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Division for Sustainable Development

Sustainable Development in the 21st century (SD21)

Food and Agriculture: The future of sustainability

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DRAFT

Study prepared by Daniele Giovannucci

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The concept for this paper was developed by Daniele Giovannucci of the Committee on Sustainability Development and David Le Blanc of the United Nations Department of Economic and Social Affairs (DESA).

Four broad-based groups participated in this high-level effort to solicit views of thought leaders from all facets of agriculture on how the food and agricultural system could become significantly more sustainable while best meeting the need for global food security.

Group 1: Policy and Trade Group convened by Charlotte Hebebrand of the International Food & Agricultural Trade Policy Council (IPC)[1], which promotes the role of trade in creating a more open, equitable, productive and sustainable global food & agricultural system. Contributing IPC members include high-level former government officials, agribusiness executives, farm leaders, academics and civil society leaders. IPC makes pragmatic trade policy recommendations to help solve the major challenges facing the global food & agricultural system in the 21st century—the need to promote global food security, to sustainably increase productivity, and to contribute to economic growth and development. IPC convenes influential policymakers, agribusiness executives, farm and civil society leaders, and academics from around the world in order to clarify complex issues, foster broad stakeholder participation in policy deliberations, and build consensus around pragmatic policy recommendations.

Group 2: This Business Specialists Group was convened by The Keystone Center and coordinated by Sarah Stokes Alexander, Julie Shapiro and Keith A. Wheeler.[2] The contributors for this paper are primarily, but not exclusively, private sector oriented, representing input companies, traders, and food and retail companies as well as several university perspectives. The Keystone Center seeks to solve our society's most challenging environmental, energy, and public health problems. As an independent facilitator and mediator, it convenes leaders in the public, private, and civic sectors to solve problems and advance good public policy through productive dialogue. The Keystone Center facilitates Field to Market, an alliance of producers, agribusinesses, food companies, retailers, and conservation organizations that is working to facilitate quantification and identification of key environmental and socioeconomic sustainability outcomes and metrics, foster industry-wide dialogue, and generate processes for continued improvement in sustainable commodity agricultural production

Group 3: The Rural Livelihoods and Poverty Expert Group was coordinated by Danielle Nierenberg of Worldwatch Institute's Nourishing the Planet project[3], an evaluation of agricultural innovations that are working to alleviate hunger and poverty, while also protecting natural resources and promoting environmental sustainability and social justice. The group consisted of a diverse set of contributors ranging from authorities on the role of gender in agriculture and leaders of farmers groups to NGO

[1] www.agritrade.org
[2] http://www.keystone.org/spp/environment/sustainability/field-to-market
[3] www.worldwatch.org/nourishingtheplanet

activists and academics from major universities. Despite the participants' different backgrounds and viewpoints, a number of common themes emerged that point toward agro-ecological solutions that can that can address challenges to our food system, including the negative effects of climate change on crop production and a growing population.

Group 4: An Agricultural Production and Environmental Sustainability Group was convened by Sara Scherr and Jeffrey Milder of EcoAgriculture Partners[4], which offers an independent platform for cross-sectoral dialogue and action among diverse stakeholders — from farmers and community organizations to international businesses, policy makers, NGOs and donors — striving for a world where agricultural communities manage their landscapes as eco-agriculture to enable them simultaneously to enhance rural livelihoods, conserve biodiversity and ecosystem services, and sustainably produce crops, livestock, fish, and fiber. The Group included researchers and agricultural NGO and farmer leaders from 14 countries who have been developing and promoting innovative agricultural production systems that have ecosystem benefits.

Danielle Nierenberg, Karen Hansen-Kuhn, Sophia Murphy and Shiney Varghese all contributed important data and research for the paper.

Dozens of experts representing many different countries offered their views for the paper. Of course, the views represented in synthesis do not necessarily reflect the contributors' specific views or the specific endorsement of the entities they represent. The overall paper is an independent synthesis of many views wherein some consensus points have emerged. Despite the diversity of sectors represented here, we feel that there could be even more producer, consumer, or rural community representatives in the mix. As we look to downscale these conversations in the future from the global scale to the more regional/national/local scale, any conversation on sustainability should directly involve the producers themselves.

We would like to acknowledge the more than 60 contributors from 23 countries for the time and thoughtful inputs that have enriched this process. Alphabetically they are:

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Celia Harvey (Vice-President, Conservation International, USA)
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Charlotte Hebebrand (Chief Executive,, International Food & Agricultural Trade Policy Council USA)

[4] http://www.ecoagriculture.org

Hans Herren (President, Millennium Institute, USA)
Jikun Huang (Director, Center for Chinese Agricultural Policy - Chinese Academy of Sciences China)
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Contents

1. Introduction

The rural world faces a profound challenge. It is already home to about three-quarters of the world's poorest people and faces the challenging conditions of increasingly limited resources such as water, land, and its younger people due to migration.[5] Yet, we expect rural lands to intensify production and feed a third more people in the coming decades. We expect the rural world to care for the ecosystem that agriculture has played a part in degrading. We expect that the rural world can offer communities a socio-cultural rootedness that we value in society. We expect this even in the face of the realities trending precipitously in the other direction.

Essentially, if we expect to create or sustain something close to an optimal balance of the social, environmental and economic aspects of agriculture, it does not take a scientist to conclude that the current course will simply not suffice. The rural world is much more than agriculture and yet it is agriculture that most impacts the rural space and whose products enable us all, rural and urban dwellers alike, to live.

In the past decade, researchers have clearly identified the range of scenarios for food and agriculture and identified the past impacts as well as the many challenges we face. Accordingly, there is considerable agreement about the nature and causes of these challenges. The challenges are not only those of our crops and animal husbandry but also those of our soils, biodiversity, and water. However, given the interpretations of past developments that are framed by diverse values and world views, there has been less accord about the best solutions.

The many contributors to this paper, despite having diverse world views, find that they share a number of conclusions about how to achieve a more sustainable food and agriculture system. This will surprise some. Because fundamentally different world views tend to feed many common disagreements, the group addressed these distinctions head on. The group understood that dynamic results can come from working together and that to move forward means to seek the areas of consensus based on the evidence.

And so, this paper invites inclusiveness as a starting point from which to give fair and reasonable expression to distinct world views. In doing so it identifies areas of consensus as the vital starting points. It does not step over the disagreements, simply gives them room for expression but does not linger on them to make a case in one way or another; as such it does not pretend to be an arbiter. Where consensus is not possible, the paper identifies the key issues that prevent consensus and suggests possibilities for further exploration.

The basic sustainable development ideas and paradigms for this study stem from the seeds germinated at the 1992 Conference on Sustainable Development, or the Rio Earth Summit. Yet, it recognizes the many advances in both understanding and achievement in the intervening two decades. Much has changed since the early 1990s, but many of the fundamental challenges the world faces, including how to reduce the number of hungry and malnourished remain the same. This paper's particular concern is for the role of food and agriculture through the lens of the social, economic, and ecological effect on low-income countries and emerging economies, but also considers the distinct issues of developed countries and the challenges they face.

[5] Undernourished people certainly teem in urban areas but the majority live in low-income rural areas of developing countries, often in higher-risk farming areas, and include many landless farmers that till other people's fields. http://www.wfp.org/hunger/faqs

Brief background

This report is one of the studies produced under the project "Sustainable development in the 21st century" (SD21), an undertaking of the Division for Sustainable Development of the United Nations Department of Economic and Social Affairs (UN DESA). The overarching objective of the SD21 project is to construct a coherent vision of sustainable development in the 21st century. The project aims to provide a high quality analytical input to the Rio+20 conference.

The report aims to explore the choices available under different scenarios for the agriculture and food sectors and, where there is agreement, on the likely consequences for long-term sustainability.

Aristotle, Galileo, and Oppenheimer would be quite familiar with one aspect of our science today. They too faced the reality that people with diverse values and politics, even diverse levels of tolerance for risk, tend to have diverse interpretations of evidence and science. Today, this is further fueled by vast amounts of data that makes it easier to select the data that suits a particular world-view and bolsters a position.

The result is that we may be increasingly operating in mental silos wherein our selected world view leads us to believe that we are correct and perhaps uniquely so. Of course, mental silos imply distinct and sometimes parochial limitations in so much as they intrinsically constrain and shelter our world view. Mental silos further influence our choices of what to measure, thus spiraling toward an ever more inward looking approach that is, in many ways, the antithesis of good science.

There are heated debates about the “right” policies for the agriculture and food sector that could lead to sustainable development, and these are sometimes fundamentally divergent because they are typically grounded in specific world views. Those views shape attitudes towards dimensions such as government intervention, how distributional issues should be addressed, and the roles of corporations and markets in society. There has often been a tendency for the proponents of different world views to advocate for “silver bullets” or blanket policies. However, in order to grasp the choices we face in addressing the challenges of the sector it is necessary to be free of our silos and honestly consider all the options. This is critical if proposed policies are to be tested not only in light of past development experience but also considered in an integrated manner that accounts for the emerging — rather than the past - economic, social, and environmental context.

This paper is a dedicated attempt to open the silos and to invite reasoned discussion, not so much about distinct values or politics, but about the range of food and agriculture evidence and the likely scenarios that we will jointly face. It stems from a belief that the issues we face are serious. Our agri-food systems are intimately tied to looming water shortages, environmental degradation, and political instability due to higher food costs or shortages. The issues are not those of political bickering but issues of the quality of life and even death for considerable numbers of people. Even where food appears plentiful, in the more affluent realms of many decision makers, the available choices in our agri-food systems are exacerbating lifestyle and consumption patterns that are leading to costly health crises as substantial portions of the population — about one-third in the US alone - are becoming significantly overweight and even obese. From too much to too little, food is so primal and so interwoven into our world views that it can be difficult to look at the evidence with a neutral, open mind.

The goal of the paper is to bring to light the “high impact” areas for consideration by decision-makers, focusing on areas of consensus and areas where decisions will have to be taken. The contributors to this report are a very diverse group of global agri-food leaders that see the value of

stepping outside of their silos. Each of these leaders proposes key avenues to move forward and points to the roadblocks in the way. By synthesizing these approaches we see areas of convergence. We can also see the areas of divergence and thus better determine what is missing or what needs to be convincingly demonstrated in order to get greater agreement. The purpose of this report is not to diminish or deny any approach toward sustainability; instead it is to explore the potential value of each in the spirit of open scientific inquiry.

The consensus of these thought leaders on both innovative and of well-developed approaches is a valuable starting point to go beyond merely partisan discussions. Finding the areas of common ground keep discussions and collaboration open and that spirit itself could be a prerequisite of sustainability.

Methodology

We solicited input from dozens of leading experts in different dimensions of sustainable agriculture, representing the perspectives of the natural and social sciences, developing and developed countries, policy and academia, NGOs and farmers. Respondents were asked to provide concise answers to the following broad questions:

1) What have been the 2-3 most significant recent trends in food and agriculture since the original Rio Summit in 1992?
2) What are the most important actions that have to occur in the next 20 years to ensure sustainable food and agriculture systems?
3) What are the top 3 issues and which are a priority to do first?

After initial discussions, the following categories were selected as guideposts for the comments of the participants although they were not strictly limited to these:

1. Global nutrition security
2. Water
3. Soil
4. Technology
5. Biofuels
6. Rural livelihoods and role of small holders
7. Climate change
8. Natural resources and biodiversity
9. Health and food safety

The complementary topics of finance, logistics, price volatility, food sovereignty, subsidies and trade were also covered as each contributor deemed appropriate.

We also asked that they consider the following in their replies, the role of:

- Governments (enabling framework, taxes and incentives, role in research and extension)
- Markets (including post-harvest) and consumption (prices, access, demand trends)
- Farmers and their organizations
- Business, supply chains, and power relations within the chains
- Natural resource inputs (water, soil, seeds, labor, fertilizer, biocide, veterinary)
- Trade (free, distortions, standards), trade institutions, and intellectual property rights
- Consumers
- Land tenure and land markets
- Financing (including official development assistance foundations, and private)
- Agricultural practices on productivity, conservation, volatility, biodiversity, ecosystem services and climactic adaptation

To ensure fair representation of distinct values and world views, a set of four Expert Group Coordinators gathered and synthesized the work of those contributors with whose world views they are familiar and frequently interact. Each Expert Group Coordinator was asked to also consider the Expert inputs in terms of their social, economic, and ecological impacts: the three balanced lenses of sustainability.

There is particular concern for the impact on low-income countries and emerging economies, but we also considered the distinct issues of developed countries (food deserts and food-related diseases i.e. obesity and diabetes).

The overall process was designed and managed by the Project Coordinator who drafted the final report in collaboration with the Group Coordinators.

In the final section of this paper, we will synthesize key areas of agreement, complementarity, and disagreement among the diverse groups of expert contributors. The narrative thus strives to provide a balanced view of the relative frequency and emphasis of the views expressed. In many areas, quotations highlight salient arguments and examples that powerfully express or illustrate key messages of each group.

2. State of agriculture and food: An overview

2.1 Introduction: The food challenge

Of the world's 1.1 billion extremely poor people, about 74 % (810 M) live in marginal areas and rely on small-scale agriculture. While the world currently produces enough food to feed everyone, at least one billion people remain food insecure.[6] Although the incidence of hunger dropped from a ratio of one in three in 1960 to affecting roughly one in seven people by the 1990s, the trend reversed in the 1990s and the absolute number of people blighted by hunger continues to grow. In 2009, for the first time in history the population considered to be malnourished exceeded one billion people (see Fig 2.1).

Figure 2.1 Trend of undernourished people 1970-2010

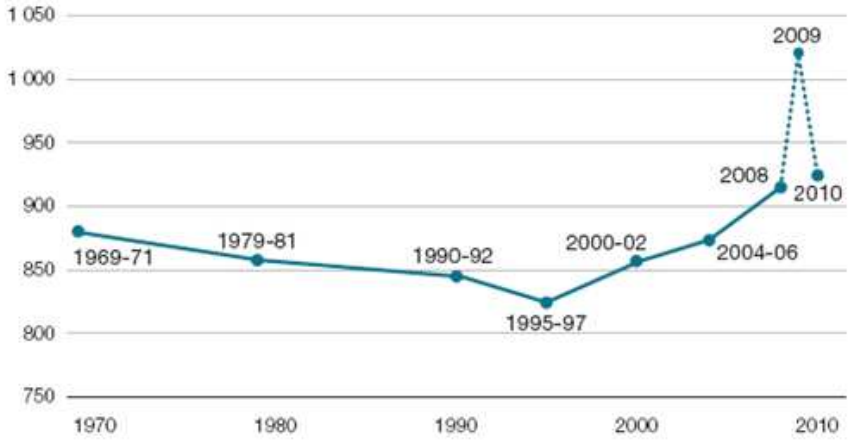


FIGURE 3. Number of undernourished people in the world (Millions of people)

Source: FAO, 'State of food insecurity in the world' and FAO, 'Global hunger declining, but still unacceptably high'. Taken from Rural Poverty Report 2011

Sub-Saharan Africa has the highest proportion of undernourished people, 30 percent in 2010, while the Asia Pacific region has the most undernourished people (578 million) according to the FAO. Two thirds of the world's undernourished live in just seven countries — Bangladesh, China, the Democratic Republic of Congo, Ethiopia, India, Indonesia and Pakistan.[7] Nearly all countries, even some of the wealthiest, have some level of food insecurity.

> "The world's hungry are not just numbers. They are people — poor women and men struggling to bring up their children and give them a better life."
>
> Yukiko Omura, IFAD

[6] FAO, September 14, 2010. http://www.fao.org/news/story/en/item/45210/icode/
[7] FAO, September 14, 2010. http://www.fao.org/news/story/en/item/45210/icode/

Global agricultural production increased at an average rate of two percent a year between 1961 and 2007.[8] The unprecedented increase of the last 6 decades resulted primarily from yield increases but also from some expansion of land area under irrigation and under cultivation.[9]
It is also estimated that by 2050 we will add another 2.3 billion people to the current population of 7 billion,[10] with most of this increase happening in countries that are home to significant numbers of people suffering from food insecurity, malnutrition, and extreme poverty[11] (See Fig. 2.2). If the UN's prediction is correct, then if current dietary consumption patterns continue on the same trajectory, feeding more than 9 billion people by 2050 means that we will need to produce as much food in the next 40 years as we have in the last 8-10,000.[12]

Definition of Food Sustainability: ensuring nutrition security without sacrificing the long term health of the ecosystems and vital cultures that provide our food.

Figure 2.2 Global population and expected growth by region

[8] http://www.globalharvestinitiative.org/documents/GAP%20Report.pdf
[9] The FAO estimates that the increases in world crop production from 1961–1999, are due to increases in: land area farmed or grazed (15% contribution); yield per unit area (78% contribution); and cropping intensity (7% percent contribution). FAO. 2006. World's Agriculture towards 2030/2050. Rome: FAO and FAO. 2003. World's Agriculture towards 2015/2030. Rome: FAO
[10] The "median-variant" scenario of the U.N. Population Division
http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf
[11] 2010 Revision of World Population Prospects. U.N. Population Division of the Department of Economic and Social Affairs
[12] http://www.globalharvestinitiative.org/index.php/policy-center/improving-agricultural-research-funding-structure-and-collaboration/

Source: UN data from Global Harvest Initiative GAP Report, 2011

Challenges to Food Security

The realization of "food security for all" faces a number of inter-related challenges. While there are barriers to access and distribution in urban areas[13] IFAD estimates that nearly 3/4 of those living in extreme poverty reside in rural areas. Many rural areas in developing countries often lack agricultural extension services, processing capacity, credit, roads, irrigation, transportation, energy and storage infrastructure. For urban and rural populations alike, the lack of adequate income is one of the main hurdles to overcoming hunger. This is particularly true for women whose challenges are exacerbated by less access to land, scarce credit, and lower levels of education.

Chronic hunger is fundamentally not an issue of just more food; it is an issue of access. India, for example, is a net exporter of food with millions of tons of grain in storage, and 47% of its children are malnourished. India is not unique; the situation is similar in a number of countries. So, while increasing production is an important part of the strategy for keeping food prices reasonable, hunger often has more to do with access and poverty and sometimes politics. It can be best understood as an issue of opportunity. It occurs when people lack the opportunity to translate a full day's work into enough food or money. Reducing poverty and inequality, particularly for women who provide most of the family's food, is key to solving hunger.[14] The High Level Panel of Experts on Food Security and Nutrition (HLPE) in its report on food security and volatility cautions that public investments must likewise be re-oriented.[15]

Box 2.1 Recommendations of The High Level Panel of Experts on Food Security and Nutrition

The HLPE report recommended:

- that governments consider distinct *trade rules* from a food security perspective for low-income, food deficit countries.
- a look at forms of international cooperation regarding world food *stocks* and guidelines for their efficient management
- tighter regulation and oversight of commodity market speculation on the grounds that private individuals and firms enjoy the benefits of increased speculation, while the public has to pay for any systemic failures
- that governments abolish biofuels targets, subsidies, and tariffs
- looking at waste, both in developed and developing country contexts
- the need to rethink agricultural production systems from an ecological perspective

[13] http://www.ers.usda.gov/Publications/ERR97/ERR97.pdf

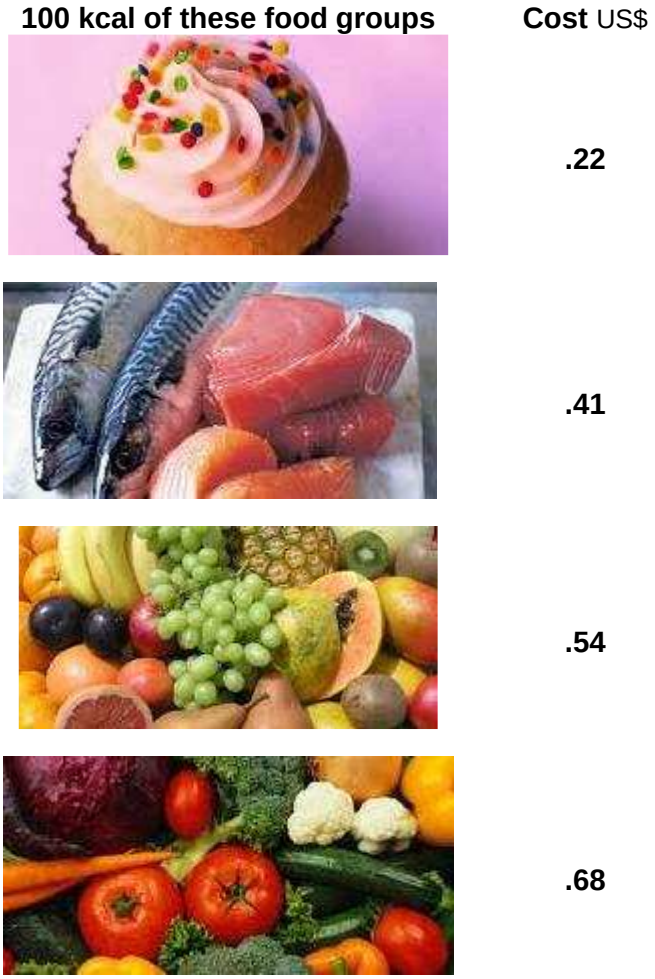
[14] Gittinger,J.Price, Sidney Chernick, Nadine Horenstein, Katrine Saito.1990 . Household Food Security and the Role of Women. World Bank Discussion Paper. Washington, D.C.

[15] HLPE, 2011. Price volatility and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security: Rome.

> Food security exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.
>
> United Nations Committee on World Food Security

Moving from hunger to health requires not just calories but also the consideration of nutrition. Nutrition security goes beyond the basic food security calories needed for survival. It often requires a diversity of foods in addition to the starchy staple crops and basic cereals. These sources of nutrition include fruits, vegetables, and some diverse proteins. For the poor, good nutrition can be an additional cost challenge even in the wealthiest countries (Figure 2.3).

Figure 2.3 Cost of US food products relative to their nutritive value



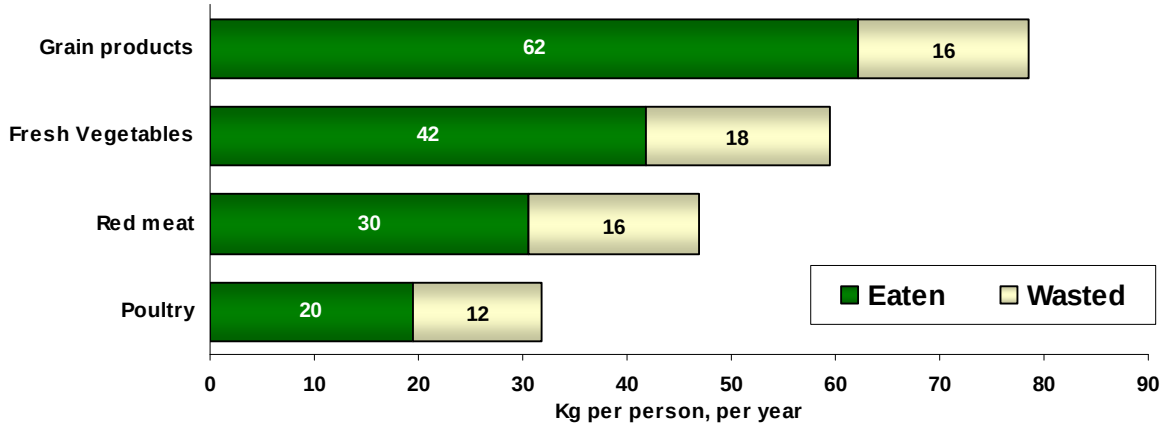
Based on characteristics of 1387 foods from the Food and Nutrient Database for Dietary Studies and the Center for Nutrition Policy and Promotion food prices database.
Source: Drewnowski, Adam. 2010. The cost of US foods as related to their nutritive value. *American Journal of Clinical Nutrition*. 2010 November; 92(5): 1181–1188.

Well-functioning markets can be a crucial component for providing overall adequate nutrition security yet, in certain cases, at least some food will need to be locally farmed and available. Thus, the challenge facing the global community is not only to increase production to meet the caloric requirement of a growing population, but to ensure access to nutritional food to ensure healthy and productive lives.

Waste

Politics and markets affect the availability of food and so does waste. In fact, waste may be the single most important area that can be addressed with relative ease. It accounts for losses exceeding 1 billion metric tons each year. Every year, consumers in rich countries waste almost as much food (222 million tons) as the entire net food production of sub-Saharan Africa (230 million tons).[16] On average, 30-40 percent of all food is wasted before it reaches peoples' stomachs.[17] In wealthier countries much of the losses occur at the retail and consumer levels while in poor countries this is due to poor post-harvest technologies including processing, storage, and preservation. Reports note that in the UK, approximately one-third of all food purchased is not eaten.[18] The U.S., with more than 14 percent of its population classified as food insecure[19], has nonetheless high levels of waste as Figure 2.4 illustrates. According to the US Environmental Protection Agency, food waste accounts for nearly 13% of municipal solid waste in the United States.[20]

Figure 2.4 Average waste of select foods in the US (in kiliograms per person per year)



*2008 data US
Source: USDA, H. Wells and J. Buzby as reported in National Geographic July, 2011.

In addition to the waste and loss, the additional conversion of some foods to non-human uses (i.e. animal feed) then up to half the world's harvest disappears between field and the table. While a substantial percentage of the world's grain output today is fed to animals, The World Bank notes

[16] Swedish Institute for Food and Biotechnology. 2011. Global Food Losses and Food Waste. FAO: Rome.
[17] Godfray, HC, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C.2010. Food security: the challenge of feeding 9 billion people. Science, Vol. 327 no. 5967 pp. 812-818
[18] Knight, A. and Davis, C. 2007. What a waste! Surplus fresh foods research project, S.C.R.A.T.C.H. Available online at: http://www.veoliatrust.org cited in UNEP's "The environmental food crisis"
[19] USDA 2010 (http://www.ers.usda.gov/Briefing/FoodSecurity/), more than 6.7 million households with very low food security (i.e., multiple instances of reduced food intake and disrupted eating patterns) according to Nord, M., M. Andrews, and S. Carlson. 2009. Household Food Security in the United States, 2008, USDA, Economic Research Service, ERR-83.
[20] Jean Buzby, Jeffrey Hyman, Hayden Stewart, Hodan Wells. The Value of Retail- and Consumer-Level Fruit and Vegetable Losses in the United States, *Journal of Consumer Affairs*. Volume 45, Issue 3, pages 492–515, Fall 2011

that at least 11 percent of the world's corn crop is fed to cars and trucks in the form of biofuels, as are many other food crops such as soybean, canola and sugarcane.[21]. In terms of efficiency, livestock is challenged by many other food sources. For example, the U.S. National Soybean Research Laboratory notes that soy can provide up to 15 times more digestible protein per hectare than most livestock. Many less well-known legumes have even higher levels of protein.

The challenges of emerging dietary habits for human health and ecosystem health

For the first time in history, among both poor and affluent segments of society, the quality of nutrition and diet poses entirely new health care challenges that we have never faced on a wide scale.[22] Globally, there are more than 1 billion overweight adults, at least 300 million of them obese.[23] Obesity is just one of these challenges that, according to the World Health Organization and several medical journals, predisposes a population to numerous related chronic ailments from diabetes to cardiovascular disease, hypertension, stroke, and even certain forms of cancer.[24] A number of countries in Asia, the Middle East, Northern Europe, the Americas, and the Pacific now have increasingly overweight and obese populations and the specific characteristics and quantities of foods they eat have become a serious threat to their health.[25] The numbers may be difficult to believe. In the US, a majority is overweight and a third of the adult population is obese.[26] Conversely, and somewhat paradoxically, nearly 15% of the U.S. population is food insecure.[27]

Changing dietary habits, particularly among the fast-growing populations of developing countries, are creating an increased demand for milk and meat-based proteins (see Fig 2.5). [28] Livestock is increasingly fed the same types of grains favored by humans.

Grains such as rice wheat, and maize account for about half of human caloric intake.[29] About half of the world's grain is now used to produce animal feed and animal consumption is projected to

[21] Timilsina, Govinda and Ashish Strestha. 2010. Biofuels: Markets, Targets, and Impacts. Policy Research Working Paper No. 5364. World Bank. Washington, DC.

[22] In 2007, Dr. Benjamin Caballero, of the Johns Hopkins University School of Public Health, noted that recently, "the human race reached a sort of historical landmark, when for the first time in human evolution the number of adults with excess weight surpassed the number of those who were underweight". In The Global Epidemic of Obesity: An Overview. *Epidemiologic Reviews.* Vol 29, Issue1. 1-5

[23] World Health Organization http://www.who.int/dietphysicalactivity/media/en/gsfs_obesity.pdf
Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. 2000. Establishing a standard definition for child overweight and obesity worldwide: International survey BMJ;320:1240-1243

[24] WHO. 2000. Obesity: Preventing and managing the global epidemic. Technical Report Series 894: Geneva
Yusuf, Salim, *et al*..2005. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study. *The Lancet*. Vol 366, Issue 9497, 5-11, pp. 1640-1649
Kelly, T, W Yang, CS Chen, K Reynolds, J He. 2008. Global burden of obesity in 2005 and projections to 2030. *International Journal of Obesity* 32, 1431-1437

[25] Yach, Derek, David Stuckler, Kelly Brownell. 2006. Epidemiologic and economic consequences of the global epidemics of obesity and diabetes. *Nature Medicine* Vol 12, 62-66

[26] Katherine M. Flegal, Margaret D. Carroll, Cynthia L. Ogden, Lester R. Curtin. 2010. Prevalence and Trends in Obesity Among US Adults, 1999-2008 Journal of the American Medical Association. 2010;303(3):235-241.
Baskin, M. L., Ard, J., Franklin, F. and Allison, D. B. 2005, Prevalence of obesity in the United States. Obesity Reviews, 6: 5–7.

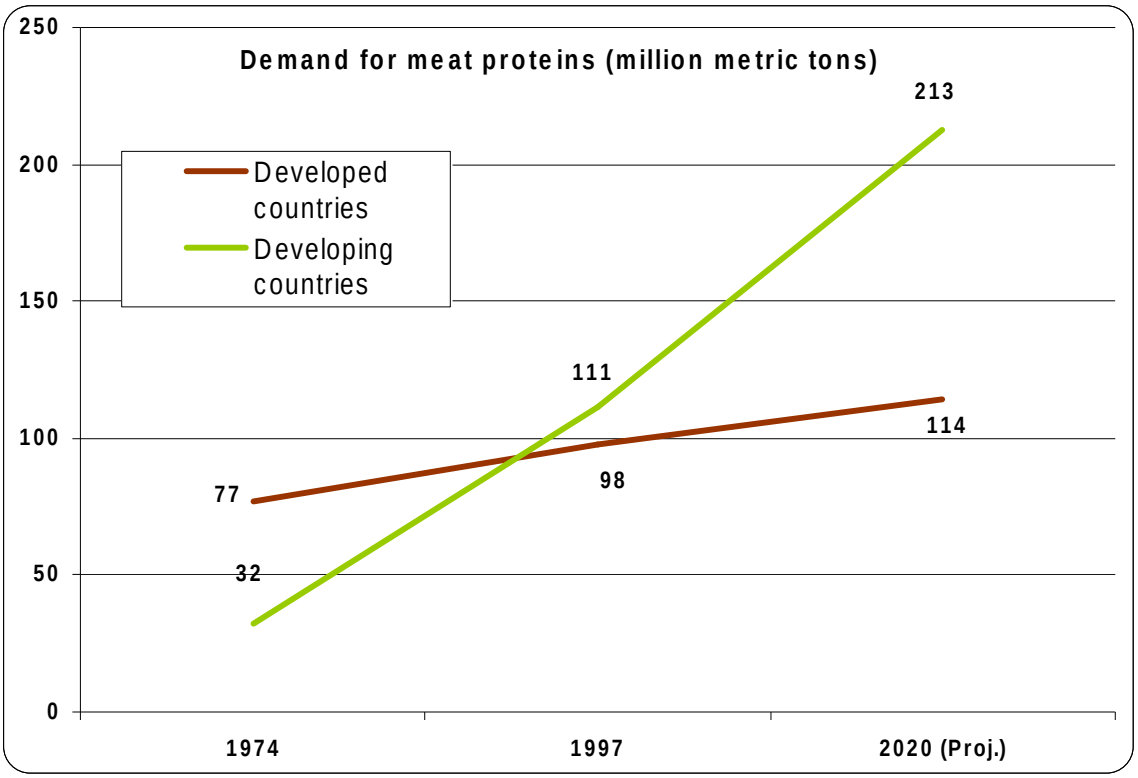
[27] Measured as percent of households that were food insecure at least some time during that year. Alisha Coleman-Jensen, Mark Nord, Margaret Andrews, and Steven Carlson. 2011. Household Food Security in the United States in 2010. USDA Economic Research Report 125; Washington, D.C.

[28] Christopher Delgado. 2003. Rising Consumption of Meat and Milk in Developing Countries Has Created a New Food Revolution. Journal of Nutrition. Vol. 133 no, 11 pp.3907-3910

[29] FAO. 2002. World agriculture: towards 2015/2030: Summary report: FAO: Rome

increase about 50% between 2000 and 2050.[30] A change in the availability of grains has an effect on the food available for a large part of the human population. Finding alternative animal feed sources (e.g. waste matter, perennial shrubs and grasses that can be grown on lands unsuitable for annual food crops, cellulose materials and marine biomass) will be critical if current meat consumption patterns continue.

Fig 2.5 Shifting demand for meat-based proteins



Source: Rosegrant, Mark. Michael Paisner, Siet Meijer, Julie Witcover, 2001, 2020 Global Food Outlook: Trends, Alternatives, and Choices, International Food Policy Research Institute.

Though there is some evidence, it is not clear to which extent these shifting dietary consumption patterns of livestock products may have unintended human health consequences,[31] but it is clear that intensive meat production is a resource-intensive system.[32] This is particularly true for

[30] FAO. 2006. Livestock's long shadow, pp. 416. FAO, Rome. Online at: www.fao.org/docrep/010/a0701e/a0701e00.HTM Accessed November 2011. Though not all feed grain is consumable by humans – by products of other industries are often used for livestock feed.
Keyzer, M.A., M.D. Merbis, I.F.P.W. Pavel, C.F.A. van Wesenbeeck. 2005. Diet shifts towards meat and the effects on cereal use: can we feed the animals in 2030? *Ecological Economics*. Volume 55, Issue 2, 1 November 2005, Pages 187-202

[31] Cordain, Loren, S Boyd Eaton, Anthony Sebastian, Neil Mann, Staffan Lindeberg, Bruce Watkins, James O'Keefe and Janette Brand-Miller. 2005. Origins and evolution of the Western diet: health implications for the 21st century. *American Journal of Clinical Nutrition*, Vol. 81, No. 2, 341-354, February 2005
Yotopoulos, Pan. 1985. Middle-Income Classes and Food Crises: The "New" Food-Feed Competition. *Economic Development and Cultural Change.* Vol. 33, No. 3 (April 1985), pp. 463-483

[32] Kanaly, Robert, Lea Ivy Manzanero, Gerard Foley, Sivanandam Panneerselvam, Darryl Macer. 2010. Energy Flow, Environment and Ethical Implications for Meat Production, Bangkok, UNESCO:. Online at: http://unesdoc.unesco.org/images/0018/001897/189774e.pdf Accessed November 2011.
Wirsenius, S., C. Azar, G. Berndes. 2010. How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030? *Agricultural Systems*, vol. 103, pp. 621-638.

Confined Animal Feeding Operations (CAFOs) whose popularity has soared in comparison to managed grazing systems. The resources used for the production of some meat, for example, are substantially greater than those needed for other common foods. An astonishing 15,500 liters of water is needed to produce a kilogram of beef (Table 2.1) and meat production takes a toll on the environment in a number of other ways: it is energetically inefficient when animals are fed with food-crops (Table 2.1); deforestation and land degradation are often associated with livestock grazing; and livestock is responsible for more greenhouse gases (ca. 18%) than the global transportation sector.[33]

Table 2.1. Relative resources used for the production of beef

Resource	Quantity	Yields
Land	1 hectare	185 kg of beef
	1 hectare	13,000 kg of potatoes
Water	1,300 liters	1 kg of wheat
	15,500 liters	1 kg of beef
Energy	2 calories	1 calorie of soy protein
	70 calories	1 calorie of beef protein
Grains	6-20 kg	1 kg of beef

Sources: 1) Ephraim Leibtag, "Corn Prices Near Record High, But What About Food Costs?" In USDA , *Amber Waves*, February 2008. Online: http://www.ers.usda.gov/AmberWaves/February08/Features/CornPrices.htm
2) James Galloway, Marshall Burke, G. Eric Bradford, Rosamond Naylor, Walter Falcon, Ashok Chapagain, Joanne Gaskell, Ellen McCullough, Harold Mooney, Kirsten Oleson, Henning Steinfeld, Tom Wassenaar and Vaclav Smil.2007. International Trade in Meat: The Tip of the Pork Chop. Ambio Vol. 36, No. 8 Royal Swedish Academy of Sciences.
3) Various water use data www.waterfootprint.org/?page=files/productgallery.
4) FAO. 2006. Livestock's long shadow, FAO: Rome.
5) Robert Kanaly, Lea Manzanero, Gerard Foley, Sivanandam Panneerselvam, Darryl Macer. 2010. Energy Flow, Environment and Ethical Implications for Meat Production. UNESCO: Bangkok
6) the yield potential of existing potato genotypes could raise this average to 40,000 kg/ha - http://www.cipotato.org/publications/belgtech/sources
7) Ayres, Ed. 1999. "Will We Still Eat Meat?" Time Magazine Vol 154, issue 19, p 106-111
N.B. the ecological footprints of smaller livestock such as poultry are smaller.

Mixed crop-livestock systems, often at a smallholder level, produce about half of the world's food and are necessary for food security.[34] While traditional animal production is a vital and necessary part of our food systems, particularly in semi-arid areas such as the Sahel, Andes, and Central Asia, the more intensive production systems have very different resource requirements.[35]

[33] For example, 70% of deforested land in the Amazon is used as pasture. Nellemann, C., MacDevette, M., Manders, T., Eickhout, B.,Svihus, B., Prins, A. G., Kaltenborn, B. P. (Eds). 2009. The environmental food crisis – The environment's role in averting future food crises. United Nations Environment Programme, GRID-Arendal. Also see FAO. 2006. Livestock's long shadow. FAO, Rome
[34] Herrero, M., P. K. Thornton, A. M. Notenbaert, S. Wood, S. Msangi, H. A. Freeman, D. Bossio, J. Dixon, M. Peters, J. van de Steeg, J. Lynam, P. Parthasarathy Rao, S. Macmillan, B. Gerard, J. McDermott, C. Seré, and M. Rosegrant. 2010. Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems. *Science* 12: 327 (5967), 822-825
[35] De Vries, M and IJM de Boer (2010) Comparing environmental impacts for livestock products: a review of life cycle assessments. Livestock Science Vol. 128 (1-3) 1-11
Goffman, Ethan. 2012. The Environmental Impact of Meat. Ann Arbor, MI: ProQuest.

One of the biggest challenges facing the livestock industry is to engage the technologies and policies that will internalize the environmental costs.[36] Accounting for the resources and related pollution could make CAFOs less appealing than integrated livestock systems that do not compete with common human foods and have few negative environmental impacts (e.g., small livestock and aquaculture systems).[37] Though unlikely, UNEP estimates that if current annual meat consumption were stabilized at the 2000 level (37 kg/capita) in 2050 that would keep enough cereal available for human consumption to feed 1.2 billion people (400 million tons).

Pressures on food prices

According to IFPRI, even without climate change, "the prices of rice, maize, and wheat are projected to increase by 25 percent, 48 percent, and 75 percent, respectively, by 2050, in a business-as-usual scenario"[38]. There are a number of complex factors that drive food prices.[39] Competition for natural resources from other sectors adds to the environmental challenge. Valuable farm land is being lost as most of the coming population growth will reside in cities, expanding them considerably and presenting increasing pressures on arable lands.[40] The expansion of biofuels production is taking some key commodities out of the food stream and into the fuels markets [41] Shifting dietary demand for livestock products in developing countries is creating significant new pressures for grains and water. These factors all respond to policy signals and together they drive a significant evolution of agricultural market dynamics and contribute to increasing food prices.[42] Food prices, after many decades of decline, have trended upward for most of the last decade (Figure 2.6)

Commentators attributed the food price crisis of 2007 - 2008 to many causes. The intergovernmental organization background paper prepared for the G20 Agriculture Ministers, as well as the High Level Panel of Experts report for the Committee on World Food Security (CFS), both published in 2011, offer a similar list but distinct interpretations of the relative weight of each factor. The list includes demand shocks (especially from the biofuel industry); supply

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[36] deHaan, C, Henning Steinfeld, Harvey Blackburn. 1997. Livestock and the Environment: Finding a balance. Commission of the European Communities, The World Bank, and the governments of Denmark, France, Germany, The Netherlands, United Kingdom, and the United States of America.

[37] FAO. 2005. Pollution from industrialized livestock production. Livestock Policy Brief No.2 FAO
Full cost accounting would monetize societal costs such as carbon emissions, agricultural runoff and eutrophication, ecosystem degradation, fossil fuel use, and groundwater depletion; and value societal benefits such as maintenance of crop genetic diversity, wildlife habitat, carbon sequestration, water and air purification, and nutritional value of foods. Price signals that fairly reflect the relative costs and benefits to society of different forms of agriculture are perhaps the most comprehensive and efficient way to achieve systemic shifts toward sustainable agriculture and food systems. (EcoAgriculture Partners)
FAO. 2005. Pollution from industrialized livestock production. Livestock Policy Brief No.2 FAO

[38] Rosegrant, Mark 2011. "Improving Investments, Policies, and Productivity Is Critical to Combating Hunger and Malnutrition. 2011 Ag Economic Forum Keynote Address (St. Louis, MO May 23-24)

[39] Derek Headey, Shenggen Fan. 2010. Reflections on the global food crisis : how did it happen? how has it hurt? and how can we prevent the next one? Research Monograph 165. International Food Policy Research Institute: Washington, D.C.

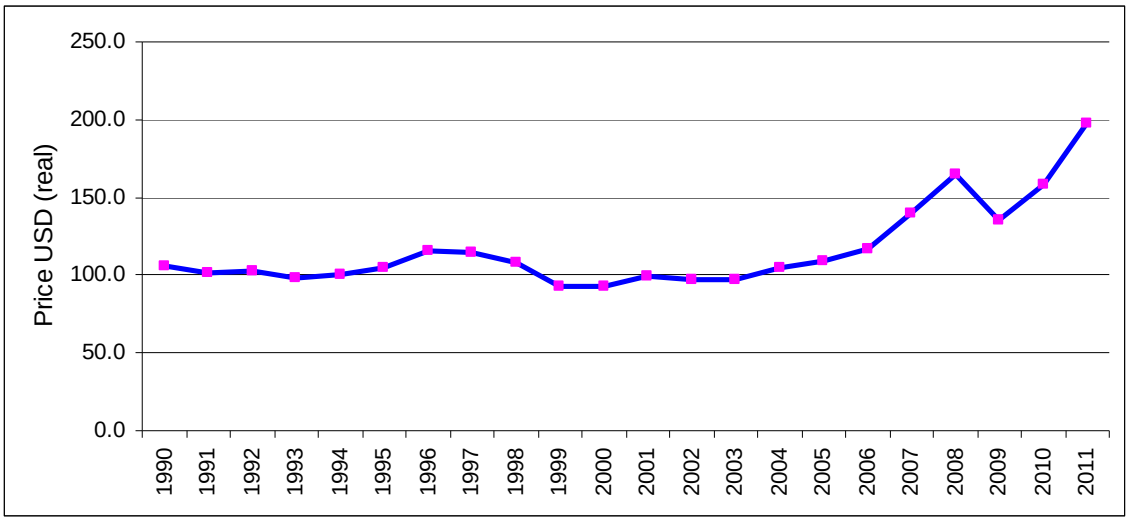
[40] Cohen, Joel. 2002. World Population in 2050: Assessing the Projections. In: Seismic Shifts: the Economic Impact of Demographic Change, ed. Jane Sneddon Little and Robert K. Triest, pp. 83-113. Federal Reserve Bank of Boston Conference Series No. 46.

[41] Baffes, John. 2010. More on the Energy/Non-Energy Commodity Price Link. *Applied Economics Letters*. 17: 1555-58.

[42] Philip C. Abbott Christopher Hurt Wallace E. Tyner (2011), What's Driving Food Prices in 2011? Farm Foundation Issue Report; USA.
Siwa, Msangi, Mark Rosegrant. 2011. Feeding the Future's Changing Diets: Implications for Agriculture Markets, Nutrition, and Policy. Paper 3 presented at 2020 Conference: Leveraging Agriculture for Improving Nutrition and Health February 10-12, 2011; New Delhi, India.
Contributions of the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security to the UN CFS in 2011.

constraints (including the low level of stocks to use ratios in a number of the heavily traded grains, including corn and wheat); and, problems in the systems of distribution, particularly trade, due to export bans imposed by a number of governments in countries that are significant agricultural commodity exporters. The speculation on commodity markets, which some commentators dismissed as not relevant to the price crisis,[43] has continued to trouble some regulators, economists, and traders.

Figure 2.6. Annual Real Food Price Index



Source: FAO and deflated using the World Bank Manufactures Unit Value Index (MUV) rebased from 1990=100 to 2002-2004=100

The reemergence of high and volatile prices in 2010, following a brief drop in prices in the wake of the global financial crisis, suggest that the current situation is different in important respects to previous episodes of price volatility (such as occurred in the early 1970s), in large part because it is persisting longer and may signal a transition to higher prices and increased volatility.

Higher prices incentivize increased production and are positive for farmers who are able to benefit from access to markets. For consumers, however, particularly those that are poor, the effects can be daunting. Many of those classed as being in extreme poverty spend nearly 70% of their incomes on food.[44] The roughly one billion undernourished are all too easily joined by several billion others at the margins of food insecurity who struggle to feed themselves and their households and are also vulnerable to even small food price increases. That group is especially poorly served by safety nets, where these are accessible.

Rising food prices have been key elements of destabilization and civil unrest in a number of countries in recent years. Serious disturbances and food-related riots affected Bangladesh, Burkina Faso, Cameroon, Egypt, Ethiopia, Mexico, Morocco, Mozambique, Philippines, Senegal, Thailand, Uganda and Zimbabwe among others.[45]

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[43] Derek Headey, Shenggen Fan. 2010. Reflections on the global food crisis: how did it happen? how has it hurt? and how can we prevent the next one? Research Monograph 165. International Food Policy Research Institute: Washington, D.C.

[44] Rajiv Shah. 2010. Clinton Global Initiative Annual Meeting. New York, September 21, 2010. Online at http://www.usaid.gov/press/speeches/2010/sp100921.html

[45] Trostle, Ronald. 2008. Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices. Economic Research Service, USDA: Washington, D.C.
A recipe for riots. The Economist May 28, 2011 p.54

Overall, increasing incomes and access are likely to be better long-term solutions than artificially trying to keep domestic prices low with price controls and restrictions, which can be negative for rural areas, reduce incentives to provide the needed increase in production, and have negative spillover effects on international markets.

2.2 Shifting organization of the agriculture sector

Public debates on agriculture and food security have broadened in recent years to better understand the role of governance. Good governance -- understood as the institutions and processes that determine rules or policy -- is vital to implementing more effective measures.

The challenges in the agricultural sector affect different stakeholders differently. Several types of classification have been proposed to understand the complexities and to develop appropriately targeted responses. Such categorizations respond the understanding that there is no one-size-fits-all approach and that any approach must adapted or interpreted in light of the particular local or regional context.

The World Bank offered 3 categorizations in its 2008 World Development Report on Agriculture for Rural Development. That report groups countries into three groups: Urbanized countries; Transforming countries; and Agriculture-based countries, acknowledging that some countries have regional heterogeneity wherein the three worlds may co-exist.[46]

Another orientation, perhaps less macro-economic, suggests that the main participants in agriculture can be better understood and addressed when categorized into three different Rural Worlds[47]. These three Rural Worlds may sometimes co-exist in the same region and they will require, and respond to, very different developmental approaches. (see Box 2.1)

Box 2.2 Three Rural Worlds

Rural World 1. Industrial farms that are globally competitive, embedded in agribusiness, commodity producers and processors, politically connected, export-driven, adopters of Green Revolution and sometimes transgenic technologies.

Rural World 2. Family farms and landed peasantry that are locally orientated, with access to and control of land, multiple enterprises, undercapitalized, declining terms of trade, the 'shrinking middle' of agriculture.

Rural World 3. Marginal farmers and pastoralists, primarily in developing countries facing fragile livelihoods, limited access to productive resources, multi-occupational migrants straddling rural and urban residencies, dependent on low-wages and family labor.

Of course, these 2 families of categorizations — suggested by the World Bank and IIED — are not mutually exclusive. They are simply different ways of considering the agricultural situation and thus can lend themselves to distinct developmental approaches and different points of entry for investment or policy.

[46] Agriculture for Development, WDR 2008, http://siteresources.worldbank.org/INTWDR2008/Resources/WDR_00_book.pdf

[47] Adapted from work by Bill Reimer and David Davila Villers presented in Vorley, Bill. 2002. Sustaining Agriculture: Policy, Governance, and the Future of Family-based Farming. A synthesis report of the collaborative research project 'Policies That Work for Sustainable Agriculture and Regenerating Rural Livelihoods. London: International Institute for Environment and Development.

Agriculture and food systems are complex. A differentiated approach makes it possible to develop better-targeted national and international policies. Whether categorized at the national level or by scale of production, groups have differing:

- ability to deal with resource related constraints (water scarcity, soil quality, climate related problems), including labor and capital
- access to networks, information and extension advice (including nutrient management and pest management;
- access to inputs suited to their specific needs and ecosystems;
- access to markets (particularly in light of increasing concentration in supply chains)

Shifting roles and governance from public to private

The importance of private sector has undoubtedly increased. Apart from the continued importance of policy (taxation, subsidy, trade)[48], regulatory (food safety), and some public investment (research and infrastructure), government now rarely takes the active role in food and agriculture that was common in the late 20th century. As public spending on the sector has steadily declined, it has also shifted away from the needs of poorer producers.[49] There is certainly evidence of joint public-private research and an increasing amount of research is now carried out by private companies who are keen to have intellectual property rights to compensate them for their investments.[50] The functional structures of the food and agriculture world (markets, inputs, extension) are now more frequently managed by the private sector.

Overall development assistance to agriculture in developing countries also decreased from 20% of Official Development Assistance in the early 1980s to 3% by 2007, exacerbating the impacts of decreased spending by national governments.[51] (See Figure 2.7) The World Bank points out that while 75 percent of the world's poor live in rural areas in developing countries, only small percent of official development assistance goes to agriculture.[52]

[48] Subsidies for agriculture have declined in relative terms in the past decades but for major northern producers they still greatly exceed the levels provided by most developing country governments. This has negative implications for resilient local markets especially in agriculture-based economies, particularly those in Rural Worlds 2 and 3

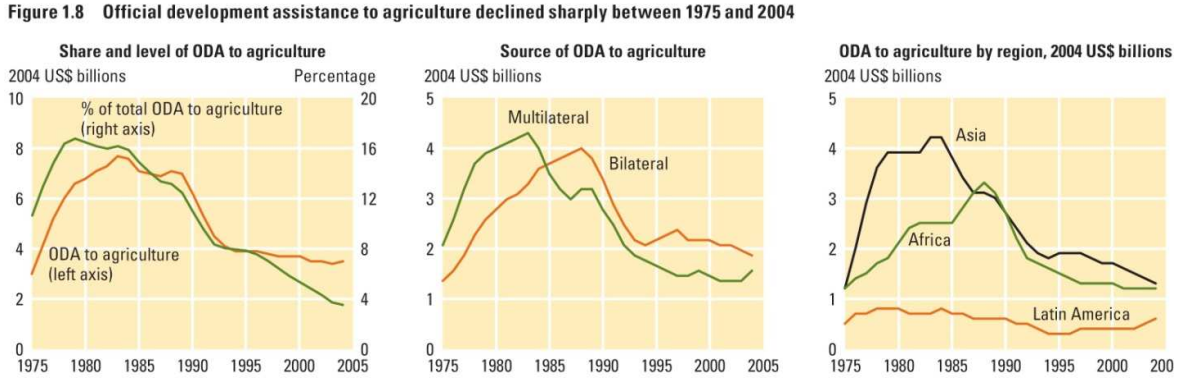
[49] Pardey, P., J. Alston, R. Piggott (eds.). 2006. Agricultural R&D in the developing world: Too little, too late? Washington, DC: International Food Policy Research Institute.
Gardner, Bruce and William Lesser. 2003. International Agricultural Research as a Global Public Good. American Journal of Agricultural Economics,Vol. 85, No. 3, pp. 692-697

[50] Byerlee, Derek and Ruben Echevarria (Eds.) 2002. Agricultural Research Policy in an Era of Privatization. Cambridge, UK: CABI International.

[51] McIntyre Beverly, Hans Herren, Judi Wakhungu, Robert Watson (Eds.). 2009. International Assessment of Agricultural Knowledge, Science and Technology for Development. IAASTD, Washington, D.C
Also: Agricultural Technology for Development. 2009. Secretary-General's Report to the 64th General Assembly. UN: New York

[52] World Bank. 2007. World Development Report 2008: Agriculture for Development. Wash., D.C.

Figure 2.7 Official development assistance to agriculture declines



Role of firms in governance

If agricultural systems are to better serve the public demand and also contribute to broader development goals such as reducing hunger, it will be necessary to consider the current roles of private firms at various scales of production. For example, the public sector's greatly reduced role in the provision of rural crop services (extension, storage, marketing) leaves private suppliers of seeds, fertilizers and biocides as well as cooperatives and farmer organizations to play increasingly important roles in this regard as the main sources of advice and information to farmers.

Globally, corporate power has grown to easily rival the influence and effect of the state, changing the dynamics of local and global food systems. This private power, while seeking profits, is also increasingly under pressure to work towards sustainable modes of production and processing as concerns about resources and supply availability increase and consumers are ever more aware of corporate roles and their impact on food and agriculture. Several of the world's leading food companies, for example, have made strong public commitments to sourcing products that are independently certified to be in compliance with public and private sustainability standards.

In both the corporate space as well as the public space, agriculture discussions are increasingly oriented toward ecological approaches that recognize the limits imposed by natural resources and toward improved social outcomes. The OECD, UNCSD, and UNEP have taken a lead in promoting the concept of a green economy[53] and multilaterals such as the IDB, IFAD, IFC, and the World Bank now consider similar approaches more seriously in their agriculture portfolios. Leading food firms such as Unilever, Kraft, and Mars are committing to sustainable sourcing policies with verifiable ecological and social standards. Yet, there is little agreement on the definition or functional parameters of a "green economy".

Today, many claim descriptors such as *green* and *sustainable*. Indeed, terms such as *sustainable agriculture*, *sustainable intensification*, *agro-ecology*, and the *evergreen revolution* are used widely in the contemporary discourse on food and agriculture without clarity about the definitions, boundaries, mechanisms, and outcomes of such approaches. With this in mind, we canvassed leading experts from all domains of sustainable agriculture to improve our

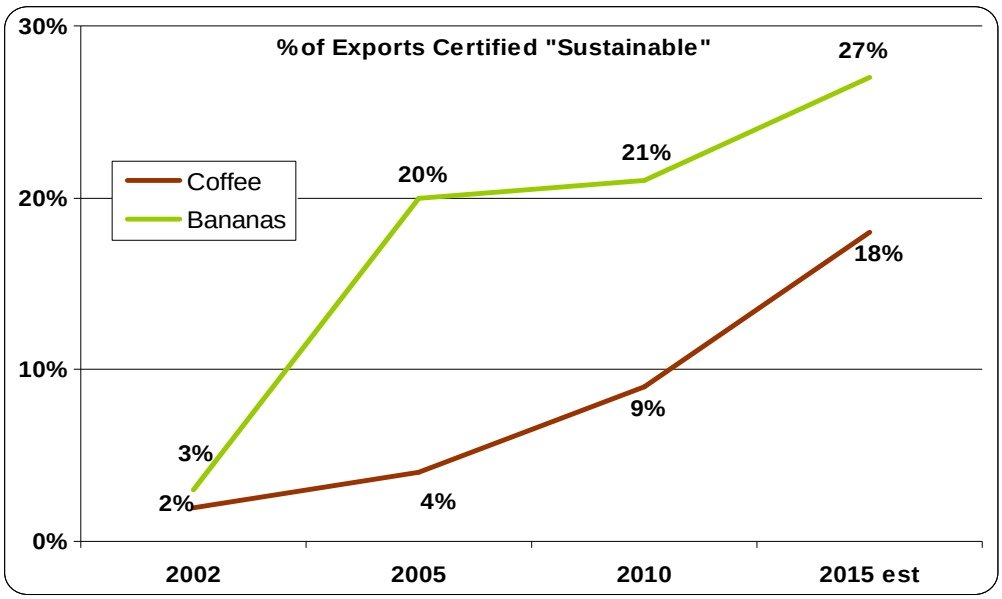
[53] OECD Report: Agriculture and green growth, http://www.oecd.org/dataoecd/40/24/48289829.pdf or UNEP, 2011, Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication.

understanding because, without at least some clear way for measuring, "green" or "sustainable" are at risk of becoming meaningless or simply cheap marketing terms.

In the absence of other credible forms of eco-social legitimacy, firms are increasingly turning to voluntary standards such as Organic, Fair Trade, Rainforest Alliance, UTZ Certified, Social Accountability, 4C, and Forest Stewardship Council, among others. They understand that consumers, in this context where neither the corporation nor the state offer a credible guarantee, may prefer to trust such public or civil-society standard-setting processes that operate essentially as new forms of social contract.[54]

Market-driven solutions are promoted by many as ideal ways to drive sustainable practices and standards or certifications have become the mechanism of choice. However, concerns have begun to emerge about the extent of the benefits of sustainability-oriented certifications. Until recently, there have been no reliable and globally comparable metrics to understand the effects of sustainability initiatives and with the proliferation of sustainability labels — 426 available in 2011 – a reasonable understanding is important.[55] The question of their effects is a significant one because these standards are being adopted by millions of producers and certified products are fast-growing and substantial multi-billion dollar market segments. For example, coffee, the world's most valuable export crop, and bananas, the most important fruit in global trade have both seen substantial shifts in the past decade and expect similar trends in the future. (see Fig 2.8).

Figure 2.8 Growth of sustainability certifications for two major export crops



Percent of total exports (green coffee and bananas) certified by independent third parties as complying with measures of sustainability
Source: Daniele Giovannucci, for coffee. For banana: FAO, Rainforest Alliance, ACP-EU Technical Centre for Agricultural and Rural Cooperation, FLO, Agritrade.cta, Forschungsinstitut fuer biologischen Landbau (FiBL).

[54] Giovannucci, Daniele, and Stefano Ponte. 2005. The Collective Formulation and Effectiveness of Public & Private Sustainability Standards: In special issue of Food Policy Journal, "Private Agri-food Standards: Implications for Food Policy and the Agrifood Systems."
[55] Not all are certifications, or third party verified, but nearly three-fourths of them have emerged in the last 20 years in all sectors including agriculture and food.

The structure and dynamics of sustainability standards attempt to address many environmental, economic, and public welfare issues at origin. Yet, we simply do not understand their effects. Their sometimes complex processes and different types of indirect costs can diminish their benefits and can effectively make them barriers to entry for some producers. More accurate and lower-cost methods of understanding important sustainability parameters are now emerging; these range from carbon sequestration to social justice to soil quality. Several initiatives exist, among them is the independent Committee on Sustainability Assessment (COSA), partnering with a number of organizations around the world, to develop innovative measurement tools that are globally comparable and establish sound empirical evidence of the extent and nature of the sustainability impacts in agriculture. [56]

New governance challenges are emerging and will need a blend of public and private interests to creatively address them. Processes that strengthen the ability of farmers and communities to engage with both agribusiness and government are likely to lead to not only better resource management and technology use but also to improved productivity and well-being.[57] These governance challenges include areas of land use, traditional knowledge and intellectual or cultural property rights as well as mechanisms to ensure the active involvement of women who are often at the center of decisions on food production and consumption around the world. Women make up at least half of the world's farmers and tend to have some different needs and approaches that most policy is not sensitive to and is therefore likely to be less effective in reaching its objectives. Women in developing countries, for example, often don't have access to land tenure or credit and financial services. They lack access to education and extension services as well, making it hard for them to implement new technologies.

Integration and global markets

Trade liberalization and deregulation have deepened the integration of many previously controlled markets into the global economy. More open markets have contributed to a diversification of food and supplies, new market opportunities, and efficiency gains related to comparative advantage. The Research Program on Climate Change, Agriculture and Food Security (CCAFS)[58] notes that agriculture trade will assume even more importance as climate change challenges national agriculture systems to satisfy domestic food needs. The benefits of trade liberalization are indeed considerable but have not been without costs, particularly as less affluent producers adjust to the creation of a new competitive landscape. The increasingly global nature of markets and agribusiness presents a challenge for smaller scale agriculture.

Industrial farms of Rural World 1 likely benefit from the increased exchanges of a liberalized trading system. Consumers also benefit from lower prices when global markets function well. Family farms or landed peasants, which belong to Rural World 2, find it daunting to deal with these changes and with a new competitive landscape. Many are unsuccessful. Both as cause and effect of this new competitive landscape is a greater consumer dependence on fewer firms and larger operators and a decline in the viability of many small and medium farmers.[59]

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[56] Milder ,J., L.Gross and A.Class. 2012. Assessing ecological impacts of agricultural eco-standards. Washington, D.C.: EcoAgriculture Partners and International Finance Corporation.

[57] Market mechanisms are now available that provide smallholders with effective protection against weather and price risks for their crops – making them accessible and affordable is key.

[58] A strategic partnership of the CGIAR and the Earth System Science Partnership

[59] Thomas Reardon, C. Peter Timmer, and Julio A. Berdegué. Supermarket Expansion in Latin America and Asia . Implications for Food Marketing Systems. In *New Directions in Global Food Market*. Chapter 4 USDA Economic Research Service: Washington, D.C. http://www.ers.usda.gov/publications/aib794/aib794f.pdf

The vast majority of the world's farmers are smallholders and small farms are at risk. A trend toward the dominance of larger farms is occurring in some countries even as fragmentation and population growth is leading to ever smaller — and perhaps unsustainable -- farms in others. In the case of European Union farms, even with relatively high levels of subsidy protection in some cases, recent farm income volatility has been more pronounced in small farms than in large farms.[60] In the United States, the USDA notes that there has been a steady decline in the numbers of farmers belonging to Rural World 2 over the last four decades. Globally too, this shift has led to unabated urban migration. In sub-Saharan Africa, 14 million people move to cities each year, a migration that is second only to the massive rural-to-urban shift happening in China. Clearly, rural livelihoods have suffered a steady relative decline in many regions. Women farmers are among the worst affected. Their lack of access to extension advice, credit, land tenure, inputs, and even a voice in decisions negatively affects the entire family and the food security of entire regions.

In recent decades, public neglect of agriculture in developing countries, even as their food needs increased, combined with distortionary subsidies in Rural World 1 led to a number of developing countries shifting from being net exporters to becoming net importers of food, especially of grains. With the current trajectory, by 2030 developing countries are likely to become even more import-dependent with estimates of net grain imports amounting to some 265 million metric tons annually - almost three times present levels.[61] With the role of trade as an important ingredient for global food security, it is crucial to reinvest in the agricultural sectors of poorer countries and to continue pushing for an end to the subsidies in wealthier countries that serve to distort trade and exacerbate the disadvantages of the poor.

Increased role of technology and innovation

While technological innovation has always been important in agriculture, the increasing scale of some agriculture, the increasing difficulties of production, increasing natural resource constraints, and the relative value of labor is making effective technology an ever more critical factor. Technology comes in many forms, complex and simple. People perceive it in different ways. Some relate technology to Inputs, others to computer-based systems, some to GMOs and others to ways of managing agriculture systems.

One form, biotechnology has emerged as a powerful way to manipulate genes and has resulted in both revolutionary advances as well as considerable controversy. Not all biotechnology is GMO; new genomics are enabling rapid advances in more traditional methods with almost none of the contention that can apply to GMOs.

Information and communication technology (ICT) is providing revolutionary advances as well. The best known of these may be the precision farming facilitated by satellite sensing to deliver spatially customized nutrient cocktails via computerized mega farm equipment. However, ICT is also facilitating much more democratized precision farming tools for small farmers that can lead to an integrated soil and nutrient management curriculum and extension system with protocols that are adaptable to local conditions (Box 2.3).

[60] A change in income greater than 30 % was experienced in 64 % of small farms and 45 % of large farms (compared with average of prior three years) during the period 1998-2007. Since the income of small farms is in most cases lower, even modest changes in revenue or costs can cause high relative changes in income
http://ec.europa.eu/agriculture/rica/pdf/Brief201101.pdf

[61] FAO. 2002. World agriculture: towards 2015/2030: Summary report: FAO: Rome

Box 2.3. Agriculture research reaches farmers to improves yields and environment [62]

In rice, a major crop with limited growth in yields, significant improvements are coming from the application of innovative ICT. One such effort transforms agronomic practices by way of a cell phone — an increasingly common item in rural villages. A farmer can call a toll-free number and answer 10 to 12 questions orally regarding his specific farm characteristics and location. An extension agent can do the same. Cloud-based computing analyzes the information on the basis of the known range of fertilizer response functions for that crop and the specific conditions and time of year (rainfall patterns, temperatures, etc). In a matter of minutes, the farmer's cell phone receives a message with recommendations for the optimal fertilizer combination and dosage.

This Site Specific Nutrient Manager (SSNM) not only optimizes the use of expensive inputs but also improves the likelihood of getting the best yields. In China, India, Indonesia, Vietnam, and the Philippines pilot applications of the SSNM have improved average net returns by $100 to $300 per hectare. Better nutrient management also offers environmental benefits such as reduced nitrogen runoff.

Ecological research is leading to new understanding of agroecosystem function that is enabling yield growth through improved nutrient cycling, water utilization, improved pest and disease management, nitrogen-fixation, and synergistic plant interactions.[63] We are discovering a host of possibilities in integrated food and nature systems that can offer both reasonably high yields and a sensible balance with nature. Such production systems will feature improved spatial configuration and coordinated landscape management that will incorporate more perennials that have been selected or bred for higher yield and commercial value. These systems will likely reduce their dependence on non-renewable inputs and integrate more advanced biological processes for sustainable intensification that conserve natural resources including soil and water. A sampling of such emerging approaches includes:

- Evergreen and Conservation agriculture
- Multi-strata agroforestry in farm and pasture systems
- Fertilizer micro-dosing
- Farm and village-scale rainwater harvesting
- Perennializing grains

Agro-ecological methods, based on locally adapted practices and new science, will increase the efficiency of inputs used, and realize multifunctional synergies among species and systems. Better management of ecosystems for benefits such as rainwater control and improved soil health will be sources of yield growth and stability.

Technology is certainly not limited to large-scale farmers and can mean innovations and new methods of production or management practices such as intensive mixed agroforestry. A number of valuable innovations emerge at local levels that rarely have the opportunity to be shared and widely adopted. These include many diverse approaches ranging from the System of Rice Intensification (SRI)[64] to the use of cover crops or green manure to improve soil fertility. There is a growing enthusiasm for such ecosystem friendly and site-adapted agricultural systems emerging throughout sub-Saharan Africa and around the world.

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[62] Sources: Irrigated Rice Research Consortium; F. Bresciani personal communication Nov 7, 2011; See also: Buresh RJ, Witt C. 2008. Balancing fertilizer use and profit in Asia's irrigated rice systems. Better Crops with Plant Food 92(1):18–22; Dobermann A, Witt C, Dawe D (eds). 2004. Increasing the productivity of intensive rice systems through site-specific nutrient management. Enfield, NH (USA) and Los Baños (Philippines): Science Publishers, Inc., and International Rice Research Institute (IRRI); Technologies meet farmers. In *Rice Today* Vol. 10, No. 4 (Oct-Dec 2011)

[63] IAASTD, op cit.; National Academies of Science, 2010, Toward Sustainable Agricultural Systems in the 21st Century. NAS: Washington, DC.

[64] Africare, Oxfam America, WWF-ICRISAT Project (2010). More Rice for People, More Water for the Planet. WWF-ICRISAT Project, Hyderabad, India. And also http://sri.ciifad.cornell.edu/

One comprehensive review of 286 projects in 57 developing countries looked at the effect of applying diverse agro ecological technologies to farming practices. It found that the average crop yield was 79 percent over the yields using previous production practices.[65] Although there are relatively few comprehensive comparative studies to evaluate these sustainable agricultural practices, a growing number of studies are beginning to document the significant production, livelihood and environmental benefits of agro-ecological practices (e.g. Committee on Sustainability Assessment, Worldwatch Institute's Nourishing the Planet project).

In 2010-11, Nourishing the Planet spent 18 months in the field looking at environmentally sustainable ways of alleviating hunger and poverty in sub-Saharan Africa and Asia. The project both spotlights and assesses the state of agricultural innovations with an emphasis on sustainability, diversity, and ecosystem health, as well as productivity. The project also considers the institutional infrastructure needed by each of the approaches analyzed, suggesting what sort of companion investments are likely to determine success—from local seed banks to processing facilities and from pro-poor value chains to marketing bureaus.

Bill Vorley notes that, "From the local community perspective, national policy is often invisible and largely ignores the complex local reality of rural livelihoods, especially for smallholders. This sometimes creates the space in which innovative practices and novel 'experiments' may emerge. But without being rooted in a strong institutional backing, these 'islands of success' frequently fail to spread or be scaled up."[66] We concur with him and also ask: what technology or combination of public and private mechanisms can we engage to make use of these islands?

In Kibera, Kenya one of the largest slums in sub-Saharan Africa, women farmers are obliged to raise vegetables in what they call "vertical farms" due to very limited space. These women use tall sacks filled with dirt to grow their crops and have thus helped to improve their families' nutrition, food security, and even income from surplus sales.[67] In Niger, with the help of the International Center for Research in the Semi-Arid Tropics (ICRISAT) women who are part of the Africa Market Garden, are using effective technologies such as solar-powered drip irrigation to grow okra, tomatoes, eggplant and other vegetables that are not only producing more vegetables for home consumption, but even to sell for additional income, part of which is contributed to a group savings account for local investment.[68]

Novel technologies may help resolve some of agriculture's more pressing challenges and may offer some long-term solutions to problems that we are just recognizing. For example, novel technology for meat grown from stem cells (without a living animal) can provide varied proteins free of many of the environmental[69] and ethical concerns that may accompany large-scale livestock production.

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65 J. Pretty, "Can Sustainable Agriculture Feed Africa? New Evidence on Progress, Processes and Impacts,"Environment, Development, and Sustainability, vol. 1, nos. 3-4 (1999), pp. 253-74.

66 Vorley, Bill. 2002. Sustaining Agriculture: Policy, Governance, and the Future of Family-based Farming. A synthesis report of the collaborative research project 'Policies That Work for Sustainable Agriculture and Regenerating Rural Livelihoods. London: International Institute for Environment and Development.

67 Danielle Nierenberg, "Vertical Farms: Finding Creative Ways to Grow Food in Kibera." Worldwatch Institute: Nourishing the Planet, at http://blogs.worldwatch.org/nourishingtheplanet/vertical-farms-finding-creative-ways-to-grow-food-in-kibera-africa-agriculture-farmers-food-security-hunger-income-kenya-urban-farming-kiberia-urban-harvest-women-vertical-farms-soladarites-red-cross/

68 Danielle Nierenberg, "Africa Market Garden: A Smarter Approach to Agriculture," Worldwatch Institute: Nourishing the Planet

69 Scientific American (June 2011) notes that meat production contributes 17% of global GHG emissions.

In developing countries, the decline in public investments in agriculture has coincided with policies that weakened or dismantled public services and institutions such as agricultural research and extension services.[70] Public spending on agriculture and agriculture research has been universally declining, as a share of total public spending from 1974 to 2004. Nevertheless, agriculture-related growth drives better rural incomes in developing countries and is three times more likely to reduce poverty than GDP growth in other sectors of the economy.[71]

Increased concentration and dependence in food supply

Our food supply is undergoing concentration at two levels: in the supply chains and in the number of food species and varieties. While concentration can certainly present some economies of scale, it can also elevate the scale of risk. We depend heavily on only a handful of foods despite ample historic evidence that this is perilous. It is not only Ireland's great potato famine, but also many more localized tragedies all over the globe that should serve as ample warning.[72] There are still well over 50,000 edible plants in the world, but nearly two-thirds of the world's food comes from only 3: rice, corn, and wheat. We rely on only 15 plants for 90 percent of our food.[73] Rice feeds more people than anything else and corn is the most diversely used with the US supplying about 40% of the world's total.[74]

Clearly some varieties are preferred and it is natural that they would be popular. Yet, as the cautionary tale of Teosinte suggests, there is incalculable value in preserving the plant diversity we have since the loss of functional varieties with some highly valuable traits may be irrevocable. [75] One study compared USDA listings of commercial seed varieties sold in the U.S. seed houses in 1903 with those in the U.S. National Seed Storage Laboratory in 1983 (Figure 2.9). Finding that about 93 percent of the varieties had gone "extinct", the survey suggests the scope of the dilemma.[76]

Not only do we lose access to potentially useful characteristics in the genetic varieties, but also nutritional diversity — important for health -- can be at risk as increasingly fewer food crops dominate our research and trading systems.

When the few crops or market systems on which we depend falter, the consequent volatility can be devastating to producers and to consumers alike. A number of low income countries depend heavily on one food crop and many are net importers of that crop. For example, people in Bangladesh, Cambodia, and Myanmar depend on rice for nearly ¾ of their caloric intake,[77] while

[70] http://www.unctad.org/en/docs/presspb20081_en.pdf

[71] Alain de Janvry and Elisabeth Sadoulet. 2010. Agricultural Growth and Poverty Reduction: Additional Evidence. World Bank Research Observer vol. 25, no.1 or WDR 2008

[72] The dominant variety (Lumper potato) succumbed to blight, resulting in a famine that killed over a million people and caused another million to flee (1845-1849). Sheko cattle, native to Ethiopia, have a natural resistance to tsetse fly-borne diseases that greatly reduce pastoral efforts in Africa, yet they are now nearly extinct. They could be selectively bred to increase production in the region.

[73] http://www.fao.org/docrep/u8480e/u8480e07.htm

[74] US produced 41.9% of global corn total 2009-10 (National Corn Growers Association "World of Corn 2010")

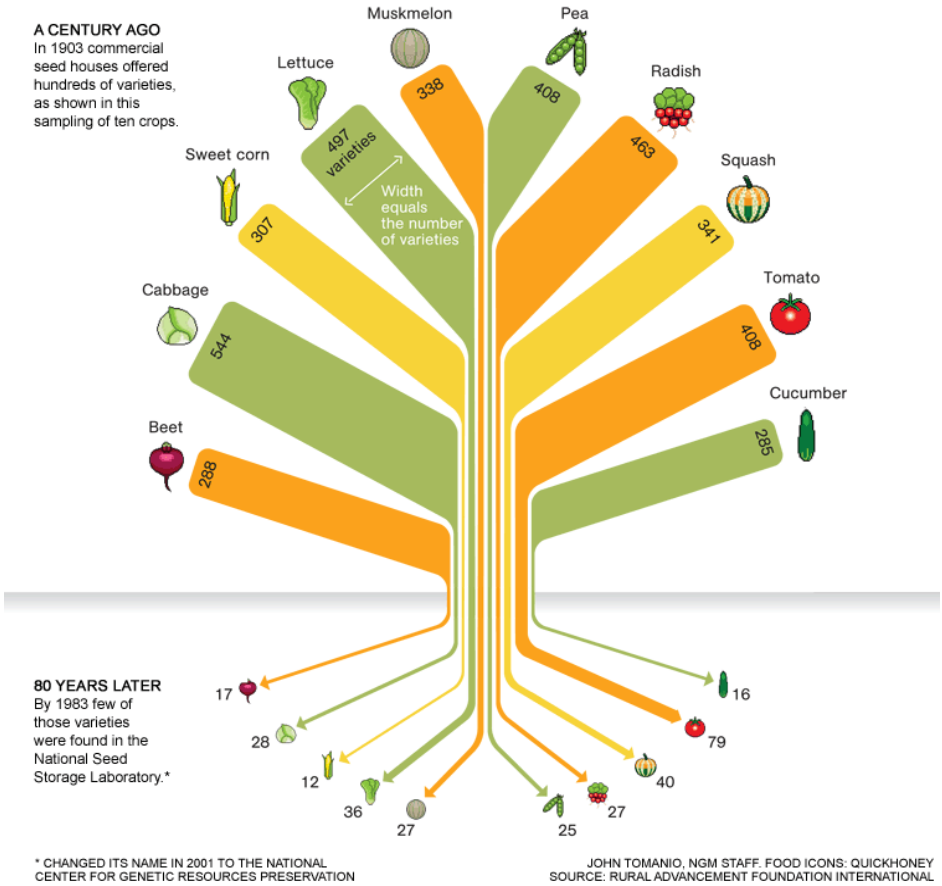
[75] Teosinte, a wild relative of corn (maize), is resistant to half of the major diseases that affect corn and – since the 1970s -- scientists have used.its genes to breed improved cultivars that reduce losses thus help to keep corn prices low. Had it not been preserved in the wild until scientists figured out how to use it, we could not have prevented billions of dollars in disease-related losses in the world's corn crops. World Conservation Monitoring Center. 1992. Global Biodiversity: Status of the Earth's Living Resources. Redding, U.K.: WCMC

[76] Rural Advancement Foundation International 1983 as cited in http://ngm.nationalgeographic.com/2011/07/food-ark/food-variety-graphic

[77] IRRI World Rice Statistics http://irri.org/our-science/targeting-and-policy/world-rice-statistics

the populations of Malawi, Zambia and Lesotho depend on corn for well over half of their calories.[78]

Figure 2.9 The declining diversity of agricultural varieties



Source: NGM.com.

The growth of retail chains and supermarkets around the world has changed food distribution systems. In some cases, this can create new market opportunities. In others it leads to new challenges to food producers facing a limited number of buyers, and to consumers dealing with larger but fewer retail outlets.[79] Globally, "Increasing consolidation and market domination by large processing, trading, and retail firms," along with the "disappearance of traditional auction or spot markets for exchange of farm products and their replacement by various forms of contracts and vertical control," mean major structural changes in the way markets operate.[80] The Government Accountability Office in the United States (2009) similarly reports that:[81]

> "*Concentration generally has increased at all levels of the food marketing chain in all agricultural sectors since the 1980s.*[82] *At the farm level, less than 2 percent of farms*

[78] Smale, Melinda, Derek Byerlee, Thom Jayn. 2011. Maize Revolutions in Sub-Saharan Africa Policy Research Working Paper 5659. Wash., D.C.: The World Bank.
[79] http://dfid-agriculture-consultation.nri.org/summaries/wp13.pdf
[80] http://ilo.unimol.it/sidea/images/upload/convegno_2009/plenarie/relazione%20plenaria_sexton.pdf
[81] http://www.gao.gov/new.items/d09746r.pdf
[82] five major sectors—beef, pork, poultry, dairy, and grains

accounted for 50 percent of total sales in 2007. At the food processors' level, in general, a small number of companies accounted for a large and growing portion of sales in each of the five major agricultural sectors. For example, in the pork sector, the market share of the largest four hog slaughtering firms increased from 36 percent in 1982 to 63 percent in 2006. In addition, at the retail level, the share of grocery store sales held by the largest four firms more than doubled, from 16 percent in 1982 to 36 percent in 2005."

At the production level, large-scale CAFOs account for nearly two thirds of poultry meat production, 50 percent of egg production, and 42 percent of pork production in the US.[83] Concentrations are occurring quickly in developing countries as well. [84]

2.3 External challenges

Agriculture also faces a host of external challenges. On the one hand, the natural resources that make production possible are under pressure from degradation, climate change and competing demands such as energy. On the other hand, agricultural lands in many regions play an increasingly critical role in supplying other ecosystem services such as watershed protection and biodiversity conservation.

Increase in population

Our population trajectory means that from now to 2030, the world will need to build the equivalent of a city of one million people in developing countries every five days.[85] In the absence of reasonable population limits, the main challenges of agriculture will be to increase production and provide affordable nutrition within the current resource and environmental limits. Difficult enough; but it will be even more daunting to increase food for the bottom billions for whom access to food continues to be a substantial challenge that calls for local as well as global solutions. As Joel Cohen notes: "*..the bottom billion are so poor they cannot exercise effective demand.*"[86]

By 2025, continuing population growth and current agricultural practices will lead to 36 more countries (pop.1.4 billion) falling into the category currently occupied by 21 countries (pop. 600 million) where either good cropland or fresh water are scarce.[87] Credible research already makes it clear that there is a growing depletion of the key natural resources, including land, water, and biodiversity, that are fundamental for sustainable production.[88] No human endeavor uses more of these resources than agriculture

Agricultural land degradation and water scarcity

As the dominant form of land use on earth, agriculture faces new challenges where competition for water, land and other natural resources is growing rapidly. Agricultural growth, even its basic

[83] FAO, Commission on Genetic Resources for Food and Agriculture, The State of the World's Animal Genetic Resources for Food and Agriculture (Rome: 2007).

[84] Delgado, Christopher, Clare A. Narrod, and Marites M. Tiongco with Geraldo Sant'Ana de Camargo Barros, Maria Angeles Catelo, Achilles Costales, Rajesh Mehta, Viroj Naranong, Nipon Poapongsakorn, Vijay Paul Sharma, and Sergio de Zen. 2008. Determinants and Implications of the Growing Scale of Livestock Farms in Four Fast-Growing Developing Countries. Washington:D.C.: IFPRI.

[85] Noted in New York Times article by Sewell Chan attributed to noted population scientist, Joel Cohen's speech "Considering the Urban Planet of 2050" given to the American Academy of Arts and Sciences December 4, 2007

[86] Cohen, Joel. 1996. How Many People Can the Earth Support. p. 54 W.W. Norton & Company: New York.

[87] National Intelligence Council. 2008. Global Trends 2025: A Transformed World. United States Office of the Director of National Intelligence: Washington D.C.

[88] http://www.oecd.org/dataoecd/38/10/48224529.pdf and Global Harvest Initiative 2011 GAP Report

viability in some areas, is directly threatened by the depletion and degradation of the natural resources on which it depends.[89] Some 20,000–50,000 km^2 of potentially productive lands are lost annually through soil erosion and degradation, many more have reduced yields and 2.9 million km^2 are considered at very high risk of desertification, much of it in developing countries.[90] This degradation and conversion of cropland for non-food uses could reduce the available cropland by 8–20% by 2050 according to UNEP.

Similarly, water scarcity, exacerbated by pressure from plant and livestock diseases, weeds and insects, may reduce yields by an additional 5–25%. Agriculture uses most of our available fresh water (Fig. 2.10). In many countries the extraction rate is exceeding the rate of natural replacement with severe consequences.[91] Water scarcity may be the most powerful crop yield reducer and, similarly, droughts in the last 30 years have killed off from 20% to 62% of the national herds in 6 African countries triggering mass migrations and starvation.[92]

The concern for water, particularly in some areas, may lead to different considerations as our ability to measure water use improves. Most of us are unaware of the considerable amount of water used to produce common foods, and the differences between them. A hamburger requires about 2240 liters of water, adding a glass of beer adds 70 liters of water and the process leading to a cup of coffee uses 140 liters.[93] If the current use trajectory continues, UNEP warns that in the coming decades we may lose up to 25% of food production due to environmental breakdown.[94] These ecological problems make it clear that some of our key factors of production are at risk and challenge the expectations of production increases.

This presents a challenging dilemma given the FAO estimate that, to feed the world, agricultural production must increase 70 percent by 2050 (nearly 100 percent in developing countries).[95] Such an increase will involve production intensification, increased water use, and the likely expansion of cropping areas.[96] Clearly, if we continue with our current patterns of population growth and resource use and doggedly pursue the single goal of more production, we are in danger of environmental collapse in at least some areas.[97]

It is therefore irresponsible and even unimaginative to single-mindedly seek to intensify production without serious consideration of the natural resource base.

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[89] Nellemann, C., MacDevette, M., Manders, T., Eickhout, B., Svihus, B., Prins, A., Kaltenborn, B. (Eds). 2009. The environmental food crisis – The environment's role in averting future food crises. United Nations Environment Programme, GRID-Arendal

[90] Eswaran, H., R. Lal and P.F. Reich. 2001. Land degradation: an overview. In: Bridges, E.M., I.D. Hannam, L.R. Oldeman, F.W.T. Pening de Vries, S.J. Scherr, and S. Sompatpanit (Eds). Responses to Land Degradation. Proc. 2nd. International Conference on Land Degradation and Desertification, Khon Kaen, Thailand. Oxford Press, New Delhi, India.
Bai, Z., D. Dent, L. Olsson, M. Schaepman. 2008. Proxy global assessment of land degradation. Soil Use and Management. Vol 24, 3, pp. 223–234

[91] Economist. 2010. For Want of a Drink: A special report on water.

[92] Nellemann, C., MacDevette, M., Manders, T., Eickhout, B., Svihus, B., Prins, A., Kaltenborn, B. (Eds). 2009. The environmental food crisis – The environment's role in averting future food crises. United Nations Environment Programme, GRID-Arendal

[93] www.waterfootprint.org/?page=files/productgallery

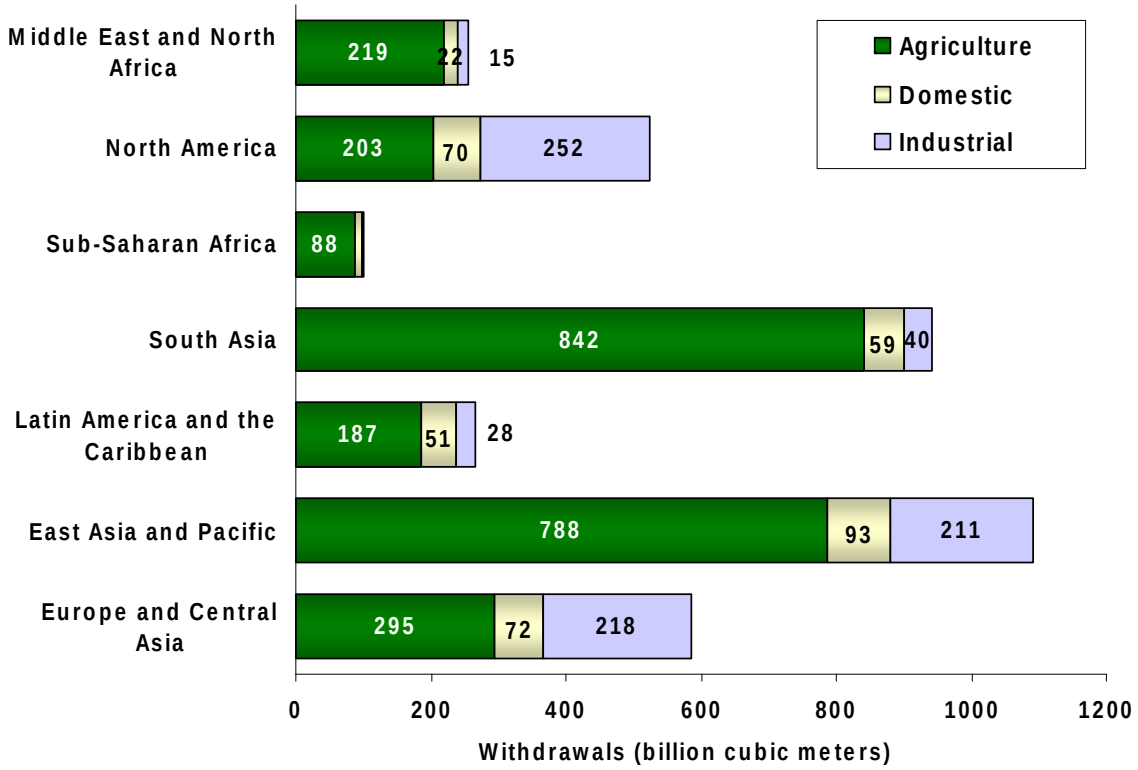
[94] Nellemann, C., MacDevette, M., Manders, T., Eickhout, B.,Svihus, B., Prins, A. G., Kaltenborn, B. P. (Eds). 2009. The environmental food crisis – The environment's role in averting future food crises. UNEP: Geneva

[95] to cope with a 40 percent increase in world population and to raise average food consumption for the currently undernourished

[96] ftp://ftp.fao.org/docrep/fao/012/ak971e/ak971e00.pdf The resource outlook to 2050: By how much do land, water and crop yields need to increase by 2050? FAO Expert Meeting, 24-26 June 2009, Rome on "How to Feed the World in 2050".

[97] some would say environmental limits have already been exceeded in some regions

Figure 2.10 Comparing water used by agriculture, industry, and households



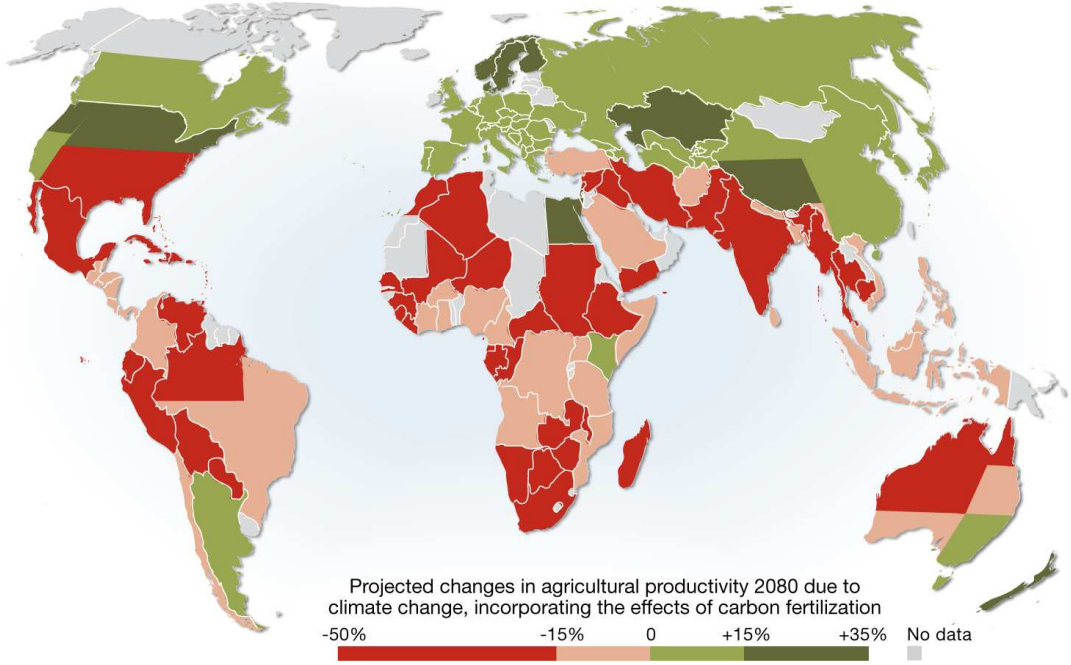
Source: Global Harvest Initiative, using FAO data

Climate change

Climate related uncertainties —manifesting as drought, floods, temperature fluctuation, and crop disease— pose what could become the greatest challenge to agricultural production and food security.[98] It is difficult to determine the actual scale or degree of change, but nearly all predictions indicate that it will be important (Fig 2.11). There are significant indications of climate-related problems already being recorded in many regions and IFPRI, among others, estimates net reductions of yields, particularly in Sub-Saharan Africa.[99] China, The world's biggest food producer and consumer, has had to relocate millions of people due to due to water shortages and Chinese authorities estimate more than 150 million people will eventually need to be relocated, from agricultural areas that are being gradually engulfed by deserts.[100] Countries are already anticipating major spatial shifts in production of important commercial crops, and associated market chains, and the need to have a different mix of varieties for crops that remain. A more climate-resilient agriculture is emerging as an urgent necessity for the 21st century.

[98] IFPRI. 2009. Climate Change Impact on Agriculture and Costs of Adaptation. Washington, D.C.
[99] For example, a 3.2 percent decline in the region's cereal production. Ringler, C., T. Zhu, X. Cai, J. Koo, and D. Wang. 2010. Climate Change Impacts on Food Security in Sub-Saharan Africa: Insights from Comprehensive Climate Change Scenarios. IFPRI Discussion Paper No. 1042. International Food Policy Research Institute: Washington, DC:
[100] Reported in London's Guardian newspaper by Jonathan Watts (5/18/09) http://www.guardian.co.uk/world/2009/may/18/china-ecorefugees-farming

Figure 2.11 Impact of climate change on agriculture by 2080



Source: http://maps.grida.no/go/graphic/projected-agriculture-in-2080-due-to-climate-change1 based on Cline, W. R. 2007. Global Warming and Agriculture: Impact Estimates by Country. Washington D.C.: Peterson Institute.

Energy market impacts on agriculture

Growing demands for energy are adding further pressures on agricultural systems, both to supply traditional bio-energy and to supply industrial biofuels. Wood and charcoal remain as very important domestic and manufacturing fuel sources in many developing countries. As forest resources have diminished, farms and pasturelands have become more important sources of these fuels now grown in woodlots, boundary plantings, or as inter-crops.

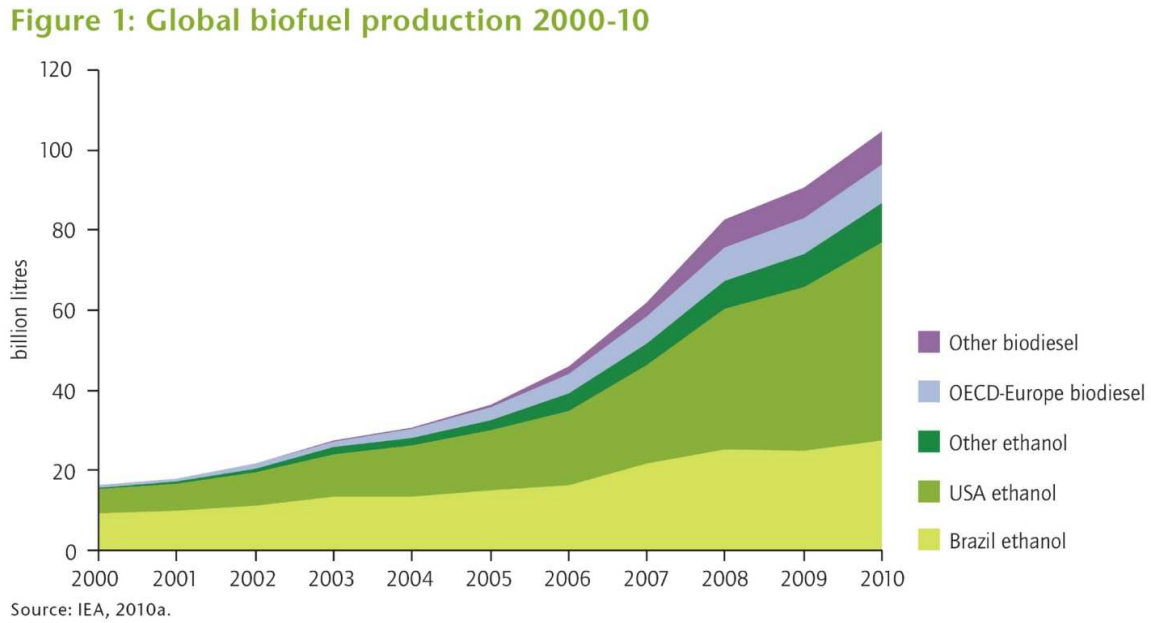
Meanwhile, between 2000 and 2007, global biofuel production tripled accounting for about three Between 2000 and 2007, global biofuel production tripled accounting for about three percent of the global transportation fuel supply.[101] At that point, about 95 percent of biofuel — both ethanol from corn and sugarcane and biodiesel from vegetable oils — was produced on 3.4 percent of global arable land.[102] By 2010, 6 percent of all global grains were being used for the production of biofuels with further growth expected.[103]

Bio-based products emerged on the market with great promise as eco-friendly alternatives to petroleum-based fuels but, in some cases, have became problematic as they affect food prices and availability. [104] The European Union and the United States are among those investing heavily in biofuel support polices. They, along with agricultural leaders such as Brazil, China, India, Indonesia, and South Africa, have announced time-bound targets to promote biofuel supply and

[101] http://www.ers.usda.gov/AmberWaves/November07/Features/Biofuels.htm
[102] Concentrated in 6 countries. Update on Global Land Use in Biofuel Feedstock Production, http://www.ers.usda.gov/Publications/WRS0801/WRS0801.pdf
[103] http://www.nytimes.com/imagepages/2011/04/07/world/20110407_cassava_graphic.html?ref=earth
[104] Timilsina, Govinda and Ashish Strestha. 2010. Biofuels: Markets, Targets, and Impacts. Policy Research Working Paper No. 5364. Washington, DC: World Bank.

demand. [105] This is affecting the availability of some food crops and consequently the price of foods.[106] For example, in 2011, some 40 percent of the U.S. corn crop is expected to be used for ethanol production.[107] (See Figure 2.12 for current production trends)

Figure 2.12 Global biofuel production



Source: http://www.iea.org/papers/2011/biofuels_roadmap.pdf

While there are differing interpretations of the impacts of this new demand on food prices and supplies, it is clear that these changes create new challenges for water and for land use decisions around the world, with particular implications for smaller scale producers.[108]

These concerns have led initiatives such as the Global Bioenergy Partnership and the Roundtable for Sustainable Biofuels to formulate sustainability criteria for the production of biofuels. However, the prospects are mixed. The International Energy Agency and other proponents are hopeful of the potential of biofuel as a transport energy source[109] while one recent study asserted that "large-scale biofuels production will be unable to comply with these criteria in 2020, and can therefore not be qualified as sustainable".[110]

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[105] International Institute for Applied Systems Analysis. 2009. Biofuels and Food Security. The OPEC Fund for International Development: Vienna and IIASA:Laxenburg Cite several studies that it delivers little or no net carbon benefits,

[106] World Bank. 2008. Double Jeopardy: Responding to High Food and Fuel Prices. Prepared for the G8 Hokkaido-Toyako Summit. World Bank: Washington, DC:
Grosh,M., A. Revenga and H. Zaman. 2008. Rising Food and Fuel Prices: Addressing the risks to future generations: Washington DC, World Bank.

[107] At least two media sources cite the figure from the USDA: Whitney McFerron and Jeff Wilson U.S. Corn Supply Shrinking as Meat, Ethanol Demand Send Crop Price Higher. Bloomberg News online Apr 8, 2011. Pollack, Andrew. "U.S. Approves Corn Modified for Ethanol". NY Times, published online February 11, 2011. However, a significant portion (ca. 40%) of the spent corn is later re-directed to the animal feed market according to the USDA's April 8, 2011 World Agricultural Supply and Demand Estimates.

[108] Abbott, Philip, Christopher Hurt, Wallace Tyner. 2011, What's Driving Food Prices in 2011. The Farm Foundation.

[109] Technology Roadmap: Biofuels for Transport, http://www.iea.org/papers/2011/biofuels_roadmap.pdf

[110] International Institute for Applied Systems Analysis. 2009. Biofuels and Food Security. The OPEC Fund for International Development: Vienna and IIASA: Luxembourg

Experts predict that the next generation of biofuel technology will more effectively convert lignocellulosic materials to fuels and engage agroforestry and community forestry to ease pressure on food crops while having potential benefits for carbon and forests. Significant potential also exists in the conversion of micro-algae to biofuel.[111]

Given that the price of oil now has a more direct effect on the price of corn (previously more indirectly as fuel costs of energy-intensive fertilizers), these trends arouse concern as an increasing number of people in developing countries are dependent on international markets for their food. Agriculture uses seven times more synthetic fertilizer today than a half a century ago although food production has not increased by as much.[112] Most countries are fertilizer importers. Thus high petroleum prices could depress the use of fertilizers that have facilitated much of the increase in farm production during the past half century'.[113]

Rethinking agriculture's role in the ecosystem: a necessary multifunctionality

Energy, industry, and urban development all compete with farmers and will have to increasingly share the same resources.[114] The historic technological and policy focus on crop and livestock production for agriculture is no longer viable if agriculture is to thrive in this new environment of multiple pressures and demands. Agriculture can no longer simply focus only on the output of food production if it is to preserve the vital resources that will provide food in the long run.

In addition to agriculture's primary function of producing food and fiber, it can also offer ecosystem services and benefits such as: the protection of biodiversity,[115] watersheds, carbon storage, and natural pollinators;[116] micro climate regulation; the maintenance of soils: and

[111] GBEP. 2008. A Review of the Current State of Bioenergy Development in G8 +5 Countries. Global Bioenergy Partnership (GBEP). SRI Consulting Business Intelligence and Toffler Associates in National Intelligence Council. 2008. Global Trends 2025: A Transformed World. US Government Printing Office: Washington DC (www.dni.gov/nic/NIC_2025_project.html)

[112] Cribb, Julian. 2010.The Coming Famine: The global food crisis and what we can do to avoid it. University of California Press

[113] ftp://ftp.fao.org/agl/agll/docs/cwfto11.pdf

[114] http://www.fao.org/docrep/012/al209e/al209e00.pdf Africa's Changing Landscape. FAO http://www.globalbioenergy.org/uploads/media/0701_FAO_Mueller__-_Some_insights_in_the_effect_of_growing_bioenergy_demand_on_global_food_security_and_natural_resources_01.pdf

[115] Note the example of Teosinte, a wild corn variety, among others in: World Conservation Monitoring Center (WCMC). 1992. Global Biodiversity: Status of the Earth's Living Resources. Redding, U.K.

[116] In one example of our dependence on biodiversity and ecosystem services, scientists using data from 200 countries found that 87 of the leading global food crops, and 35% of our total food crops, are dependent upon natural animal pollinators. Alexandra-Maria Klein, Bernard Vaissière, James Cane, Ingolf Steffan-Dewenter, Saul Cunningham, Claire Kremen, and Teja Tscharntke. "Importance of pollinators in changing landscapes for world crops" In the *Proceedings of the Royal Society B*; February 7, 2007 274:303-313;

contribute to the cultural[117] and socio-economic viability of rural areas.[118] In many regions, agricultural lands are the main source of such ecosystem services.[119]

Eco-agriculture systems therefore seek to strike a balance between production outputs, biodiversity conservation, diversified nutrition, and livelihoods.[120] Agriculture will have to become an active partner, along with other sectors, in managing resources and the environment for multiple and interrelated purposes: providing goods and services for both private and public benefit. [121] Such a paradigm of multifunctionality is thus emerging and, if nurtured, can address several of the most pressing challenges for agriculture and our resources.

In some cases, these multiple functions can be achieved at a farm level but, more typically, these eco-agriculture landscapes require coordination among diverse stakeholders. For example, land managers and resource users downstream may not have the resources or the mandate to influence land management upstream that affects their production or resource access. Key resources that will have an immediate impact such as water can only be managed in this way as an integrated landscape. These productive landscapes manifest together as a mosaic of interdependent production and conservation functions that, when managed as a whole, are greater than the sum of parts. Emphasizing the inter-relatedness and the importance of cooperation is a first educational step for policy action. Farmers, civil society, businesses, and governments need to cooperate within new structures that include and go beyond standards and certifications to manage these complex systems.

2.4 Conclusion

The rural world has shifted dramatically in recent decades. Although economic concerns continue to have clear primacy, environmental and social concerns have certainly entered into the mainstream of policy discussions and even consumer and corporate conversations. The past 20 years, since the Rio Summit in 1992, are best characterized by fast-paced learning about sustainability. Yet, the learning has been only modestly applied. Conventional, business-as-usual agriculture models are still the dominant paradigm.

For the majority of farmers, public services from agriculture institutions including infrastructure, research, extension, credit and marketing have deteriorated for decades. While NGOs, micro-lending institutions, and agribusiness have stepped in to fill some of these gaps, the overall

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[117] It is not only food production that fundamentally depends on a number of ecological processes. For many poor communities, such multifunctionality also means that agro-ecosystems can function as a direct source of medicine, ritual space, shelter materials and fuel.

[118] http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB137/RR137.pdf IWMI Research Paper 137: Wetlands, Agriculture and Poverty Reduction. http://www.fao.org/docrep/meeting/022/mb392e.pdf FAO: Climate change and micro-organism genetic resources for food and agriculture: state of knowledge, risks and opportunities; http://soils.usda.gov/use/worldsoils/papers/land-degradation-overview.html http://ec.europa.eu/environment/soil/pdf/biodiversity_report.pdf European Commission: Soil biodiversity: functions, threats and tools for policy makers; http://dfid-agriculture-consultation.nri.org/summaries/wp12.pdf (DFID report agricultural sustainability)

[119] S.Wood, K. Sebastian and S.J. Scherr. 2000. Pilot Assessment of Ecosystems: Agroecosystems. World Resources Institute: Washington, D.C.

[120] Scherr, Sara and Jeffrey McNeely. 2007. The Challenge for Ecoagriculture. In Farming with Nature (Eds) Sara Scherr and Jeffrey McNeely. Island Press: Wash., D.C.

[121] OECD. 1998. L'agriculture dans un monde en mutation : quelles politiques pour demain ? Réunion du Comité de l'agriculture au niveau des ministres, Communiqué de presse, Paris, 5-6 Mars.
FAO has used similar terms such as “Multifunctional Character of Agriculture and Land”. Also see: OECD. 2008. Multifunctionality in Agriculture: Evaluating the Degree of Jointness, Policy Implication. OECD Publishing: Paris

support to farmers has declined.[122] Information and services to farmers in developing countries are consequently more concentrated in private companies that play a large role in research, extension services, and input distribution. While government still has a critical role, these new providers must be carefully considered in policy design in order to balance private benefits with some of the public goods that are necessary for small to medium farm households.
Climate change and water scarcity have emerged as cross-cutting concerns for agriculture that clearly require the actions of a coordinated public and private governance yet here too, the urgency has resulted in very little pragmatic action. Nevertheless, the recognition of agriculture's powerful role in the ecosystem makes it more important than ever.

Concern for the wise stewardship of natural resources has made headlines globally and science now better understands the tightly woven interplay within and downstream of agricultural systems. In recent decades improved conservation practices in soil and water as well as better targeted formulation and application of fertilizers and less toxic agrochemicals have improved the ecological footprint of agriculture. However, the level of change in otherwise unsustainable agricultural practices has certainly not evolved sufficiently to permit our intensive agriculture practices to co-exist in a reasonable balance with nature.[123] In fact, allowing the environmental costs to be externalized, creates incentives to take shortcuts that compromise our resources and our environment.

Addressing the supply side is commonplace, with discussions typically revolving around ways to increase production and efficiencies. But it is much less common to discuss the demand side and its distinct characteristics. Can we jointly examine both the nutritional quality and the impact of diets to allow for better informed policy and consumer decisions? Can we be practical and fix our "leaky bucket" systems to reduce the enormous levels of food waste? Can the population increase continue to be accommodated or should means be considered to achieve a realistic balance between people and the capacity of agriculture that does not unduly stress natural ecosystems and increase the risks for existing populations?

A 2008 IAASTD report, with contributions from more than 400 scientists and agricultural experts, grappled with some of these challenges and argues that given the increasing and multiple pressures on agriculture and on the natural resource base, business as usual is no longer an option.[124] It too calls for support to climate-resilient, multifunctional agriculture that provides societal benefits such as food security even as it protects the environment.

In its policy recommendations, the High Level Panel of Experts on Food Security and Nutrition (HLPE) also cautions that new public investments must not intensify current systems but rather aim for a transition to more sustainable models of production.[125] IFPRI notes that in order to avert a food crisis we'll need to at least improve trade, address resource degradation, and encourage production in at least some of the countries now heavily dependent on food imports.[126]

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[122] http://www.unctad.org/en/docs/presspb20081_en.pdf
[123] Future Harvest and IUCN characterized agriculture as the greatest threat to biodiversity. Agriculture, by definition, has a dynamic tension with biodiversity to favor only very select species but sensible practices can reduce the negative impacts on the environment on which it ultimately depends.
[124] McIntyre Beverly, Hans Herren, Judi Wakhungu, Robert Watson (Eds.). 2009. International Assessment of Agricultural Knowledge, Science and Technology for Development. IAASTD, Washington, D.C
[125] HLPE, 2011. Price volatility and food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security: Rome.
[126] Derek Headey, Shenggen Fan. 2010. Reflections on the global food crisis : how did it happen? how has it hurt? and how can we prevent the next one? Research Monograph 165. Washington, D.C.: International Food Policy Research Institute.

3. Main challenges and priorities of global thought leaders

Most of our views on food and agriculture are profoundly influenced by our personal historical perspectives, assumptions and particular world views. Conclusions that appear irreconcilable can crumble when the views that inform these positions are examined. Rather than present just one view, we asked a number of experts with a broad range of very diverse views to contribute their professional opinions to this section. The experts were loosely arranged within four different world views by Four Expert Group Coordinators who synthesized the many contributions to make explicit the priority areas. These four world views included: a Policy Group; Business Specialists Group; Rural Livelihoods and Poverty Group; and an Agricultural Production and Environmental Sustainability Group (contributors are recognized in Section 1 of this report).

Themes addressed

We have identified 9 core issues or themes that strongly influence, and are influenced by, our food and agriculture systems:

1. Bio-based products (including biofuel)
2. Climate change
3. Global food and nutrition security
4. Health and food safety
5. Natural resources and biodiversity
6. Rural livelihoods and the role of smallholders
7. Soil
8. Technology
9. Water

In each group, the Contributing Experts have identified the major trends and drivers related to these themes to consider if we are to progress towards sustainability. In shaping answers, Contributing Experts were asked to consider the following dimensions as they saw fit: role of national governments (e.g. taxes, subsidies or incentives, research, and extension); role of farmers and their organizations; role of business (research, financing, access to markets); role of technology; role of trade (barriers; subsidies; standards); role of consumers; role of gender; functioning of land markets; and financing.

The intention was not to be comprehensive or encyclopedic but rather to provide a common framework through which the diverse world views and consequently the main areas of consensus could be identified to effectively frame the key leverage points or the most important issues on which sustainability will depend.

The sections below frame the distinct worldviews that guide these advocates of sustainable agriculture. They highlight ways in which these perspectives might align or conflict with other key perspectives on agriculture and food that focus on international trade, agribusiness, and social aspects of sustainability and equity.

These syntheses do not claim to be solely or comprehensively representative of any single group. They do not imply the agreement of any of the firms or institutions whose members provided inputs. Of course, the perspectives, priorities, and recommendations of the syntheses may not represent the views or agreement of every individual.

3.1 Policy Group[127]

Introduction: Successes and Challenges

Enormous increases in agricultural productivity thanks to the Green Revolution and the long term decline in food prices have contributed to global food security and proved Malthusian doomsayers wrong. Nonetheless, global food security has still not been attained, agricultural yields remain unacceptably low in many poor countries and agricultural productivity elsewhere is slowing down. Government efforts to support agricultural research have dropped in response to the long term decline of food prices, while increasing private sector research is narrowly focused on large scale commercial agriculture. Prices may well be reversing their long term downward trend, and extreme price volatility may be a more likely phenomenon in the future — both phenomena will have a disproportionately negative effect on the world's most vulnerable populations.

Respondents from this group agreed on the need to focus on ongoing productivity growth, but point to the need to do so using less energy and chemical intensive inputs, and responding to serious and growing natural resource constraints, particularly in water and soils. Meeting these challenges requires technological innovation and "sustainable intensification" but also a new mindset and consensus around policies that incentivize a more prudent use of limited resources. In addition to the need to focus on productivity growth, respondents view poverty as a major stumbling block for global food security.

The Importance of Technology and Innovation

Respondents all shared a sense of technological optimism. Technological improvements to allow agricultural productivity to keep pace with an expanding population were perceived as a key priority. Reference was made to the shared finding across recent forward looking exercises (IAASTD, FAO/OECD, IFPRI, UK foresight's *Global Food and Farming Futures* report, Agrimonde's *Scenarios and Challenges for Feeding the World in 2050* study), namely that technology will continue to be critically important because of the need to increase productivity, but that as indicated in the IAASTD, "business as usual is not an option " and that agricultural intensification must be socially and ecologically sustainable.

Sustainable intensification

Sustainability issues cannot be ignored, which militate for an intensification of agriculture which must be ecologically and socially sustainable, implying a set of formidable challenges for many diverse actors.

-Michel Petit

The importance of agricultural biotechnology for increasing yield and reducing pesticide use, and for facilitating greater drought tolerance and more efficient nitrogen uptake was stressed by several respondents from this group. But several cautionary notes were also struck:

- new legal arrangements were seen as necessary by one respondent to ensure the economic benefits granted to the patent holders by intellectual property rights *and* provide sufficient access for those in urgent need of innovations to avoid hunger
- the need for a global standard (or at least increased harmonization of standards) for cultivation and commercialization of GM crops was emphasized. Presently, national approval systems operate at different timeframes, resulting in asynchronous

[127] Prepared by Charlotte Hebebrand under the auspices of the International Food & Agricultural Trade Policy Council.

authorizations, meaning that a GM transaction may have been approved in a country of export but not yet in a country of import, which can lead to trade disruptions

- key questions about the possible detrimental impacts of GM crops (and hormones) have not yet properly been solved
- the societal debate over GM crops and other types of innovation in food production needs to be carefully conducted.

Whereas only one particular reference was made to another potential technological innovation — artificial photosynthesis — the need for both public and private sector investment to facilitate "breakthrough innovations" was emphasized, which nicely encapsulated the widely shared view/optimism that human ingenuity, when coupled with sufficient resources, would lead to new solutions to meet the pressing challenges facing the global food and agricultural system.

Shifts in Research and Development to Facilitate Innovation

There is a need for "new metrics," i.e. calories per hectare, yield per input to guide us towards technological innovations to reach greater efficiency.[128] Several respondents from our group also emphasized the need to focus research and development efforts on the "concrete needs of the poorest," lamenting that research focusing on smallholder needs has been neglected in the past twenty years. Given the relatively low yields per hectare in Sub-Saharan Africa, in particular, the need for intensification of smallholder production was emphasized, in order to meet food security and economic development objectives.

Biofuels (and other bio-based products) were viewed with considerable concern by a number of respondents, although several emphasized the importance of biofuels as a way to reduce reliance on fossil fuels and the opportunities this opens for agricultural producers; referring to forward looking exercises — this time from the energy realm (International Energy Agency, U.S. Energy Information Administration, Intergovernmental Panel on Climate Change's Special Report on Renewable Energy Sources and Climate Change Mitigation) — it was noted that no "2030/2050 scenario that looks at reducing emissions does so without modern biofuels/bioenergy providing some portion of transport fuels or combined heat and power." One respondent also pointed to the tremendous energy needs in rural areas in Africa, suggesting that modern biomass/biofuels could help provide energy for transport, electricity, cooking and heating. Research and development should, however, accelerate in order to make biofuels from non-food agricultural feedstock commercially viable, so as to ease food-fuel competition (see also policies below). So-called second generation biofuels produced from non-food agricultural feedstocks could still pose a problem if they compete with food crops for limited arable land and water.

Shifts in Policy to Incentivize Prudent Use of Limited Resources

Grouping together the water, soil, climate change and natural resources and biodiversity rubrics, respondents from this group expressed serious alarm about natural resource constraints and pollution. Respondents spoke of the need to change the mindset of seeing natural resources as both unlimited and of little value that has prevailed in the past towards one that is cognizant of their limitations and costs.

Most apprehension was expressed about increasing water scarcities and desertification and soil degradation at a regional level. Special attention was drawn by one respondent to water shortages and pollution in developing countries, resulting from increased use of non agricultural water uses, industrialization, investments that have gradually shifted polluting industries from developed to

[128] Jason Clay - Nature Vol.475, pp 287-289 http://www.nature.com/nature/journal/v475/n7356/full/475287a.html

developing countries, rising non point pollution from chemical uses in agriculture and an expansion of livestock sector as meat demand increases with income.

The need to prevent land degradation was highlighted by several respondents; one referred to the insufficient focus this issue has received relative to water and biodiversity. Some emphasized the need for increased capacity building in developing countries to implement improved agricultural practices, others spoke of the need for a new incentive structure. Water and soil health have been taken for granted by too many producers and incentives for more efficient use of natural resources are needed: suggestions include improved water rights and pricing and, and an increased focus on (and payments for) carbon sequestration in soils and plants.

Several stressed the need for "comprehensive" and "legally binding" agreements at the international level in order to prevent further degradation, with one cautioning, however, that "global regulation must be acceptable to both developed and developing countries" and should not constitute barriers to trade.

Urgent need to act on land degradation

We require a new focus on prevention of land degradation: land and soils are the underrated natural resources (relative to water, biodiversity). Fast rising land prices have mixed effects on sustainability of agriculture; our recent assessment on costs of inaction with regard to land degradation suggests this is a global issue and that land policy should be on the agenda prominently.

-Joachim von Braun

Running as a common thread through the more internationalist respondents' views were, on the one hand, satisfaction that the seriousness of these problems has been increasingly realized, but also frustration that despite this acknowledgement the international community has been unable to take sufficiently concrete and effective steps to counter these natural resource trends.

International community needs to get serious about climate change commitments

Over the last 20 years, the international community has repeatedly acknowledged the need to address the huge challenge of the effects of climate change. Nonetheless, there was not enough support to reach complete consensus through comprehensive agreements like the Kyoto protocol.

-Carlos Perez del Castillo

Trade & Markets

A common theme emphasized by all the respondents from this group was the need for an open trading system, which they perceived as crucial for meeting both the food security and sustainability challenges facing the global food and agricultural system.

Reference was made to what was termed as a not generally well understood common finding of recent forward-looking exercises (IAASTD, FAO/OECD, IFPRI, UK foresight, Agrimonde) which holds that international trade will have to grow, since no plausible scenario exists which would counter the growing net deficits of such major regions as the Middle East and North Africa (for sure) and Sub-Saharan Africa (most probably).

Beyond facilitating transfers from regions of surplus to regions of deficit — important in particular in light of increased extreme climatic events, such as droughts and floods, a reformed,

non-distorted agricultural system is perceived of paramount importance for opening markets for developing country exporters and contributing to improved rural livelihoods.

Free trade

Free trade is the only way to open agricultural markets for developing countries.
-Roberto Rodrigues

Those more critically inclined towards biofuels were adamant in calling for an end to government mandates and subsidies for biofuels, given their impacts on commodity prices, although a cautionary note was struck that high oil prices would make biofuel production profitable even in the absence of government incentives. One respondent, however, referred to the food versus fuel discussion stemming from "inefficient land management practices."

Respondents from this group also emphasized the role of trade in promoting sustainable development. Trade was described as facilitating a wiser use of natural resources by focusing on production in places with sufficient land and water and transfers of food and agricultural products to places where the same production would not be sustainable.

Trade promotes sustainable production

Sustainable development means that we need to use the sustainable natural resources of land and water where they are available to feed a fast growing urban population wherever they are in the world.
-Carl Hausmann

In order to realize the goal of an open trade system, respondents focused on the need to reduce trade barriers, to have science-based regulations, and to avoid unilateral and sudden national policy changes, such as export embargoes.

The need to address trade measures that create and/or exacerbate price volatility to the detriment of the most vulnerable (along with other measures that cause extreme volatility) was also highlighted by one respondent. Targeted social welfare measures are seen as more effective in protecting domestic vulnerable populations from high food prices, but budgetary limitations facing many poor countries were acknowledged. A trade system that allows some assurances and consistencies for importers was seen as an important tool for reducing the impacts of extreme price volatility, and it is also vital to tackle the domestic causes of price volatility including yield risks.

Need to tackle extreme price volatility

Commodity market volatility undermines investment (especially in small farm agriculture), sustainability, and food security: the whole range of actions to reduce volatility should be on the agenda (technology, productivity, market institutions, trade policy, etc.)
-Joachim von Braun

Focus on Smallholders is Crucial

There was widespread consensus on the need to link in particular smallholder farmers to markets, since they not only produce a large share of global food, but are also often very poor.

Focus on the smallholder

Small rural farmers are the key to solve the problem of food insecurity. This is because they produce a high percentage of world food and, at the same time, they represent one of the most vulnerable groups in terms of food security in many developing countries.

-Carlos Perez del Castillo

Linking smallholders to markets is understood to encompass a wide range of requirements, i.e. improved land titling, improved access to infrastructure, finance and risk management options, etc. One respondent pointed to the potential for public-private partnerships in creating such linkages, while another cautioned about the need to reduce the market power of international food enterprises and their marketing channels.

Waste and consumption

Whereas most respondents viewed the wasteful use of water and land in agricultural production as most problematic, several also pointed to the significant percentage of food wasted in both developed and developing countries, with most waste occurring at the retail and consumption level in the former, and resulting from post harvest losses in the latter.

Tackle food waste

Every government must seriously tackle reduction of wastes of food and food raw materials.

-Heroshi Shiraiwa

The importance of evolving public policy (including education), and perhaps even private practice, toward the availability of nutritional diets at a reasonably low-cost was recognized as being very important for many aspects of our agri-food systems, but there was considerable skepticism about the effectiveness of polity in influencing personal consumption choices.

Consumption patterns clearly matter but are hard to influence

The future evolution of nutritional diets will have dramatic consequences for food supply and utilization balances, for world trade, and most importantly for public health. Forceful public policies are called for; but we do not seem to have many proven effective measures to recommend.

– Michel Petit.

3.2 Rural Livelihoods and Poverty Group[129]

A number of major concerns and priorities emerged among the contributors in this group. They are outlined in the key themes that were most commonly noted.

Climate Change

Agriculture is the human endeavor likely to be most affected by changes in climate. And according to the Intergovernmental Planet on Climate Change, farmers in developing countries, particularly sub-Saharan Africa, will be hit the hardest by the impacts of climate change.[130] In our group, climate change emerged as a priority for nearly all of the contributors. Monique Mikhail, Sustainable Agriculture Policy Advisor, Oxfam Great Britain, mentioned that "we have pushed ourselves into the 'Anthropocene Epoch' — the geological era in which human activity is the main driver of planetary change."[131]

Despite increasing attention to climate change's impact on agriculture, funding for agricultural adaptation projects—the practices that will help pastoralists and small farmers adjust to more extreme weather events, higher temperatures, and increasing livestock and crop diseases—remain woefully underfunded.[132] According to Jacob Wanyama, coordinator of the Africa LIFE Network, an organization that works for the rights of pastoralist communities, "major donors are spending too much on adaptation rather than mitigation efforts. They still push for traditional green revolution practices, despite its negative effects on biodiversity and resilience for the future." In addition, discussion of an agriculture work program for the U.N. Framework Convention on Climate Change has been driven largely by developed country interests in creating soil carbon emissions offset credits for major emitters while funding for agricultural adaptation projects—from the Global Environmental Facility, for example—remains a small fraction of what is invested in Clean Development Mechanism and other carbon market projects,[133] writes Steve Suppan, Senior Policy Analyst in Trade and Global Governance, Institute for Agriculture and Trade Policy (IATP).[134] These carbon market proponents would reduce the multi-functionality of agriculture to that of a provider of offset credits, according to Suppan.

Luis Genaro Muñoz, General Manager of Columbia's National Federation of Coffee Growers, where prolonged climate variations are wreaking havoc on key crops such as coffee, says that there is still a lack of information about the effects of climate change on biodiversity and rural living conditions. As a result, the outcomes of mitigation and adaptation strategies are still uncertain and thus leave producers unable to effectively adjust.

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[129] Prepared by Danielle Nierenberg of Worldwatch Institute's Nourishing the Planet Project

[130] IPCC (2007) 'Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change', http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html.

[131] A term first mentioned by ecologist Eugene Stoermer but popularized by Nobel Prize-winning atmospheric chemist Paul Crutzen. http://www3.mpch-mainz.mpg.de/~air/anthropocene/

[132] "Agriculture at a Crossroads: Global Report." IAASTD (2009). http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf;

[133] See also the various articles on carbon market "readiness" projects, a full list of which is provided in the Annex; "Transitional Committee for the Green Climate Fund of the UN Framework Convention on Climate Change," Institute for Agriculture and Trade Policy (IATP), 2011.

[134] The Clean Development Mechanism, defined in Article 12 of the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO2, which can be counted toward meeting Kyoto targets. http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php.

Water

Getting "more crop per drop" was also a key concern among contributors. Currently, 70 percent of all human water use goes to irrigation.[135] John Coonrod, Executive Vice President of The Hunger Project, Robert Lawrence, Professor in Environmental Health Sciences with The Center for a Livable Future of the Johns Hopkins Bloomberg School of Public Health, and Judi Wakhungu, Executive Director of Energy Resources Management of the Global Alliance for Diversifying the Science & Engineering Workforce, point out that current industrial farming practices, population growth, and urbanization have led to an alarming decrease in water resources; and the demand from these sources continues to increase.[136] "The U.N. Food and Agriculture Organization (FAO) reports that 93 percent of depletion from aquifers is for agriculture, and irrigated areas of cropland in low-income countries are projected to expand 20 percent by 2030," writes Lawrence.

Mikhail and Bina Agarwal, Director and Professor of Economics at the Institute of Economic Growth, University of Delhi, call for more sustainable and community-based solutions, such as an integrated, community-led water resource management system, to protect our depleting water supplies. In some areas, "water resources can be better managed through community-focused solutions such as community rainwater harvesting systems," says Agarwal.[137]

Coonrod stresses water is especially problematic for impoverished women farmers, that comprise a large portion of the farm community in many countries, because they lack access to affordable, small-scale irrigation systems. These innovations—drip irrigation, treadle pumps, etc.—are also extremely important for improving the lives of women farmers because they help reduce labor and increase yields.[138]

Urban Harvest researchers, Nancy Karanja, (University of Nairobi) and Mary Njenga, (Department of Land Resource Management and Agricultural Technology at the University of Nairobi), concur with Wakhungu in suggesting the considerable urban-rural benefits of better waste water systems that allow for the reuse of some urban waste-water for agricultural irrigation.[139] These practices can help conserve water resources, while also providing a free source of nutrients to crops.

Carlos Pérez del Castillo, Board Chair of the Consultative Group on International Agricultural Research (CGIAR), calls for the development and breeding of crop varieties that are drought-

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[135] Sandra L. Postel, "Getting More Crop per Drop", *State of the World 2011: Innovations that Nourish the Planet* (New York: W. W. Norton, 2011), pp. 39-48.

[136] John Coonrod, Executive Vice President, The Hunger Project, September 14, 2011; Robert Lawrence, Professor in Environmental Health Sciences, The Center for a Livable Future , Johns Hopkins Bloomberg School of Public Health, September 17, 2011; Judi Wakhungu, Executive Director, Energy Resources Management of the Global Alliance for Diversifying the Science & Engineering Workforce in Nairobi, Kenya, September 19, 2011.

[137] World Agroforestry Centre, Southern & Eastern Africa Rainwater Network (SearNet). http://www.worldagroforestry.org/projects/searnet/.

[138] For labor requirements, P. Dreschel et al., "Adoption Driver and Constraints of Resource Conservation Technologies in Sub-Saharan Africa," International Water Management Institute (IWMI), FAO, and Humboldt University (Berlin), 2005. westafrica2.iwmi.org/projects/Adoption%20Technology/Technology_Adoption-article.htm. For water saving technologies, Sandra Postel et al., "Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and Poverty," *Water International*, March 2001, pp. 3-13; David Molden, ed., *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London and Colombo: Earthscan and IWMI, 2007), pp. 7-8.

[139] Mary Njenga et al. 2007. "Nutrient Recovery from Solid Waste and Linkage to Urban and Peri Urban Agriculture in Nairobi, Kenya," in A. Bationo et al. (Eds) Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities. , pp. 487-91. Amsterdam: Springer

resistant.[140] Lawrence highlights the need for accelerated development of water storage and aquifer recharging technologies, in addition to better crop diversity and curbing meat production and consumption to reduce water use in agriculture.[141] Helio Mattar, President of the Akatu Institute for Conscious Consumption in Brazil, on the other hand, highlighted the need for market mechanisms such as improvements in labeling that describe how much water is used in the production of particular foods and products, allowing consumers to have more information about what they are buying.

The potential risks posed by water privatization were not discussed in most responses, but Coonrod writes that one of the most negative trends he has observed has been the push to remove water from being not only a common public good but also a basic human right to a commercial commodity. This may overwhelm any of the potential benefits of improved distribution efficiencies in private systems.

Soil Quality

Global soil erosion continues to impede crop production and decrease yields. Lawrence writes that nearly a third of the earth's arable land was lost to erosion in the last half of the 20th century and continues to be lost at the rate of about 10 million hectares per year.[142]

This large-scale neglect of soils is partly due to the fact that "global institutions have given far more financial and technical support to restoring or enhancing short-term soil productivity through the addition of chemical fertilizers than they have through traditional and more sustainable use of cover crops and the addition of green manure," explains Suppan.[143]

Del Castillo mentions the importance of extension services to help smallholders improve soil health. Agricultural extension services have been reduced to minimal levels in most low-income countries, unfortunately, leaving farmers to rely on chemical and fertilizer agro-dealers who are increasingly a main source of both inputs and information.[144] Contributors also call for increases in collection of soil data in order to better understand soil dynamics in varying agroecological zones and climatic conditions because global knowledge about soil health and soil conditions has not improved much over the past 20 years.[145] According to Mikhail, "Due to the urgency of the global soil situation, mainstreaming soil fertility indicators, substantially expanding extension/capacity building/knowledge sharing efforts to scale up adoption of agroecological practices, and improving soil data collection are all necessary now."

But, ultimately, data collection is not enough. Suppan says any global soil partnership launched at the upcoming Rio+ 20 meeting should not wait for completion of a global soil survey to agree on

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[140] "Agriculture at a Crossroads: Global Report." IAASTD (2009), at http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf.

[141] "The Environmental Food Crisis," United Nations Environment Programme (UNEP), 2009. at http://www.unep.org/publications/contents/pub_details_search.asp?ID=4019

[142] D. Pimentel et al. "Environmental and economic costs of soil erosion and conservation benefits." Science 1995. 267(5301): 1117-1123.

[143] See also, A, Dorward et al., "Towards 'Smart' Subsidies in Agriculture? Lessons from a Recent Experience in Malawi," *Natural Resource Perspectives No. 116* (London: Overseas Development Institute, October 2008).

[144] Ian Scoones. 2008. Global Engagements with Global Assessments: The Case of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD).

[145] FAO. "Towards a Global Soil Partnership for Food Security and Climate Change Mitigation and Adaptation," Background Paper at http://www.fao.org/landandwater/docs/GSP_Background_Paper.pdf.

a dedicated fund for soil building. There is already a considerable body of scientific and traditional knowledge that can be applied to help farmers now.[146]

Rural Livelihoods and the Role of Small Holders - Encouraging Agroecological Farming Practices

Many of the contributors point to the important role that agroecological farming practices (defined as methods and practices that increase organic nutrient inputs, retention, and use to build soil organic matter, increase soil moisture retention, and reduce the need for synthetic fertilizers[147]) have in increasing yields and improving livelihoods. Coonrod writes that the introduction of agroecological techniques, including micro-dose fertilizer, has been one of the most important trends in land management in the past twenty years. These techniques serve to minimize cost and environmental impact while greatly increasing yields.[148] Several contributors discuss the need to move away from high-input and capital-intensive agriculture to agroecological practices. "This includes a recognition that 'new technology' does not only apply to external inputs, but to agroecological practices, innovations, and adaptations continually occurring on smallholder fields," noted Mikhail.

Wanyama notes that, "There should more work on how to promote conservation and at the same time maintain sustainable agriculture and food production for the growing global population." As Alexandra Spieldoch, Core Associate with Women Organizing for Change in Agriculture and Natural Resources Management, states, "Governments should prioritize programs to diversify their agricultural production as a means for managing soils, water, biodiversity and traditional knowledge systems. This should largely be based on agroecology, farmers' knowledge, and new partnerships among farmers, scientists and other stakeholders."[149]

On the other hand, Raj Patel, Honorary Research Fellow at the School of Development Studies, University of KwaZulu-Natal, South Africa and visiting scholar, UC Berkeley's Center for African Studies, says that the main issue, and one that he fears will be the barrier to consensus, "is whether large-scale capitalist agriculture is part of the problem or the solution." Conventional agricultural practices, which are highly dependent on fossil fuels, continue to be promoted by many governments and agricultural research institutions as the way forward for developing world farmers. On the other hand, there is a great need to popularize agroecological practices and provide opportunities to scale them up for different communities, countries, and regions. Many of the contributors expressed the need for global extension and knowledge-sharing effort to promote the scaling up of agroecological practices. These practices can have multiple benefits, including increasing yields and improving soil health, while also reduce the amount of inputs, including artificial fertilizers.

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[146] "Agriculture at a Crossroads: Global Report." IAASTD (2009), at http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf
"The Environmental Food Crisis", United Nations Environment Programme (UNEP), 2009 at http://www.unep.org/publications/contents/pub_details_search.asp?ID=4019

[147] Buck, Louise and Sara Scherr, "Moving Ecoagriculture into the Mainstream." *State of the World 2011: Innovations that Nourish the Planet* (New York: W.W. Norton, 2011) pp. 15-24.
'Agriculture at a Crossroads: Global Report.' IAASTD (2009), at http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf

[148] M. Stevenson, "Malawi Reaps the Reward of Returning to Age-Old, Chemical-Free Farming," *Theecologist.org*, 22 June 2010.

[149] Bob Watson, "How to Assist the Small Scale Farmer," IAASTD, at http://www.docstoc.com/docs/2537710/How-to-Assist-the-Small-Scale-Farmer

Encouraging Cooperation and Farmer Organization and Improving Extension
Many methods, such as community rainwater harvesting and forest management, hold great promise, but cannot be done by individual households to be effective—they, in essence, need a village. Agarwal suggests increasing "institutional innovations which focus on community and small farmer cooperation…[and] more cooperation based approaches for small holder agriculture."[150]

Farmers groups do not only need strengthening in rural areas. Karanja and Njenga highlight the involvement of local and small-scale farmers in urban and peri-urban areas as critical for success. They stress the need for national governments to support local initiatives when developing urban policies, as well as empowering urban farmer organizations to increase their participation in the policy-formulation process.

Allen Blackman, Senior Fellow at Resources for the Future, encourages "building political and community support for natural resource management in developing countries," something that could be reinforced through better extension services, as well as increasing the role farmers groups play in spreading innovations.

Women farmers groups also need more support. Coonrod emphasizes the importance of women farmers for the global food system and environment. He argues that building and strengthening women farmers' organizations should be the first step taken in the next few years in order to improve their livelihoods sustainably.[151]

Research and Extension with Small-holders
Suppan mentions that, unfortunately, most new research conducted by governments, intergovernmental institutions, and the private sector focuses on a few grains and oilseeds, and a few livestock varieties.[152] Del Castillo, Lawrence, Karanja, Njenga, and Mikhail mention that governments need to put more money into research, but research specifically focused on the needs of smallholders. Others point out that the needs of women farmers should be part of the research as well.

Mikhail discusses that extension and knowledge-sharing will impact most of the other categories. Lawrence writes that in terms of next steps, it is essential that we "expand extension services to encourage adoption of new methods of irrigation, integrated water use as discussed above with aquaculture and hydroponics, and use of integrated pest management to decrease reliance on pesticides."[153]

Health and Food Safety and New Technologies
Several of the contributors mention the connection between food safety and new technologies. Stephen Ruvuga, Executive Director of the National Network of Farmers Groups in Tanzania, mentions the popularity of the idea that GMOs will save Africa, which is questionable in terms of

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[150] Tesfahun Fenta et al., *The Ethiopian Experience in Piloting Local Innovation Supports Funds, April 2006-March 2008* (Addis Ababa, Ethiopia: Prolinnova-Ethiopia, 2008).
[151] World Cocoa Foundation (WCF), "Success Stories", in *The ECHOES Alliance Quarter TwoReport, January-March 2008* (Washington, D.C.: March 2008), pp. 27-28.
[152] "The Environmental Food Crisis", United Nations Environment Programm (UNEP), 2009 at http://www.unep.org/publications/contents/pub_details_search.asp?ID=4019.
[153] Chris Reij and David Steeds, "Success stories in Africa's drylands: supporting advocates and answering sceptics. Global Mechanism of the Convention to Combat Desertification, Rome," *Paper commissioned by the Global Mechanism of the Convention to Combat Desertification. Amsterdam: Centre for International Cooperation, Vrije Universiteit Amsterdam.* 2003. pp. 18-19.

GMOs benefits, costs and impacts.[154] According to del Castillo, the possible influence on human health of GMOs and hormones in vegetal and animal production, respectively, are the most important issues emerging over the last 20 years with relation to food safety.

In a related topic, Lawrence warns that the misuse of antibiotics threatens food health: "The misuse of antibiotics as growth promoters in industrial food animal production has produced a significant increase in antibiotic resistant bacteria, threatening the safety of the food supply, including vegetable crops irrigated with contaminated water."[155]

While new technologies are often tossed about as a potential solution to problems plaguing agriculture in developing countries, many new technologies are unknown, unaffordable, and inaccessible to smallholder farmers who form the majority of producers in most of Africa. Ruvuga states that increasing research should be devoted to technologies that are appropriate for such farmers.[156]

Helio Mattar mentions the role consumers play in whether these new technologies flourish. He says "Consumers have tended to demand healthier and safer food. Research has shown that impacts on health and safety are the main issues for consumers in relation to products."

Women in Agriculture:

Women make up the majority of the agricultural labor force in sub-Saharan Africa and in many developing countries and contributors highlight their important role. As Spieldoch states, "In spite of their central role as the majority of food producers and providers in the developing world, women are under-counted and under-valued." According to Coonrod, gender is a major barrier to improving agricultural productivity and sustainability. Their lack of access to land and land tenure is one of the most important problems.[157]

Both Mikhail and Spieldoch call for targeted interventions, including more secure land tenure and increased access to aid and extension services for women farmers. Agarwal emphasizes that "agricultural research, extension, credit, input access, tool designs, all need to be directed to reach women farmers. In her view, providing the tools, knowledge and resources to female farmers will greatly improve agricultural productivity.[158] The 2011 "Women in agriculture: Closing the gender gap for development" report from FAO concurs, showing that agricultural productivity could be substantially increased by bridging the gender gap in access to inputs available to women farmers."[159]

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[154] Stephen A. Ravuga, Executive Director, National Network of Farmers Groups in Tanzania, September 16, 2011. Noah Zerbe, "Feeding the famine? American food aid and the GMO debate in Southern Africa," *Food Policy* (Vol 29, Issue 6, December 2004) pp. 593-608.

[155] J. C. Chee-Sanford et al., "Fate and Transport of Antibiotic Residues and Antibiotic Resistance Genes Following Land Applications of Manure Waste," *Journal of Environmental Quality*, April 2009, pp. 1,086–108.

[156] Gordon Cpnway and Jeff Waage, with Sara Delaney, *Science and Innovation for Development* (London: U.K. Collaborative on Development Sciences, 2010).

[157] "Women in Agriculture: Closing the gender gap for development," *The State of Food and Agriculture 2010-2011*, Food and Agriculture Organization of the United Nations (Rome: FAO, 2011).

[158] Bina Agarwal, "Food Crises and Gender Inequality," *UN DESA Working Paper No. 107*, June 2011.

[159] "Women in Agriculture: Closing the gender gap for development," *The State of Food and Agriculture 2010-2011*, Food and Agriculture Organization of the United Nations (Rome: FAO, 2011).

Bio-Fuels
Lawrence warns that the usage of crops for biofuels instead of for human consumption threatens food security and hunger by decreasing the supply of grains for food while also potentially driving up prices.[160]

As identified by a number of contributors, governments often subsidize their biofuels in unsustainable ways. As Jan Nijhoff, Senior Agricultural Economist with the World Bank, points out, "Globally, biofuels production has been uncompetitive without major subsidies, suggesting that alternative energy sources may be more sustainable."[161] Del Castillo advocates for countries to examine their non food uses of crops and animal production (including biofuels mandates) and agrees with Nijhoff in the importance of developing new alternative technologies.

Both Mikhail and Ruvuga argue strongly against biofuels subsidies, pointing out the economic and social impacts for farmers in the U.S. and developing countries.[162]

Mikhail recommends that food security should take precedence over energy production in land usage, and states that "by making crops substitutable for oil, biofuels have facilitated contagion between energy markets and food markets. Costly biofuel programmes also draw funding away from other, more beneficial programmes. Support measures for biofuel programmes currently cost about $20 billion a year worldwide, and this is set to more than double by 2020."[163]

Land Grabs
Lawrence warns that the increasing demand for land to produce biofuels and food will result in land grabs in less developed countries, especially by large countries in order to ensure their food security. In particular, Lawrence focuses on the increase in meat consumption,[164] which requires large quantities of grain and soy to be dedicated to animal feed, as a motivation for future land grabs: "Land grabs in Africa and Latin America will likely continue as China and the Gulf States struggle to protect their food security and accommodate the appetite for meat."[165]

Ruvuga also mentions the growing problem of land grabbing by large corporations and the elite in Africa. "Because of the vastness of Africa a lot of countries have been flooded with companies that acquire land for production of biofuel with social and land-right consequences."[166]

The Missing Links and What's Needed to Move Forward
A number of contributors emphasize the importance of involving smallholder farmers when determining what steps should be taken to immediately address hunger, poverty, and environmental problems. As del Castillo states, "Many international organizations, including the FAO, have claimed that small farmers are the key to solve the problem of food insecurity."[167]

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[160] Donald Mitchell, "A Note on Rising Food Prices," World Bank Policy Research Working Paper Series, (Vol 4682), July 1, 2008.
[161] See also, M. B. Charles, R. Ryan, N. Ryan and R. Oloruntoba, "Public policy and biofuels: The way forward," Energy Policy,(vol 35, 2007) pp. 5737–5746; Peter Hazell and R. K. Pachauri (eds.) "Bioenergy and Agriculture: Promises and Challenges," *International Food Policy Research Institute* (2020 Focus No. 14, 2006).
[162] "The Environmental Food Crisis", United Nations Environment Program (UNEP), 2009 at http://www.unep.org/publications/contents/pub_details_search.asp?ID=4019.
[163] IEA (2010) World Energy Outlook 2010 estimates support for biofuels in 2009 was $20 billion, the bulk of it in the USA and EU. This figure is projected to rise to $45 billion by 2020 and $65 billion by 2035.
[164] Livestock to 2020: The Next Food Revolution. International Food Policy Research Institute (IFPRI), 1999.
[165] GRAIN, *Seized! The 2008 Land Grab for Financial and Food Security* (Barcelona: October 2008).
[166] Ibid
[167] United Nations Food and Agriculture Organization (FAO) "Smallholder Farmers in India: Food Security and Agricultural Policy" (2002); Beverly D. McIntyre, Hans R. Herren, Judi Wakhungu, and Robert T. Watson (eds.)

Spieldoch encourages governments to develop their programs based on "agroecology, farmers' knowledge, and new partnerships among farmers, scientists and other stakeholders.[168]" "Innovations by smallholders are a strategy to cope with climate variability," states Mikhail, who also writes that these "on-the-ground efforts must be linked to national and regional-level adaptation plans and rolled out at a wider scale" if they are to have any impact. Ruvuga echoes these sentiments, recommending increased dialogue between policy makers and smallholder producers.

Other contributors also mention that governments have a duty to ensure the protection of farmers' rights and to prioritize that obligation over the promotion and enforcement of strict intellectual property rules that threaten those rights. Patel says that "a reduction in the power of corporations is necessary so that the democratic process within food sovereignty can be followed."

Spieldoch recommends that "Governments should prioritize a new set of economic tools (or resurrect/transform old ones) that is based on a 'real' agriculture rather than virtual food markets. This includes taxation and fiscal policy to support infrastructure and services for rural producers and urban consumers; relevant trade measures such as tariffs, special products and special safeguard mechanisms to support food security and sustainable growth." As noted above, several of the contributors mention that governments should urgently agree to a phase-out of biofuels mandates and subsidies that provide incentives to divert food to fuel.

As policy makers and government leaders formulate their overall approaches, Spieldoch points out that "governments have already agreed on a comprehensive framework of action in food and agriculture[169] that provides a detailed list of proposed interventions. They have also signed international agreements that bind them to human rights and environmental obligations. This , as well as guidelines on the right to food, should be a reference point for immediate action," she says.

Support for these efforts from donors and the international community as a whole will be critical, including encouraging governments to deliver on their previous financial commitments—including the Maputo declaration and the L'Aquila commitments.[170] The Comprehensive Africa Agriculture Development Program (CAADP) and The Global Agriculture and Food Security Program (GAFSP) are two generally positive options," for moving forward according to Mikhail.[171]

Other contributors highlight the potential benefits of the Green Climate Fund, currently being negotiated in the UN Framework Convention on Climate Change (UNFCCC) for developing

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"Agriculture at a Crossroads," International Assessment of Agricultural Knowledge, Science and Technology (IAASTD), (2009).

[168] 'Agriculture at a Crossroads: Global Report.' IAASTD (2009), at http://www.agassessment.org/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf.

[169] United Nations, Comprehensive Framework for Action, 2008, at http://www.un.org/issues/food/taskforce/cfa.shtml.

[170] Maputo Declaration: Together Shaping Out Future, 4th Summit of ACP Heads of State and Government, Maputo, Mozambique (2004) at http://www.acpsec.org/summits/maputo/maputo_declaration_en.html; Joint Statement on Global Food Security ("L'Aquila Food Security Initiative"), Group of 8 (G8), G8 Summit, L'Aquila, Italy (2009) http://www.g8italia2009.it/static/G8_Allegato/LAquila_Joint_Statement_on_Global_Food_Security%5B1%5D,0.pdf.

[171] The Comprehensive Africa Agriculture Development Program (CAADP), http://www.nepad-caadp.net/; The Global Agriculture and Food Security Program (GAFSP), http://www.gafspfund.org/gafsp/.

countries.[172] Suppan writes, "…the funding of agricultural adaptation should be the first priority for the UNFCCC and other global institutions concerned with climate change and agriculture… [It] should have a legal personality to enable it to raise and disburse funding for adaptation projects within National Action Programs of Adaptation and subject to the fiduciary controls of the Adaptation Fund and to safeguards for civil society and smallholder participation. Particular attention should be given to supporting the adaptation of indigenous crop and livestock varieties to climate change."

The international community, in addition to providing funding for developing countries, can also play an important role in supporting local adaptations, economies, and livelihoods through the markets. "International policy should also ensure that countries receive benefits from providing global goods, notes Mikhail. Del Castillo agrees that promoting "adequate market functioning in developing countries that reduce the market power of international food enterprises and marketing channels," as well as "renewed legal frameworks to tackle the false opposition between property rights owners and final users in poor countries can improve the livelihoods of small holder farmers.

3.3 Agricultural Production and Environmental Sustainability Group[173]

Introduction: Many shades of green

The impacts of industrial agriculture and the Green Revolution in the last half of the twentieth century are now widely known and well documented: agricultural research, investment, and innovation boosted yields dramatically and reduced hunger and poverty in many regions.[174] Yet, these gains created enormous damage to ecosystems, biodiversity and climate—through both agricultural expansion and intensification—while failing to address the needs of hundreds of millions of poor people.[175] Going forward, there is widespread agreement that farmers must produce more food per unit of land, water, other inputs, and environmental impact. Even most advocates of large-scale and industrial, input-driven agriculture acknowledge the need to increase input use efficiency, reduce environmental impacts, and consider social consequences. Yet, many advocate further-reaching change that would re-imagine and transform the world's major agriculture and food systems, not just modify them incrementally.

Salient trends and looming challenges

In the past several years, the research community has produced a very strong knowledge foundation about the major trends, impacts, challenges, and alternative scenarios for food, agriculture, land, and water. As a result of this work, there is far less disagreement about the nature and causes of these challenges than about the most appropriate solutions. Nonetheless, differing interpretation of past events (and the relative emphasis placed on different factors) tends to frame differing worldviews and future courses of action. It is thus helpful to highlight some salient trends of the past 20-30 years identified by experts with especially strong sustainability and agroecological perspectives. As indicated below, experts tended to emphasize the detrimental aspects of recent trends in agriculture and food systems, (without necessarily negating the

[172] United Nations Framework Convention on Climate Change (UNFCCC). Transitional Committee for the design of the Green Climate Fund.
http://unfccc.int/cooperation_and_support/financial_mechanism/green_climate_fund/items/5869.php.
[173] Prepared under the auspices of EcoAgriculture Partners (Sara J. Scherr and Jeffrey C. Milder)
[174]Foresight The Future of Food and Farming (2011) Final Project Report. The Government Office for Science, London.
International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). 2009. Agriculture at a Crossroads.
[175] Millennium Ecosystem Assessment (http://www.maweb.org)

benefits that such systems have provided to many). These detrimental impacts frame the key challenges to forging a more sustainable alternative set of systems in the coming decades.

Trend	**Effect**
Policy, investments, and business models favor medium- and large-scale farmers over smallholders and pastoralists	Declining incomes for most farmers; smallholder distress; failure to address rural poverty and the Millennium Development Goals
Replacement of traditional agroecosystem management and endogenous inputs with synthetic external inputs and technology packages	Rapid increase in the environmental footprint of agriculture (including greenhouse gas emissions); dependence of agriculture on unsustainable sources of energy, nutrients, and water; focus on a small number of crops
Reduction in agricultural system diversity, at the gene, species, farm, and landscape levels; homogenization of agricultural landscapes	Increased vulnerability and fragility of food and agriculture systems (including to climate change); accelerating loss of wild biodiversity through both expansion and intensification
Increased pressure on local land and resource endowments, often driven by population growth and market forces, and exacerbated by weak governance and social conflict	Land degradation, widespread soil erosion, declining soil fertility, and desertification; dispossession of vulnerable farmers and rural people; rural-urban migration
Globalization and consolidation of food distribution and markets; growing urban populations; consumer choice and food marketing favors processed foods	Declining nutritive quality of foods; rise in diet-linked disease; monopolization of supply chains and reduced farmer control over production
Increased world population, increased aggregate food demand, and increased demand for higher-impact foods (e.g., meat, dairy, and air-freighted foods)	Rapid increase in the environmental footprint of agriculture; deforestation; increased opportunities for product marketing and trade
All of the above	Decline in ecosystem services *from* and *to* agricultural systems

Extrapolating these trends, we predict a new era for agriculture in which scarcity of the resources needed to produce food (i.e., land, water, energy and chemical inputs) becomes a key limiting factor alongside labor and capital, while the ecosystem services produced by agricultural landscapes become more valued economically and socially. Recent large-scale commercial investment in such means of production ("land grabbing") is evidence of their impending scarcity, while escalating food demand (amplified by increased meat consumption and appropriation of crops and arable land for biofuels) is likely to exacerbate such constraints. Thus, any serious program for agricultural sustainability must treat water, soil, biodiversity, and ecosystem services as central themes and foci for research and investment.

While policymakers often view commercial agriculture and agribusiness as the source of "serious" economic growth and food production for urban and international markets, data indicate that support for smallholders may offer the greatest leverage to increase food supplies, reduce poverty, and maintain ecosystem services. With very low baseline levels of performance, many smallholder systems could readily double or triple agricultural output, often with positive

ecosystem consequences.[176] Furthermore, a focus on smallholders tackles problems of rural poverty and local food security directly, rather than indirectly through an emphasis on aggregate food production and economic growth.[177]

However, such gains in the smallholder sector have been significantly hindered by a lack of appropriate extension services, agricultural inputs, and credit, as well as a lack of attention to female farmers and gender issues. Similarly, social capital in agricultural communities (e.g., within farmer groups, women's groups, cooperatives, and farmer networks) has been demonstrated as a critical resource to help producers identify key challenges, formulate solutions, access resources, share knowledge, and conduct adaptive management and research—but has received only modest investment and support to date.[178] Adaptive, resilient agricultural systems call for much greater attention to all of these issues.

Climate change: Fiddling while Rome burns?

> "Mainstream agricultural research and development has failed to take seriously the need to prepare for climate change. The tendency has been to seek minor adaptations (greater tolerance to droughts, floods, high temperatures, pests and pathogens) for existing systems rather than re-think the systems themselves."
>
> -Emile Frison

For decades, crop yield has been treated as a universal indicator of agricultural system performance, while aggregate food output (e.g. the often-cited mandate to increase global output by 70% or more by 2050) is treated as the starting point for most future prescriptions for food and agriculture. Yet, from the standpoint of human wellbeing, the purpose of food is to maintain good nutrition and good health. Recent decades have witnessed the progressive de-coupling of food from nutrition and health, as the total world food supply exceeds demand, while diets remain inadequate in many poor countries while becoming less nutritious and less healthy where processed foods have proliferated.[179] Developed countries have begun to witness a countervailing trend of increased interest in food quality and healthy foods, but overall the food supply is becoming more homogenized, with a progressive decline of the traditional foods and varieties once found throughout the world. Going forward, a narrow focus on yields is likely to exacerbate these trends. Conversely, a shift toward health- and sustainability-based indicators and investment criteria could revolutionize agriculture, benefit people and communities across the economic spectrum, and reduce the ecological footprint of food systems.

In recommending future directions for food and agriculture, the expert contributors reached many more points of consensus than of disagreement. There was broad concordance on the need to reverse several of the above-noted trends to make agriculture more supportive of small farmers and rural communities, more environmentally friendly, and economically beneficial to a wider cross-section of society.

[176] FAO (2011) Save and grow: a policymaker's guide to the sustainable intensification of smallholder crop production. Rome: FAO.

[177] Growth originating in agriculture, in particular the smallholder sector, is at least twice as effective in benefiting the poorest people as growth from non-agricultural sectors. FAO (2010) 'How to Feed the World', p.2. See also Ha-Joon Chang (2009) 'Rethinking public policy in agriculture: lessons from history, distant and recent', *Journal of Peasant Studies*, Volume 36, Issue 3, July 2009, pp.477-515.

[178] Love, C., Carroll, P., and Prior, J. 2010. Building Social Capital to Achieve Sustainable Farm Practices, Section 3, In Jennings, J., Woodside, D., and Packham, R. (eds) *Enabling the Sustainable Management of Natural Resources and Agricultural Production: The Role of Extension*, Australia Pacific Extension Network, Brisbane.

[179] Popkin, B. M. (2003). The Nutrition Transition in the Developing World. *Development Policy Review, 21*(5-6), 581-597. doi:10.1111/j.1467-8659.2003.00225.x

We present a synthesis of solutions and recommendations at three levels. The next section defines what a sustainable approach to agriculture and food might look like in two to four decades, in terms of both biophysical and institutional/structural dimensions. The section on "Recommendations" identifies five priority sets of actions that would require concerted effort by the global community over a few decades to bring about this more sustainable future. The final section proposes mechanisms to kick-start this green agenda in the next two years, including through the UN Conference on Sustainable Development (Rio+20).

Biophysical aspects of farm, ecosystem, and landscape management

The group is optimistic that 'green' agricultural systems can indeed meet the world's nutritional needs into the future. But they see the need for these systems to be fundamentally different in the future in five principal ways:

i. **Biodiverse**. Agricultural systems and landscapes must become vastly more diverse. At the farm level, this means crop diversification, polycultures, multiple varieties, and appropriate integration of livestock to enhance resilience, manage pest and disease risks, cycle nutrients, adapt to climate change, and use inputs most efficiently. At landscape scale this means including natural areas in and around farms to sustain biodiversity and ecosystem services for local, downstream, and external beneficiaries. Locally-developed and -adapted solutions are almost always biodiverse; with the complementary application of modern science, intensification without simplification is possible and desirable, as is the re-diversification of simplified agroecosystems to restore ecosystem services.

ii. **Agroecologically based and resource-conserving.** Systems will need to shift away from heavy dependence on non-renewable inputs and chemical-based intensification, toward sustainable intensification based on fostering ecological processes and conserving local natural resources including soil and water. Agroecological methods, based on locally adapted practices and new science, will increase the efficiency of inputs used, and realize synergizes among species and systems. Better management of ecosystems for benefits such as rainwater harvesting, flood control, wild pollination, and improved soil health will be sources of yield growth and stability.[180]

Diverse solutions for diverse contexts:
A sample of proven and emerging sustainable agriculture innovations

- Evergreen agriculture
- Conservation agriculture
- System of Rice Intensification
- Perennializing grains
- Holistic grazing management
- Agroforestry in farm and pasture systems
- Multi-strata tree-based agroforests
- Fertilizer micro-dosing
- Methane digesters in intensive livestock feeding
- Plot-, farm, and village-scale rainwater harvesting

iii. **Ecosystem-friendly**. Because they are the dominant land use globally, agricultural systems themselves must produce ecosystem services and host biodiversity, as an essential complement to natural areas. To protect soils, sequester carbon and provide compatible habitat, production systems will need to incorporate more perennial crops, grasses, palms and trees that have been selected or bred for higher yield and commercial value. Improved

[180]Liniger, Hanspeter, and William Critchley, eds. 2007.*Where the land is greener: case studies and analysis of soil and water conservation initiatives worldwide*. CTA, FAO, UNEP, and CDE on behalf of the World Overview of Conservation Approaches and Technologies (WOCAT).

spatial configuration and coordinated management of farms and landscapes will protect watersheds and habitat values.

iv. **Climate-smart**. Agricultural practices and investments must shift toward "climate-smart" systems that are more resilient to climate change and environmental variability, while simultaneously reducing emissions and sequestering carbon in multiple components of farming systems and agricultural landscapes. Climate-smart principles can and must be applied and adapted to the full range of small-, medium-, and large-scale agricultural production systems.

v. **More smallholder-based**. The greater emphasis of 21st century agricultural systems on eco-efficiency, diversity, and locally-adapted management will place a new premium on knowledge-intensive, site-specific management. Likewise it will require a strong emphasis on supporting female farmers—who dominate the smallholder sector in many regions—and on addressing issues of land and resource tenure for smallholders and rural communities. With appropriate support and technical assistance, smallholders and pastoralists can play a leading role in developing sustainable, ecologically friendly farming systems and in helping to shape local and national institutions and policies to favor such systems.

Like oil and water: Biofuels and food don't mix

"Subsidized biofuel production from food crops has no future, given the competition for land, water and other inputs. Emphasis should be on growing quality food to nourish today's and tomorrow's population."

-Hans Herren

There were, among the group, still some key points of contention:

- **Role for synthetic inputs and genetically modified organisms**. There is a wide range of views about the potential contribution of these technologies to sustainable systems. Some see opportunities for greater adoption to improve input efficiency, reduce environmental footprints, and increase resistance to pests and diseases. Others favor judicious—but diminished overall—use of such inputs, while others argue for their complete elimination.
- **"Land-sparing" versus "land-sharing"**. While there was broad consensus that agricultural systems themselves should be more efficient and have fewer negative environmental impacts, views differed as to whether agriculture should always be intensified in order to maximize yield per unit area and thereby minimize agriculture's overall land footprint. The opposing view holds that lower yields should be accepted in many places where society demands ecosystem services or other co-benefits from "multifunctional" agricultural systems. On specific plots, biophysical and economic conditions may leave farmers little real choice of which approach to pursue, but at the policy level there is much scope to shift practices toward either land-sparing or land-sharing.
- **Relative focus on priority crops.** Some commentators emphasized the need to make the production of dominant food crops more sustainable, while others focused on incorporating far more existing minor crops into systems, on substituting tree and shrub sources for grain and fodder, on incorporating improved tree crops into farming systems, or on perennializing major and novel grains. While these approaches are not necessarily mutually exclusive, prioritization becomes critical.
- **Relative emphasis on landscape solutions**. Many experts focused on plot- and farm-scale innovation, while others saw major gains from linking farm-level systems with

investment in other landscape components. While these two levels of solutions were rarely presented as being in conflict with one another, there were differences in the relative importance of each.

From food to nutrition to health: Closing the loop

"Refined commodities provide cheap calories but poor nutrition. Food-based approaches to nutrition and health absolutely require the use of biodiversity to deliver nutrient-rich diets."

-Emile Frison

Institutional innovation: Organization, governance, policy, and markets

Institutional innovation is as important as technical innovation for ensuring a sustainable future for agriculture and food systems. Contributors shared a vision for future institutions that are fundamentally different in the way they value and support the diverse functions and benefits of food, agriculture and agricultural land use. In other words, a focus on aggregate crop yields and revenues must give way to a broader view that includes food, nutrition, health, energy, forest products, ecosystem services, biodiversity, cultural values, livelihoods, and overall human well-being. To realize this vision will require six main institutional shifts:

i. **Re-invest in extension**. The recommended shift toward agroecological intensification and smallholder-led productivity gains will require massive reinvestment in extension services. Rather than simply promoting fixed technology packages, extension programs for agroecological intensification help train farmers and build local institutions that can share knowledge and resources to make use of local soil, water, and biodiversity resources and key inputs to sustain livelihoods, even in changing environmental and economic conditions.
ii. **Build innovation systems that link research and local knowledge.** Establish participatory research and knowledge sharing systems that help farmers and rural communities to develop, test, and scale-up locally-adapted farm and land management systems and enterprises. Using open-source infrastructure, such systems should link research institutions, educators and extension providers, and local communities to share knowledge and innovation from diverse sources and create a networked 'virtual laboratory' of farmers experimenting with new climate-smart agricultural practices.
iii. **Development strategies that link the diverse benefits**. Develop public and private investment strategies and programs that explicitly link food, nutrition, ecosystem and human health, crossing sectoral divisions when needed.
iv. **Green business models**. Develop new business models for the agricultural sector that create public and private value in ways that also benefit farmers, communities, and ecosystems.[181] Future agricultural businesses will focus less on non-renewable inputs and more on opportunities such as full food cycle/system productivity, food-based health enhancement, waste management, farmer information systems, mobile banking, crop insurance, green inputs, management services, extension support, and management and sale of ecosystem services. Such models may be supported and motivated by minimum standards of sustainable production and by voluntary eco-certification systems.
v. **Policies harmonized across sectors**. Reflecting the broader valuation of food and agriculture noted above, policies will need to be harmonized more systematically across the agriculture, environment, energy and social development sectors, at local, national and international levels. Similarly, landscapes, territories, and regions will need to strike a balance between local food sovereignty, economic diversification, and trade; the most resilient communities are likely to be those that invest strongly in all of these.

[181]World Economic Forum. 2010. Realizing a New Vision for Agriculture: A roadmap for stakeholders.

vi. **Addressing the demand side**. Aggregate food demand is influenced heavily by population growth, changing consumption patterns (particularly the rising demand for animal products), and high levels of food waste. Rather than take future food targets (e.g., 70% demand increase by 2050) for granted, leaders can significantly shape total demand in myriad ways, from subsidy policy and environmental regulations, to investment in infrastructure and supply chains, to education policy and public information campaigns. Reductions in aggregate demand will free up "working space" to conserve land and natural resources, reduce agricultural inputs, and increase the resilience of food systems through greater diversification.

Get green or get out: What role for business?

"There won't be progress, or winners, without losers. Some of today's players in the agri-food system may simply have no place under the new paradigm, while new ones will emerge."

-Hans Herren

"The agricultural inputs sector must develop new business models that move beyond products (based on non-renewable resources) to service provision, knowledge transfer, and technology to underwrite resilient, eco-friendly production."

-John Buchanan

Several key points of contention emerged with respect to institutions and the structural environment for food and agriculture:

- **Role of meat in diets**. Because livestock feed is a key driver of new crop demand, a principal source of greenhouse gas emissions, and a major cause of ecosystem degradation, many experts highlighted the need to change meat and livestock systems. But the group is split between those who think norms, policies, and incentives should shift to reduce the role of livestock products in diets, and those who favor strong action to shift to more sustainable livestock production, especially grazing, integrated farming systems, more efficient livestock (e.g., small livestock and aquaculture systems), and feed sources that do not compete with food for humans.
- **Roles of agribusiness in sustainable, pro-poor agricultural development**. Some consider that agroecological systems may be less attractive and profitable than conventional systems for the agribusiness sector, which now focuses heavily on agricultural inputs and bulk commodity trade. These commentators thus see a much greater role for public sector and farmer organizations in future, and perhaps a proportionally smaller role for agribusiness. Others argued that agribusiness, shaped by government policy and civil society pressure, can readily adapt to find profitable opportunities in sustainable agriculture. Burgeoning interest in the many forms of green labeling, eco-certification, and supply chain standards shows considerable promise. Similarly, new models for linking agribusiness investment to the needs of small- and medium-scale farmers suggest that profitability, social equity, and poverty alleviation may be mutually supportive, if investments are carefully crafted.[182] A key challenge is to move beyond pilot activities of good actors to mainstream socially and environmentally beneficial private investment in agriculture.

[182] Porter, M.E. & Kramer, M.R., 2011. The Big Idea: Creating Shared Value. *Harvard Business Review*, 89(2), p.62-77. Available at: http://hbr.org/2011/01/the-big-idea-creating-shared-value/ar/pr. Also see: World Economic Forum 2010. Op. cit.

- **Role of international investment in land and agriculture**. Related to the previous point, there is a range of views on the potential contribution of international private investment in agricultural land, production, and markets. Some see significant potential for low-income countries to mobilize investment for sustainable agriculture, helping to fill critical gaps in areas such as rural value chains that can support smallholders and large farms alike. Others, noting the negative social and environmental impacts of recent "land grabs," emphasized the difficulty of imposing sustainability standards on foreign investors and the risks of giving investors privileged access to critical natural resources that diverts them away from domestic production and local use.
- **Role of agricultural commodity trade**. Several experts highlighted a need for significant revision of trade rules for agricultural commodities to encourage sustainable production, equitability, and investment for long-term national food security. But the group is split between those who see the role of trade mainly as a buffer to address risks and uncertainties in national food production, and those who think long-term sustainability will benefit from yet greater specialization among countries, reflecting unequal natural resource endowments (e.g., trading ecosystem services from rainforests for food produced elsewhere, or dry countries importing high water-demanding food crops).

In some cases, the different viewpoints on appropriate biophysical and institutional approaches boil down to a question of prioritization in the context of limited financial and human resources. In other cases, where different proposed solutions seem to emerge from different understandings of the facts, a stronger evidence base might result in stronger alignment of recommendations. In other cases, disagreements are more profoundly based in values and ideology, or entrenched political and economic interests.

Recommendations

In order to realize the future vision described above, the expert group recommended five priority actions that could be implemented concretely over the next 20 years:

i. **Build the rural innovation base, supported by strong social capital**. Governments, donors, and the private sector should expand investment in the 'rural innovation base' of education, extension, technology, and information systems to support the next generation of sustainable agricultural businesses and rural economic development. Doing so will entail much stronger training for farmers and rural entrepreneurs (including formal schooling, extension, and adult education); better access to information on soil and water management practices, and market conditions; local participatory research programs and learning alliances; strong engagement of women; and participation of the public, private and NGO sectors. It will also include efforts to increase social capital among farmer groups, networks, and communities, which are documented to be effective and essential in supporting resilient agriculture-based livelihoods and a diverse, economically robust rural sector.

Research and extension: Version 2.0

"We must create inclusive innovation forums or 'learning alliances' that move away from the pipeline model of innovation to a systemic one that engages farmers and civil society organizations alongside researchers and policymakers to increase the sustainability and adaptive capacity of food and agricultural systems."

-Shambu Prasad

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ii. **Develop policies that link food, nutrition, and human health.** Rather than a food system that ignores or exacerbates health problems and a costly health system that treats problems caused by poor diet, governments should work with the private sector to develop an integrated approach in which food—and the agricultural systems that supply it—is the foundation of good nutrition and health. This integrated approach would address policies and subsidies that favor certain crops and processed over fresh foods; encourage and provide support for nutritious varieties, crops, and crop mixes; and conduct integrated planning and programming for health campaigns and investments, particularly to address diet-linked maladies. These issues concern developing and developed countries alike.

iii. **Greatly expand publicly funded agriculture and land management research.** Without neglecting basic research on trait improvement of staple crops, public-interest agricultural research should greatly expand its emphasis on agroecology and sustainable agriculture, including strong components in soil science, agronomy, crop/livestock varieties, resilience, climate-smart agriculture, food-based nutrition, water use efficiency, agriculture and ecosystem services, biodiversity conservation and use, and understanding of tradeoffs and synergies. These themes dictate a general shift away from reductionist, productivist foci toward integrated, inter-disciplinary approaches that are also participatory, demand driven, and linked closely to extension. They also require complementing research on new products (e.g., germplasm and other inputs) with much more research on agricultural practices and systems.

Public actors for public goods

"States and donors have an important role to play in the transition to socially inclusive and ecologically based farming systems that are knowledge intensive rather than external input intensive and may therefore be less attractive to private companies."

-Markus Arbenz

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iv. **Establish new financial support and investment for sustainable agriculture.** Current perverse agricultural subsidies and expenditures should be re-directed to support extension, infrastructure, farm and business credit, governance innovations, and land and resource rights, to support multifunctional, productive, and sustainable agroecological systems. Existing national and international rural anti-poverty investments, and emerging climate funds, must address and strengthen small-scale producer livelihoods holistically—not piecemeal—by supporting more directly the sustainable management of natural resources for rural livelihoods. Similarly, much greater coordination and alignment of aid programs is needed to reduce waste, share lessons learned, and avoid sending conflicting messages and mandates to recipient communities and governments. Finally, efforts are needed to channel new private investment to support socially-beneficial and environmentally-friendly agriculture and rural land use.

v. **Launch national campaigns for sustainable food supply chains**. Governments should develop integrated national programs to support sustainable agricultural supply chains. Three key elements of such programs are: a) combinations of regulations, incentives, and voluntary standards to spur gains in input use efficiency, reduced environmental impacts, and climate neutrality; b) initiate major national efforts to reduce pre- and post-harvest farm losses as well as transport, processing, and storage losses, including the development of mechanisms and incentives that allow private actors to participate in and profit from improved food quality and avoided losses; and c) providing farmers with accurate price signals by monetizing the key societal values (other than food) generated by agricultural landscapes.

Some first steps to kick-start a global sustainable agriculture agenda

The UN Conference on Sustainable Development (Rio+20) presents an opportunity to engage governments and establish an international infrastructure to carry forward the agenda presented in this paper. Key tangible steps would include agreements among member states to:

1) **Recognize integrated, agroecological farming and landscape management as the most promising approach to address the linked challenges of climate change, food and water security, biodiversity loss, poverty eradication and sustainable development, and identify the scaling-up of such systems through policy and farmer support as an urgent global priority for sustainable development**.
2) **Facilitate local, landscape, national, and regional dialogues across sectors dependent on land and water resources to negotiate areas of conflict and forge a shared vision and policy directions to address competing uses of land and water**. Increase public awareness of climate change as a threat to food and agriculture, of the multiple benefits of low carbon development, and of the importance of shifting consumption patterns to signal a preference for low-carbon and ecosystem-friendly options.
3) **Support a widespread transition to agroecological practices**. Funds for such an initiative may be generated by re-directing resources from perverse agricultural, input, and biofuel subsidies; developing programs of payments for ecosystem services to farmers, including pro-poor carbon markets; and establishing a small levy on futures trades in agricultural commodities.
4) **Scale up support for research on agroecological production systems and sustainable landscape management**. Examples include: ecosystem-friendly practices (agroecology, agroforestry, perennial agriculture, green water management); sustainable landscape management for REDD implementation; re-orienting biotechnology research to focus on ecosystem benefits; and optimal landscape mosaic design and management. Include an international training program for graduate research.
5) **Mobilize multi-stakeholder learning and action alliances at different levels**. Examples include negotiation platforms that have been set up for biological corridors, model forests, watershed co-management, and bio-regional management around the world.
6) **Establish an International Knowledge Center for Sustainable Landscapes as a global resource to generate and share information, science, technology, case studies, and policy solutions to align agricultural development, ecosystem and climate management, and local livelihoods.** This Center should have regional nodes and networks, and can link with on-going knowledge-sharing initiatives such as the Evergreen Agriculture Alliance in Africa; the Landcare network in Australia and worldwide; the International Partnership for Satoyama Initiative; the Landscapes for People, Food and Nature Initiative; and the International Model Forest Network.
7) **Establish regional Agricultural Landscape Investment Funds for Africa, Asia and Latin America to scale up investment in integrated farming systems and landscape management generating multiple benefit streams.** These funds could be implemented through new mechanisms, or incorporated into existing public and private agricultural, environment and climate adaptation and mitigation investment programs(e.g., Green Climate Fund, Feed the Future).
8) **Guarantee the rights of farmers and other rural producers**. Nations should address rights to free, prior and informed consent and to participation in decision making related to agriculture (including production, distribution, pricing, marketing, standard setting, policy making, and regulation), and empower farmers to exercise these rights. Scale up investment in land titling and security tenure, and support the process mapped out by governments at the Commission for Food Security to eradicate unjust land investments. Strengthen women's land rights and access to agricultural extension and credit; and commit policies to meet benchmarks for pro-poor, pro-women, and rights-based governance of land, water and other natural resources.
9) **Launch a global initiative to reduce food waste**. This can include efforts to scale up successful models of sustainable supply chains, local sourcing, and certification.
   Establish a policy and incentive framework to address the externalities of agriculture. This

framework would monetize societal costs such as fossil fuel use, carbon emissions, agricultural runoff and eutrophication, ecosystem destruction and degradation, and groundwater depletion; and societal benefits such as maintenance of crop genetic diversity, wildlife habitat, carbon sequestration, water and air purification, and nutritional value of foods. Price signals that reflect the relative costs and benefits to society of different forms of agriculture are perhaps the most comprehensive and efficient way to achieve systemic shifts toward sustainable agriculture and food systems.

3.4 Business Specialists Group[183]

Overview of perspectives

Respondents from this group generally emphasized the importance of addressing food security and nutritional security issues through increased productivity of safe, healthy, and affordable food, either as a primary priority or as a consideration in addressing other priorities. A majority emphasized the importance of rural livelihoods and the role of smallholders, particularly in Africa, as well as the important role of technology — defined broadly from basic infrastructure to genetics. Respondents also commented on key issues regarding water, soil, climate change, biodiversity and other natural resources, the role of biofuel and bio-based products, and the importance of transparent and information-based supply chains. Some noted that the priority of these issues can vary depending on the scale (e.g., global, regional, or national).

Population trends and nutrition security

On a global basis, the agricultural and food system faces the significant challenge of a projected world population of 9 billion by mid-century. Even with global growth in the absolute number of undernourished, the total numbers of undernourished people is significantly lower in parts of Asia today, despite continued high population growth. The frequency of famine in Africa has significantly diminished, thanks in part to an upgrade in famine early warning and food aid delivery systems. But with a predicted population growth of 2 billion more than present, and three times more per capita income, consuming twice as much as today,[184] food sufficiency will be a major concern, especially in the developing world. Crop production will have to double to meet this demand. Building a resilient and sustainable agricultural and food system is our only solution. This sustainable food system will have to account for natural resource inputs, adapting agricultural practices, bringing a sustainability framework into the global and local markets, and improving supply chains to be more resilient.

Sustainability and Rural Livelihoods

Rural smallholder farmers, particularly in developing and least developed countries, still account for the majority of those living in extreme poverty. Some rural smallholder farmers leave the farm and move to urban settings in search of better livelihoods. Yet, this decrease in rural smallholder farmers when combined with the overall increase in urban populations and food demand is not translating to a supply opportunity for small, rural growers. Market access, whether local, regional or global, for smallholder farmers continues to present challenges and limit opportunities. Ensuring equal opportunity for small holder farmers is important for rural vitality; one respondent noted, however, that ensuring equal opportunity does not mean ensuring equal outcomes, and that competition is important to drive good decisions and innovation at the small farmer level, the same as at the multinational business level.

As we look to expanding the promise of technologies we need to adapt them to smallholder farming for use in developing countries. In addition, we will need to expand capacity development for the utilization of these technologies across all farming regimes. Research in these areas needs to be stepped up and this requires more training of scientists, especially African scientists. New solutions have to be sought that are environmentally sustainable while increasing productivity, against a backdrop of a world where the climate is changing. Greater understanding

[183] Prepared under the auspices of the Keystone Center by Sarah Stokes Alexander , Julie Shapiro , and Keith A. Wheeler. The majority of contributors to this section are from the business sector, there were also several contributors from academia and the non-governmental sector

[184] Clay, Jason (2011) Nature. Volume: 475. Pages: 287–289.

of linkages between healthy ecosystems, ecosystem services, food production and human-wellbeing is fundamental to developing this definition of sustainable productivity.

In Africa, small land parcels are often not economically viable, and there is a need for land policies that can strive to consolidate parcels or to get smallholder farmers into cooperatives to ensure economics of scale in training and marketing, or agro-processing. Women play an important role in small shareholder agricultural production, particularly in Africa, and programs and policies targeted at women are also important. A number of African countries including Mozambique, Mali and Kenya have amended legislation to allow women to inherit land. Now that this has happened, women will be able to farm their land with surety, and to invest in their soils. Funding organizations now have to reciprocate to ensure women receive the agricultural resources including support, training, and information.

Sustainability and technology practices

The increase in sustainable agriculture performance in the OECD countries over the past 20 years was made possible by a combination of agricultural policy reforms (significant de-coupling of farm subsidies from production incentives, both in the United States and the European Union) plus the steady emergence of new "precision farming" technologies that allow farmers to cut down on wasteful input use, using GPS auto-steered tractors, GIS mapping of fields, computer-operated variable rate application machinery, drip irrigation, seeding technologies that allow zero tillage, and genetically engineered crops that can allow farmers to protect against weeds and insects with fewer pesticide sprays.

Emerging technologies can be broken into four distinct classes that are driving a transformation in the systems that shape individual farming operations into global integrated enterprises.

- **i.** First is the rapid adoption of genetically modified organisms (GMOs), referred to as biotechnology. Biotechnology in major crops has been the most rapidly adopted technology in the history of agriculture[185]. However, GMOs remain controversial and domestic policies, trade barriers, technology costs, and intellectual property concerns all limit access to this technology for many of the world's farmers and cropland areas.[186]
- **ii.** The second technology class is the utilization of GPS (Global Positioning Systems) technologies. This technology as the driver of precision agriculture has allowed growers to produce more, with less crop inputs and energy usage.
- **iii.** The third wave of technologies is the utilization of satellite-based remote monitoring and infield sensing technologies. These will greatly aid in the global and regional monitoring of crop productivity and weather-related impacts.
- **iv.** The fourth has been the global diffusion of cellular and wireless communication technologies coupled with the increasing ubiquity of the Internet. These provide information on market pricing, supply and demand trends, and remote assistance to farmers.

Each of these technologies, individually, has greatly supported the way we think, see and make sustainable operation choices in agriculture and food systems. As we are beginning to integrate these technologies, and as the price of internet access, computing power, and data storage continues to decline, we are seeing the emergence of sustainable agriculture decision support tools that are being deployed to meet the needs of growers.

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[185] James, Clive. 2010. Global Status of Commercialized Biotech/GM Crops: 2010. International Service for the Acquisition of Agri-biotech Applications Brief No. 42. ISAAA: Ithaca, NY.(Executive Summary)

[186] Derived from ISAAA, 2010 and FAOSTAT. ISAAA reported total biotech area in 2010 at 148 million hectares. FAOSTAT reported total global cropland area of 1.53 billion hectares in 2008.

Sustainability and natural resource inputs (water, soil)

Over the past two decades, there has been a realization that both small-scale and large-scale agriculture has been causing unsustainable environmental degradation. The concept of sustainable agriculture has taken hold across all sectors both public and private. Issues such as integrated and multifunctional food systems, eco-efficiency, ecosystem services, supply chain management, climate change, deforestation, biodiversity loss, sustainable water use, human activity footprints, nitrogen and phosphorus non-point source pollution, and human health and safety are part of the agricultural and food dialogue. Part of "defining" what sustainability means in 21st century agriculture and food systems will be centered on increasing global agricultural productivity to meet the needs of 9 billion people while acknowledging and working within the limits of natural systems.

Despite talk about slowdowns in the growth rates of farm productivity around the world, the past 20 years have actually seen an acceleration of total factor productivity growth (TFP) in farming.[187] Agriculture within the OECD world during the same time period has made some notable progress toward environmental sustainability. According to a 2008 report on the environmental performance of agriculture in the OECD countries, during the period 1990-2004 the total volume of food production increased in these countries by 5 percent, but the land area used in farming fell by 4 percent, water use in irrigation fell by 9 percent, excess nitrogen use fell by 17 percent, pesticide use fell by 5 percent, and greenhouse gas emissions from agriculture fell by 3 percent. In addition, energy use in agriculture increased at only one sixth the rate of increase in the rest of the economy.[188] Total factor productivity growth (TFP) in farming in Africa during the past 20 years has remained very low, and is increasing only slowly, especially in the sub-Saharan regions.

Water is increasingly recognized as a limited resource in many parts of the world. Forty percent of the world's food supply is produced on the 18 percent of cropland that is irrigated.[189] Globally, agriculture is the major user of water, often without an efficient means of application. It is estimated that it takes one liter of water to produce one calorie of food. Globally, most irrigated areas are already stressed or in a state of physical decline. Drought and dry spells in exclusively rain-fed areas account for the majority of food security emergencies. This issue has been increasingly recognized as a significant threat under many of the current climate change scenarios. The adoption of conservation tillage, modern genetics and new mechanical irrigation has increased the amount of 'crop per drop'. Water quality is also greatly deteriorating in many parts of the world, especially for the majority of poor people in developing countries who do not have easy access to potable water. Agriculture is increasingly competing for water resources with municipal and industrial needs.[190] We have already seen human conflicts and migration due to water shortages in parts of Africa.

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[187] Total factor productivity (TFP) is a time series data related to broad agricultural outputs which included farming, livestock, forestry, and fisheries and 3 conventional inputs: labour, land, and capital, to construct an index of total factor productivity (TFP) A TFP index is simply the ratio of an output index to an input index. Therefore, growth in TFP is the residual share of output growth after accounting for changes in land, labor, and other conventional agricultural inputs. Changes in TFP can be interpreted as a measure of the collective contribution of non-conventional inputs in agriculture, such as improvements in input quality, market access, economies of scale, and technology. See Alston, Julian, George Norton, Philip Pardey.1995. Science under scarcity: Principles and practice for agricultural research evaluation and priority setting. Cornell University Press: Ithaca, NY .

[188] OECD (2008), *Environmental Performance of Agriculture in OECD countries since 1990*, Paris, France

[189] Comprehensive Assessment of Water Management in Agriculture. 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Columbo: International Water Management Institute.

[190] Ibid.

Soils rich in organic matter with good tilth or structure are the foundation for any successful cropland. High quality soils, among many benefits: 1) require less additional fertilizer and thus reduce the potential for nitrous oxide emissions; (2) retain and filter water more efficiently, thus reducing the need for irrigation, reducing runoff and reducing off-field movement of pesticides and excess nutrients; and (3) improve farm productivity and profitability. Soil conservation and efficient soil input management have seen a rebirth in focus on the past twenty years. This has been due to enhanced research on a variety of tillage systems that reduce soil erosion that tie into modern farming practices and technologies. These practices have been enabled by the increased and targeted use of soil amendments, including fertilizers and chemicals. Productivity in many parts of the globe has increased due to these technologies, but sometimes at a cost — both economic and environmental. The productivity gain due to these technologies is often out of reach for many smallholder farmers in developing countries due to cost and lack of capacity development. Many developing countries have witnessed increasing and unacceptable soil loss due to a lack of technology, training and policy incentives. Increased attention is being paid to helping farmers in developing nations, especially Africa overcome some of these barriers related to soil inputs.

A focus on soil carbon has come to the attention of many interested in GHG mitigation. It has been reported that Africa has been losing 1% of soil organic matter every year for the past 50 years.[191] The organic matter in soil is a significant storehouse of CO2, and increases greatly under conservation tillage and other carbon sensitive management practices.

Sustainability and landscape change (biodiversity, conservation, ecosystem services and climatic adaptation)

Conservative estimates suggest 6 million hectares per year are converted from natural settings to cropland production, pressuring habitats harboring biodiversity.[192] These losses can be attributed to increasing human consumption and the persistence of poverty.[193] In order to increase productivity, we will need to increase production per hectare and also the number of hectares under farming. It is estimated that we will need 100 million additional hectares in active production. This will be a daunting challenge. An estimated 70% of the land that is suitable for growing food is already in use or under some form of protection. For 50 years, farmland has grown at 0.4% a year, at the cost of natural habitat. In the past decade, as developing economies have grown, this has increased to 0.6% and, with it, more biodiversity has been lost.[194] There is a significant opportunity to focus on agricultural land rehabilitation for areas that have been eroded and depleted, rather than opening new lands. This will help in conserving our remaining biodiversity in our forest and wetland ecosystems, and increase the amount of carbon stored in the soil. In addition, strategies to stem conversion through intensification of productivity (land sparing) must be considered along with strategies focusing on ecosystem services and multi-functionality of working croplands.

Climate change is beginning to be felt in many parts of the agricultural world and will threaten resources described above, including water, soils, and biodiversity. Africa, in particular, will experience higher temperatures and less predictable rainfall. Globally, there is likely going to be disruptions in our water regimes, impacts on plant productivity — both positive and negative -- and most importantly enhanced agricultural pest movement and disease outbreak. Food

[191] Clay, Jason (2011) Nature. Volume: 475. Pages: 287–289.
[192] Deinlinger, K. and Byerlee, D. 2011. Rising Global Interest in Farmland: Can it Yield Sustainable and Equitable Benefits. The International Bank for Reconstruction and Development/The World Bank.
[193] Kanagasabai, S. 2010. Textbook on Environmental Studies.PHI Learning Private Limited. New Dehli. pp 61.
[194] Ibid

production shocks in some areas (Russia, Australia, Pakistan and most recently the Horn of Africa) may be related to climate change. The increasing challenge of adaptation linked to climate change will require urgent investment in Africa. This investment will be needed for better rural roads, improved seeds, more fertilizer, and more irrigation, as a precursor to the other technologies described above. Across the entire globe we will have to become exponentially more efficient related to our agricultural inputs in order to maximize our outputs.

Sustainability and Markets (post-harvest processes, quality and safety, bio-based products, and supply chain standards)

The long standing track record of steady progress on food security was halted five years ago, primarily due to escalating oil prices and the "financialization of commodities".[195] Increased demand for food and energy due to increasing population and global purchasing power have reduced carryover stocks to historically low levels as demand has outstripped supply several times over the past decade.[196] Further, significant quantities of harvested food are lost during the postharvest stage. A shortage of grain in the world market has contributed to rising food prices globally and to a shortage of grain commodities available for food aid for emergency programs.

Food quality and safety concerns also characterize food security discussions. Demand for nutritional quality must be considered in addition to demands for increased productivity. Foods can also become carriers of disease and pathogens due to poor post-harvest handling, causing morbidity and mortality. Agri-food supply chains are global and more vulnerable to a range of food safety threats. International and cross-border trade can only be successful when food safety can be guaranteed, and lack of consumer confidence in government regulatory functions has increased the cost of effective food safety regulation. In addition, broader demand for nutritional definitions of "quality" and the nutritional value of products must also be recognized and acted upon.

Biofuel production has increasingly influenced food security discussions. Increasing oil prices and government incentives aimed at reducing greenhouse gas emissions and achieving energy security have combined to significantly increase energy production from biomass. Bio-based fuels can provide opportunities for energy development, including in developing countries. However, biofuels can be problematic when diversion of grain to biofuel production in the US and in developing food deficit countries can influence global and local grain shortages and drive up costs of basic foodstuffs.

Openness, transparency, and integration of agricultural and food supply chains is beginning to be realized through the initiation of life cycle assessments, formulation of standards definitions, and increased disclosure and traceability. With information integration between the public and private sectors in terms of supply and demand, sights can be turned to enhanced sustainability practices that influence the long term sustainability of agricultural and food systems.

Future Choices: Recommendations and Next Steps

Based on the prioritization of issues described above and specific next steps suggested by contributors, the following recommendations and next steps are provided for addressing food and agricultural challenges. Recommendations do not necessarily represent the total consensus or the

[195] Baffes, J. and Haniotis, T. 2010. Placing the 2006/08 Commodity Price Boom in Perspective. World Bank Group. Policy Research Working Paper 5371. http://econ.worldbank.org.

[196] United States Department of Agriculture. Foreign Agriculture Service. Production, Supply and Distribution Database http://www.fas.usda.gov/psdonline/

specific individual opinions of contributors, and draw from diverse communication and feedback received.

i. Vision, Leadership, and Collaboration

- There needs to be a new vision of the global agricultural and food system with goals of food security, food safety, transparency, and sustainability.
- There needs to be multi-sectoral leadership (government, private sector and civil society) in every nation holding to the commitment to honor pledges to increase public spending on agriculture and food, especially in Africa.
- The need for more communications and education amongst all stakeholders will become critical as the pressures on the agricultural and food systems amplify due to population increases and climate change impacts.

ii. Research and Extension

- Science and data must underlie collaborative decision-making.
- The need to train more scientists and extension agents is at a critical juncture. This is especially true in Africa. The numbers of plant breeders and other agricultural research specialists are falling at an alarming rate, extension is being cut globally as the new economic realities take hold, and the need to train farmers on the new technologies — both biological and information - is key to gaining the productivity needed to ensure food sufficiency. Private sector models of extension should be evaluated looking at overall effectiveness, farmer profitability and productivity impact, especially in Africa.

iii. Rural Livelihoods and Small Shareholders

- Invest in land policies, research, training and extension, technology (broadly defined, at appropriate scales), and infrastructure to increase productivity, sustainability, and market access for small landholders, including women, and particularly in Africa.

iv. Technology

- Increase investment in and reward innovation for all forms of technology, ranging from basic infrastructure, biotechnology, equipment technology, information technology, energy technology, communication technology, post-harvest processing technology, ecosystem sensing and monitoring technology, regional seasonal climate forecasting technology, irrigation and water management technology, and food safety technology.
- These technologies need to be built with open standards on platforms that insure interoperability, rapid adaptation, and integration and can work at varying scales and economic reality of farming practices.

v. Natural Resources and Landscape Change

- Reverse trends in water and soil degradation through extension and training and optimal use of technologies.
- Value ecosystem services and internalize environmental impacts, e.g., through carbon trading programs.
- Rehabilitate degraded lands and optimize production on working lands to prevent habitat loss through conversion of new lands, while also exploring opportunities for multifunctional working lands that produce multiple environmental and productivity benefits.
- Climate change increases the magnitude and urgency of investment in adaptation and mitigation strategies to address natural resource limits and impacts.

vi. National Security, Policy and Incentives

- Policies for food security and aid must promote economic and environmental viability.
- Trade barriers, regulations, and standards must be considered and coordinated to preserve quality and safety while also increasing opportunity for market access, productivity innovation, and trade efficiency.
- Technology growth and innovation to meet sustainability challenges must be incentivized.
- Incentivize ecosystem service markets that maximize environmental and socioeconomic benefits of agricultural production.
- In Africa, increase public spending on agricultural development to accelerate farm productivity growth. Support access to education and decision tools, technology mobilization, infrastructure, and land ownership policies that allow for economically viable production as well as women's land ownership rights.
- Incentives for bio-based products must be considered for their potential impacts on energy and food security (both positive and negative).

vii. Monitoring

Global integrated monitoring systems are a key element needed in our agricultural and food systems (local to global) to insure that we are achieving the change necessary to feed 9 billion sustainably. These systems need to be developed jointly by countries around the globe with the support and coordination from multi-national interdisciplinary bodies, including FAO, CGIAR, UNEP, WMO, and others. The private sector needs to be an active participant, utilizing their monitoring capabilities and to provide the data inputs necessary to link the entire food chain. These systems need to build on existing efforts in a collaborative way and in an open and transparent manner.

4. Our choices: Agriculture and food in a changing world

There is widespread consensus that, going forward, farmers must produce more food per unit of land, water, and agrochemicals. They will also have to do this while ensuring the provision of various critical ecosystem services. These expectations pose quite a challenge and the outcome depends considerably on the response from millions of mostly small and medium farmers. Yet, civilization's great advances often occur in the face of challenges and when a new paradigm is explored. Marconi's radio made telegraphs obsolete and motor vehicles made the idea of faster animal-drawn carriages unnecessary. Similarly, the supply-oriented paradigm of "more" is in itself clearly inadequate to meet the challenges that we face. In fact our supply orientation is so outdated and unresponsive to our current needs that it is causing its own problems, particularly for our environment and natural resources. We have a pressing need for new paradigms from which to create the policies and structures that reduce the formidable environmental impacts and consider the social consequences of our evolving agri-food systems. Rather than simply "more" production, we must also consider what would be "better" production and better food systems.

It is not easy in our current economic system to combine the goals of more food, better environment, and reduced poverty, particularly where the private sector has few incentives to provide public benefits. Visionary companies are important but they are not enough. Without strong policy support, even strong managers are less likely to risk short term gains or market share for long-range benefits.

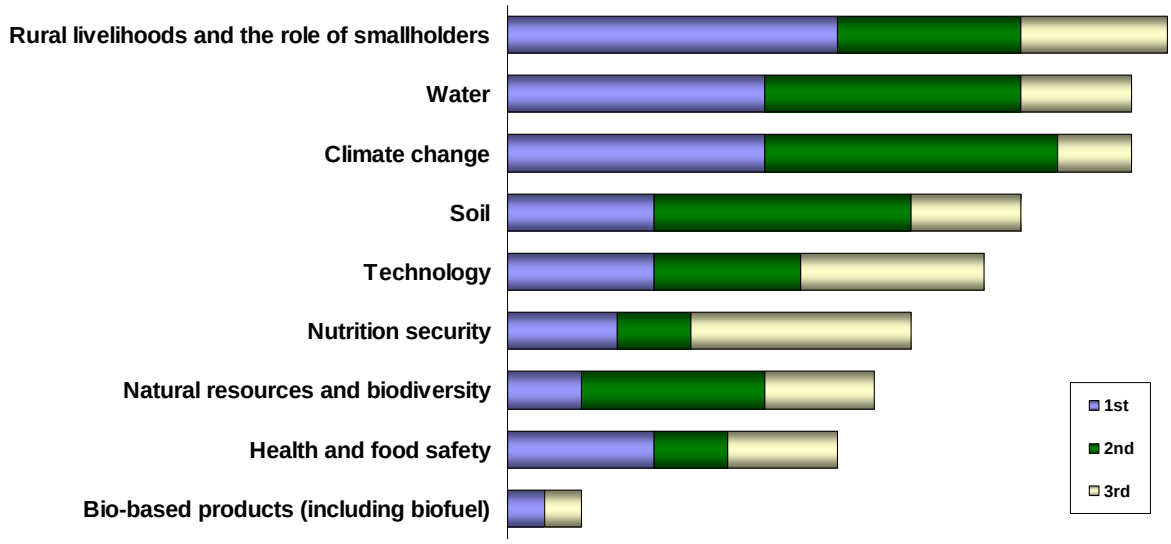
There are many who advocate a profound re-thinking of our current models and, to better serve our coming needs, would re-imagine and transform the world's major agriculture and food systems, not just modify them incrementally. Recent decades have seen such re-imagining result in radical and world-changing innovations in every field from politics (social network media) to healthcare (nanotech-based diagnostics and drugs) and communication (mobile telephony). How do leading thinkers imagine our future food and agriculture world?

4.1 The next 20 years: Ranking priorities

Most of the more than 60 contributors ranked the themes below in order of their importance over the coming 2 decades. They offered rather diverse areas of primary focus, yet there are a number of common priorities. "Rural livelihoods and the role of smallholders" led the voting with Water, Climate Change, Soils, and Technology were next in line as important issues to address (Figure 4.1 illustrates).

Such priorities can be useful to understand the shifting views of what we will most need to address. However, they can appear as distinct concerns when, in fact, they are intrinsically interrelated. Brazilian agriculture policy, a drought in Asia, and the corporate purchasing choices of large buyers are among the many disparate factors that affect global, not just local, food systems and demonstrate every day that our systems are inextricably connected.

Figure 4.1. Ranking for 1st, 2nd, and 3rd most important themes to address



Note: Responses weighted equally and adjusted to each of the four thematic groups accounting for 25% of the total to eliminate overrepresentation of groups with more contributors. The Policy group had 3 write-in votes (one in each ranking) for "non-distorted trade system" and the Agricultural Production and Environmental Sustainability group had 8 write-in votes (all ranking third) for "consumption and demand patterns" and "markets-supply chains".

4.2 What a new era for agriculture looks like: Consensus areas

In light of the *State of Agriculture* and the *Main Trends and Challenges* identified in section two and the main visions of different world views elaborated in section three,[197] this section looks at where there is agreement and where there is not. Being explicit about both the differences and the areas of consensus enables us to focus on realistic efforts right now.

Important areas of consensus emerged among all four groups as being necessary for a sustainable food and agriculture system.[198] Nine key areas have been further developed and formulated here as the key paths of action:

1. Organized small and medium farmers, fully including women farmers, should be a primary focus of investment – recognizing that private enterprise will play a significant role in many solutions
2. Define the goal in terms of human nutrition rather than simply "more production"
3. Pursue high yields within a healthy ecology – they are not mutually exclusive and policy and research must reflect that

[197] Policy and Trade Group; Business Specialists Group; Rural Livelihoods and Poverty Expert Group; and Agricultural Production and Environmental Sustainability Group.
[198] Of course, not all of the contributors agreed with all of the conclusions and some disagreements were substantial, so, this section addresses both consensus and the major disagreements that will require additional work to bridge differences.

4. Impel innovation and the availability of diverse technologies suitable in different socioeconomic and ecological contexts
5. Significantly reduce waste along the entire food chain
6. Avoid diverting food crops and productive land for biofuels, but explore decentralized biofuel systems to promote energy and livelihood security that also diversify and restore rural landscapes
7. Insist on intelligent and transparent measurement of results - we cannot manage what we cannot measure
8. Develop and adapt public and private institutions that can effectively respond to these new goals
9. Motivate and reward investments and business systems that result in measurable impacts to the "public good"

Who

1. Organized small and medium farmers, fully including women farmers, should be a primary focus of investment.

Both food security and environmental benefits, especially in developing countries, will continue to depend upon increased and more secure production among small and medium farmers. And they have proven that they can do it. In parts of peri-urban China the yields of food crops on small parcels of land (less than one hectare) provide not only diversified subsistence for the household but also substantial supplies of marketable produce as well — all without excessive agrochemical use.[199] Even where markets are lacking in urban areas, such as Havana and Dar es Salaam, for example, a substantial percentage of the cities' total fresh food comes from very small intensively farmed urban plots within both cities.[200] So, farm scale itself is less the problem than the ability to cooperate and get access to necessary resources such as knowledge, financing, markets, and inputs.

▪ **Farmer organizations and extension services are indispensable**. These require consistent public policy and friendly institutional support in order to thrive. Extension must also be co-managed and evaluated by producers and adequately incentivized so as to tailor public-private models of extension for both their effectiveness and their overall sustainability impact.

▪ **Women play a very important role in agricultural production and especially in household food security; agricultural programs and policies that address women as part of a dynamic solution can empower rather than marginalize them.** There is clear consensus among the contributors to this paper and between leading development and agriculture organizations, including IFAD, FAO, WFP, the World Bank, and the United Nations Committee on World Food Security that gender equality is a core premise and a central pillar of development.[201] Land tenure

[199] IFAD Organic Agriculture and Poverty Reduction in Asia …cite
[200] John Whitfield. 2009. Seeds of an Edible City Architecture. *Nature,* Vol 459, pp. 914-915. Adriana Premat. State Power, Private Plots and the Greening of Havana's Urban Agriculture Movement. *City & Society*, Vol 21, Issue 1, pages 28–57, June 2009
[201] Recent reports include: the 2011 FAO's "State of Food and Agriculture" that addresses "women in agriculture: closing the gender gap for development" and World Bank. 2011. World Development Report 2012 on Gender Equality and Development. The World Bank: Washington DC

is particularly important so that they can farm with surety and invest in their farms and soils. They will also need more training, information, and credit.[202]

▪ **Private enterprise will play a major role in any solutions.** Companies have enormous impacts that can be positive or negative. Few policy tools are as effective as market and price signals to value and foster the key public goods and societal values that can be generated by agricultural landscapes. Companies have enormous impacts, so it will be vital to learn how to appropriately manage and incentivize firms to ensure that their activities result in public benefits even if these may sometimes be intrinsically less profitable.

What

2. Define the goal in terms of human nutrition rather than simply "more production"

▪ **Agriculture policy and investment will be smarter to focus on improved human health and access to nutrition, and not only on increasing food supply.** We are simultaneously faced with record numbers of malnourished people and an explosion of obesity and diet–related diseases. Since food crises and malnourishment occur even in countries that have adequate production and are net exporters, access to nutrition is a vital issue. Yet, the consistent failure of structural mechanisms to shift food from abundant sources to areas of need reflects both persistent market imperfections and policy failures.

▪ It makes sense not to completely rely on them for all the solutions to this complex problem. If food security is also perceived as a national security issue, then it is smart to have balanced policies that — while continuing to refine and improve the trade regimes and market delivery systems — also stimulate more localized resiliency and self-provision of at least some foods rather than having marginal groups rely solely on purchasing and markets.[203] If done with care for environmental and social concerns, localized systems can also offer an opportunity to improve local well-being by fostering greater crop and nutrition diversity.

It is foolish to depend completely on local foods or completely on trade, both are valuable for food security

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▪ **Subsidies for foods that do not contribute to public health must be eliminated. Public funding should support not only research for low-cost, high-nutrition options but also the systems of access to sound nutrition (e.g. via schools and local markets).** The current food system's valuable technical breakthroughs in increased shelf-life and variety are increasingly overshadowed by the issue of nutrition quality since some foods are associated with a variety of ailments including heart disease, some cancers, diabetes, and obesity.

Despite mounting evidence of the essential role played by women in agriculture and food security, they continue to be neglected in investment and programs by their own governments and by many donors as well.

[202] Some aspects such as the need to make land rights, finance, training, and technology available to women farmers has been somewhat studied but less is known about the best ways to do that or to help women create access and opportunity.

[203] Headey, Derek and Shenggen Fan. 2010. Reflections on the global food crisis: how did it happen? how has it hurt? and how can we prevent the next one? Research Monograph 165. International Food Policy Research Institute: Washington, D.C.

3. Pursue high yields within a healthy ecology – they are not mutually exclusive and policy and research must reflect that.

- **Agriculture will become a central feature in the management of healthy ecosystems and multifunctionality will become a key consideration** as we evolve beyond just 'yield per hectare' to broader working definitions of 'productivity' in agricultural landscapes that encompass valued ecosystem services such as water infiltration, carbon sequestration, and conservation of biodiversity.

- **Invest in water-conscious agricultural systems.** Water's role in agriculture is pivotal, particularly to generate the necessary increases in productivity. There is complete agreement that many fresh water sources are in decline and agriculture is increasingly competing for water resources while water quality is also deteriorating in many parts of the world. The adoption of conservation tillage, modern genetics (not necessarily GMOs) and mechanical or drip irrigation can further increase the amount of 'crop per drop'. Policies that support the concept of multifunctional agriculture can contribute to water quality at the landscape level and remedy contamination with improved management of erosion and of nutrient or biocide applications. Fair allocation and sometimes pricing of scarce water resources can encourage increased efficiency by all users.

- **To conserve our remaining biodiversity, the best option is to focus on rehabilitating agricultural and pastoral areas that have been eroded and degraded**, **rather than converting new lands** since most suitable new land is a repository for important biodiversity or otherwise fragile. Soil health determines the productivity and resilience of agriculture and, along with valuable soil organic matter, soil health is in decline in many agricultural areas.[204]

- **Climate-smart production systems will be vital for necessary adaptation**. Agriculture both contributes to climate change (GHG emissions mostly via livestock, deforestation, and fertilizers) and is also in turn affected by the shifts in climate. Impacted areas will need to rely on food from healthy regional and international markets. At the same time, food production must adapt and become more resilient. Even where agricultural conditions could benefit from climate change (i.e., more rain in semi-arid areas or higher temperatures in cold regions) the near-term benefits are still likely to be very limited as farmers adapt to new conditions, soils, and cultivation methods. This will require considerable investment in more adaptable crop varietals and expanding farmer training in appropriate methods. Considerable opportunities exist for improving indigenous crops, many of which are already adapted to harsh environments and resistant to disease.

- **We need to aggressively invest in a combination of market mechanisms and policies that advance agriculture while scaling-up the approaches that improve its delivery of ecosystem services**. This is critical since biodiversity, genetic resources and traditional knowledge continue to be examined and assessed predominantly as an economic value and subject to national sovereignty, this reduces the scope for more appropriate valuation and for the broad cross-border cooperation necessary to safeguard such resources and use them in non-depleting ways.

[204] About half of agriculture's positive contribution to climate change – as a carbon sink – is from soil organic matter; yet, each year, this is eroding and degrading in many regions at an alarming rate.

Agriculture is slowly moving
from being managed as an extractive industry
to one that is more renewable.

How

4. Impel innovation and the availability of diverse technologies suitable in different socioeconomic and ecological contexts

It will be most productive to integrate both traditional and scientific knowledge to address the future food and agriculture challenges.

- **Technology matters most if it is affordable and if it is appropriate to scale and conditions.** Developing countries are littered with decades of failed projects that do not take that into account. Technologies need to become increasingly democratized and more widely available in low-cost forms to small and medium producers. From the re-discovery and re-application of integrated indigenous systems to new scientific breakthroughs we already have many useful tools and technological resources that need to be made more available to small and medium farmers. These include:
  - improved breeding for new traits
  - climate-resilient agricultural systems, such as precision farming and remote field sensing that more efficiently utilize irrigation and inputs, sequester carbon and reduce GHG emissions.
  - improvement of minor or neglected crops
  - perennializing grains
  - mobile phone-based systems and other information technologies for price information, plant analysis, and digital transactions

Technology can facilitate the sort of swift adaptability that will be increasingly necessary as climate change and other pressures mount. Information and communications technology is enabling innovation to both reach users in all but the most remote areas with information and methods and also emerge from them in the form of novel practices. Creating more local capacity to access and use very low-cost information systems is an area of broad consensus. Globally-integrated monitoring systems can now produce timely public information with forecasts of food sufficiency in every country around the globe.[205]

Technology is not solely based on complex machines and sophisticated science, we must include production or resource management systems whose native ingeniousness is in the simple ways of doing things that work well. There are many local-level and worthwhile innovations that are pro-poor and enable local food security but they are not attracting attention or investment. Some, like *zai* pits, developed to store water for trees or crops in dryland regions or the use of companion planting (i.e. leguminous trees and ground cover) have spread widely among farmers in many countries and with many crops. But many languish because they are not as obvious or may not be inherently lucrative as a business model or may apply only to a limited

[205] See existing systems e.g. Communication Education and Public Awareness (CEPA)

region. Yet these innovations, if systemically captured and valued, could lead to considerable cross-learning and low-cost sharing.

Simplicity may be why governments and development agencies overlook such efforts in favor of more sophisticated technologies. Simple cost-benefit analysis coupled with a practical understanding of how technology spreads can facilitate thousands of such simple innovations. Indeed, without such simple technological precursors, it is considerably riskier to introduce more sophisticated technology. **The global interest in identifying, stimulating, and transferring practical innovation needs to manifest in visible incentives and investment to encourage systemic innovation and reward breakthroughs across the entire food system and especially at the local level.**

Rather than operate with a false dichotomy between high yields and healthy ecology, we must evolve technology complementarity to play multiple roles of improving both inputs and natural resource management in the same system.[206] To do this requires moving away from the outdated pipeline model of research and innovation toward models that create inclusive learning alliances that engage farmers, private firms, and civil society organizations alongside researchers and policymakers.

Technologies will become increasingly democratized
and more widely available in low-cost forms.
They can be game-changers..

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5. Significantly reduce waste along the entire food chain

▪ **Waste will be a top focus** since it is most responsive to investment and policy. Reducing waste can, relatively effortlessly, add a considerable percentage to our food supply and have positive environmental consequences.

6. Avoid diverting food crops and productive land for biofuels, but explore decentralized biofuel systems to promote energy and livelihood security that also diversify and restore rural landscapes.

▪ **Biofuels, particularly second and third generation technologies[207], have potential to provide more energy security and even contribute to rural livelihoods but they are counter-productive when they divert arable land and food sources**. Using sound metrics to understand the outcomes will likely suggest that any support or subsidy only apply to biofuels that do not negatively impact the food economy.

7. Insist on intelligent measurement of results — we cannot manage what we cannot measure

[206] While contributors had diverse perspectives regarding the role of GMOs, as noted later in this section, they agreed on many other aspects of technology.
[207] more efficiently converted biofuels that are available from non-food sources such as grasses, lignocellulose, and algae would not compete directly with food production and also be ecologically superior.

▪ **In an era of "big data" we must use our new technical impact measurement ability to drive performance-based investment and intelligent policy**. [208] Improved science-based metrics are emerging to define common and comparable indicators of sustainability based on empirical data. Advances in several fields now enable more comprehensive understanding of what works and what does not. So, for the first time, we can assess not only simple economic or financial outcomes but the accompanying social and environmental ones as well.[209] If we can thus better manage our outcomes we can better guide smart investments and policy toward those approaches that provide effective multi-level solutions while elucidating the relative efficiency or distortionary effects of subsidies, green incentives, and environmental taxes.

Critical Conditions

8. Develop and adapt public and private institutions that can effectively respond to these new goals

▪ **Our institutions, particularly government, must have a purposeful vision to invest in community well-being and to secure and restore natural resources in and around farming landscapes—especially water, grasslands and forests—in ways that also increase agricultural productivity and enhance resilience to climate change.** The right policies will mobilize government, civil society and private finance investment in this vision of agriculture.

▪ A policy and incentive framework that addresses the main externalities of agriculture must increasingly emerge based on recent advances in our understanding and our ability to measure and realistically value both societal costs (e.g. carbon emissions, ecosystem degradation, and groundwater depletion) and societal benefits (e.g. crop genetic diversity, carbon sequestration, water purification, and nutritional value of foods). A combination of clear policy and price signals that reveal the relative costs and benefits to society of different forms of agriculture are perhaps the most comprehensive and efficient way to achieve systemic shifts toward sustainable agriculture and food systems.

▪ **Promoting innovations must be on the agenda of more effective public institutions**. For example, can the public sector effectively support private participation in better soil management and watershed protection? Can the public sector advance the capacity and fair governance processes necessary to facilitate smallholder participation in value chains? Or can we create the strong policy and incentives to reduce the considerable waste and better distribute the food we already produce?

▪ Many Governments have decreased relative investment in agriculture in recent decades. The result was expected to be increased private sector investment and even efficiencies in some areas. However, it is now clear that private enterprise will not fill all the gaps adequately. Thoughtful government investment — preferably complementing the comparative advantages of private investment — is absolutely necessary if we are to improve the handling of the issues that most

[208] McKinsey Global Institute looks at how new technology and methods permit new insights and advantages in "Big data: The next frontier for innovation, competition, and productivity" Improved data handling ability opens up many new opportunities and may be "a key factor in how nations, not just companies, compete and prosper". (Brown Brad, Michael Chui, and James Manyika. 2011 Are you ready for the era of 'big data'? McKinsey Quarterly October 2011)
[209] We are beginning to understand the impact that different agricultural approaches have on sustainability. Scientific efforts include: Keystone Field to Market, Yale University/CIESIN Environmental Sustainability Index, Ecological Footprint, and the Committee on Sustainability Assessment (COSA).

affect the poor such as: food security; wide availability of inputs; extension and knowledge services; local market and storage systems; and land tenure.

9. Motivate and reward investments and business systems that result in measurable impacts to the "public good"

▪ **New institutions and their emerging standards are collaborating with business, and producers, to accelerate our shift toward sustainability.** In an ever sharper competitive landscape and amidst unprecedented levels of transparency, smart firms are recognizing the limitations of various resources they depend on, from crops to goodwill**.** Commercial standards are evolving in dramatic ways from serving merely as vital trade lubricants toward providing a means to accelerate the evolution and transparency of markets to provide greater public benefits. Food safety is an important result of good standards and is best achieved as a combined public and private investment with clear governance and oversight functions that are adequately funded by mandate. Voluntary standards, including those involved in carbon markets, social accounting, organic, and other environmental standards are among the new market mechanisms that connect profits with the provision of public benefits. Can voluntary standards bodies serve as civil governance institutions and enable sustainability in agriculture? There is certainly increasing partnership between these standards bodies, governments and official development agencies. Corporations are also partnering with them at an unprecedented pace. Several of the world's most successful food companies including Kraft, Mars, Unilever, and Starbucks have made public commitments to buy substantial portions of their raw materials from "sustainable" sources that are third-party certified by voluntary standards bodies.

▪ Trade is an important tool that can best serve all countries, only when distorting practices are eliminated. Meanwhile, there is need for greater investment in domestic production-related constraints in most developing countries so that they can both fully benefit from trade opportunities and better address domestic needs.

▪ At the ground level, **few investments or policies would provide more incentive for improved agricultural practices than to increase access of small and medium enterprises, including farmers, to reasonable credit that is targeted to diversified and resilient ecoagriculture systems**. Although the category of impact investing targeting sustainability is still a modest portion of overall global investment, it will direct almost USD 4 billion toward specific impact objectives in 2012 and is an economically effective way to complement government and philanthropic spending to support agricultural sustainability at scale.[210]

Efficient and equitable markets are created by strong governments, not by self-governing markets.

4.3 Seven remaining areas of disagreement

Despite the considerable consensus described above, there remain some areas of significant disagreement. Some of these are due to differing worldviews or values. But many disagreements

[210] Saltuk, Yasemin, Amit Bouri, Giselle Leung 2011. Insight into the Impact Investment Market. J.P. Morgan and the Global Impact Investing Network: New York

could be amenable to moderation or even solution through better dialogue or addressed through analysis and science. To create the space for strategies that begin to address the disagreements we must first clearly identify the challenges.

Topic Lacking Consensus	Questions/Concerns arising from Discussion	Strategies for Moving Forward
Will large or small scale farming best deliver food security?	In order to provide adequate food along with necessary social and environmental benefits, do we focus principally on larger scale capital and technology-based intensification or also on more traditionally-oriented agriculture intensification?	◘ Recognize that smallholders will likely continue to play a key part globally in the coming two decades ◘ Rather than large vs. small, apply research to better understand when each is appropriate ◘ Critical to have good governance systems that account for both large and small scale agriculture to promote equitable land and natural resource control, positive environmental outcomes, market access, and nutrition security ◘ Provide institutional support and funding for smallholder associations to facilitate scale and aggregation ◘ Test existing evidence of highly productive small farm systems, can they be adapted and spread? ◘ Integrate balanced measures of both productive efficiency and multi-functionality in the research on scale agriculture
What roles should corporations have in our food systems?	How can we overcome the considerable distrust of corporations to deliver well on sustainability? Can intellectual property rights be formulated such that they stimulate innovation and are not negative for poor farmers?	◘ Joint government, private and civil leadership efforts with transparent and balanced representation ◘ Explore how we can realize the market efficiency benefits of corporate supply systems without sacrificing all farmer and consumer control ◘ Transparent and neutral bodies pledged to measure and report consistently on key indicators to ensure commitments are honored ◘ Incentivizing innovation (i.e. tax breaks) around key food crops for the poor to reduce or eliminate royalties and IP burdens for them ◘ Innovate ways of sharing public-private value of genetic resources

What role should GMOs play in improving food security?	- Is fear preventing development of useful tools for food security? - Can concerns about the potential for negative long-term health and environmental impacts be eased? - Reflecting the lessons of the recent financial crises, can private decisions adversely affect our public food system? - Can the technology be effective for poorer producers and food insecure areas? - How will intellectual property rights to genetic resources interface with traditional systems of farmers' access to seeds and seed-sharing?	◘ New forms of governance, continuing dialogue, and public-private collaboration need to be carefully engineered if these capabilities are to be harnessed to provide a balance of both public and private benefits. ◘ Distinguish genetic breeding from cross-species GMOs to avoid demonization of technology advances that are more commonly agreed upon by experts as simple and safe ◘ Continue research on potential benefits and risks but with broader participation for credibility ◘ Increase assistance to developing countries to develop and implement bio-safety regimes ◘ Identify ways to address liability concerns ◘ Increase international data-sharing on approvals to reduce trade obstacles
How much agrobiodiversity should we promote in our farming systems?	- Is it wiser to focus on increasing and protecting production of current main crops (i.e., maize, wheat, rice) for efficiency and food security or to focus more on diversified systems with higher crop and varietal diversity (i.e., substitutes for livestock feed, underutilized species, local foods) for ecological and climate change resilience?	◘ Better research to compare tradeoffs and synergies of agrobiodiversity in terms of both food production efficiencies and risks ◘ Estimate the potential investment and market development costs to achieve commercial viability of agro-biodiverse systems in at least select areas with high agro-biodiversity value.
What agricultural production technologies will best deliver sustainable food security?	What is the optimal balance between input-based (e.g. synthetic fertilizers or biocides) and ecologically-based production approaches (e.g. bio-controls, compost)?	More practical research to understand: ◘ the knowledge gaps to deliver both significant ecosystem services and high levels of production. ◘ trade-offs in balancing high production levels with potential negative human or environmental consequences ◘ how to improve efficiency and reduce volumes of any applications, whether natural or synthetic, by better tailoring to particular farming systems and farming regions ◘ how to evolve better management of natural biological (and lower-cost) alternatives that have equal or better net effectiveness, particularly for smaller farmers who cannot consistently rely on having non-renewable off-farm inputs.

How can we adapt to growing demand for livestock products?	How are we to address the food and ecological challenges posed by increased consumption of livestock products if we are to meet the nutrition needs of growing populations?	◘ explore more efficient practices including decentralized methods and select animals that better fit into a resource-constrained environment ◘ increase education and policy support for optimal balanced diets ◘ explore existing tissue research creating meat from industrial, non-animal processes[211]
How can trade best affect food security?	How can countries determine the right mix of trade and other instruments in order to ensure food security in different country contexts?	◘ Rather than a black-white perspective - since shortages of the world's main food crops tend to affect multiple countries and thus call for more agile trade regimes - focus assessments on when selective trade barriers may be temporarily useful to protect against subsidized or predatory practices and when they ought to be removed in the complex equation of food security. ◘ Ensure that trade negotiations recognize that any viable concept of free trade must also be a more equitable food and agricultural trade system that eliminates trade distorting practices. ◘ Explore how we can optimally combine: a) increased levels of investment in diverse domestic crops; b) multi-market access; and c) adequate measures to reduce and cope with increased price volatility and shortages.

For the first time at a global level, the scarcity of multiple resources to produce food (land, water, energy and inputs) becomes a key limiting factor and we must use this challenge to stimulate creative innovation

4.4 Conclusion

To handle growing food demand, it is clear that "business as usual" is not a viable option.

Investing in more of the same is unlikely to give us better or different results. We have taken some steps toward recognizing the need for sustainability but we have not fundamentally altered the way we measure, understand, and incentivize our agricultural systems. If many current processes are intrinsically not working or not sustainable, they need more than partial "green-ing" to be workable. They need a broader vision and bolder ideas that help nourish both people and the planet.

A new vision of sustainable agriculture must be practical and realistic and integrate sensible short-term transitions to reduce the discomfort of change. Yet, it will still inevitably require a sustained level of commitment to principles beyond those of instant gratification.

[211] Tuomisto, Hanna and M. Joost Teixeira de Mattos. 2011. Environmental Impacts of Cultured Meat Production. Environmental Science & Technology., 45 (14), pp 6117–6123

This is not a minority view. The ideas put forward here are widely shared by the world's leading scientists and thinkers on agricultural development.[212] There is, quite simply, no question about the need to alter our current "business as usual" approach and update the way we manage the intrinsically intertwined food and environmental systems on which we depend.

The political and financial landscape has recently lurched from crisis to crisis. Waiting for a crisis to happen in agriculture is a very dangerous strategy for change. Many would say that having about a billion people malnourished and another billion obese is already the precursor of a potentially deepening morass from which there will be no easy exit. Amidst increasing populations, will we wait to take meaningful action as the stakes escalate? New options are available now to begin a shift and to create a more sustainable food and agriculture system. We need not be bogged down in the areas of disagreement when there are so many areas of common agreement in agriculture. Among a number of leading thinkers, we have considerable consensus about ways to go forward. We can build on that and there is much that can be done. We need only begin.

[212] Details vary, but a review of the recent major agriculture reports from the World Bank, the UK's Foresight Programme, IFPRI, Agrimonde, the International Assessment of Agricultural Knowledge, Science and Technology for Development and others concur on the identification of similar challenges and some of the solutions.