardly surprising because, in virtually all

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[61] See generally Tokar, *supra* note 10; see also Berger *supra* note 9.
[62] See Sasson, *supra* note 17; see also Persley & Lantin, *supra* note 47; Ryan-Harshman, *supra* note 29; see also the Council for Biotechnology Information (an industry think-tank of leading agricultural biotechnology companies committed to the promotion of biotechnology and its benefits), http://www.whybiotech.com/ (last visited Jan. 13, 2010).
[63] See ECONOMIC AND SOCIAL ISSUES IN AGRICULTURAL BIOTECHNOLOGY (R.E. Evenson et al., eds., 2002); Krimsky & Wrubel, *supra* note 26; Tokar, *supra* note 10; CAREY FOWLER & PAT MOONEY, SHATTERING: FOOD, POLITICS AND THE LOSS OF GENETIC DIVERSITY (1990); K. Ravis Srinivas, *Sustainable Agriculture, Biotechnology and the Emerging Global Trade Regime*, 31 ECON. POL. WEEKLY 1922, 1923(1996).

civilizations known to mankind, food has a symbiotic relationship with medicine.[64] Food biotechnology, a subset of biotechnology and, indeed, agricultural biotechnology, is "the use of living organisms, or parts of living organisms to create new, or improved food products."[65] The advent of agricultural biotechnology, like biotechnology in general, has revolutionized nutritional and food science. The increasing role of agricultural biotechnology as a significant source of global food supply and the interrelation between agriculture, food, nutritional health and medicine makes agricultural biotechnology a critical aspect of public health discourse.

Food security and food safety provide a strong foundation for disease prevention. Also, they are crucial incentives for prolonging life, as they provide an appropriate basis for organized effort by the community or population for informed choices toward a healthy life style. Consequently, food security and food safety are critical to public health. Although the present analysis focuses on the public health ramifications of food security and food safety, it bears mentioning that public health transcends, and is not limited to, the two subjects.[66] The central focus of public health is the prevention of diseases through strategic interventions aimed at promotion of healthy life style, informed choices and general surveillance of potential threats to the health of the population.[67]

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[64] In many indigenous and local communities, there is no stark line of distinction between food and medicine. On a general conceptual level, where hunger is construed as a disease, food is a cure. Beyond that, the ecological harmony prevalent in the indigenous conceptual worldview extends to the fusion or unity of purpose between food and medicine. On the connection between food, culture and medicine, see Pascalev, *supra* note 57.

[65] See Ryan-Harshman, *supra* note 29, at 845.

[66] *Supra* note 5.

[67] *Id.* See also the Preamble to the Constitution of The World Health Organization, http://www.searo.who.int/LinkFiles/About_SEARO_const.pdf (last visited Jan. 13, 2010). For a classical conceptualization and examination of the concept of public health, see C-E. A. Winslow, *The Untilled Field of Public Health* 51 SCIENCE 23 (1920); *supra* note 5.

We have already noted that the extent to which agricultural biotechnology promotes food security is dubious or at best uneven in relation to different elements of food security. Opinion on biotechnology's impact on food safety is equally conflicted. A positive alignment between agricultural biotechnology and food safety translates into a positive impact on public health. Conversely, if we posit that products of agricultural biotechnology or food biotechnology and GMOs in general are not safe foods, then of necessity, agricultural biotechnology's impact on public health would be potentially negative.

d) Chemicalization of Agriculture

Food safety concerns over the products of agricultural biotechnology are integral aspects of reservations over the latter's environmental impact and general concern about its sustainability.[68] In this regard, it is not unusual to lump these concerns with more enduring public health worries over the increased chemicalization of agricultural production. Agricultural biotechnology is often lumped together with other variants of what has been called conventional agriculture, which is characterized by intense mechanization, scientific plant breeding, hybridization and severe use of agrochemicals for herbicidal and pesticidal ends. In terms of its mechanization and industrial appeal, agricultural biotechnology shares common features with its precursors. However, with

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[68] See Miguel Altieri, *Genetic Engineering in Agriculture: The Myths, Environmental Risks and Alternatives* (2001), http://www.mindfully.org/GE/GE2/GE-Ag-Myths-Risks-Altieri.htm (last visited Feb. 16, 2011); see also Richard Hindmarsh, *The Flawed Sustainable Promise of Genetic Engineering,* 21 THE ECOLOGIST 196 (1991).

regard to its emphasis on genetic engineering, agricultural biotechnology marks a significant evolution in conventional agriculture.

Major criticism of conventional agriculture during the period preceding the full-blown introduction of genetic engineering centred on excessive chemicalization and mechanization of the agricultural process, especially at the wake of the defunct Green Revolution.[69] Concerns over the environmental impact, sustainability, and general reservations regarding the escalation of costs of agro-inputs constituted the albatross of the Green Revolution initiative.[70] In addition, scientists have linked chemical fertilizers and the introduction of excess nitrogen on water systems with an increase in carcinogens on the environment and consequently, the rate of cancer in the population.[71] Overall, even though the Green Revolution accomplished, to some, extent the increased production of high yielding varieties (HYVs) of target crops to address global hunger and food crisis in the post World War II period, the overall social cost of chemicalized agriculture remains a matter of continuing inquiry.

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[69] See Conway *supra* note 41, at 44–45; see also Gonzalez (2004), *supra* note 10, at 423; VANDANA SHIVA, THE VIOLENCE OF THE GREEN REVOLUTION: THIRD WORLD AGRICULTURE, ECOLOGY AND POLITICS (1991); STRUCTURAL ADJUSTMENT, THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT (David Reed, ed., 1996).

[70] *Supra* note 69.

[71] Many critics of the Green Revolution refer to the negative environmental impact of the excessive use of chemical fertilizers, especially on ground water and on the food chain with consequence in the escalation of cancer, lupus, and several immune diseases, as well as alleges and asthma. Some associate the use of chemical fertilizers as part of corporate consolidation between agricultural, chemical and petro-chemical industries' dominance in global grain supplies and food production, a situation that has continued in the current era of genetic engineering and modern agricultural biotechnology. See, for example, Daniel Peer, *The Toxic Consequences of Green Revolution*, US News & World Report, July 7, 2008, http://www.usnews.com/articles/news/world/2008/07/07/the-toxic-consequences-of-the-green-revolution.html (last visited Jan. 2, 2010); see also Peter Rosset, Joseph Collins, and Frances Moore Lappé , *Lessons from the Green Revolution: Do We Need New Technologies to End Hunger?* http://www.biotech-info.net/lessons.html (last visited Feb. 3, 2011).

In a way, genetic engineering-driven agricultural biotechnology marks a remarkable shift in the scientific template in agricultural innovation. However, there appears to be no dedicated attempt to explore the extent to which agricultural biotechnology is distinguishable from its precursor and other forms of conventional agriculture. It is hardly surprising that most of the criticism of the failed Green Revolution have been transferred to agricultural biotechnology – and for a good reason. However, such wholesale transfer of fault and general conflation of the internal dynamics of conventional agriculture has not allowed for a dispassionate investment of effort to truly appraise the nature of changes in agricultural production brought about by full-blown genetic engineering.[72] The vociferous nature of the exchange between promoters and opponents of agricultural biotechnology is one that hardly accommodates a dispassionate attempt to scrutinize those claims with the benefit of the doubt.

For instance, agricultural biotechnology is often portrayed as an alternative to chemicalized agriculture of the Green Revolution era.[73] The argument is that through genetic engineering, agricultural biotechnology has potential to reduce the use of chemical for agricultural purposes. Assuming this claim has any iota of credibility at all, the reduction of chemicals from the agricultural process will disburden it from a huge public health and food safety concerns that have continued to dog industrial agriculture. Secondly, as already noted, genetic engineering has real potential to facilitate radical

[72] The role of corporate interests in the promotion of the Green Revolution and the enthronement of what analysts have called petro-dependant or chemical farming was one of the Achilles' heels of Green Revolution. In comparison to the Green Revolution era, the contemporary epoch of genetic engineering-centred agricultural biotechnology is virtually shaped by corporate interests with very limited public involvement. In addition to other criticism of genetic engineering, this state of affairs justifies the tendency to conflate Green Revolution dynamics with genetic engineering and agricultural biotechnology.
[73] See Krimsky & Wrubel, *supra* note 26, at 213; *Agro-Biodiversity*, *supra* note 14, at 225; see generally Ryan-Harshman, *supra* note 29.

reduction in the use of water for agricultural purposes. Similarly, as we have noted, proponents argue that agricultural biotechnology potentially promotes the use of less land to grow more food. Assuming these claims to be conclusive or even tenable, their overall "social economics of scale" for human agricultural endeavor would warrant serious consideration for the future of agriculture. The reality, however, is that like most scientific claims, the devil lies in the details.

In addition, most claims in the arena of biotechnology are readily matched with counterclaims. For example, casting doubt over the potential of biotechnology to reduce use of agricultural chemicals, it has been noted that, "the use of chemicals inducers to activate desired traits is a feature of agro-biotechnology that dampens the hope of respite from chemicalized agriculture. Contrary to its promoters' claims, agro-biotechnology is implicated in the increased use of agro-chemicals."[74] Similarly, the potential of agricultural biotechnology to use less land, thereby potentially freeing up land for other uses is admittedly an economic efficiency model. But that feat can be counterbalanced by concentration of agricultural biotechnology on a few monocrops at the expense of agro-biodiversity, which encourages the growing of diverse variety of agricultural products through several methods[75] and in different ecological and diverse socio-cultural settings. Because of its relative novelty, the inchoate nature of scientific claims in general, as well as the passionate propaganda with which agricultural biotechnology is promoted and resisted, it has not been easy to accurately audit aspect of its claims that warrant being taken more seriously than others.

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[74] *Agro-Biodiversity*, *supra* note 14, at 225 and n. 49.
[75] *Agro-Biodiversity*, *supra* note 14, at 223 and n. 37.

Indeed, the complex and generally intricate nature of the scientific and technological processes involved in agricultural biotechnology do not lend themselves to cherry picking of one process or outcome over others. For instance, genetic engineering interventions may accomplish storage or marketing objectives such as elongating the shelf life and promoting efficient handling of sensitive fruits and vegetables. However, the overall health and environmental ramification of such fruits and vegetables, the process of their production may not be immediately evident. A full-scale exploration of the real and potential impact of genetic engineering and agricultural biotechnology is outside the scope of this project.

The prevailing reservations and skepticisms over genetic engineering have not retarded its advancement. The continued entrenchment of agricultural biotechnology in global food production is a reality that can no longer be wished away. However, as with new technologies and scientific innovations, the imperative for a prudent and critical approach to genetic engineering is no less compelling. Genetic engineering in particular and agricultural biotechnology generally presents significant opportunities in specific areas that are open to constructive exploitation. In this regard, the next section examines the potential impact of agricultural biotechnology on aspect of global public health crisis.

3. Agro-Biotech and Global Public Health

As noted already, lack of access to essential drugs for populations in need appear to dominate contemporary discussion on global public health crisis.[76] Similarly, crisis management of specific pandemics through sometimes *ad hoc* manufacture and dispensing of required vaccines and other epidemiological interventions define recent public health interventions on a global level.[77] Although these models of public health interventions incorporate therapeutic and preventive elements, the latter is at the core of public health imperative. Historically, occasional outbreaks of diseases that constitute threats to public health require both therapeutic and preventive interventions.[78] In such contexts, the essence of therapeutic intervention on affected members of the population is preventive, especially in regard to epidemics and other infectious diseases that expose the population to danger. When an infected member of the population is treated, the risk of the spread of the disease to others is contained. Public health is preventive health.[79] Most of preventive "medicine" is about encouraging a physically active and generally healthy life style. This is often accomplished through various forms of pubic centered education on personal and public hygiene, habit and general promotion of prudent choices in diverse spheres that have ramification for overall health and wellbeing of both the individual and the community.

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[76] See, for example, Richard E. Gold, *Gene Patents and Medical Access*, 49 INTELL. PROP. F. 20 (2009); Alexander G. Watson, *International Intellectual Property Rights: Do TRIPS' Flexibilities Permit Sufficient Access to Affordable HIV/AIDS Medicines in Less-developed Countries?* B.C. INT'L & COMP. L. REV. (2009); Maxwell R. Morgan, *Medicines for the Less-developed World: Promoting Access and Innovation in the Post TRIPS Environment*, 64 U. Toronto Fac. L.J. 45 (2006); James Thuo Gathii, *Rights, Patents, Markets and the Global AIDS Pandemic*, 14 FLA. J. INT'L L. 261 (2002); Thomas K. Mirabile, *AIDS, Africa and Access to Medicines*, 11 DETROIT COLL. L. J. INT'L L. 175 (2002); See generally, *supra* note 1 and accompanying text.

[77] See *supra* note 2 and accompanying text; see also Thomas Pogge, *Human Rights and Global Health: A Research Program*, 36 METAPHILOSOHPY 182 (2005).

[78] See OBIJIOFOR AGINAM, GLOBAL HEALTH GOVERNANCE: INTERNATIONAL LAW AND PUBLIC HEALTH IN A DIVIDED WORLD 46–59 (2005).

[79] *Supra* note 5.

Apart from occasional outbreak of diseases that are not necessarily linked to a population's lifestyle choices, significant pressures on today's public health are lifestyle-driven. For instance, "mutual relationships among environmental, social variables, nutrition, and public health, and nutritional deprivation" have long been implicated as factors that predispose a population to disease.[80] According to the World Health Organization (WHO), nutritional deficiency is a driver of adverse health outcome and it makes other stressors such as infectious disease most potent. The organization describes "malnutrition as the greatest single risk factor contributing to the global burden of disease."[81]

The Food and Agriculture Organization (FAO) is a specialized organ of the United Nations with mandates that include improving the quality of nutrition, food and agricultural supplies and general standard of living of local populations.[82] Its estimates for the last decade put the number of undernourished peoples in world at 815 million, a number that has recently risen to 963 million[83] and continues to grow in the wake of current global food crises. While 777 million of those hungry in the last decade lived in less-developed countries, now there are 907 million of them. According to the FAO, "[o]f

[80] See Richard D. Semba, *Nutrition and Development: A Historical Perspective*, in NUTRITION AND HEALTH IN LESS-DEVELOPED COUNTRIES 6 (Richard Semba & Martin W. Bloem, eds., 2002).
[81] ROLAND LAPONTE, TED SCHRENCKER, DAVID SANDERS & WILMA MEEUS, FATAL INDIFFERENCE: THE G8 AFRICAN AND GLOBAL HEALTH (2004), *available at* http://www.idrc.ca/en/ev-45682-201-1-DO_TOPIC.html (references to this book are mainly from Chapter Five of the online version, entitled "Nutrition, Food Safety and Biotechnology").
[82] See *Statement of Mandate*, FOOD AND AGRICULTURE ORGANIZATION, http://www.fao.org/about/mission-gov/en/; see also Shaw, *supra* note 10, at 67–68.
[83] See FAO, *Number of Hungry People Rises to 963 Million* online at http://www.fao.org/news/story/en/item/8836/ (last visited Feb. 16, 2011). These figures are the latest available, from 2008.

these, 65 percent live in only seven countries: India, China, the Democratic Republic of Congo, Bangladesh, Indonesia, Pakistan and Ethiopia".[84]

Despite notable progress in Southeast Asia, especially in Thailand and Vietnam, almost two-third of the world's hungry live in Asia (i.e. 583 million).[85] Sub-Saharan Africa has the unenviable record of highest proportion of undernourished people in the total population, with one in three people chronically hungry (i.e. 236 million).[86] Overall, Asia and Sub-Saharan Africa post the highest rates of child malnutrition on a global scale. Multiple combinations of interrelated but innumerable factors – including illiteracy, poverty, high food prices, political instability, harsh climatic conditions, and recent economic downturn – accounts for this dangerous and gloomy profile.

The FAO criterion for undernourishment is premised on daily intake of calories at a level regularly "insufficient to meet dietary energy requirement."[87] In *Fatal Indifference*, Laponte et al. point out that the FAO criterion "does not refer to shortages of micronutrients, such as iodine, vitamin A and iron, that may be critical for health, and which affect much larger number of people."[88] Malnutrition is a significant factor in the high rate of infant and maternal mortality and generally low life expectancy in many less-developed countries. The developmental and economic impact of malnutrition as a public health challenge to less-developed countries is recognized at diverse international

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[84] *Id*.
[85] *Id*.
[86] *Id*.
[87] *Supra* note 81.
[88] *Id*.

institutions and *ad hoc* global policy forums, notably the United Nations, the WHO, FAO, UNICEF, the World Bank, and even the G8 of the world industrialized nations.[89]

Strikingly, the United Nations Millennium Development Goals (MDGs), which outline the international development objectives projected to be realized by the year 2015, identify key aspects of the factors linked to public health crisis in less-developed countries.[90] They include reduction of extreme poverty and hunger, child mortality, improvement of maternal health, combating of specific disease epidemic, promotion of universal primary education, gender equality and empowerment of women. These heads of objectives bear direct relevance to nutritional health. For example, poverty has a chicken-and-egg relationship with illiteracy. Jointly and severally, they escalate the cycle of ignorance that undermines the promotion and management of a healthy maternal and infant life style for the collective health of the population. The final part of the MDGs focuses on the forging of a global "partnership of development." This omnibus part of the MDG centres on collaborative strategies between developed and less-developed countries, which target development initiatives aimed primarily at poverty eradication.

Similar to the sentiments in the MDGs, the G8 of industrialized nations have made commitment to International Development Goals (IDGs) in regard, among other things, to tackling the scourge of poverty in less-developed countries.[91] It seeks to reduce the number of children less than five years old who are underweight, which is the key

[89] *Id*.
[90] See the elaboration of the MDG online at http://www.un.org/millenniumgoals/ (last visited Feb. 16, 2011).
[91] *Supra* note 81.

indicator of poverty for the G8. The G8 Action Plan for Africa[92] makes mention of food security in the context of economic development, and includes the adoption of new biotechnologies. The suitability of agricultural biotechnology for less-developed countries, as well as the appropriate modality for its uptake remains a policy challenge. So far, this has been approached in multiple combinations of development assistance, agricultural assistance, food aid, emergency food reliefs, etc.

Prevailing inequities in the international trade framework and the global political economics of agriculture cast a dubious cloud on the sincerity and true motives of agricultural assistance and food aid for less-developed countries.[93] Food aid and agricultural assistance critics have insinuated a number of ulterior motives tenable under those initiatives.[94] As between the recipient countries, their local producers, on the one hand, and the donor countries and their agro-biotech companies, on the other, it is not clear who actually benefits from food aid or other forms of agricultural assistance.[95] Also, it is hard to ascertain whether food aid and agricultural assistance advances food security in the recipient or in the donor countries.[96]

[92] Adopted by the G8 leaders in Kananaskis, Alberta, Canada, in 2002 pursuant to the New Partnership for Africa's Development (NEPAD). The latter is an Africa-driven initiative to identify and tackle priority areas of the continent's development challenges.
[93] See Gonzalez (2004), *supra* note 10; Laponte et al., *supra* note 81, at chapters 5 and 7; cf. Shaw, *supra* note 10.
[94] According to Laponte et al., *supra* note 81, food "aid is motivated at least partly by a desire to absorb domestic surpluses," see also Shaw, *supra* note 10, at 21.
[95] Shaw, *supra* note 10.
[96] See Laponte et al., *supra* note 81, at Chapter 7, which explores the negative impact of agricultural subsidies by industrialized countries on agricultural production, food security and export potentials of recipient countries.

Similar sentiments apply in regard to perceived negative impact of emergency food reliefs. Akin to the tendency of big pharmaceutical companies to donate patented drugs that are on the verge of expiration to needy populations[97], donors capitalize on food aid for "food dumps" to offload surplus agricultural products to circumvent WTO anti-dumping rules.[98] Continued agricultural subsidies in developed countries destroy the export capacity of food aid recipients, a situation that raises doubts on the altruistic foundation of food aid. Non-emergency food aid presents a potential threat to food security in recipient countries. They open up markets for donor countries as well as upset the traditional pattern of food production in recipient countries.[99]

The public health impact of nutritional deficiencies in less-developed countries assumes a crisis dimension.[100] Despite the reservation trailing the nature of agricultural biotechnology and the suspect nature of agricultural assistance and GMO food aid, agricultural biotechnology is an attractive incentive to tackle malnutrition as the "greatest single risk factor contributing to the global burden of disease." The potential of agricultural biotechnology as a tool to alleviate malnutrition in less-developed countries and among less-endowed populations is only one aspect of its possible impact on public health. In other regards, such as biopharming, agricultural biotechnology, especially

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[97] See Shah, *supra* note 2.
[98] Laponte et al., *supra* note 81.
[99] See generally Shaw, *supra* note 10; Laponte et al., *supra* note 81.
[100] See Sasson, *supra* note 17; see also Laponte et al., *supra* note 81; MEDICINS SANS FRONTIERES, MALNUTRITION: HOW MUCH IS BEING SPENT? (Nov. 2009), *available at* http://www.msf.org/source/malnutrition/2009/NutritionHowMuchIsBeingSpent.pdf (last visited Feb. 16, 2011). For a discussion of how rampant malnutrition is a factor in the mental, physical and intellectual development of more than 100 million children globally and how parental nutrition education is superior to large, politically motivated feeding or aid programs, see WORLD BANK, REPOSITIONING NUTRITION AS CENTRAL TO DEVELOPMENT: A STRATEGY FOR LARGE-SCALE ACTION (2006), *available at* http://siteresources.worldbank.org/NUTRITION/Resources/281846-1131636806329/NutritionStrategy.pdf (last visited Feb. 16, 2011).

genetic engineering, is used to exploit living organisms for the production of pharmacologically active substances. In the context of other complex disciplinary convergences, genetic engineering facilitates the "pharming" of crucial organs for complex medical procedures and pharmaceutical R&D. Agricultural biotechnology is an integral aspect of the twenty-first century medical revolutions in ways that re-enforce the traditional affinity between agriculture, food and medicine.[101]

a) The Case for Bio-fortification and Functional Food: Two Analogies

Of particular interest in this article is role of agricultural biotechnology in the development of so-called functional food. In the words of one analyst,

> "[f]ood fortification to improve the nutritional quality of diets was first practiced during the mid-1990s. […] The potential of foods to provide health benefits is known as functional food research, which is somewhat of a misnomer because all foods are functional. The term nutraceuticals may be more appropriate, even though it tends to medicalize the food supply. Biotechnology, specifically genetic engineering will assist the food industry in capturing the highest market potential for functional food.[102]

Besides market capture for functional foods, agricultural biotechnology is potentially a strategic resource for reversing the negative effect of malnutrition as a significant risk

[101] See generally Sasson, *supra* note 17; Ryan-Harshman, supra note 29; see also Kuhnlein & Turner, *supra* note 57.
[102] Ryan-Harshman, *supra* note 29, at 847.

factor to global public health crisis. To accomplish this objective, especially for less-developed countries and other disadvantaged or malnourished populations, we must of necessity de-emphasize the market economic dynamics or the political economics of agriculture for the developmental imperative and the urgent intervention considerations invoked by the association of malnutrition with public health crises.[103] That way, we are most likely to temper if not get around most of the existing obstacles, including resistances to GMOs and products of agricultural biotechnologies. From the FAO data highlighted above,[104] the statistics on the public health impacts of malnutrition on less-developed countries of Africa and Asia depict the problem in a crisis mode. It is a problem requiring an urgent intervention. This "crisis interventionist approach" in the use of agricultural biotechnology to address negative public health impact of malnutrition in less-developed countries can be analogized to two patterns of response to public health challenges at various national and global levels, namely the anti-obesity campaigns in developed countries and the global public good approach to health provisions.

i) The Anti-obesity Campaign

Various governments of the industrialized world, including the US, Canada, France, UK and most other European countries have responded to the "obesity epidemic" that has

[103] Many critics of agricultural biotechnology or industrial agriculture (e.g. Tokar, *supra* note 10; Gonzalez, 2004, *supra* note 10; Conway, *supra* note 4; Altieri, *supra* notes 37& 68; FRANK ELLIS, AGRICULTURAL POLICIES IN DEVELOPING COUNTRIES (1992); E.M. Young, *supra* note 41) agree that both forms of agricultural production jointly or severally advance the neoliberal political economics of agriculture and create a culture of dependence on external multi-national agro-allied corporations by less-developed countries for food. Indeed, in order to adapt agricultural biotechnology for meaningful crisis intervention, we need to create a platform in which the application of benefits of agricultural biotechnology is need-, rather than market-driven.
[104] *Supra* notes 83 and 84 and accompanying text.

arisen in those countries since the 1990s.[105] Although the WHO recognized obesity as a global epidemic that constitutes an ongoing threat to public health, countries at highest risk are those in the affluent regions of the world. Like malnutrition, obesity is mostly a life style-based crisis, even thought it has genetic ramifications in some cases.

Leading the way, the WHO issued its promotional document on the dangers of obesity and related diseases titled *World Strategy for Food, Physical Exercise and Health.*[106] According to the WHO, "[t]he strategy addresses two of the main risk factors for noncommunicable diseases, namely, diet and physical activity, while complementing the long-established and ongoing work carried out by WHO and nationally on other nutrition-related areas, including malnutrition, micronutrient deficiencies and infant- and young-child feeding."[107] In some industrialized countries more than half of the population falls within the overweight and obesity borderline category. For the first time in those countries overweight and obesity constitute significant threat to life expectancy resulting in health and social impacts on a comparable scale to other entrenched public health challenges, notably smoking, for example.[108] Also, like malnutrition, the impact of

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[105] The World Health Organization reports that in 2008 1.5 billion adults were overweight—and nearly 500 million of these were obese: WHO, *Obesity and Overweight*, http://www.who.int/mediacentre/factsheets/fs311/en/ (last visited Feb. 16, 2011). The Median percentage for the prevalence of obesity in OECD countries is almost 15 percent according to 2006/2007 figures. According to the 2009 US Center for Disease Control (CDC) figures, 26.1% of US population was obese in 2008 compared to 25.5% the year before. The US has the highest percentage of obesity amongst the 30 OECD countries. For a review of the latest CDC report on obesity across the US, see Miranda Hitti and Louise Chang, *How Fat is Your State?* WEBMD.COM, (July 8, 2009), http://www.webmd.com/diet/news/20090708/how-fat-is-your-state (last visited Feb. 16, 2011); see also HEALTH AT A GLANCE 2009: OECD INDICATORS (2009).

[106] WHO, WORLD STRATEGY FOR FOOD, PHYSICAL EXERCISE AND HEALTH (2004), *available at* http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf (last visited Feb. 16, 2011).

[107] *Id*.

[108] For instance, Statistics Canada reports that the number of obese Canadians doubled between late 1978 and 2005 and has continued to go up. See Statistics Canada, *Obesity – the Key Figures According to*

obesity in overall population health is hardly an isolated one. For instance, the rise in obesity correlates to increase in cardiovascular diseases, Type 2 diabetes, various forms of cancer as well as myriad psychological and psychosocial problems and other dangerous, and often terminal, health conditions.[109]

At different national governmental levels, most developed countries responded to the obesity epidemic through the institutionalization of a combination of various public health education and lifestyle awareness programs. These include revisions of the dietary and physical exercise regimen, especially for youths and school-age children in public schools and elsewhere, labeling regimes for food and food-processing industries, including restaurants and eateries.[110] Also, these countries embarked on dedicated education and various campaigns using the diverse new media to sensitize the public on the dangers of obesity and the life styles that predispose populations to it.[111] Such campaigns have also elicited innovative responses in both public and private sporting, outdoor and indoor physical exercise entrepreneurships now enhanced by new

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Statistics Canada Online, http://obesity.ulaval.ca/obesity/generalities/prevalence.php> (last visited Feb. 4, 2011); for more up-to-date statistics, see Public Health Agency of Canada, *Obesity in Canada a Snapshot*, http://www.phac-aspc.gc.ca/publicat/2009/oc/pdf/oc-eng.pdf> (last visited Feb. 4, 2011).

[109] See Human Resources Canada, *Indicators of Well-Being in Canada*, http://www4.hrsdc.gc.ca/.3ndic.1t.4r@-eng.jsp?iid=6> (last visited Feb. 4, 2011).

[110] For example, noting the association of saturated and trans-fat, excess sugar and calories with obesity, most beverage companies have capitalized on the market niche for low trans/saturated fat and calorie-/sugar-free brands. On an annual basis, Health Canada issues *Canada's Food Guide* and *Physical Activity Guide to Healthy Active Living*, which highlight suggested national dietary and physical activity regimens for various age groups as a public health promotion strategy. For the current guides, see http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php (last visited Feb. 16, 2011).

[111] For example, the US Congress mandated the Centers for Diseases Control and Prevention to initiate nutrition and physical activities and related programs as a nation-wide strategy to tackle obesity and other chronic diseases. In 2006, the CDC published the first report on the progress of the initiative in 20 states. See Sue Lin Yee, Pam Williams-Piehota, Asta Sorensen, Amy Roussel, James Hersey & Robin Hamre, *The Nutrition and Physical Activity Program to Prevent Obesity and Chronic Diseases: Monitoring Progress in Funded States*, 3(1) PREV. CHRONIC DIS. A23 (2006), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1500956/pdf/PCD31A23.pdf> (last visited Feb. 3, 2011).

information technologies. As well, these campaigns have resulted in positive reactions from the biotechnology, food, beverages and allied industries that now capitalize on the opportunity to advance R&D on functional and anti-obese foods and drinks.[112]

The proactive role of many industrialized countries in promoting the nutritional health of the population pursuant to their anti-obesity public health programs takes the form of a crisis intervention strategy. Recently, the current US First Lady, Michelle Obama, unveiled her White House Legacy Initiative, which is aimed at curbing childhood obesity. Dubbed the "Let's Move" campaign, it marks a significant renewal of attention to obesity, in a crisis-intervention fashion, for a country that is said to spend $150 billion annually on preventable obesity-related diseases.[113] In this crisis mode, objections or traditional libertarian criticisms to state paternalism and state erosion of citizens' free choice in regard to regulatory intervention on food and beverages are easily blunted by the overarching public regarding objectives that underlie the anti-obesity campaigns.[114]

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[112] Food product labelling is an important aspect of the work program and mandate of the United States Food and Drug Administration and the Department of Agriculture, and their Canadian Counterparts, Health Canada and Canada's Food Inspection Agency (which administers Canada's *Food and Drugs Act* and associated regulations). In the last few decades, the labelling regimes for a number of food items, especially beverages and general groceries, have been required to include information on nutritional values, ingredients, calories, fat, trans fat, carbohydrates, cholesterol and sugar counts.

[113] See *On Michelle Obama's Obesity Campaign* (Editorial), THE SAN FRANCISCO CHRONICLE, (Feb. 10, 2010, at A-13), *available at* http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2010/02/09/EDQM1BUHO3.DTL (accessed Feb. 20, 2010).

[114] For insight into the ideology-driven debate on state paternalism on citizen's food choices and related matters, see the self-explanatorily titled book: DAVID HARSANYI, NANNY STATE: HOW FOOD FASCISTS, TEETOTALING DO-GOODERS, PRIGGISH MORALISTS, AND OTHER BONEHEADED BUREAUCRATS ARE TURNING AMERICA INTO A NATION OF CHILDREN (2007). Compare Kenneth Calman, *Beyond the "Nanny State": Stewardship and Public Health*, 123(1) Public Health e6-e10 (2009), *available at* http://www.publichealthjrnl.com/issues?Vol=123> (last visited Jan. 18, 2011). Calman argues that the state has the duty to preserve the health of the individual and the public and that such a duty would often necessitate restricting citizen's choices. In November 2010, the Board of Supervisors of the California City of San Francisco voted overwhelmingly to ban the practice by restaurants to offer children free toys with meals containing more than prescribed levels of calories, sugar and fat, like the so-called Happy Meal, one of the niches of the global fast food giant, McDonald's . The ban, which is sure to outrage libertarians, is scheduled to take effect at the end of 2011. See Joe Eskenazi, *San Francisco Bans Happy Meal*, SAN

That approach is comparable to the present proposal to extend and use agro-biotech food fortification mechanisms and products to less-developed countries in order to tackle the public health menace that malnutrition, like obesity, poses. As already noted, this strategy does not of necessity dispense with valid objections and lingering criticism of agricultural biotechnology, especially in the context of less-developed countries. But pragmatically from a crisis point of view, the strategy assumes an urgency that eclipses some, even the most pertinent, of the objections.

ii) Global Public Good Approach to Functional Food

The second analogous response is global in scale and scope. As mentioned earlier, recent discourses on global public health crisis focus on lack of access to essential drugs for needy populations.[115] In part, this is blamed on the unaffordable cost of such drugs as a result of the extant global intellectual property system. Because of endemic poverty, the majority of people in the less-developed world cannot pay for essential drugs.[116] Consequently, pharmaceutical R&D does not target their health needs.[117] In the hard and cold economics of pharmaceutical R&D, it does not matter that the less-developed world constitutes 90% of the global population in urgent need of health care.[118] Consequently, the public health needs of less-developed countries, especially in regard to access to

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FRANCISCO WEEKLY (Nov. 2, 2010), *available at* http://blogs.sfweekly.com/thesnitch/2010/11/happy_meal_ban_passes_--_with.php (last visited Nov. 6, 2010).

[115] See *supra* note 1 and accompanying text.

[116] *Id*.

[117] See DRAHOS & BRAITHWAITE, SUPRA NOTE 4 AT 167–168: "[p]atent-based R & D is not responsive to demand, but to ability to pay."

[118] See Els Toreele, Martine Usdin, & Pierre Chirac *A Needs-Based Pharmaceutical R&D Agenda for Neglected Diseases* (July 31, 2004), http://www.who.int/intellectualproperty/topics/research/Needs%20based%20R&D%20for%20neglected%20diseases%20Els%20Pierre%20Martine.pdf (last visited Feb. 16, 2011); see also P. Trouiller, P. Olliaro. E. Torreele, J. Orbinski, R. Laing & N. Ford *Drug Development for Neglected Diseases: A Deficient Market and a Public-health Policy Failure*, 22:359 (9324) LANCET 2188 (2002).

essential drugs, take the status of "global public goods." The latter refers to those goods that cannot be provided by market forces.[119] Accordingly, since the provision of such goods are outside the capacity of relevant national governments and market forces, the responsibility to do so becomes a matter for concerted international effort.[120]

For some analysts, the global public goods argument explains the role of NGOs, the WHO and various national and intergovernmental organizations in the facilitation of access to essential drugs outside a strict market paradigm to stem public health crisis in less-developed countries.[121] In recent times, there has been a proliferation of diverse charities, foundations and private non-profit initiatives that now constitute active players in the public health dynamics of less-developed countries.[122] There is no dearth of literature on the emergent patterns or forms of private public partnerships under which these initiatives operate. For the most part, the essential drugs required to tackle aspects of public health crises in less-developed countries are subject to patents held by pharmaceutical companies. Without doubt, these companies are central to emerging forms of non-market or quasi-market interventions toward to the supply of essential medicines to populations in need.[123] Given their high stakes in intellectual property, they

[119] See WHO, GLOBAL PUBLIC GOODS FOR HEALTH, *available at* http://whqlibdoc.who.int/publications/9241590106.pdf; see also GLOBAL PUBLIC GOODS FOR HEALTH: HEALTH ECONOMICS AND PUBLIC HEALTH PERSPECTIVES (R. Smith, R. Beaglehole, D. Woodward, & N. Drager, eds., 2003).

[120] For further perspectives on global public goods, including environmental protection, public health, education, and scientific advancement, see Keith E. Maskus & Jerome H. Reichman, *The Globalization of Private Knowledge Goods and the Privatization of Global Public Goods*, 7 J. Int'l Econ. L. 279 (2004).

[121] Oxfam, Oguamanam, Oriola, *supra* note 2.

[122] See Oxfam, Oguamana, Oriola, *id*. (for reference to such organizations as The Bill & Melinda Gates Foundation, The William Jefferson Clinton Foundation, the Wellcome Trust, Universities Allied for Essential Medicines, Medicines Sans Frontiers and several disease specific initiatives such as the Roll-Back Malaria Program, Drugs for Neglected Diseases Initiative, the Global Network for Neglected Diseases and the United States Presidential Emergency Plan for AIDS Relief).

[123] See Oguamanam, *supra* note 2.

are actively engaged in negotiating forms of private public partnerships (PPP) in pharmaceutical R&D, targeting key vaccines and the supply of essential drugs and delivery of urgent medical relief to needy populations via forms of non-market interventions.[124]

The foregoing situation is not entirely different from, and can be analogized to the need to extend fortified biotechnology food products (as global public goods) to tackle malnutrition as a source of public health burden in less-developed countries. Agricultural biotechnology, like pharmaceutical production, is an innovation-intensive enterprise. Like the pharmaceuticals, most biotechnology products are subject to patents. Given that most of the malnourished population in less-developed countries lives on less than one dollar per day, they are unable to afford functional biofortified foods necessary for mitigating their endemic malnutrition.[125] Agricultural-biotechnology companies control most of the patents in the area of GM food products. These companies have the potential for assist in the development and delivery of targeted biofortified or functional foods as public health incentives. They are critical stakeholders on how these initiatives are implemented. Naturally, agricultural biotechnology companies are interested actors in the programs presently underway regarding the development and dissemination of biofortified food crops targeting populations in need.

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[124] Examples include Advance Market Commitments, Product Development Partnerships, Priority Review Voucher, etc. For a general review of these and other frameworks, see Oxfam, *supra* note 2.

[125] Critics of agricultural biotechnology harp on the twin subjects of access and affordability. For example, Altieri, *supra* note 37, at 2 observes: "[m]ost biotechnological innovations available today bypass poor farmers: first because these farmers cannot afford the seeds that are protected by patents owned by biotechnology corporations, and second, because this modern technology is not adapted to the marginal environments where resource-poor farmers live."

Intervention at a global scale for hunger containment reflects a mélange of crisis-management and broader socio-economic policy approaches. Consequently, the global food and agricultural landscape is buffeted by a complex array of bureaucracies operating at multifarious levels, including intergovernmental, regional, national, non-governmental, private and diverse civil society initiatives.[126] Given the technology-/research-intensive nature and obligate interdisciplinarity of food and agricultural subject matters, the global agricultural and food question is often one of political economics. Inherently, within that matrix are the interrelated issues of equity, access, markets, and development in the context of the tension between public and private interest in agricultural and food production. Of all the variegated global food and agricultural institutions ably discussed in John Shaw's recent work, *Global Food and Agricultural Institutions*, perhaps none more than the Consultative Group on International Agricultural Research (CGIAR) reflects the practical imperative for a non-market or public goods approach in the extension of the benefit of agricultural biotechnology as public health incentive in less-developed countries.

b) The HarvestPlus Model

The CGIAR was established in 1971 as a private-public initiative that manages the use and access to samples to plant genetic resources (PGRs) in global *ex situ* seed banks for agricultural research, including plant breeding. The principal sponsors/financiers of CGIAR include the FAO, the International Fund for Agricultural Development (IFAD), the United Nations Development Program (UNDP), the World Bank, private charities and various national governments. It is worth noting that these publicly held PGRs in *ex*

[126] See Shaw, *supra* note 10.

situ global seed banks were historically sourced from centers of biodiversity, mainly less-developed countries. CGIAR held "the largest single genetic materials, comprising 650,000 accessions (about 10 percent of the world's collection)" until 2008.[127] The CGIAR describes itself, "as a strategic alliance of countries, international and regional organizations, and private foundations supporting 15[128] international agricultural centers (IARCs) that work with national agricultural research systems and civil society organizations, including the private sector".[129] These federating IARCS exist as autonomous entities but are jointly committed to the CGIAR mission of providing "the world's largest investment in generating public goods for the benefit of poor agricultural communities in the developing countries."[130] According to the CGIAR, the alliance "applies cutting-edge science to foster sustainable agricultural growth" to reduce poverty and enhance human, agricultural and environmental wellbeing that benefits the poor.[131]

CGIAR's activities focus on five thematic strategies and priorities aimed at the delivery of the benefits of agricultural innovation to the needy in less-developed countries. They include sustainable approaches to agricultural production, promotion of national agricultural research capacity, germplasm taxonomy, collation, conservation and dissemination, and policy research on interrelated agricultural subject matters, such as food, health, new technologies and natural resources conservation.[132] With the complement of the International Food Policy Research (IFPRI), one of its federating

[127] Shaw, *supra* note 10, at 161.
[128] 13 of these IARCs are located in less-developed countries.
[129] *Supra* note 60, at 282, n. 42.
[130] See Shaw, *supra* note 10, at 153.
[131] See CGIAR, *Who We Are*, http://www.cgiar.org/who/index.html (last visited Feb. 4, 2011).
[132] See CGIAR SCIENCE COUNCIL, SUMMARY OF REPORT ON SYSTEM PRIORITIES FOR CGIAR RESEARCH 2005–2015 (2005).

IARCs, CGIAR's policy research has recently garnered traction in the areas of poverty alleviation, eradication of hunger and malnutrition. Under the auspices of its programmatic model, the Global Challenge Program, CGIAR launched the Generation Challenge Program aimed at extending the benefits of biotechnology, especially molecular biology, to the global stock of genetic resources and putting them at the disposal of needy families and farming communities to plug the gap between hungry and healthy families.[133]

To shore up its dwindling financial fortune in the 1990s and, in part, "to draw attention to agriculture by pointing out its close links with high-profile issues, such as the environment, health and conflict,"[134] the CGIAR embarked on a conscious re-branding effort that resulted in the near-renaming of IARs as "Future Harvest Centers". Essentially, the Future Harvest [FH] brand was the coordinating platform for launching the CGIAR effectively into the biofortification campaign. The FH highlighted the link between agriculture and myriad development issues, including the public health impact of nutritional deficiencies and the remedial role of biotechnology, specifically via the biofortification option.

Unfortunately, FH was the first casualty of its own success. Its social and development marketing quickly lost favour with CGIAR leadership and key donors. Consequently, the FH brand was disbanded. In-house post-mortem reflection on the early demise of FH

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[133] See CGIAR, *The Generation Challenge Programme,* http://www.generationcp.org/ (last visited Feb. 4, 2011).

[134] See Nathan Russell & Ruth Raymond, *Collective Communications on the CGIAR: A Short History of a Long Standing Endeavour*, http://www.cgiar.org/pdf/scw_HistoryofCollective%20Communications.pdf (last visited Feb. 16, 2011).

initiative implicates internal intrigues within the federating IARCs under the CGIAR umbrella.[135] It also points to perceived conflict between resource mobilization and communication. The latter is quite instructive as it may provide a clue to donor disaffection for the FH modus operandi. It is possible that given FH's emphasis on social marketing and on development, some donors were not pleased that proprietary interests in the PGRs innovations within the FH agenda were completely out of the equation. CGIAR is a private-public partnership and terms of access to the benefits of its innovation remain a contentious issue. FH's *modus operandi* and orientation toward social marketing and development may not have adverted to that historic delicate balance that characterizes debates over CGIAR's oversight or role in regard to use and access to PGRs in *ex situ* seed banks under its jurisdiction.[136] Private stakeholders within the CGIAR have yet to dissociate their interest from proprietary control of research outcomes.

Despite the demise of FH strategy, the CGIAR, in alliance with its affiliate IARs, has continued the biofortification project. The primary vehicle has been the HarvestPlus initiative, "a global alliance of research institutions and implementing agencies coming together to breed and disseminate crops with nutritive value (biofortification), e.g. with higher content of iron, zinc and vitamin A."[137]

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[135] *Id.*
[136] For instance, Mgbeoji and others suggest that CGIAR was set up and allowed free hand to access global gene banks to facilitate the funneling of the South's PGRs to the North's industrial agricultural complex, which could no longer be guaranteed at the formal end of colonialism. See IKECHI MGBEOJI, GLOBAL BIPORACY PATENTS, PLANTS AND INDIGENOUS KNOWLEDGE 106 (2006); see also WILLIAM LESSER, SUSTAINABLE USE OF GENETIC RESOURCES UNDER THE CONVENTION ON BIOLOGICAL DIVERSITY: EXPLORING ACCESS AND BENEFIT SHARING ISSUES 99 (1997).
[137] See Sasson, *supra* note 17, at 14.

In terms of its governance framework, HarvestPlus is a partnership between the Colombia- and US-based International Center for Tropical Agriculture (CIAT) and IFPRI, both are CGIAR's IARCs. HarvestPlus is administered by a Project Advisory Committee (PAC) which is composed, in part, by representatives of both CIAT and IFPRI.[138] After its launch in 2004, HarvestPlus is on record as the first recipient of funding for biofortification research granted by the Bill and Melinda Gates Foundation (BMGF), an organization that is also proactive in a public goods approach to global health crises, especially in less-developed countries. HarvestPlus has since expanded its donor list, marking a strategic new phase in non-profit interest in activities of CGIAR and in the advancement of public goods approach to agricultural biotechnology. HarvestPlus prides itself "as a global leader in developing biofortified crops and now works with more than 200 agricultural and nutrition scientists around the world."[139]

Experts claim that "biofortification is backed by sound science."[140] Investigations of scientific integrity of biofortification confirm that most staple crops have substantial and useful genetic traits and variations that are stable across a range of growing environments. They also affirm that breeding programs can easily manage nutritional quality traits in many staple crops while traits for qualitative nutrition can be fused with greater agronomic traits capable of enhancing yields.[141]

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[138] See *Breeding Crops for Better Nutrition*, HARVESTPLUS.ORG, http://www.harvestplus.org/content/governance (last visited Feb. 4, 2011).
[139] *About HarvestPlus,* HARVESTPLUS.ORG, http://www.harvestplus.org/content/about-harvestplus (last visited Feb. 16, 2011).
[140] Sasson, *supra* note 17, at 14
[141] *Id*.

HarvestPlus's initial efforts at biofortification focus on six select staple crops over which pre-breeding studies have been completed. They are beans, cassava, sweet potatoes, rice maize and wheat. Although these crops are low in micronutrients, they are subject to high consumption in less-developed countries. Combining conventional and novel breeding techniques, as well as molecular biological insights, biofortification is a quasi biotechnological intervention program aimed at inducing or boosting micronutrient-enhancing traits in the target crop for improved nutritional outcomes. In essence, it is a nutraceutional or functional food initiative. Since 2005, these crops have remained active targets of different aspects of biofortification R&D that seeks to extend nutritional benefits to vulnerable and malnourished populations in less-developed countries. Cumulatively, these crop ranges are critical sources of staple food for a significant population groups in Mexico, for example, and most less-developed countries of Asia, Africa and South America.

HarvestPlus's phased program of work has a far-reaching, ambitious scope. Among its stated aims are to determine nutritionally optimal breeding objectives; to screen CGIAR germplasm for high iron, zinc and beta-carotene amounts; to initiate crosses of high-yielding adapted germplasm for selected crops; to document cultural and food-processing practices, and determine their impact on micronutrient content and bioavailability; to identify the genetic markers available to facilitate the transfer of traits through conventional and novel breeding strategies; to carry out *in vitro* and animal studies to determine the bioavailability of the enhanced micronutrients in promising lines; and to initiate bio-efficiency studies to determine effect on biofortified crops on micro-nutrient status on humans.[142]

c) Biofortification: Drawbacks and Benefits

As already noted, most of the criticisms associated with uptake of agricultural biotechnology, food aid and agricultural assistance, especially by less-developed countries are tenable in regard to biofortified food products. For example, Altieri argues that:

> People do not exhibit vitamin A deficiency because rice contains little vitamin A, or beta- carotene, but rather because [instead of a more varied diet] their diet has been reduced to rice and almost nothing else […] A magic-bullet solution, which places beta-carotene into rice while leaving poverty, poor diets and extensive monoculture intact, is unlikely to make any durable contribution to wellbeing.[143]

Similarly, Laponte et al. point out that countries of the G8 undermine food security and nutritional welfare of less-developed countries, especially in sub-Sahara Africa. They point to the hypocrisy of EU countries that limit fishing vessels within their waters to protect stock and simultaneously engage in paying generous compensation for European fishers affected by the depletion of stock and tightened restrictions on fishing. Contrary to G8 and EU posturing on food security in less-developed countries, they pressure those

[142] See CGIAR/HARVEST PLUS, HARNESSING AGRICULTURAL BIOTECHNOLOGY TO IMPROVE THE HEALTH OF THE POOR: PLANT BREEDING TO COMBAT MICRONUTRIENT DEFICIENCY, 3 (2003) *available at* http://www.zab.uni-freiburg.de/forschung/HarvestPlusBrochure.pdf (last visited Feb. 16, 2011).
[143] See *supra* note 37.

less-developed countries to grant unsustainable fishing licences. Through those licences, European vessels engage in factory-style overfishing activities, which result in the depletion of fish stocks and a threat to the nutritional balance and health of coastal communities, especially in Africa.[144]

Despite these and several other drawbacks, as an initiative with significant public health benefit, the biofortification program has more to commend than to condemn it. Clearly, it is one of several concurrent and multi-pronged approaches to tackling nutritional crises in less-developed countries. It is hardly a magic bullet for everything wrong with the global political economics of food and agriculture. Given the backdrop of malnutrition-driven public health crises in less-developed countries, biofortification becomes a compelling option, at least in terms of its empirical and timely results that match the urgency posed by these crises.

Other mutually re-enforcing mechanisms with biofortification for addressing the nutritional crisis as public health intervention strategy include continuing nutritional education, especially targeting parents and children as the 2006 World Bank Studies on nutrition indicate.[145] Indeed dietary uptake of micronutrient-rich vegetables, fruits, animal and fish products, remains an important aspect of improving the nutritional profile in less-developed countries that needs to be promoted as matter of lifestyle, akin to physical exercise in the containment of obesity epidemic.

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[144] See Laponte et al., *supra* note 81. Focusing on the Mauritanian experience, they argue that G8 practices contribute directly to the problems of facing Africa's human and economic development. One such practice, involves factory fishing off Africa's coast.
[145] See *supra* note 100 and accompanying text.

A few features of the biofortification initiative under the CGIAR extol it in relation to the general skepticism around agricultural biotechnology. First, it is being implemented by the CGIAR/IFPRI within a pubic goods approach to the extension of the benefits of agricultural innovation to the poor. Second, so far, CGIAR has co-opted the private sector in the elaboration of this public goods vision. Even though the outcome of this experience remains inchoate, it assists in fostering practical understanding of public-private partnership in the context of food and agriculture as a global public good. Third, unlike the GMOs and other products of biotechnology, thus far, the HarvesPlus biofortification project targets key staple crops that are selected not necessarily on the basis of their market relevance. Rather, the crops are attractive because of their endemic or integral profile to the food culture of the target population. Fourth, the operational modality of the HavestPlus initiative aims at boosting self-reliance and knowledge transfer for members of indigenous and local communities. This is in contrast to the tendency by the biotechnology industrial complex to lock up knowledge by a combination of intellectual property and technology control mechanisms and to encourage dependence and reliance on external interests by these communities. The HarvestPlus model is a potential scheme to adapt modern biotechnology "to the marginal environments where resource-poor farmers live".[146]

Fifth, the emphasis of biofortification program on key staple foods may not align with traditional diversity of agricultural crops in the target population. However, since biofortification under the HarvestPlus program involves publicly held germplasms in the IARCs' *ex situ* gene banks, many of which are located in less-developed countries, the

[146] Contrast *supra* note 125 and accompanying text.

program takes the form of agricultural assistance rather than food aid. It exposes members of indigenous and local communities to dynamic new ways of dealing with their traditional landraces. Further, the broad outreach of the initiative and diverse collaborations undergirding its implementation create ample knowledge transfer and knowledge convergence opportunities. The ability to extend biofortification to traditional landraces of indigenous and local communities is perhaps one way of developing biotechnology locally under a culturally sensitive, purposeful and pragmatic arrangement.

The interest of the BMGF and a few other not-for-profit organizations in the biofortification and functional food program is instructive and symbolic in several respects. First, it identifies in a positive way the link between agricultural biotechnology and public health, especially in less-developed countries. The BMGF is already a significant player in addressing the lapses in pharmaceutical R&D and in plugging the access gap to essential drugs for needy population. As already noted, the access freeze to essential drugs for needy populations is an aspect of the global public health crisis that is now tackled both by a combination of therapeutic and preventive strategies. The biofortification project is mainly a preventive public health strategy.

Increased interest of public, private and non-profit entities in the HarvestPlus biofortification project will raise similar issues in regard to intellectual property and proprietary control of research and innovation. The CGIAR, its IARCs and the HarvestPlus program focus on germplasms from publicly held gene banks. That does not necessarily settle the intellectual property question, especially given the diversity of interest of the multifarious collaborating institutions. Also, the biofortification program provides a platform R&D opportunity, with capacity for expansion to other crops and markets beyond less-developed countries. That potential for expansion of the biofortification to program to developed countries outside the public goods parameter will raise strong intellectual property and market opportunities that stakeholders in the program will be inclined to exploit.

As in the pharmaceutical R&D sector, a major challenge for all stakeholders in the biofortification project is to develop a business model or proprietary control strategy, including intellectual property that advances their objectives. Presently, insofar as malnutrition in less-developed countries accounts for a significant part of the global burden of disease, and consequently a public health crisis, biofortification represents a viable option for mitigating the crisis. As such, the global public goods argument is equally applicable and provides an appropriate basis for leveraging intellectual property or proprietary constraints in order to realize the full benefits of this form of biotechnology intervention to public health.

Conclusion

Like most paradigmatic technologies, biotechnology – especially in the context of agriculture – is a subject of controversy in some quarters. While proponents and opponents of agricultural biotechnology are locked in deep disagreement over the veracity of various claims made in regard to the overall contributions of agricultural biotechnology, this has not slowed the rapid pace of global uptake of agricultural technology as the source of twenty-first century global food supply. Against the backdrop of historical transformation in agricultural production, genetic engineering-driven agricultural biotechnology marks a remarkable shift in the scientific template of agricultural innovation. Such a change has opened modern agriculture to greater opportunities that are often clouded by the ideological and passionate oppositions to agricultural biotechnology as well as such oppositions that arise from the global political economics of agriculture, especially in regard to food security.

However, a more pragmatic and prudent approach to the promise and potentials of agricultural biotechnology easily demonstrates the benefits of this form of innovation in other areas of need, particularly in regard to malnutrition as a critical aspect of global public health crises, especially in less-developed countries. It is possible that given the urgency and the crisis undertone of malnutrition, a strategic deployment of agricultural biotechnology in a constructive manner that adapts insights thereof to local and cultural sensitivities of target populations and associated agricultural practices could mitigate, if not help re-appraise, the characteristic misapprehensions over agricultural biotechnology. Like all paradigmatic innovations, the challenge of agricultural biotechnology lies in negotiating its access for those in need and in balancing its pros-and-cons and its sustainability for ultimate public good. The choice is not between changing the food supply and changing consumer habits to meet health needs. We need to do both. Agricultural biotechnology spurs important evolutions within the food industry and opens opportunities, alongside other forms of agricultural practices for a targeted revolution in nutritional awareness and education with potential to positively impact nutrition-related global public health crises, especially in the less-developed world.