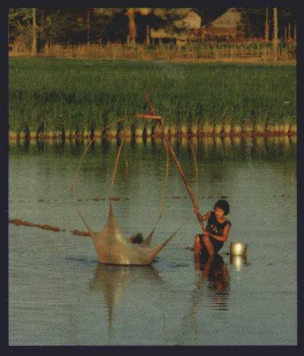
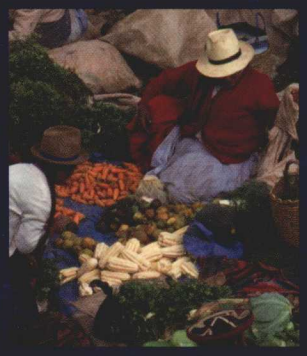
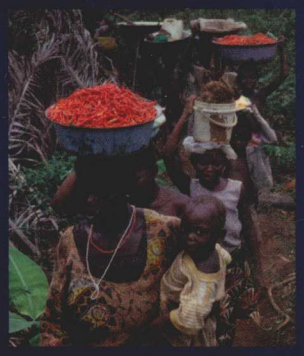
Agriculture at a Crossroads

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



Synthesis Report

IAASTD

International Assessment of Agricultural Knowledge, Science and Technology for Development

Synthesis Report

A Synthesis of the Global and Sub-Global IAASTD Reports

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IAASTD

International Assessment of Agricultural Knowledge, Science and Technology for Development

Synthesis Report

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International Assessment of Agricultural Knowledge, Science and Technology for Development

Foreword

The objective of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) was to assess the impacts of past, present and future agricultural knowledge, science and technology on the:

- reduction of hunger and poverty,
- improvement of rural livelihoods and human health, and
- equitable, socially, environmentally and economically sustainable development.

The IAASTD was initiated in 2002 by the World Bank and the Food and Agriculture Organization of the United Nations (FAO) as a global consultative process to determine whether an international assessment of agricultural knowledge, science and technology was needed. Mr. Klaus Töepfer, Executive Director of the United Nations Environment Programme (UNEP) opened the first Intergovernmental Plenary (30 August-3 September 2004) in Nairobi, Kenya, during which participants initiated a detailed scoping, preparation, drafting and peer review process.

The outputs from this assessment are a Global and five Sub-Global reports; a Global and five Sub-Global Summaries for Decision Makers; and a cross-cutting Synthesis Report with an Executive Summary. The Summaries for Decision Makers and the Synthesis Report specifically provide options for action to governments, international agencies, academia, research organizations and other decision makers around the world.

The reports draw on the work of hundreds of experts from all regions of the world who have participated in the preparation and peer review process. As has been customary in many such global assessments, success depended first and foremost on the dedication, enthusiasm and cooperation of these experts in many different but related disciplines. It is the synergy of these interrelated disciplines that permitted IAASTD to create a unique, interdisciplinary regional and global process.

We take this opportunity to express our deep gratitude to the authors and reviewers of all of the reports—their dedication and tireless efforts made the process a success. We thank the Steering Committee for distilling the outputs of the consultative process into recommendations to the Plenary, the IAASTD Bureau for their advisory role during the assessment and the work of those in the extended Secretariat. We would specifically like to thank the cosponsoring organizations of the Global Environment Facility (GEF) and the World Bank for their financial contributions as well as the FAO, UNEP, and the United Nations Educational, Scientific and Cultural Organization (UNESCO) for their continued support of this process through allocation of staff resources.

We acknowledge with gratitude the governments and organizations that contributed to the Multidonor Trust Fund (Australia, Canada, the European Commission, France, Ireland, Sweden, Switzerland, and the United Kingdom) and the United States Trust Fund. We also thank the governments who provided support to Bureau members, authors and reviewers in other ways. In addition, Finland provided direct support to the Secretariat. The IAASTD was especially successful in engaging a large number of experts from developing countries and countries with economies in transition in its work; the Trust Funds enabled financial assistance for their travel to the IAASTD meetings.

We would also like to make special mention of the Regional Organizations who hosted the regional coordinators and staff and provided assistance in management and time to ensure success of this enterprise: the African Center for Technology Studies (ACTS) in Kenya, the Inter-American Institute for Cooperation on Agriculture (IICA) in Costa Rica, the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, and the WorldFish Center in Malaysia.

The final Intergovernmental Plenary in Johannesburg, South Africa was opened on 7 April 2008 by Achim Steiner, Executive Director of UNEP. This Plenary saw the acceptance of the Reports and the approval of the Summaries for Decision Makers and the Executive Summary of the Synthesis Report by an overwhelming majority of governments.

Signed:

Co-chairs
Hans H. Herren
Judi Wakhungu

Director
Robert T. Watson

Preface

In August 2002, the World Bank and the Food and Agriculture Organization (FAO) of the United Nations initiated a global consultative process to determine whether an international assessment of agricultural knowledge, science and technology (AKST) was needed. This was stimulated by discussions at the World Bank with the private sector and nongovernmental organizations (NGOs) on the state of scientific understanding of biotechnology and more specifically transgenics. During 2003, eleven consultations were held, overseen by an international multistakeholder steering committee and involving over 800 participants from all relevant stakeholder groups, e.g., governments, the private sector and civil society. Based on these consultations the steering committee recommended to an Intergovernmental Plenary meeting in Nairobi in September 2004 that an international assessment of the role of AKST in reducing hunger and poverty, improving rural livelihoods and facilitating environmentally, socially and economically sustainable development was needed. The concept of an International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) was endorsed as a multithematic, multi-spatial, multi-temporal intergovernmental process with a multistakeholder Bureau cosponsored by the FAO, the Global Environment Facility (GEF), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Bank and World Health Organization (WHO).

The IAASTD's governance structure is a unique hybrid of the Intergovernmental Panel on Climate Change (IPCC) and the nongovernmental Millennium Ecosystem Assessment (MA). The stakeholder composition of the Bureau was agreed at the Intergovernmental Plenary meeting in Nairobi; it is geographically balanced and multistakeholder with 30 government and 30 civil society representatives (NGOs, producer and consumer groups, private sector entities and international organizations) in order to ensure ownership of the process and findings by a range of stakeholders.

About 400 of the world's experts were selected by the Bureau, following nominations by stakeholder groups, to prepare the IAASTD Report (comprised of a Global and five Sub-Global assessments). These experts worked in their own capacity and did not represent any particular stakeholder group. Additional individuals, organizations and governments were involved in the peer review process.

The IAASTD development and sustainability goals were endorsed at the first Intergovernmental Plenary and are consistent with a subset of the UN Millennium Development Goals (MDGs): the reduction of hunger and poverty, the improvement of rural livelihoods and human health, and facilitating equitable, socially, environmentally and economically sustainable development. Realizing these goals requires acknowledging the multifunctionality of agriculture: the challenge is to simultaneously meet development and sustainability goals while increasing agricultural production.

Meeting these goals has to be placed in the context of a rapidly changing world of urbanization, growing inequities, human migration, globalization, changing dietary preferences, climate change, environmental degradation, a trend toward biofuels and an increasing population. These conditions are affecting local and global food security and putting pressure on productive capacity and ecosystems. Hence there are unprecedented challenges ahead in providing food within a global trading system where there are other competing uses for agricultural and other natural resources. AKST alone cannot solve these problems, which are caused by complex political and social dynamics, but it can make a major contribution to meeting development and sustainability goals. Never before has it been more important for the world to generate and use AKST.

Given the focus on hunger, poverty and livelihoods, the IAASTD pays special attention to the current situation, issues and potential opportunities to redirect the current AKST system to improve the situation for poor rural people, especially small-scale farmers, rural laborers and others with limited resources. It addresses issues critical to formulating policy and provides information for decision makers confronting conflicting views on contentious issues such as the environmental consequences of productivity increases, environmental and human health impacts of transgenic crops, the consequences of bioenergy development on the environment and on the long-term availability and price of food, and the implications of climate change on agricultural production. The Bureau agreed that the scope of the assessment needed to go beyond the narrow confines of science and technology (S&T) and should encompass other types of relevant knowledge (e.g., knowledge held by agricultural producers, consumers and end users) and that it should also assess the role of institutions, organizations, governance, markets and trade.

The IAASTD is a multidisciplinary and multistakeholder enterprise requiring the use and integration of information, tools and models from different knowledge paradigms including local and traditional knowledge. The IAASTD does not advocate specific policies or practices; it assesses the major issues facing AKST and points towards a range of AKST

options for action that meet development and sustainability goals. It is policy relevant, but not policy prescriptive. It integrates scientific information on a range of topics that are critically interlinked, but often addressed independently, i.e., agriculture, poverty, hunger, human health, natural resources, environment, development and innovation. It will enable decision makers to bring a richer base of knowledge to bear on policy and management decisions on issues previously viewed in isolation. Knowledge gained from historical analysis (typically the past 50 years) and an analysis of some future development alternatives to 2050 form the basis for assessing options for action on science and technology, capacity development, institutions and policies, and investments.

The IAASTD is conducted according to an open, transparent, representative and legitimate process; is evidence-based; presents options rather than recommendations; assesses different local, regional and global perspectives; presents different views, acknowledging that there can be more than one interpretation of the same evidence based on different worldviews; and identifies the key scientific uncertainties and areas on which research could be focused to advance development and sustainability goals.

The IAASTD is composed of a Global assessment and five Sub-Global assessments: Central and West Asia and North Africa (CWANA); East and South Asia and the Pacific (ESAP); Latin America and the Caribbean (LAC); North America and Europe (NAE); Sub-Saharan Africa (SSA). It (1) assesses the generation, access, dissemination and use of public and private sector AKST in relation to the goals, using local, traditional and formal knowledge; (2) analyzes existing and emerging technologies, practices, policies and institutions and their impact on the goals; (3) provides information for decision makers in different civil society, private and public organizations on options for improving policies, practices, institutional and organizational arrangements to enable AKST to meet the goals; (4) brings together a range of stakeholders (consumers, governments, international agencies and research organizations, NGOs, private sector, producers, the scientific community) involved in the agricultural sector and rural development to share their experiences, views, understanding and vision for the future; and (5) identifies options for future public and private investments in AKST. In addition, the IAASTD will enhance local and regional capacity to design, implement and utilize similar assessments.

In this assessment agriculture is used to include production of food, feed, fuel, fiber and other products and to include all sectors from production of inputs (e.g., seeds and fertilizer) to consumption of products. However, as in all assessments, some topics were covered less extensively than others (e.g., livestock, forestry, fisheries and the agricultural sector of small island countries, and agricultural engineering), largely due to the expertise of the selected authors. Originally the Bureau approved a chapter on plausible futures (a visioning exercise), but later there was agreement to delete this chapter in favor of a more simple set of model projections. Similarly the Bureau approved a chapter on capacity development, but this chapter was dropped and key messages integrated into other chapters.

The IAASTD draft Report was subjected to two rounds of peer review by governments, organizations and individuals. These drafts were placed on an open access web site and open to comments by anyone. The authors revised the drafts based on numerous peer review comments, with the assistance of review editors who were responsible for ensuring the comments were appropriately taken into account. One of the most difficult issues authors had to address was criticisms that the report was too negative. In a scientific review based on empirical evidence, this is always a difficult comment to handle, as criteria are needed in order to say whether something is negative or positive. Another difficulty was responding to the conflicting views expressed by reviewers. The difference in views was not surprising given the range of stakeholder interests and perspectives. Thus one of the key findings of the IAASTD is that there are diverse and conflicting interpretations of past and current events, which need to be acknowledged and respected.

The Global and Sub-Global Summaries for Decision Makers and the Executive Summary of the Synthesis Report were approved at an Intergovernmental Plenary in April 2008. The Synthesis Report integrates the key findings from the Global and Sub-Global assessments, and focuses on eight Bureau-approved topics: bioenergy; biotechnology; climate change; human health; natural resource management; traditional knowledge and community based innovation; trade and markets; and women in agriculture.

The IAASTD builds on and adds value to a number of recent assessments and reports that have provided valuable information relevant to the agricultural sector, but have not specifically focused on the future role of AKST, the institutional dimensions and the multifunctionality of agriculture. These include: FAO State of Food Insecurity in the World (yearly); InterAcademy Council Report: Realizing the Promise and Potential of African Agriculture (2004); UN Millennium Project Task Force on Hunger (2005); Millennium Ecosystem Assessment (2005); CGIAR Science Council Strategy and Priority Setting Exercise (2006); Comprehensive Assessment of Water Management in Agriculture: Guiding Policy Investments in Water, Food, Livelihoods and Environment (2007); Intergovernmental Panel on Climate Change Reports (2001 and 2007); UNEP Fourth Global Environmental Outlook (2007); World Bank World Development Report: Agriculture for Development (2008); IFPRI Global Hunger Indices (yearly); and World Bank Internal Report of Investments in SSA (2007).

Financial support was provided to the IAASTD by the cosponsoring agencies, the governments of Australia, Canada, Finland, France, Ireland, Sweden, Switzerland, US and UK, and the European Commission. In addition, many organizations have provided in-kind support. The authors and review editors have given freely of their time, largely without compensation.

The Global and Sub-Global Summaries for Decision Makers and the Synthesis Report are written for a range of stakeholders, i.e., government policy makers, private sector, NGOs, producer and consumer groups, international organizations and the scientific community. There are no recommendations, only options for action. The options for action are not prioritized because different options are actionable by different stakeholders, each of whom have a different set of priorities and responsibilities and operate in different socioeconomic and political circumstances.

Contents

Executive Summary of the Synthesis Report

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Statement by Governments on Executive Summary

All countries present at the final intergovernmental plenary session held in Johannesburg, South Africa in April 2008 welcome the work of the IAASTD and the uniqueness of this independent multistakeholder and multidisciplinary process, and the scale of the challenge of covering a broad range of complex issues. The Governments present recognize that the Global and Sub-Global Reports are the conclusions of studies by a wide range of scientific authors, experts and development specialists and while presenting an overall consensus on the importance of agricultural knowledge, science and technology for development they also provide a diversity of views on some issues.

All countries see these Reports as a valuable and important contribution to our understanding on agricultural knowledge, science and technology for development recognizing the need to further deepen our understanding of the challenges ahead. This Assessment is a constructive initiative and important contribution that all governments need to take forward to ensure that agricultural knowledge, science and technology fulfils its potential to meet the development and sustainability goals of the reduction of hunger and poverty, the improvement of rural livelihoods and human health, and facilitating equitable, socially, environmentally and economically sustainable development.

In accordance with the above statement, the following governments approve the Executive Summary of the Synthesis Report.

Armenia, Azerbaijan, Bahrain, Bangladesh, Belize, Benin, Bhutan, Botswana, Brazil, Cameroon, People's Republic of China, Costa Rica, Cuba, Democratic Republic of Congo, Dominican Republic, El Salvador, Ethiopia, Finland, France, Gambia, Ghana, Honduras, India, Iran, Ireland, Kenya, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Libyan Arab Jamahiriya, Maldives, Republic of Moldova, Mozambique, Namibia, Nigeria, Pakistan, Panama, Paraguay, Philippines, Poland, Republic of Palau, Romania, Saudi Arabia, Senegal, Solomon Islands, Swaziland, Sweden, Switzerland, United Republic of Tanzania, Timor-Leste, Togo, Tunisia, Turkey, Uganda, United Kingdom of Great Britain, Uruguay, Viet Nam, Zambia (58 countries).

While approving the above statement the following governments did not fully approve the Executive Summary of the Synthesis Report and their reservations are entered in the Annex to the Executive Summary.

Australia, Canada, United States of America (3 countries).

Executive Summary of the Synthesis Report of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD)

This Synthesis Report captures the complexity and diversity of agriculture and agricultural knowledge, science and technology (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? 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 eight cross-cutting themes. 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.

The International Assessment of Agricultural Knowledge, 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 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 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 (1) current social and economic inequities and political uncertainties about war and conflicts; (2) uncertainties about the ability to sustainably produce and access sufficient food; (3) uncertainties about the future of world food prices; (4) changes in the economics of fossil-based energy use; (5) the emergence of new competitors for natural resources; (6) increasing chronic diseases that are partially a consequence of poor nutrition and poor food quality as well as food safety; and (7) 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 acknowledgment 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 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; (1) multiple commodity and non-commodity outputs are jointly produced by agriculture; and (2) 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 nonexistent.

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.[1] 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.[2] 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.

[1] Botswana.

[2] USA.

> *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.[3]
>
> [3] UK.

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.

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 post-harvest pest management; and increasing small-scale farm diversification. Policy options for addressing food security include developing high-value and underutilized 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 integrated pest management (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 the 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 reemerging 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. Additional 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 for 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 (ur-

ban 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 information and communication technologies (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 development and sustainability 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 greenhouse gas (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 life-cycle 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 [4]

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 these risks 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 genetically modified organisms (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 genetically modified (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 research and development (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

[4] China and USA.