

environmentally sustainable without sacrificing yield, overcome high marketing costs thus enabling them to harness their market potential.

Gender: Women, who play a critical role in agriculture in most developing countries must be empowered. Gender and social equity in AKST policies and practices is critically important and women must be involved in decision-making. Realizing the potential of women in agriculture requires strengthening public institutions and NGOs to understand the changing roles of women as well as their access, *inter-alia*: (i) to education; (ii) to market and S&T information; and (iii), ownership and control of economic and natural resources. This can be accomplished through legal measures, appropriate credit schemes, support for women's income generating activities, reinforcement of women's organizations and networks, and providing explicit priority to women's farmers groups in value-added chains so that they can benefit from market-based opportunities.

Trade: There is an urgent need to reduce and eliminate trade distorting subsidies and support the development of basic institutions and infrastructure prior to opening national agricultural markets to international competition otherwise there can be long-term negative effects for poverty, food security and the environment. The challenge is to make small-scale farmers profitable and benefit from an equitable trade regime. While trade can be beneficial to the poor, it will, however, require: (i) differentiation in policy frameworks and institutional arrangements; (ii) national policy flexibility in order to assist the small-scale sector; (iii) removal of barriers for exports where developing countries have a competitive advantage; (iv) reduction of escalating tariffs between developed and developing countries, and between developing countries for processed commodities; and (v) deep preferential access to markets for LDCs. These trade reforms need to be accompanied by increased access to credit for small-scale farmers, increased public investment in rural infrastructure and public goods, removal of resource-use distorting subsidies, taxes on environmental and social externalities, addressing property rights and payments to farmers for ecosystem services, e.g., carbon sequestration.

R&D: Increased public sector investment in R&D and extension services has a high economic pay-off and is urgently needed in many developing countries where investments to date are inadequate. In addition, there is a need to stimulate private sector investments. AKST is needed to reduce production costs in order to make food affordable to the consumer and profitable for the farmer, while being environmentally and socially sustainable.

The Challenge: The overall challenge is to double agricultural production during the next 25-50 years to meet the increased demand based on projected demographic and economic changes, as well as reducing post-harvest loss. The food needs to be nutritious, affordable and safe and produced in an environmentally and socially sustainable manner. The challenge is to meet this increased demand at a time of:

- Increased competition for water from other sectors and a changing climate;
- Increased competition for land from biofuels and infrastructure;
- land policy conflicts;
- less labor due to endemic diseases, e.g., malaria, HIV-AIDS, and rural to urban migration;
- less biodiversity at the genetic, species and ecosystem levels;
- local and regional air pollution, e.g., tropospheric ozone and acid deposition; and
- climate change – changes in temperature, precipitation, sea level, extreme weather events such as floods, droughts and heat waves represent a major challenge, especially in the tropics and sub-tropics, where hunger is prevalent today. Crops, forests, livestock and fisheries are all projected to be impacted, most negatively. Hence, advances in AKST are needed to develop temperature, drought, pest and salinity tolerant crops and trees, and address the issue of emerging animal diseases.

Conclusion: Business-as-usual will not work. We need to build upon the successes of the past and avoid the mistakes – to summarize the key messages:

- agriculture must be viewed as multi-functional;
- there is a need for increased emphasis on agro-ecological approaches and use of appropriate technologies;
- support the small-scale farmer, through policies and investments;
- empower women;
- integrate local and traditional knowledge with formal knowledge;
- equitable trade reform with national flexibility; and
- increased investments in R&D and extension services.

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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, on-farm biodiversity, nutrient, pest

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.

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

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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 u0.11&d-8nr[(c6(in scie6(alvhawT7 Td(ac AKST)6(

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 gene

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

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;

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

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 health 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

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.