Testimony to the Financial Services Committee of the US House of Representatives

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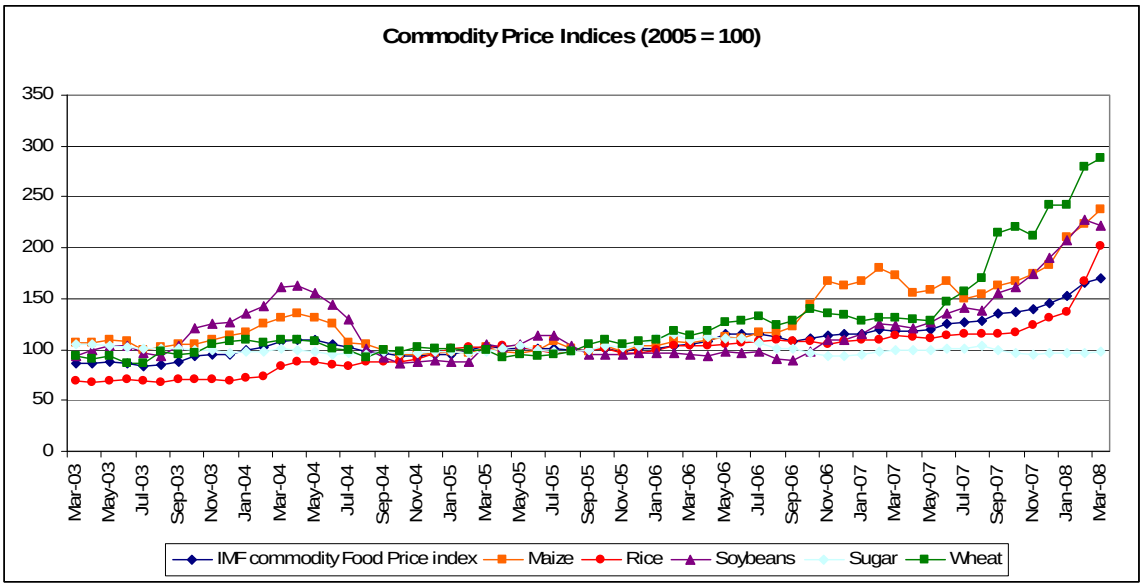
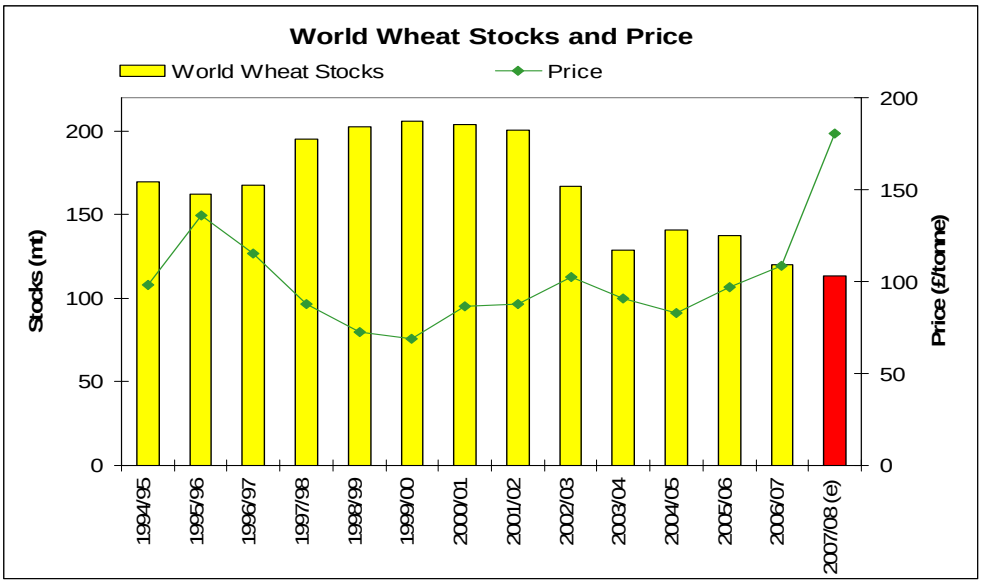
Do we have a food crisis: Are the recent prices increases a harbinger of the future?

The recent food price increases are a major cause for concern around the world – the price of wheat and rice has doubled in the last six months and international dairy prices increased sharply in 2007 recording particularly sharp gains in late spring. In March 2008, rice prices on the world market were at a 19-year high and wheat prices at a 28-year high, although in real terms they are at similar levels to prices in the mid-1990s. In developing countries, where most of the household income is spent on food, increased food prices are undermining attempts to reduce hunger and pushing some of the world's poorest people into abject poverty.

The following figure (from IMF) shows the change in commodity prices over the last 5 years.



The underlying causes of the most recent increases in food prices are complex and include factors such as increased demand from rapidly growing economies (especially China), poor harvests due to an increasingly variable climate (e.g., the Australian drought), the use of food crops for biofuels (e.g., maize for bioethanol), higher energy and fertilizer prices, low food stocks, speculation on the commodity futures market, and then, in response to the high food prices export, restrictions on agricultural products from a number of significant exporters to protect domestic consumers (e.g., Argentina, India and Ukraine).



A key question is whether these price increases are a momentary blip - the result of an unfortunate series of events, or are they a harbinger of the future? Some factors impacting food prices are shorter term than others. For example, the effects of adverse weather conditions tend to be relatively short-lived, but recurrent. Longer-term issues include the impact of global warming, which may give rise to more enduring climate change and more frequent occurrences of extreme weather events leading to potentially greater agricultural price variability in future.

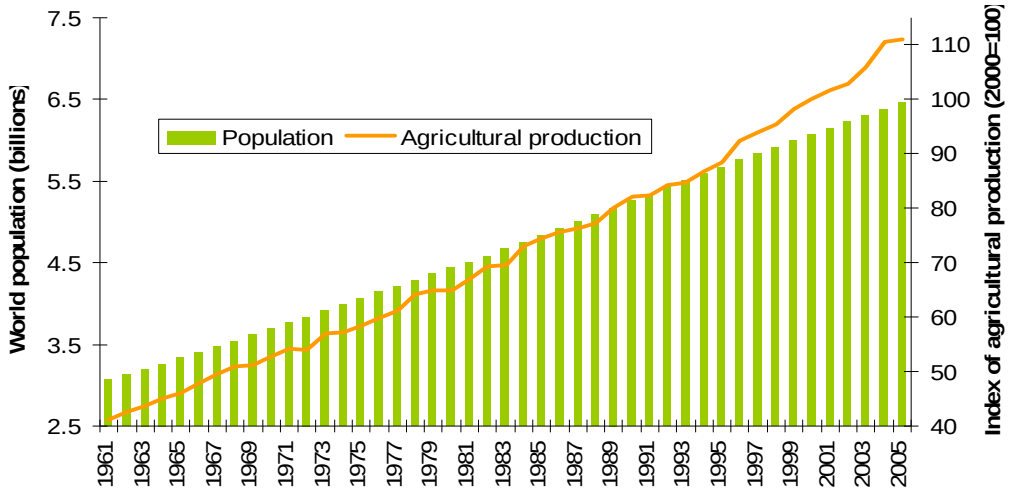
There is already evidence that the current high prices are stimulating increased production, but it may take a number of years to rebuild stocks to levels that markets are comfortable with. But if the high prices are more than a blip, what else do we need to know if we are to provide sustainable, nutritious and affordable food for the world in an environmentally and socially sustainable manner?

I was the director of the IAASTD, which involved more than 400 experts from around the world, which assessed the role (past, present and future) of agricultural knowledge, science and technology on reducing hunger and poverty, improving rural livelihoods and facilitating environmentally, socially and economically sustainable development. Annex I lists the key findings from the Global Summary for Decision Makers, while Annex II is the Executive Summary of the Synthesis Report.

Meeting the goal of affordable nutritious food for all in an environmentally and socially sustainable manner is achievable, but it cannot be achieved through current agricultural 'business as usual' – we must recognize that business as usual is not an option. Instead, if a large part of the world isn't to go hungry in the 21st Century, we need nothing short of a new 'agricultural revolution', with a more rational use of scarce land and water resources, an equitable trade regime, as well as widespread recognition and action on climate change. We also need to recognize that in this changing world we need new tools, which means increased investments in agricultural knowledge, science and technology. We also need to care about rural livelihoods – the employment opportunities and working conditions of rural laborers and their families, as well as small-scale farmers, traders, and small scale agro-enterprises. These are the people that are hurting most because of the food crisis. Existing and new S&T can only help us reach development goals if we understand that land security and tenure, appropriate technologies and good governance are critical to better food security and conserving precious resources such as land, soil and water.

It is undeniable that over the past century, agricultural science and new technologies have boosted production, with enormous gains in yields and reductions in the price of food. But these benefits have been unevenly distributed. While we in the West are surprised if there isn't a choice of bread in the supermarket on a Sunday evening, over 850 million people still go to bed hungry every night, especially in parts of sub-Saharan Africa and South East Asia. Primarily this is a problem of distribution and local production, but solutions are going to be increasingly difficult. In coming decades we need to double food production, meet food safety standards, enhance rural livelihoods and stimulate economic growth in an environmentally and socially sustainable manner. All of this at a time when there will be less labor in many developing countries as a result of HIV/AIDs and other endemic diseases (e.g., malaria in Africa), when competition from other sectors will make water even more scarce, when there be less arable land due to soil degradation and competition from biofuels, increasing levels of regional air pollution in many developing countries, loss of biodiversity, and when the climate will be changing, due to human activities giving us higher temperatures, changing rainfall and more frequent floods and droughts.

World population and agricultural production 1961-2005



Source: FAO

The new agricultural revolution that we'll need to meet this challenge will require a fundamental rethinking of the role of agricultural knowledge, science and technology. Agriculture can no longer be thought of as production alone, but the inescapable interconnectedness of agriculture's different economic, social and environmental roles and functions must be explicitly recognized.

Thankfully, many of the technologies and practices we need to meet the challenge of sustainable agriculture already exist. For instance, we know how to manage soil and water more effectively to increase water retention and decrease erosion; we already have access to microbiological techniques to suppress diseases in soils and conventional biotechnology (plant breeding) can help us produce improved crop varieties. But climate change and new and emerging animal diseases are throwing up problems that we haven't considered before and which will need advances in agricultural knowledge, science and technology to address.

Climate change has the potential to irreversibly damage the natural resource base on which agriculture depends, and in general adversely affects agricultural productivity. While moderate increases in temperature can have small beneficial effects on crop yields in mid- to high-latitudes, in low-latitudes even moderate temperature increases are likely to have negative effects on yields. Water scarcity and the timing of availability will increasingly constrain production, and it will

be critical to take a new look at water storage to cope with more extreme precipitation events, higher intra- and inter-seasonal variations (floods and droughts), and increased evapotranspiration. Climate change is already affecting, and is likely to increase, invasive species, pests and disease vectors all adversely affecting agricultural productivity. Advances in agricultural knowledge, science and technology will be required to develop improved crop traits, e.g., temperature, drought, pest and salt tolerance. In addition, it will be critical to reduce greenhouse gas emissions from the agricultural sector - methane from livestock and rice and nitrous oxide from the use of fertilizers.

And while biofuels can offer potential benefits over the rising costs of fossil fuels, energy security issues, reducing greenhouse gas emissions and rural economies, the IAASTD concluded that the production of first generation biofuels, which are predominantly produced from agricultural crops (e.g., bioethanol from maize), can raise food prices and reduce our ability to alleviate hunger. There is also considerable debate over the environmental impact of biofuels, including their greenhouse gas emissions and their impact on biodiversity, soils and water. Increased public and private investments are needed for next-generation biofuels, such as cellulosic ethanol and biomass to liquids technologies, so that cheaper and more abundant feedstocks can be converted into biofuels -- the biofuel demands on agricultural land and on pristine forest must be reduced.

Against a backdrop of a changing climate and the threat of even larger parts of the world going hungry it is clear that integrated advances in biotechnology, remote sensing and communication technology for instance, will be important in providing opportunities for more resource-efficient and site-specific agriculture.

Currently the most contentious issue in agricultural science is the use of recombinant DNA techniques to produce transgenic products because there is not widespread agreement on the environmental, human health and economic risks and benefits of such products. Dependent on how the technology develops, it is possible that GM crops could offer a range of benefits over the longer term that could make a contribution to dealing with food security problems and managing the effects of climate change. Research and development is needed to bring to market crops with new traits that would benefit, inter-alia, small-scale farmers in developing countries e.g. disease-resistance, drought-tolerance, improved nutritional characteristics, and more efficient use of nitrogen fertilizer. However, it is likely to be several years at least before these new traits might reach possible commercial application. At the same time, it needs to be recognized that small-scale farmers in many parts of Africa could increase their yields significantly with current non-GM crops and inputs, given access to markets, financing and improved rural infrastructure. This highlights the importance of securing a successful outcome to the Doha trade round. In addition, more attention needs to be focused on reducing post-harvest losses in poor countries, as currently between 30-40% of the food grown is lost before reaching markets.

Opening national agricultural markets to international competition can offer economic benefits, but can lead to long term negative effects on poverty alleviation, food security and the environment without basic national institutions and infrastructure being in place. Therefore, trade policy reform that provides a more equitable global trading system can help make small-scale farmers profitable and enhance the ability of developing countries to achieve food security while ensuring environmental sustainability. Developing countries would also benefit from the removal of barriers for products in which they have a competitive advantage by a reduction of escalating tariffs for processed commodities in both developed and developing countries.

Specifically, our ability to produce affordable nutritious food that is accessible to everybody in the future will mean addressing several of the drivers of the current increase in food prices. We will need to decrease the vulnerability of agricultural productivity to projected changes in climate, develop the next generation of biofuels, and transform the trade system to benefit the small-scale farmer.

Short term interventions to establish a sustainable and secure food system that meets the basic food needs of all people:

The challenge for international financial institutions is to reassess standard policy prescriptions, e.g., trade liberalization, dependence of developing countries in export cash crops, appropriate technologies, and withdrawal of the state from the agricultural sector.

In the short-term, international financial institutions and development agencies can assist developing countries with the impacts of high prices by:

- Recognizing that business as usual is not an option and that increasing the productivity and profitability of the small scale farm sector is critically important to food security in developing countries – there should be increased support for small scale farmers who should be at the centre of development policies that promote production of locally appropriate crops;
- Supporting emergency interventions to boost domestic agricultural production of food crops that are locally important for food security - these interventions need to focus on supporting the small scale farm sector, e.g., post harvest facilities, market feeder roads, improving access and tenure to land and productive resources, provide access to credit, etc.
- Promoting an increase in national public investment and regional co-operation in agricultural knowledge, science and technology, with a focus on drylands, fisheries, mountain and coastal ecosystems, orphan crops, crop-livestock systems, and climate change impacts; and
- Establishing national safety nets and public food distribution systems to provide the poorest and most vulnerable members of the populations with resources to meet their basic needs as well as to protect them against food price shocks. Increasingly, organizations such as the U.N. Food and Agriculture Organization are saying aid should be provided in the form of cash or food coupons rather than food shipments, which can affect producers and markets in recipient countries and distort international trade.

Medium to long term interventions to establish a sustainable and secure food system that meets the basic foods needs of all people:

In the medium to longer-term the World Bank and other international financial institutions can assist in establishing a sustainable and secure food system that meets the basic foods needs of all people by:

- Targeting AKST toward strategies that combine productivity with protecting natural resources such as soils, water, forests, and biodiversity by supporting biologically diverse agroecological farming and grazing methods, especially those practiced sustainably by small-scale food producers, which the IAASTD found makes agriculture more resilient, adaptive and capable of contributing to the elimination of hunger and rural poverty;
- Assisting crop and livestock production systems adjust to increasing rainfall variability, higher intensity rainfall events, and rising temperatures;
- Supporting programs to improve the fundamentals for small-scale farmers and rural livelihoods – security of access and tenure to land and resources; access to credit for the small-scale farm sector; access to seeds and other inputs; rural infrastructure such as market feeder roads, post-harvest facilities, and investment in local value addition; local, regional and international market information and access;
- Assisting countries to find the appropriate balance between the production of export crops, which help a country's balance of payments, but does not ensure food security or buffer a country from volatile international market prices, and support for production of the subsistence crops needed to meet the needs of the domestic populations;
- Supporting programs to internalize environmental externalities and provide payment or reward for environmental services;
- Promoting public-private-CSO involvement in AKST with accountability for social and environmental outcomes;

- Assisting countries develop basic national institutions and infrastructure to take advantage of international trade and macro-level policy changes to enable AKST linkages with development goals;
- Assisting countries to build and reform the AKST skill base (basic sciences, social, political and legal knowledge) and innovation capacities of rural communities and consumers; and
- Building national and regional food stocks, which can be of use in meeting emergency needs resulting from the frequent natural disasters in regions such as south-east Asia.

Meeting the goal of affordable nutritious food for all, in an environmentally sustainable manner is achievable. The future is not pre-ordained, but is in our collective hands. While we can build upon our successes, we must also recognize that an extrapolation of business-as-usual will not suffice. Instead, we need to be bold enough to rethink agriculture. Most importantly, if we are to help improve the welfare of poor and disadvantaged people, we need to acknowledge that the time to act is now.

Annex I to Testimony by Robert T. Watson to House Financial Services Committee

International Assessment of Agricultural Knowledge, Science and Technology for Development

Key Findings from Global Summary for Decision Makers

1. Agricultural Knowledge, Science and Technology (AKST) has contributed to substantial increases in agricultural production over time, contributing to food security. This has been achieved primarily through a strong focus on increasing yields with improved germplasm, increased inputs (water, agrochemicals) and mechanization. These increases in productivity have contributed to a net increase in global food availability per person: from 2360 kcal in the 1960s to 2803 kcal per person per day in the 1990s, at a time when world population significantly increased.

2. People have benefited unevenly from these yield increases across regions, in part because of different organizational capacities, sociocultural factors, and institutional and policy environments. While in South Asia the percentage of people living in poverty (<US$2 per day) has decreased from 45 to 30%, in sub-Saharan Africa (SSA), for example, this percentage (around 50%) has remained the same over the last 20 years. Value added per agricultural worker in 2003 (in 2000 US$) in OECD countries was 23,081 with a rate of growth of 4.4% for 1992-2003. For SSA, the figures are respectively 327 and 1.4%.

3. Emphasis on increasing yields and productivity has in some cases had negative consequences on environmental sustainability. These consequences were often not foreseen as they occurred over time and, some occurred outside of traditional farm boundaries. For instance, 1.9 billion ha (and 2.6 billion people) today are affected by significant levels of land degradation. Fifty years ago water withdrawal from rivers was one-third of what it is today: currently 70% of freshwater withdrawal globally (2700 km^3 – 2.45% of rainfall) is attributable to irrigated agriculture, which in some cases has caused salinization. Approximately 1.6 billion people live in water-scarce basins. Agriculture contributes about 60% of anthropogenic emissions of CH_4 and about 50% of N_20 emissions. Inappropriate fertilization has led to eutrophication and large dead zones in a number of coastal areas, e.g. Gulf of Mexico, and some lakes, and inappropriate use of pesticides has lead to groundwater pollution, and other effects, for example loss of biodiversity.

4. The environmental shortcomings of agricultural practice associated with poor socioeconomic conditions create a vicious cycle in which poor smallholder farmers have to deforest and use new often marginal lands, so increasing deforestation and overall degradation. Loss of soil fertility, soil erosion, breakdown in agroecological functions have resulted in poor crop yields, land abandonment, deforestation and ever-increasing movement into marginal land, including steep hillsides. Existing multifunctional systems that minimize these problems have not been sufficiently prioritized for research. There is little recognition of the ecosystem functions that mitigate the environmental impacts.

Multifunctionality

The term multifunctionality has sometimes been interpreted as having implications for trade and protectionism. This is **not** the definition used here. In IAASTD, multifunctionality is used solely to express the inescapable interconnectedness of agriculture's different roles and functions. The concept of multifunctionality recognizes agriculture as a multi-output activity producing not only commodities (food, feed, fibers, agrofuels, medicinal products and ornamentals), but also non-commodity outputs such as environmental services, landscape amenities and cultural heritages.

The working definition proposed by OECD, which is used by the IAASTD, associates multifunctionality with the particular characteristics of the agricultural production process and its outputs; (i) multiple commodity and non-commodity outputs are jointly produced by agriculture; and (ii) some of the non-commodity outputs may exhibit the characteristics of externalities or public goods, such that markets for these goods function poorly or are non-existent.

The use of the term has been controversial and contested in global trade negotiations, and it has centered on whether "trade-distorting" agricultural subsidies are needed for agriculture to perform its many functions. Proponents argue that current patterns of agricultural subsidies, international trade and related policy frameworks do not stimulate transitions toward equitable agricultural and food trade relation or sustainable food and farming systems and have given rise to perverse impacts on natural resources and agroecologies as well as on human health and nutrition. Opponents argue that attempts to remedy these outcomes by means of trade-related instruments will weaken the efficiency of agricultural trade and lead to further undesirable market distortion; their preferred approach is to address the externalized costs and negative impacts on poverty, the environment, human health and nutrition by other means.

5. Projections based on a continuation of current policies and practices indicate that global demographic changes and changing patterns of income distribution over the next 50 years will lead to different patterns of food consumption and increased demand for food. In the reference run, global cereal demand is projected to increase by 75% between 2000 and 2050 and global meat demand is expected to double. More than three-fourths of growth in demand in both cereals and meat is projected to be in developing countries. Projections indicate a probable tightening of world food markets with increasing resource scarcity adversely affecting poor consumers and poor producers. Overall, current terms of trade and policies,and growing water and land scarcity, coupled with projected changes in climate is projected to constrain growth in food production.

6. Agriculture operates within complex systems and is multifunctional in its nature. A multifunctional approach to implementing AKST will enhance its impact on hunger and poverty, improving human nutrition and livelihoods in an equitable, environmentally, socially and economically sustainable manner.

7. An increase and strengthening of AKST towards agroecological sciences will contribute to addressing environmental issues while maintaining and increasing productivity. Formal, traditional and community-based AKST need to respond to increasing pressures on natural resources, such as reduced availability and worsening quality of water, degraded soils and landscapes, loss of biodiversity and agroecosystem function, degradation and loss of forest cover and degraded marine and inshore fisheries. Agricultural strategies will also need to include limiting emission of greenhouse gases and adapting to human-induced climate change and increased variability.

8. Strengthening and redirecting the generation and delivery of AKST will contribute to addressing a range of persistent socioeconomic inequities, including reducing the risk of conflicts resulting from competing claims on land and water resources; assisting individuals and

communities in coping with endemic and epidemic human and animal diseases and their consequences; addressing problems and opportunities associated with local and international flows of migrant laborers; and increasing access to information, education and technology to poorer areas and peoples, especially to women. Such redirection and strengthening requires thorough, open and transparent engagement of all stakeholders.

9. Greater and more effective involvement of women and use of their knowledge, skills and experience will advance progress towards sustainability and development goals and a strengthening and redirection of AKST to address gender issues will help achieve this. Women farmers, processors and farm workers have benefited less from AKST than men overall and poor women least of all. Efforts to redress persistent biases in their access to production resources and assets, occupational education and training, information and extension services have met with limited success. Many of the societal, policy-related and operational impediments to more equitable progress, as well as the private and public costs of such an uneven pattern of development, are well understood as are the factors that discourage more determined action to empower women.

10. Many of the challenges facing agriculture currently and in the future will require more innovative and integrated applications of existing knowledge, science and technology (formal, traditional and community-based), as well as new approaches for agricultural and natural resource management. Agricultural soil and biodiversity, nutrient, pest and water management, and the capacity to respond to environmental stresses such as climate change can be enhanced by traditional and local knowledge systems and current technologies. Technological options such as new genotypes of crops, livestock, fish and trees and advances in plant, livestock and fish breeding, biotechnology, remote sensing, agroecology, agroforestry, integrated pest and nutrient management and information and communication technologies (ICTs) will create opportunities for more resource-efficient and site-specific agriculture.

Biotechnology
The IAASTD definition of biotechnology is based on that in the Convention on Biological Diversity and the Cartagena Protocol on Biosafety. It is a broad term embracing the manipulation of living organisms and spans the large range of activities from conventional techniques for fermentation and plant and animal breeding to recent innovations in tissue culture, irradiation, genomics and marker-assisted breeding (MAB) or marker assisted selection (MAS) to augment natural breeding. Some of the latest biotechnologies, called 'modern biotechnology', include the use of *in vitro* modified DNA or RNA and the fusion of cells from different taxonomic families, techniques that overcome natural physiological reproductive or recombination barriers.

11. Some challenges will be resolved primarily by development and appropriate application of new and emerging AKST. Such AKST can contribute to solutions provided appropriate institutions and capacities are in place. Examples include combating livestock diseases, e.g. vaccine development; mitigating greenhouse gas emissions from agriculture; reducing the vulnerability of agriculture to a changing climate; reducing the heavy reliance of agriculture and commodity chains on fossil fuels; and addressing complex socioeconomic issues regarding local, national and international public goods.

12. Targeting small-scale agricultural systems by forging public and private partnerships, increased public research and extension investment helps realize *existing* opportunities. Strengthening participatory research and extension partnerships, development-oriented local governance and institutions such as cooperatives, farmer organizations and business associations, scientific institutions and unions support small-scale producers and entrepreneurs to capture and add value to existing opportunities on-farm, postharvest and in non-farm rural enterprises. In some instances, opportunities lie in those small-scale farming systems that have high water, nutrient and energy use efficiencies and conserve natural resources and biodiversity without sacrificing yield, but high marketing costs do not allow them to harness these

opportunities. The underlying principles, processes and knowledge may be relevant and capable of extrapolation to larger scale farming systems, particularly in the face of climate change effects.

13. Significant pro-poor progress requires creating opportunities for innovation and entrepreneurship, which explicitly target resource poor farmers and rural laborers. This will require simultaneous investments in infrastructure and facilitating access to markets and trade opportunities, occupational education and extension services, capital, credit, insurance and in natural resources such as land and water. The increasing market influence of large scale buyers and market standards are especially challenging for small producers necessitating further innovation in public and private training, education and extension services and suitable legal, regulatory and policy frameworks.

14. Decisions around small-scale farm sustainability pose difficult policy choices. Special and differential treatment for developing countries is an acknowledged principle in Doha agricultural negotiations and it is accepted that developing countries can have this special treatment especially on the grounds of food security, farmer's livelihoods and rural development. Suitable action is considered necessary at the international and national level to enable small farmers to benefit from these provisions. New payment mechanisms for environmental services by public and private utilities such as catchment protection and mitigation of climate change effects are of increasing importance and open new opportunities for the small-scale farm sector.

15. Public policy, regulatory frameworks and international agreements are critical to implementing more sustainable agricultural practices. Urgent challenges remain that call for additional effective agreements and bio-security measures involving transboundary water, emerging human and animal diseases, agricultural pests, climate change, environmental pollution and the growing concerns about food safety and occupational health. Achieving development and sustainability goals calls for national and international regulations to address the multiple economic, environmental and social dimensions of these transboundary issues. These policies need to be informed by broad-based evidence from natural and social sciences with multistakeholder participation. Improved governance and strengthening engagement of stakeholders can redress some of the inadequacies where identified in AKST arrangements that often privilege short-term over long-term considerations and productivity over environmental and social sustainability and the multiple needs of the small-scale farm sector.

16. Innovative institutional arrangements are essential to the successful design and adoption of ecologically and socially sustainable agricultural systems. Sustainable agricultural production is more likely when legal frameworks and forms of association provide secure access to credit, markets, land and water for individuals and communities with modest resources. Creating market-based opportunities for processing and commercializing agricultural products that ensure a fair share of value addition for small-scale producers and rural laborers is critical to meeting development and sustainability goals.

17. Opening national agricultural markets to international competition can offer economic benefits, but can lead to long term negative effects on poverty alleviation, food security and the environment without basic national institutions and infrastructure being in place. Some developing countries with large export sectors have achieved aggregate gains in GDP, although their small-scale farm sectors have not necessarily benefited and in many cases have lost out. The small-scale farm sector in the poorest developing countries is a net loser under most trade liberalization scenarios that address this question. These distributional impacts call for differentiation in policy frameworks as embraced by the Doha work plan (special and differential treatment and non-reciprocal access). Developing countries could benefit from reduced barriers and elimination of escalating tariffs for processed commodities in developed and developing countries; and they could also benefit from reduced barriers among themselves; deeper generalized preferential access to developed country markets for commodities important for rural livelihoods; increased public investment in local value addition; improved access for small-scale farmers to credit; and strengthened regional markets.

18. Intensive export oriented agriculture has increased under open market operations but has been accompanied by both benefits and adverse consequences depending on circumstances such as exportation of soil nutrients and water, unsustainable soil or water management, or exploitative labor conditions in some cases. AKST innovations that address sustainability and development goals would be more effective with fundamental changes in price signals, for example, internalization of environmental externalities and payment or reward for environmental services.

19. The choice of relevant approaches to adoption and implementation of agricultural innovation is crucial for achieving development and sustainability goals. There is a wide range of such approaches in current use. In the past, most AKST policy and practice in many countries were undertaken using the 'transfer of technology' approach. A critical decision for AKST stakeholders is the selection of approaches suited to the advancement of sustainability and development goals in different circumstances.

20. More and better targeted AKST investments, explicitly taking into account the multifunctionality of agriculture, by both public and private sectors can help advance development and sustainability goals. Increased investments in AKST, particularly if complemented by supporting investments in rural development (for example, infrastructure, telecommunications and processing facilities) can have high economic rates of return and reduce poverty. AKST investments also generate environmental, social, health, and cultural impacts. More evidence is needed on the actual levels and distributional effects of the economic and non-economic benefits and costs of these investments for better targeting of future AKST investments.

21. While public private partnerships are to be encouraged the establishment and enforcement of codes of conduct by universities and research institutes can help avoid conflicts of interest and maintain focus on sustainability and development in AKST w**hen private funding complements public sector funds.** Government capacity to understand, and where necessary mediate public/private partnerships, can be assisted for instance by means of monitoring systems.

22. Achieving sustainability and development goals will involve creating space for diverse voices and perspectives and a multiplicity of scientifically well-founded options, through, for example, the inclusion of social scientists in policy and practice of AKST helps direct and focus public and private research, extension and education on such goals. Diverse and conflicting interpretations of past and current events, coupled with the under-valuation of different types of AKST limit progress in the field. Understanding the underlying sources of competing interpretations of AKST is crucial to addressing goals. Some interpretations have been privileged over others and have helped push formal AKST along certain pathways, to the neglect of other scientifically sound options. Some of the by-passed options originate in traditional knowledge or civil society experience and may be better able to contribute to poverty reduction, social inclusion, equity and generate multifunctional outcomes.

Annex II to Testimony by Robert T. Watson to House Financial Services Committee

International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD)

Executive Summary of the Synthesis Report

This Synthesis Report captures the complexity and diversity of agriculture and AKST across world regions. It is built upon the global and five sub-global reports that provide evidence for the integrated analysis of the main concerns necessary to achieve development and sustainability goals. It is organized in two parts that address the primary animating question: how can AKST be used to reduce hunger and poverty, improve rural livelihoods, and facilitate equitable environmentally, socially, and economically sustainable development? The eight cross-cutting themes include: bioenergy, biotechnology, climate change, human health, natural resource management, trade and markets, traditional and local knowledge and community-based innovation, and women in agriculture and is organized in two substantive parts. In the first part we identify the current conditions, challenges and options for action that shape AKST, while in the second part we focus on the eight cross-cutting themes.

The International Assessment of Agricultural Science and Technology for Development (IAASTD) responds to the widespread realization that despite significant scientific and technological achievements in our ability to increase agricultural productivity, we have been less attentive to some of the unintended social and environmental consequences of our achievements. We are now in a good position to reflect on these consequences and to outline various policy options to meet the challenges ahead, perhaps best characterized as the need for food and livelihood security under increasingly constrained environmental conditions from within and outside the realm of agriculture and globalized economic systems.

This widespread realization is linked directly to the goals of the IAASTD: how Agricultural Knowledge, Science and Technology (AKST) can be used to reduce hunger and poverty, to improve rural livelihoods and to facilitate equitable environmentally, socially and economically sustainable development. Under the rubric of IAASTD, we recognize the importance of AKST to the multifunctionality of agriculture and the intersection with other local to global concerns, including loss of biodiversity and ecosystem services, climate change and water availability.

The IAASTD is unique in the history of agricultural science assessments, in that it assesses both formal science and technology (S&T) and local and traditional knowledge, addresses not only production and productivity but the multifunctionality of agriculture, and recognizes that multiple perspectives exist on the role and nature of AKST. For many years, agricultural science focused on delivering component technologies to increase farm-level productivity where the market and institutional arrangements put in place by the state were the primary drivers of the adoption of new technologies. The general model has been to continuously innovate, reduce farm gate prices and externalize costs. This model drove the phenomenal achievements of AKST in industrial countries after World War II and the spread of the Green Revolution beginning in the 1960s. But, given the new challenges we confront today, there is increasing recognition within formal S&T organizations that the current AKST model requires revision. Business as usual is no longer an option. This leads to rethinking the role of AKST in achieving development and sustainability goals; one that seeks more intensive engagement across diverse worldviews and possibly contradictory approaches in ways that can inform and suggest strategies for actions enabling to the multiple functions of agriculture.

In order to address the diverse needs and interests that shape human life, we need a shared approach to sustainability with local and cross-national collaboration. We cannot escape our predicament by simply continuing to rely on the aggregation of individual choices, to achieve

sustainable and equitable collective outcomes. Incentives are needed to influence the choices individuals make. Issues such as poverty and climate change also require collective agreements on concerted action and governance across scales that go beyond an appeal to individual benefit. At the global, regional, national and local levels, decision makers must be acutely conscious of the fact that there are diverse challenges, multiple theoretical frameworks and development models and a wide range of options to meet development and sustainability goals. Our perception of the challenges and the choices we make at this juncture in history will determine how we protect our planet and secure our future.

Development and sustainability goals should be placed in the context of (i) current social and economic inequities and political uncertainties about war and conflicts; (ii) uncertainties about the ability to sustainably produce and access sufficient food; (iii) uncertainties about the future of world food prices; (iv) changes in the economics of fossil based energy use; (v) the emergence of new competitors for natural resources; (vi) increasing chronic diseases that are partially a consequence of poor nutrition and poor food quality as well as food safety; and (vii) changing environmental conditions and the growing awareness of human responsibility for the maintenance of global ecosystem services (provisioning, regulating, cultural and supporting).

Today there is a world of asymmetric development, unsustainable natural resource use, and continued rural and urban poverty. Generally the adverse consequences of global changes have the most significant effects on the poorest and most vulnerable, who historically have had limited entitlements and opportunities for growth.

The pace of formal technology generation and adoption has been highly uneven. Actors within North America and Europe (NAE) and emerging economies who have captured significant economies of scale through formal AKST will continue to dominate agricultural exports and extended value chains. There is an urgent need to diversify and strengthen AKST recognizing differences in agroecologies and social and cultural conditions. The need to retool AKST, to reduce poverty and provide improved livelihoods options for the rural poor, especially landless and peasant communities, urban informal and migrant workers, is a major challenge.

There is an overarching concern in all regions regarding poverty alleviation and the livelihoods options available to poor people who are faced with intra- and inter-regional inequalities. There is recognition that the mounting crisis in food security is of a different complexity and potentially different magnitude than the one of the 1960s. The ability and willingness of different actors, including those in the state, civil society and private sector, to address fundamental questions of relationships among production, social and environmental systems is affected by contentious political and economic stances.

The acknowledgement of current challenges and the acceptance of options available for action require a long-term commitment from decision makers that is responsive to the specific needs of a wide range of stakeholders. A recognition that knowledge systems and human ingenuity in science, technology, practice and policy is needed to meet the challenges, opportunities and uncertainties ahead. This recognition will require a shift to nonhierarchical development models.

The main challenge of AKST is to increase the productivity of agriculture in a sustainable manner. AKST must address the needs of small-scale farms in diverse ecosystems and to create realistic opportunities for their development where the potential for improved area productivity is low and where climate change may have its most adverse consequences. The main challenges for AKST posed by multifunctional agricultural systems include:

- How to improve social welfare and personal livelihoods in the rural sector and enhance multiplier effects of agriculture?
- How to empower marginalized stakeholders to sustain the diversity of agriculture and food systems, including their cultural dimensions?
- How to provide safe water, maintain biodiversity, sustain the natural resource base and minimize the adverse impacts of agricultural activities on people and the environment?

- How to maintain and enhance environmental and cultural services while increasing sustainable productivity and diversity of food, fiber and biofuel production?
- How to manage effectively the collaborative generation of knowledge among increasingly heterogeneous contributors and the flow of information among diverse public and private AKST organizational arrangements?
- How to link the outputs from marginalized, rain fed lands into local, national and global markets?

Multifunctionality

The term multifunctionality has sometimes been interpreted as having implications for trade and protectionism. This is **not** the definition used here. In IAASTD, multifunctionality is used solely to express the inescapable interconnectedness of agriculture's different roles and functions. The concept of multifunctionality recognizes agriculture as a multi-output activity producing not only commodities (food, feed, fibers, agrofuels, medicinal products and ornamentals), but also non-commodity outputs such as environmental services, landscape amenities and cultural heritages.

The working definition proposed by OECD, which is used by the IAASTD, associates multifunctionality with the particular characteristics of the agricultural production process and its outputs; (i) multiple commodity and non-commodity outputs are jointly produced by agriculture; and (ii) some of the non-commodity outputs may exhibit the characteristics of externalities or public goods, such that markets for these goods function poorly or are non-existent.

The use of the term has been controversial and contested in global trade negotiations, and it has centered on whether "trade-distorting" agricultural subsidies are needed for agriculture to perform its many functions. Proponents argue that current patterns of agricultural subsidies, international trade and related policy frameworks do not stimulate transitions toward equitable agricultural and food trade relation or sustainable food and farming systems and have given rise to perverse impacts on natural resources and agroecologies as well as on human health and nutrition. Opponents argue that attempts to remedy these outcomes by means of trade-related instruments will weaken the efficiency of agricultural trade and lead to further undesirable market distortion; their preferred approach is to address the externalized costs and negative impacts on poverty, the environment, human health and nutrition by other means.

Options for Action

Successfully meeting development and sustainability goals and responding to new priorities and changing circumstances would require a fundamental shift in AKST, including science, technology, policies, institutions, capacity development and investment. Such a shift would recognize and give increased importance to the multifunctionality of agriculture, accounting for the complexity of agricultural systems within diverse social and ecological contexts. It would require new institutional and organizational arrangements to promote an integrated approach to the development and deployment of AKST. It would also recognize farming communities, farm households, and farmers as producers and managers of ecosystems. This shift may call for changing the incentive systems for all actors along the value chain to internalize as many externalities as possible. In terms of development and sustainability goals, these policies and institutional changes should be directed primarily at those who have been served least by previous AKST approaches, i.e., resource-poor farmers, women and ethnic minorities. Such development would depend also on the extent to which small-scale farmers can find gainful off-farm employment and help fuel general economic growth. Large and middle-size farmers continue to be important and high pay-off targets of AKST, especially in the area of sustainable land use and food systems.

It will be important to assess the potential environmental, health and social impacts of any technology, and to implement the appropriate regulatory frameworks. AKST can contribute to radically improving food security and enhancing the social and economic performance of agricultural systems as a basis for sustainable rural and community livelihoods and wider economic development. It can help to rehabilitate degraded land, reduce environmental and

health risks associated with food production and consumption and sustainably increase production.

Success would require increased public and private investment in AKST, the development of supporting policies and institutions, revalorization of traditional and local knowledge, and an interdisciplinary, holistic and systems-based approach to knowledge production and sharing. Success also depends on the extent to which international developments and events drive the priority given to development and sustainability goals and the extent to which requisite funding and qualified staff are available.

Poverty and livelihoods

Important options for enhancing rural livelihoods include increasing access by small-scale farmers to land and economic resources and to remunerative local urban and export markets; and increasing local value added and value captured by small-scale farmers and rural laborers. A powerful tool for meeting development and sustainability goals resides in empowering farmers to innovatively manage soils, water, biological resources, pests, disease vectors, genetic diversity, and conserve natural resources in a culturally appropriate manner. Combining farmers' and external knowledge would require new partnerships among farmers, scientists and other stakeholders.

Policy options for improving livelihoods include access to microcredit and other financial services; legal frameworks that ensure access and tenure to resources and land; recourse to fair conflict resolution; and progressive evolution and proactive engagement in Intellectual Property Rights (IPR) regimes and related instruments. Developments are needed that build trust and that value farmer knowledge, agricultural and natural biodiversity; farmer-managed medicinal plants, local seed systems and common pool resource management regimes. Each of these options, when implemented locally, depends on regional and nationally based mechanisms to ensure accountability. The suite of options to increase domestic farm gate prices for small-scale farmers includes fiscal and competition policies; improved access to AKST; novel business approaches; and enhanced political power.

Food security

Food security strategies require a combination of AKST approaches, including the development of food stock management, effective market intelligence and early warning, monitoring, and distribution systems. Production measures create the conditions for food security, but they need to be looked at in conjunction with people's access to food (through own production, exchange and public entitlements) and their ability to absorb nutrients consumed (through adequate access to water and sanitation, adequate nutrition and nutritional information) in order to fully achieve food security.

Food security [is] a situation that 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. (FAO, The State of Food Insecurity 2001)

Food sovereignty is defined as the right of peoples and sovereign states to democratically determine their own agricultural and food policies.

AKST can increase sustainable agricultural production by expanding use of local and formal AKST to develop and deploy suitable cultivars adaptable to site-specific conditions; improving access to resources; improving soil, water and nutrient management and conservation; pre- and postharvest pest management; and increasing small-scale farm diversification. Policy options for addressing food security include developing high-value and under-utilized crops in rain fed areas; increasing the full range of agricultural exports and imports, including organic and fair trade products; reducing transaction costs for small-scale producers; strengthening local markets; food safety nets; promoting agro-insurance; and improving food safety and quality. Price shocks and

extreme weather events call for a global system of monitoring and intervention for the timely prediction of major food shortages and price-induced hunger.

AKST investments can increase the sustainable productivity of major subsistence foods including orphan and underutilized crops, which are often grown or consumed by poor people. Investments could also be targeted for institutional change and policies that can improve access of poor people to food, land, water, seeds, germplasm and improved technologies.

Environmental sustainability

AKST systems are needed that enhance sustainability while maintaining productivity in ways that protect the natural resource base and ecological provisioning of agricultural systems. Options include improving nutrient, energy, water and land use efficiency; improving the understanding of soil-plant-water dynamics; increasing farm diversification; supporting agroecological systems, and enhancing biodiversity conservation and use at both field and landscape scales; promoting the sustainable management of livestock, forest and fisheries; improving understanding of the agroecological functioning of mosaics of crop production areas and natural habitats; countering the effects of agriculture on climate change and mitigating the negative impacts of climate change on agriculture.

Policy options include ending subsidies that encourage unsustainable practices and using market and other mechanisms to regulate and generate rewards for agro/environmental services, for better natural resource management and enhanced environmental quality. Examples include incentives to promote IPM and environmentally resilient germplasm management, payments to farmers and local communities for ecosystem services, facilitating and providing incentives for alternative markets such as green products, certification for sustainable forest and fisheries practices and organic agriculture and the strengthening of local markets. Long-term land and water use rights/tenure, risk reduction measures (safety nets, credit, insurance, etc.) and profitability of recommended technologies are prerequisites for adoption of sustainable practices. Common pool resource regimes and modes of governance that emphasize participatory and democratic approaches are needed.

Investment opportunities in AKST that could improve sustainability and reduce negative environmental effects include resource conservation technologies, improved techniques for organic and low-input systems; a wide range of breeding techniques for temperature and pest tolerance; research on relationship of agricultural ecosystem services and human well-being; economic and non-economic valuations of ecosystem services; increasing water use efficiency and reducing water pollution; biocontrols of current and emerging pests and pathogens; biological substitutes for agrochemicals; and reducing the dependency of the agricultural sector on fossil fuels.

Human health and nutrition

Inter-linkages between health, nutrition, agriculture, and AKST affect the ability of individuals, communities, and nations to reach sustainability goals. These inter-linkages exist within the context of multiple stressors that affect population health. A broad and integrated approach is needed to identify appropriate use of AKST to increase food security and safety, decrease the incidence and prevalence of a range of infectious (including emerging and re-emerging diseases such as malaria, avian influenza, HIV/AIDS and others) and chronic diseases, and decrease occupational exposures, injuries and deaths. Robust agricultural, public health, and veterinary detection, surveillance, monitoring, and response systems can help identify the true burden of ill health and cost-effective, health-promoting strategies and measures. Addition investments are needed to maintain and improve current systems and regulations.

- *Increasing food security* can be facilitated by promoting policies and programs to diversify diets and improve micronutrient intake; and developing and deploying existing and new technologies for the production, processing, preservation, and distribution of food.

- *Increasing food safety* can be facilitated by effective, coordinated, and proactive national and international food safety systems to ensure animal, plant, and human health, such as investments in adequate infrastructure, public health and veterinary capacity, legislative frameworks for identification and control of biological and chemical hazards; and farmer-scientist partnerships for the identification, monitoring and evaluation of risks.
- *The burden of infectious disease* can be decreased by strengthening coordination between and the capacity of agricultural, veterinary, and public health systems, integrating multi-sectoral policies and programs across the food chain to reduce the spread of infectious diseases, and developing and deploying new AKST to identify, monitor, control, and treat diseases.
- *The burden of chronic disease* can be decreased by policies that explicitly recognize the importance of improving human health and nutrition, including regulation of food product formulation through legislation, international agreements and regulations for food labeling and health claims, and creation of incentives for the production and consumption of health-promoting foods.
- *Occupational and public health* can be improved by development and enforcement of health and safety regulations (including child labor laws and pesticide regulations), enforcement of cross-border issues such as illegal use of toxic agrochemicals, and conducting health risk assessments that make explicit the tradeoffs between maximizing livelihood benefits, the environment, and improving health.

Equity

For AKST to contribute to greater equity, investments are required for the development of context-specific technologies, and expanded access of farmers and other rural people to occupational, non-formal and formal education. An environment in which formal science and technology and local and traditional knowledge are seen as part of an integral AKST system can increase equitable access to technologies to a broad range of producers and natural resource managers. Incentives in science, universities and research organizations are needed to foster different kinds of AKST partnerships. Key options include equitable access to and use of natural resources (particularly land and water), systems of incentives and rewards for multifunctionality, including ecosystem services, and responding to the vulnerability of farming and farm worker communities. Reform of the governance of AKST and related organizations is also important for the crucial role they can play in improving community-level scientific literacy, decentralization of technological opportunities, and the integration of farmer concerns in research priority setting and the design of farmer services. Improving equity requires synergy among various development actors, including farmers, rural laborers, banks, civil society organizations, commercial companies, and public agencies. Stakeholder involvement is also crucial in decisions about IPR, infrastructure, tariffs, and the internalization of social and environmental costs. New modes of governance to develop innovative local networks and decentralized government, focusing on small-scale producers and the urban poor (urban agriculture; direct links between urban consumers and rural producers) will help create and strengthen synergistic and complementary capacities.

Preferential investments in equitable development (e.g., literacy, education and training) that contribute to reducing ethnic, gender, and other inequities would advance development goals. Measurements of returns to investments require indices that give more information than GDP, and that are sensitive to environmental and equity gains. The use of inequality indices for screening AKST investments and monitoring outcomes strengthens accountability. The Gini-coefficient could, for example, become a public criterion for policy assessment, in addition to the more conventional measures of growth, inflation and environment.

Investments

Achieving development and sustainability goals would entail increased funds and more diverse funding mechanisms for agricultural research and development and associated knowledge systems, such as:

- Public investments in global, regional, national and local public goods; food security and safety, climate change and sustainability. More efficient use of increasingly scarce land, water and biological resources requires investment in research and development of legal and management capabilities.
- Public investments in agricultural knowledge systems to promote interactive knowledge networks (farmers, scientists, industry and actors in other knowledge areas); improved access to ICT; ecological, evolutionary, food, nutrition, social and complex systems' sciences; effective interdisciplinarity; capacity in core agricultural sciences; and improving life-long learning opportunities along the food system.
- Public-private partnerships for improved commercialization of applied knowledge and technologies and joint funding of AKST, where market risks are high and where options for widespread utilization of knowledge exist.
- Adequate incentives and rewards to encourage private and civil society investments in AKST contributing to development and sustainability goals.

In many developing countries, it may be necessary to complement these investments with increased and more targeted investments in rural infrastructure, education and health.

In the face of new global challenges, there is an urgent need to strengthen, restructure and possibly establish new intergovernmental, independent science and evidence-based networks to address such issues as climate forecasting for agricultural production; human health risks from emerging diseases; reorganization of livelihoods in response to changes in agricultural systems (population movements); food security; and global forestry resources.

Themes

The Synthesis Report looked at eight AKST-related themes of critical interest to meeting IAASTD goals: bioenergy, biotechnology, climate change, human health; natural resource management; trade and markets; traditional and local knowledge and community-based innovation; and women in agriculture.

Bioenergy

Rising costs of fossil fuels, energy security concerns, increased awareness of climate change and potentially positive effects for economic development have led to considerable public attention to bioenergy. Bioenergy includes traditional bioenergy, biomass to produce electricity, light and heat and first and next generation liquid biofuels. The economics and the positive and negative social and environmental externalities differ widely, depending on source of biomass, type of conversion technology and local circumstances.

Primarily due to a lack of affordable alternatives, millions of people in developing countries depend on traditional bioenergy (e.g. wood fuels) for their cooking and heating needs, especially in sub-Saharan Africa and South Asia. This reliance on traditional bioenergy can pose considerable environmental, health, economic and social challenges. New efforts are needed to improve traditional bioenergy and accelerate the transition to more sustainable forms of energy.

First generation biofuels consist predominantly of bioethanol and biodiesel produced from agricultural crops (e.g. maize, sugar cane). Production has been growing fast in recent years, primarily due to biofuel support policies since they are cost competitive only under particularly favorable circumstances. The diversion of agricultural crops to fuel can raise food prices and reduce our ability to alleviate hunger throughout the world. The negative social effects risk being exacerbated in cases where small-scale farmers are marginalized or displaced from their land. From an environmental perspective, there is considerable variation, uncertainty and debate over the net energy balance and level of GHG emissions. In the long term, effects on food prices may be reduced, but environmental effects caused by land and water requirements of large-scale

increases of first generation biofuels production are likely to persist and will need to be addressed.

Next generation biofuels such as cellulosic ethanol and biomass-to-liquids technologies allow conversion into biofuels of more abundant and cheaper feedstocks than first generation. This could potentially reduce agricultural land requirements per unit of energy produced and improve lifecycle GHG emissions, potentially mitigating the environmental pressures from first generation biofuels. However, next generation biofuels technologies are not yet commercially proven and environmental and social effects are still uncertain. For example, the use of feedstock and farm residues can compete with the need to maintain organic matter in sustainable agroecosystems.

Bioelectricity and bioheat are important forms of renewable energy that are usually more efficient and produce less GHG emissions than liquid biofuels and fossil fuels. Digesters, gasifiers and direct combustion devices can be successfully employed in certain settings, e.g., off-grid areas. There is potential for expanding these applications but AKST is needed to reduce costs and improve operational reliability. For all forms of bioenergy, decision makers should carefully weigh full social, environmental and economic costs against realistically achievable benefits and other sustainable energy options.

Biotechnology

The IAASTD definition of biotechnology is based on that in the Convention on Biological Diversity and the Cartagena Protocol on Biosafety. It is a broad term embracing the manipulation of living organisms and spans the large range of activities from conventional techniques for fermentation and plant and animal breeding to recent innovations in tissue culture, irradiation, genomics and marker-assisted breeding (MAB) or marker assisted selection (MAS) to augment natural breeding. Some of the latest biotechnologies ('modern biotechnology') include the use of *in vitro* modified DNA or RNA and the fusion of cells from different taxonomic families, techniques that overcome natural physiological reproductive or recombination barriers. Currently the most contentious issue is the use of recombinant DNA techniques to produce transgenes that are inserted into genomes. Even newer techniques of modern biotechnology manipulate heritable material without changing DNA.

Biotechnology has always been on the cutting edge of change. Change is rapid, the domains involved are numerous, and there is a significant lack of transparent communication among actors. Hence assessment of modern biotechnology is lagging behind development; information can be anecdotal and contradictory, and uncertainty on benefits and harms is unavoidable. There is a wide range of perspectives on the environmental, human health and economic risks and benefits of modern biotechnology, many of which are as yet unknown.

Conventional biotechnologies, such as breeding techniques, tissue culture, cultivation practices and fermentation are readily accepted and used. Between 1950 and 1980, prior to the development of GMOs, modern varieties of wheat increased yields up to 33% even in the absence of fertilizer. Modern biotechnologies used in containment have been widely adopted; e.g., the industrial enzyme market reached US$1.5 billion in 2000. The application of modern biotechnology outside containment, such as the use of GM crops is much more contentious. For example, data based on some years and some GM crops indicate highly variable 10-33% yield gains in some places and yield declines in others.

Higher level drivers of biotechnology R&D, such as IPR frameworks, determine what products become available. While this attracts investment in agriculture, it can also concentrate ownership of agricultural resources. An emphasis on modern biotechnology without ensuring adequate support for other agricultural research can alter education and training programs and reduce the number of professionals in other core agricultural sciences. This situation can be self-reinforcing since today's students define tomorrow's educational and training opportunities.

The use of patents for transgenes introduces additional issues. In developing countries especially, instruments such as patents may drive up costs, restrict experimentation by the individual farmer or public researcher while also potentially undermining local practices that enhance food security and economic sustainability. In this regard, there is particular concern about present IPR instruments eventually inhibiting seed-saving, exchange, sale and access to proprietary materials necessary for the independent research community to conduct analyses and long term experimentation on impacts. Farmers face new liabilities: GM farmers may become liable for adventitious presence if it causes loss of market certification and income to neighboring organic farmers, and conventional farmers may become liable to GM seed producers if transgenes are detected in their crops.

A problem-oriented approach to biotechnology R&D would focus investment on local priorities identified through participatory and transparent processes, and favor multifunctional solutions to local problems. These processes require new kinds of support for the public to critically engage in assessments of the technical, social, political, cultural, gender, legal, environmental and economic impacts of modern biotechnology. Biotechnologies should be used to maintain local expertise and germplasm so that the capacity for further research resides within the local community. Such R&D would put much needed emphasis onto participatory breeding projects and agroecology.

Climate change

Climate change, which is taking place at a time of increasing demand for food, feed, fiber and fuel, has the potential to irreversibly damage the natural resource base on which agriculture depends. The relationship between climate change and agriculture is a two-way street; agriculture contributes to climate change in several major ways and climate change in general adversely affects agriculture.

In mid- to high latitude regions moderate local increases in temperature can have small beneficial impacts on crop yields; in low-latitude regions, such moderate temperature increases are likely to have negative yield effects. Some negative impacts are already visible in many parts of the world; additional warming will have increasingly negative impacts in all regions. Water scarcity and the timing of water availability will increasingly constrain production. Climate change will require a new look at water storage to cope with the impacts of more and extreme precipitation, higher intra- and inter-seasonal variations, and increased rates of evapotranspiration in all types of ecosystems. Extreme climate events (floods and droughts) are increasing and expected to amplify in frequency and severity and there are likely to be significant consequences in all regions for food and forestry production and food insecurity. There is a serious potential for future conflicts over habitable land and natural resources such as freshwater. Climate change is affecting the distribution of plants, invasive species, pests and disease vectors and the geographic range and incidence of many human, animal and plant diseases is likely to increase.

A comprehensive approach with an equitable regulatory framework, differentiated responsibilities and intermediate targets are required to reduce GHG emissions. The earlier and stronger the cuts in emissions, the quicker concentrations will approach stabilization. Emission reduction measures clearly are essential because they can have an impact due to inertia in the climate system. However, since further changes in the climate are inevitable adaptation is also imperative. Actions directed at addressing climate change and promoting sustainable development share some important goals such as equitable access to resources and appropriate technologies.

Some “win-win” mitigation opportunities have already been identified. These include land use approaches such as lower rates of agricultural expansion into natural habitats; afforestation, reforestation, increased efforts to avoid deforestation, agroforestry, agroecological systems, and restoration of underutilized or degraded lands and rangelands and land use options such as carbon sequestration in agricultural soils, reduction and more efficient use of nitrogenous inputs;

effective manure management and use of feed that increases livestock digestive efficiency. Policy options related to regulations and investment opportunities include financial incentives to maintain and increase forest area through reduced deforestation and degradation and improved management and the development and utilization of renewable energy sources. The post-2012 regime has to be more inclusive of all agricultural activities such as reduced emission from deforestation and soil degradation to take full advantage of the opportunities offered by agriculture and forestry sectors.

Human health

Despite the evident and complex links between health, nutrition, agriculture, and AKST, improving human health is not generally an explicit goal of agricultural policy. Agriculture and AKST can affect a range of health issues including undernutrition, chronic diseases, infectious diseases, food safety, and environmental and occupational health. Ill heath in the farming community can in turn reduce agricultural productivity and the ability to develop and deploy appropriate AKST. Ill health can result from undernutrition, as well as over-nutrition. Despite increased global food production over recent decades, undernutrition is still a major global public health problem, causing over 15% of the global disease burden. Protein energy and micronutrient malnutrition remain challenges, with high variability between and within countries. Food security can be improved through policies and programs to increase dietary diversity and through development and deployment of existing and new technologies for production, processing, preservation, and distribution of food.

AKST policies and practices have increased production and new mechanisms for food processing. Reduced dietary quality and diversity and inexpensive foods with low nutrient density have been associated with increasing rates of worldwide obesity and chronic disease. Poor diet throughout the life course is a major risk factor for chronic diseases, which are the leading cause of global deaths. There is a need to focus on consumers and the importance of dietary quality as main drivers of production, and not merely on quantity or price. Strategies include fiscal policies (taxation, trade regimes) for health-promoting foods and regulation of food product formulation, labeling and commercial information.

Globalization of the food supply, accompanied by concentration of food distribution and processing companies, and growing consumer awareness increase the need for effective, coordinated, and proactive national food safety systems. Health concerns that could be addressed by AKST include the presence of pesticide residues, heavy metals, hormones, antibiotics and various additives in the food system as well as those related to large-scale livestock farming.

Strengthened food safety measures are important and necessary in both domestic and export markets and can impose significant costs. Some countries may need help in meeting food control costs such as monitoring and inspection, and costs associated with market rejection of contaminated commodities. Taking a broad and integrated agroecosystem and human health approach can facilitate identification of animal, plant, and human health risks, and appropriate AKST responses.

Worldwide, agriculture accounts for at least 170,000 occupational deaths each year: half of all fatal accidents. Machinery and equipment, such as tractors and harvesters, account for the highest rates of injury and death, particularly among rural laborers. Other important health hazards include agrochemical poisoning, transmissible animal diseases, toxic or allergenic agents, and noise, vibration and ergonomic hazards. Improving occupational health requires a greater emphasis on health protection through development and enforcement of health and safety regulations. Policies should explicitly address tradeoffs between livelihood benefits, and environmental, occupational and public health risks.

The incidence and geographic range of many emerging and re-emerging infectious diseases are influenced by the intensification of crop and livestock systems. Serious socioeconomic impacts can arise when diseases spread widely within human or animal populations, or when they spill over from animal reservoirs to human hosts. Most of the factors that contribute to disease emergence will continue, if not intensify. Integrating policies and programs across the food chain can help reduce the spread of infectious diseases; robust detection, surveillance, monitoring, and response programs are critical.

Natural resource management

Natural resources, especially those of soil, water, plant and animal diversity, vegetation cover, renewable energy sources, climate, and ecosystem services are fundamental for the structure and function of agricultural systems and for social and environmental sustainability, in support of life on earth. Historically the path of global agricultural development has been narrowly focused on increased productivity rather than on a more holistic integration of NRM with food and nutritional security. A holistic, or systems-oriented approach, is preferable because it can address the difficult issues associated with the complexity of food and other production systems in different ecologies, locations and cultures.

AKST to resolve NRM exploitation issues, such as the mitigation of soil fertility through synthetic inputs and natural processes, is often available and well understood. Nevertheless, the resolution of natural resource challenges will demand new and creative approaches by stakeholders with diverse backgrounds, skills and priorities. Capabilities for working together at multiple scales and across different social and physical environments are not well developed. For example, there have been few opportunities for two-way learning between farmers and researchers or policy makers. Consequently farmers and civil society members have seldom been involved in shaping natural resource management policy. Community-based partnerships with the private sector, now in their early stages of development, represent a new and promising way forward.

The following high priority NRM options for action are proposed:

- Use existing AKST to identify and address some of the underlying causes of declining productivity embedded in natural resource mismanagement, and develop new AKST based on multidisciplinary approaches for a better understanding of the complexity in NRM. Part of this process will involve the cost-effective monitoring of trends in the utilization of natural resource capital.
- Strengthen human resources in the support of natural capital through increased investment (research, training and education, partnerships, policy) in promoting the awareness of the societal costs of degradation and value of ecosystems services.
- Promote research “centers of AKST-NRM excellence” to facilitate less exploitative NRM and better strategies for resource resilience, protection and renewal through innovative two-way learning processes in research and development, monitoring and policy formulation.
- Create an enabling environment for building NRM capacity and increasing understanding of NRM among stakeholders and their organizations in order to shape NRM policy in partnership with public and private sectors.
- Develop networks of AKST practitioners (farmer organizations, NGOs, government, private sector) to facilitate long-term natural resource management to enhance benefits from natural resources for the collective good.
- Connect globalization and localization pathways that link locally generated NRM knowledge and innovations to public and private AKST.

When AKST is developed and used creatively with active participation among various stakeholders across multiple scales, the misuse of natural capital can be reversed and the judicious use and renewal of water bodies, soils, biodiversity, ecosystems services, fossil fuels and atmospheric quality ensured for future generations.

Trade and markets

Targeting market and trade policies to enhance the ability of agricultural and AKST systems to drive development, strengthen food security, maximize environmental sustainability, and help make the small-scale farm sector profitable to spearhead poverty reduction is an immediate challenge around the world.

Agricultural trade can offer opportunities for the poor, but current arrangements have major distributional impacts among, and within, countries that in many cases have not been favorable for small-scale farmers and rural livelihoods. These distributional impacts call for differentiation in policy frameworks and institutional arrangements if these countries are to benefit from agricultural trade. There is growing concern that opening national agricultural markets to international competition before basic institutions and infrastructure are in place can undermine the agricultural sector, with long term negative effects for poverty, food security and the environment.

Trade policy reform to provide a fairer global trading system can make a positive contribution to sustainability and development goals. Special and differential treatment accorded through trade negotiations can enhance the ability of developing countries to pursue food security and development goals while minimizing trade related dislocations. Preserving national policy flexibility allows developing countries to balance the needs of poor consumers (urban and rural landless) and rural small-scale farmers. Increasing the value captured by small-scale farmers in global, regional and local markets chains is fundamental to meeting development and sustainability goals. Supportive trade policies can also make new AKST available to the small-scale farm sector and agroenterprises.

Developing countries would benefit from the removal of barriers for products in which they have a comparative advantage; reduction of escalating tariffs for processed commodities in industrialized and developing countries; deeper preferential access to markets for least developed countries; increased public investment in rural infrastructure and the generation of public goods AKST; and improved access to credit, AKST resources and markets for poor producers. Compensating revenues lost as a result of tariff reductions is essential to advancing development agendas.

Agriculture generates large environmental externalities, many of which derive from failure of markets to value environmental and social harm and provide incentives for sustainability. AKST has great potential to reverse this trend. Market and trade policies to facilitate the contribution of AKST to reducing the environmental footprint of agriculture include removing resource use distorting subsidies; taxing externalities; better definitions of property rights; and developing rewards and markets for agroenvironmental services, including the extension of carbon financing, to provide incentives for sustainable agriculture.

The quality and transparency of governance in the agricultural sector, including increased participation of stakeholders in AKST decision making is fundamental. Strengthening developing country trade analysis and negotiation capacity, and providing better tools for assessing tradeoffs in proposed trade agreements are important to improving governance.

Traditional and local knowledge and community-based innovation

Once AKST is directed simultaneously toward production, profitability, ecosystem services and food systems that are site-specific and evolving, then formal, traditional and local knowledge need to be integrated. Traditional and local knowledge constitutes an extensive realm of accumulated practical knowledge and knowledge-generating capacity that is needed if sustainability and development goals are to be reached. The traditional knowledge, identities and practices of indigenous and local communities are recognized under the UN Convention on Biological Diversity as embodying ways of life relevant for conservation and sustainable use of biodiversity; and by others as generated by the purposeful interaction of material and non-material worlds embedded in place-based cultures and identities. Local knowledge refers to capacities and activities that exist among rural people in all parts of the world.

Traditional and local knowledge is dynamic; it may sometimes fail but also has had well-documented, extensive, positive impacts. Participatory collaboration in knowledge generation, technology development and innovation has been shown to add value to science-based technology development, for instance in Farmer-Researcher groups in the Andes, in Participatory Plant Breeding, the domestication of wild and semi-wild tree species and in soil and water management.

Options for action with proven contribution to achieving sustainability and development goals include collaboration in the conservation, development and use of local and traditional biological materials; incentives for and development of capacity among scientists and formal research organizations to work with local and indigenous people and their organizations; a higher profile in scientific education for indigenous and local knowledge as well as for professional and community-based archiving and assessment of such knowledge and practices. The role of modern Information and Communication Technologies (ICTs) in achieving effective collaboration is critical to evolving culturally appropriate integration and merits larger investments and support. Effective collaboration and integration would be supported by international intellectual property and other regimes that allow more scope for dealing effectively with situations involving traditional knowledge, genetic resources and community-based innovations. Examples of misappropriation of indigenous and local people's knowledge and community-based innovations indicate a need for sharing of information about existing national *sui generis* and regulatory frameworks.

Women in agriculture

Gender, that is socially constructed relations between men and women, is an organizing element of existing farming systems worldwide and a determining factor of ongoing agricultural restructuring. Current trends in agricultural market liberalization and in the reorganization of farm work, as well as the rise of environmental and sustainability concerns are redefining the links between gender and development. The proportion of women in agricultural production and postharvest activities ranges from 20 to 70%; their involvement is increasing in many developing countries, particularly with the development of export-oriented irrigated farming, which is associated with a growing demand for female labor, including migrant workers.

Whereas these dynamics have in some ways brought benefits, in general, the largest proportion of rural women worldwide continues to face deteriorating health and work conditions, limited access to education and control over natural resources, insecure employment and low income. This situation is due to a variety of factors, including the growing competition on agricultural markets which increases the demand for flexible and cheap labor, growing pressure on and conflicts over natural resources, the diminishing support by governments for small-scale farms and the reallocation of economic resources in favor of large agroenterprises. Other factors include increasing exposure to risks related to natural disasters and environmental changes, worsening access to water, increasing occupational and health risks.

Despite progress made in national and international policies since the first world conference on women in 1975, urgent action is still necessary to implement gender and social equity in AKST policies and practices if we are to better address gender issues as integral to development processes. Such action includes strengthening the capacity of public institutions and NGOs to improve the knowledge of women's changing forms of involvement in farm and other rural activities in AKST. It also requires giving priority to women's access to education, information, science and technology, and extension services to enable improving women's access, ownership and control of economic and natural resources. To ensure such access, ownership and control legal measures, appropriate credit schemes, support for women's income generating activities and the reinforcement of women's organizations and networks are needed. This, in turn, depends on strengthening women's ability to benefit from market-based opportunities by institutions and policies giving explicit priority to women farmer groups in value chains.

A number of other changes will strengthen women's contributions to agricultural production and sustainability. These include support for public services and investment in rural areas in order to improve women's living and working conditions; giving priority to technological development policies targeting rural and farm women's needs and recognizing their knowledge, skills and experience in the production of food and the conservation of biodiversity; and assessing the negative effects and risks of farming practices and technology, including pesticides on women's health, and taking measures to reduce use and exposure. Finally, if we are to better recognize women as integral to sustainable development, it is critical to ensure gender balance in AKST decision-making at all levels and provide mechanisms to hold AKST organizations accountable for progress in the above areas.