A REGIONAL RICE STRATEGY FOR SUSTAINABLE FOOD SECURITY IN ASIA AND THE PACIFIC

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A regional rice strategy for sustainable food security in Asia and the Pacific

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FOREWORD

The 31st Session of the FAO Regional Conference for Asia and the Pacific (APRC) held in Hanoi in March 2012 called upon FAO to coordinate the development of a rice strategy for the region. This call was made in the backdrop of the food crisis of 2007/08 and increased attention being paid to the development of the rice sector by national governments and international agencies.

To respond to the call, the FAO Regional Office for Asia and the Pacific (RAP) formed a special task force to formulate a rice strategy through the mobilization of its internally available technical expertise as well as an advisory group of eminent experts called "The External Rice Advisory Group (ERAG)." The ERAG met twice during 2013 to provide neutral and unbiased advice to the task force for the preparation of the rice strategy.

It is recognized that rice strategies and policies are country-specific. However, given the increasing interlinkages among sectors and countries, a national strategy is best formulated when guided by insights and parameters identified within a framework on regional and global assessments of the situation and outlook. A single regional rice strategy does not capture the diversity that exists in rice production systems and policy priorities across countries in this large and diverse region.

The main aim of this strategy document is to provide evidence-based strategic guidelines to member nations to help them (1) develop and adjust their rice sector strategies in the light of broader regional and global trends and national priorities and (2) choose among key strategic options while considering the implied trade-offs (or consequences). The outputs are presented in the form of strategic options and the implied trade-offs (or consequences) instead of being prescriptive. The intention is to enrich the strategy and policy formulation deliberations of member countries for achieving sustainable food security.

The formulation of this regional rice strategy required contributions from various experts and specialists. First, I would like to thank the ERAG members for their valuable suggestions and guidance:

- Professor M.S. Swaminathan, Emeritus Chairman and Chief Mentor of the M.S. Swaminathan Research Foundation, who served as ERAG Chair
- Dr Shenggen Fan, Director General of the International Food Policy Research Institute (IFPRI)
- Dr Bruce J. Tolentino, Deputy Director General for Communication and Partnerships, of the International Rice Research Institute (IRRI)
- Dr Peter McCormick, Deputy Director General of the International Water Management Institute (IWMI)
- Dr Lourdes Adriano, Advisor and Practice Leader – Agriculture, Food Security and Rural Development, Asian Development Bank (ADB)
- Dr Hoonae Kim, Director of the Asia and Pacific Division, International Fund for Agricultural Development (IFAD)
- Dr Patrick Labaste, Sector Leader for Agriculture and Rural Development, World Bank
- Dr Apichart Pongsrihadulchai, Advisor to the Minister for Agriculture and Cooperatives in Thailand
- Dr Yang SaingKoma, a representative of Civil Society Organizations (CSOs), i.e. Asian Farmers' Association for Sustainable Rural Development (AFA) and the Cambodian Center for Study and Development in Agriculture (CEDAC)
- Dr Peter Timmer, Thomas D. Cabot Professor of Development Studies, emeritus, Harvard University

In addition, other experts who directly made contributions during ERAG meetings were Dr Sanmugam Prathapar, IWMI Theme Leader on Productive Water Use; Dr Vijai Pal Singh, Ex-Principal Scientist of the India Agricultural Research Institute and Director (Crops and Research) of the All India Rice Exporters Association; Dr He Changchui, former FAO Deputy Director-General Operations; and Dr Ren Wang, Assistant Director-General of the Agriculture and Consumer Protection Department, FAO headquarters in Rome.

An earlier draft of this strategy document was presented to representatives of member states and development partners, including participants from some 18 countries in the region, during the "Consultative Meeting on Rice Strategy for Asia and the Pacific" in Pattaya, Bangkok, on 28 January. The workshop endorsed the strategy document while making some suggestions for improving the previous draft. I am grateful for the valuable comments and suggestions offered by them during the workshop and subsequently.

I wish to express my gratitude to Dr R.B. Singh, former RAP Assistant Director-General/Regional Representative, for his guidance and leadership given to the internal special task force as team leader with support from Ramesh Sharma, RAP technical focal point, and Naoki Minamiguchi, RAP operational focal point/ERAG secretary.

I would also like to acknowledge the contributions made by the RAP staff who prepared several thematic papers, made presentations during ERAG meetings and reviewed earlier drafts of this document, namely, Purushottam Mudbhary, Subash Dasgupta, Bui Ba Bong, Thierry Facon, ChungTe Tzou, Rosa Rolle, Shashi Sareen, Ralph Houtman, Sumiter Broca, Simmathiri Appanah and David Dawe.

Finally, I wish to convey my special thanks to Dr Sushil Pandey, Senior FAO Consultant, for drafting this document in consultation with the ERAG experts and RAP staff and for undertaking revisions.

I sincerely hope that this strategy will serve as a usual document to member states, help them to develop or adjust their rice strategy, and promote the contribution of the rice sector to global food security.

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FAO Regional Office for Asia and the Pacific

ACRONYMS

ADB	Asian Development Bank
AFA	Asian Farmers' Association for Sustainable Rural Development
AFSIS	ASEAN Food Security Information System
AMIS	Agricultural Market Information Systems
APRC	Asia Pacific Regional Conference
APTERR	ASEAN Plus Three Emergency Rice Reserve
ASEAN	Association of South East Asian Nations
ATIGA	ASEAN Trade in Goods Agreement
AWD	Alternate wetting and drying
CEDAC	Cambodian Center for Study and Development in Agriculture
CSOs	Civil Society Organizations
CSRFS	Climate-Smart Rice Farming Systems
ERAG	Expert Rice Advisory Group
GAP	Good Agricultural Practices
GIAHS	Globally Important Agricultural Heritage Systems
GI	Geographical Indicators
GMP	Good Manufacturing Practices
GMS	Greater Mekong Sub-region
GRiSP	Global Rice Science Partnership
ICT	Information and communication technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMT	Irrigation management transfer
IPM	Integrated pest management
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
NARES	National agricultural research and extension systems
NGO	Non-government organization
NTB	Non-trade barriers
PIC	Pacific Island countries
PIM	Participatory irrigation management
REO	Regional Economic Organizations
SAARC	South Asian Association for Regional Cooperation

SAFTA	South Asian Free Trade Area
SIRP	Sustainable intensification of rice production
SPS	Sanitary and phyto-sanitary
SRI	System of Rice Intensification
SSC	South-South Cooperation
SSNM	Site-specific nutrient management
TRQ	Tariff Rate Quota
UNESCO	United Nations Educational, Scientific and Cultural Organization
URAA	Uruguay Round Agreement on Agriculture
WTO	World Trade Organization

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EXECUTIVE SUMMARY

The setting

In 2012, FAO member states in the Asia-Pacific region, on the occasion of the 31st Session of the FAO Regional Conference for Asia and the Pacific (APRC) convened in Hanoi, Viet Nam, requested the Organization to coordinate the formulation of a regional rice strategy. This request was the culmination of increasing discussions within and outside FAO, notably in Asia and especially in the wake of the food crisis of 2007/08, on a number of prospective issues surrounding rice, ranging from productivity and resource use efficiency to policy, trade and the future demand outlook.

It is important to recognize that although rice strategies and policies are country-specific, national strategy is best formulated when guided by insights and parameters identified within a framework on regional and global assessment of the situation and outlook. This is important in view of the increasing interlinkages of the various factors that affect rice sector and the economy as well as national and regional food security. A single regional rice strategy does not capture the diversity that exists in rice production systems and policy priorities across countries in this large and diverse region. However, several aspects related to trade policy, regional cooperation, managing price volatility and technology development can benefit from a common framework. Beyond these common areas, it would be more useful to consider policy/strategies in the context of country-specific situations.

A special task force was formed for this purpose by the FAO Regional Office for Asia and the Pacific by mobilizing internally available technical expertise, and an advisory group of eminent experts was constituted. The Expert Rice Advisory Group (ERAG) met twice to provide advice to the task force for the preparation of the rice strategy.

The main aim of the strategy document is to provide evidence-based strategic guidelines to member nations to help them (1) develop/adjust their rice sector strategies in the light of broader regional/global trends and national priorities and (2) choose among key strategic options while considering the implied trade-offs (or consequences). The outputs are presented in the form of strategic options and the implied trade-offs (or consequences) instead of being prescriptive. The intention is to enrich the strategy and policy formulation processes of member nations for achieving sustainable food security.

Challenges and opportunities in regional rice sector development

Rice is the staple of Asia and it is central to the food security of about half of the world population. Asia accounts for more than 90 percent of world rice production and consumption. Rice production is an important source of livelihood for around 140 million rice-farming households and for millions of rural poor who work on rice farms as hired labour. It is a strategic commodity as the overall economic growth and political stability of the region depend on an adequate, affordable and stable supply of this staple crop. Despite the substantial increase in rice production in the wake of the Green Revolution, important challenges remain in ensuring an adequate and stable supply of this important commodity affordably to poor consumers. Major challenges are the need to produce more rice to meet the rising demand driven by population growth despite slower growth or even a decline in per capita consumption in some countries; deceleration in the growth of rice yield; environmental degradation associated with intensive rice production; a decline in rice biodiversity and loss of rice heritage; global climate change; increasing competition for land, labour and water from industrial and urban sectors; changes in dietary composition with income growth and urbanization; and changes in the demographic composition of labour in rural areas. Similarly, achieving stability in rice price is an important challenge in the context of transmission of shocks due to the increased interconnectedness of rice with other sectors and instability in trade policies of the major exporting countries.

Despite these challenges, several new opportunities exist to increase the impact of the rice sector in enhancing food security and reducing hunger, malnutrition and poverty. Modern scientific approaches and new technologies are making it possible to increase rice productivity in a sustainable manner, add nutritive value to rice, reduce losses from drought and flood, reduce the environmental footprint of rice production and make the rice production system "climate-smart." Similarly, new opportunities are now available for enhancing rice value chains, reducing post-harvest losses, adding value through secondary processing and ensuring higher quality and safety of rice and rice products. Regional networks for the sharing of rice technology and market information are being established to raise productivity and stabilize the market supply through improved trading arrangements.

Overall, the major strategic issues for the region now are how to modernize and transform the rice sector, given the various challenges. Asian economies are undergoing transformation and there is now a clear need and major opportunities for the rice sector also to transform itself. As opposed to the business-as-usual approach, forward-looking and innovative solutions must be found for a major strategic re-orientation of the rice sector.

A vision for the rice sector

Given these challenges and opportunities, a vision statement is needed to guide the strategic re-orientation of the rice sector. The vision for the rice sector is that of *"food-secure, better- nourished and prosperous rice farmers and consumers in the Asia-Pacific region who benefit equitably from a vibrant, innovative and transformed rice sector that is more productive, efficient and environmentally sustainable by 2030."*

Implicit in this vision statement is the role of Asia in improving world food security as Asia is a net exporting region accounting for 70 percent of world rice exports. The traded volume of rice is small and accounts for only about 7 percent of total world consumption. Nevertheless, trade plays an important role in enhancing the food security of importing countries, including those within the region itself. As Africa is currently a major destination for Asian rice exports, the food security of Africa at least in the near term will depend on Asia's ability to maintain its exportable surplus, although production within Africa is likely to increase over time.

Global rice demand and trade outlook

Various outlooks for 2030 indicate the global demand for rice to be in the range of 503-544 million metric tonnes. This is equivalent to the average growth rate of approximately 1 percent per year relative to total consumption of 439 million tonnes in 2010. This demand growth is driven mainly by the growth in population although the changing consumption pattern also has an influence. Asian rice consumption is projected to account for close to two-thirds of this total increase in demand by 2030. Additional demand will arise from export markets and the projected increase in exports from Asia in 2022 relative to 2013 is in the range of 5-7 million tonnes, with additional imports into Africa being 2-3 million tonnes. Overall, the trade outlook for 2022 is of world rice trade of about 46 million tonnes which represents an expansion of 8-9 million tonnes relative to the projection for 2013.

This outlook highlights the need to intensify rice production in Asia to meet the rising demand as the possibility of expanding the area is limited. The projected yield growth required for meeting the increasing demand is 1.2-1.5 percent per year taking into account the likely future reductions in rice area arising from competition for land from other uses. This projected growth rate is higher than the growth rate of rice yields in the late 1990s and early 2000s.

Strategic objectives

The following six strategic objectives are derived from the vision, given the outlook scenario:

Objective 1 (O1): Increase the productivity and nutrition value of rice sustainably to meet the increasing global demand (**Increase productivity, nutrition value and sustainability**).

Objective 2 (O2): Enhance the rice value chain by improving food quality, diversity and food safety while reducing post-harvest losses (**Enhance value chain and reduce post-harvest losses**).

Objective 3 (O3): Improve mitigation/adaptation of rice farming to climate change and improve farmers' capacity to cope with risk (**Mitigate/adapt to climate change and reduce risk**).

Objective 4 (O4): Minimize the environmental footprint of rice production and enhance the ecosystem functions of rice landscapes, including the protection/promotion of rice heritage and culture and landscape management (**Conserve environment and heritage**).

Objective 5 (O5): Improve the efficiency, reliability and fairness of domestic and international rice markets for stabilizing rice price and supply, ensuring equitable access by the poor and promoting regional collaboration (**Promote fair and efficient market and trade**).

Objective 6 (O6): Enhance the well-being and livelihoods of smallholders, women and the new generation of rice producers by improving adjustments to long-term changes in demography, farm size and labour supply (**Improve organization of production, and empower youth and women**).

It is to be noted that these six strategic objectives are not independent of each other and interlinkages result in complementarities and trade-offs. This is especially the case with Objective 6 regarding adjustments in the organization of production. The adjustment path followed will affect technology adoption, input use and the nature of the value chain, which in turn affects the pace of adjustment. The basic idea is to identify win-win options when possible while taking explicit account of the trade-offs when national development goals indicate certain specific priorities across these objectives.

Key themes and options

Various technological and policy options are available for making progress towards achieving the strategic objectives listed above but the choice of one or a combination of options may result in certain trade-offs (or consequences). It is important that member nations be aware of not only the options but also the associated trade-offs while choosing among the options. The relative priorities among objectives may vary across countries depending on their national development goals and these relative priorities determine the choice of options.

Various technological and policy options are covered under the following 11 broad thematic areas:

- Sustainable intensification of rice production
- Climate change mitigation/adaptation and risk management
- Environment and rice heritage
- Water and irrigation
- Smallholder farmers and farmer organizations
- Gender roles and empowerment of youth and women
- Food quality, safety and nutrition
- Value chains and post-harvest operations

- Policies on rice price, trade and stock
- Regional cooperation on rice
- Food and nutrition security in Pacific Island countries (PICs)

The main text presents a detailed analysis of these key themes, options and trade-offs implied in the choice of various options. The summary below highlights some key points under each theme.

Sustainable intensification of rice production

The major technological options for various rice ecosystems (irrigated, rainfed lowland, upland and coastal) can be grouped into three types: those that are related to improved rice varieties, those that involve better management of the crop and inputs and those that involve changes at the cropping/farming systems level. A sustainable intensification of rice production involves the integration of technologies of genetic and agronomic improvement as well as mechanization into an ecosystems approach to achieve higher productivity, profitability and resource use efficiency, while protecting and even enhancing the environment.

The promising rice technological options that are ready or near ready for farmer adoption include a new generation of hybrid varieties with higher yield potential and new inbred varieties with multiple tolerance of abiotic (drought/submergence/salinity) and biotic stresses. Similarly, crop and resource management practices designed to improve input use efficiency, save input costs and reduce the environmental footprint of irrigated rice production include site-specific nutrient management (SSNM), integrated pest management (IPM) and water-saving technologies such as alternate wetting and drying (AWD) and aerobic rice systems. Some trade-offs are likely to be involved, however, in the use of these technologies. For example, AWD may save field-level water use but this can result in a higher use of agro-chemicals (herbicides) for controlling a potential increase in weed infestation. It may lead to increased emission of nitrous oxide – a potent greenhouse gas. AWD may also reduce the environmental services provided by wetland paddies.

At the cropping systems level, a number of options such as rice-fish, rice-livestock, rice-legume, rice-wheat and rice-millet systems could be suitable depending on the rice production environment. Such systems can provide income and balanced nutritional outcome to farmers. Opportunities also exist for "green" or "organic" products that have clear market niches.

The Regional Rice Initiative (RRI), a pilot initiative implemented in 2013 under FAO Strategic Objective 2, field-tested some practices for the sustainable intensification of rice production in three Asian countries. The RRI can be considered, in synergy with the regional rice strategy, as a vehicle to test technical options with small farmers and national governments.

Climate change mitigation/adaptation and risk management

The major options for climate change mitigation and adaptation are rice varieties that are tolerant of multiple stresses such as drought, submergence, salinity, insects/diseases and high temperature. Similarly, cropping systems changing from double rice cropping to a rice-wheat rotation, rice-legume or rice-upland crops may be suitable. Mitigation options include the AWD method of irrigation to reduce the emission of methane, site- and season-specific nutrient management to reduce the emission of nitrous oxide and the use of rice straw for energy generation and as animal feed instead of burning in open fields. The trade-offs in the use of these practices involve balancing the emission of various greenhouse gases (carbon dioxide, methane and nitrous oxide) while increasing crop water productivity as methane is emitted under flooded field conditions, but more nitrous oxide is emitted when rice fields are partially dried.

Options that improve risk management in rice production include timely and reliable weather forecasts, improved access to institutional credit, crop insurance, policies that promote crop and income diversification in rural areas and increased trade to even out rice surpluses and deficits across countries and regions.

Environment and rice heritage

The protection of the rice environment and heritage is a type of ecosystem service provided by rice fields. However, the intensification of rice systems based on excessive and improper use of agro-chemicals and other related practices has resulted in a negative environmental footprint. These and other broader economic and social changes are also negatively affecting rice biodiversity and rice heritage, which are important for the long-term sustainability of rice production. Major options to overcome these problems include integrated pest and nutrient management practices, landscape/community-level interventions for watershed protection, protection of important heritage sites, promotion of ecotourism and the development of marketable rice products with "cultural identity." Equally important is to make the best use of existing international tools, such as Globally Important Agricultural Heritage Systems (GIAHS), to promote agricultural heritages, and to apply the concept of Geographical Indicators (GI) to ensure the quality and origin of agricultural and agro-food products.

Water and Irrigation

Water is a critically important resource for rice production. However, water availability for rice production is becoming scarcer both physically and economically. In addition, deterioration of water quality because of agro-chemical load and other contaminants is an increasing concern. Major options for rice production include improved on-farm water management for raising crop water productivity, modernization of irrigation systems and the conjunctive use and management of surface water and groundwater. Water harvesting and more effective use of rainwater are some of the key options for rainfed areas.

Smallholder farmers and farmer organizations

Given the small average farm size in several major rice-growing countries in Asia, rice production is likely to be carried out mainly by smallholders in the near term despite the underlying pressure for an expansion of farm size. For efficiency, smallholder farmers need to be able to reap the benefit of scale in production and marketing by being organized in institutions that reduce transaction costs and increase overall efficiency. Such institutions include group farming, contract farming, community organizations and farmer cooperatives. Capacity building and empowerment of such farmer organizations and farmer groups are hence needed to increase the efficiency of smallholder agriculture and to connect smallholders effectively with the market for income generation.

Gender roles and empowerment of youth and women

Women not only provide labour for rice farming but they also play a far more important intellectual role in all aspects of rice cultivation, consumption, conservation and commerce. Given this, food and nutrition security in the future will depend in important ways on ensuring that gender roles are well integrated into food security systems. Major options to mainstream gender roles and empower women include mechanization to reduce drudgery and increase women's labour productivity, targeted training programs to improve women's capacity to make managerial decisions, tertiary and vocational education programs for women, the promotion of women's participation in demonstration trials and farmer meetings and the development of programs that incorporate the special roles of women in food security systems.

Food quality, safety and nutrition

Food quality, safety and nutritional value are important considerations, especially for modern health-conscious consumers. Various options available for improving the quality, safety and nutritional value of rice are biofortification (such as Golden Rice), rice fortification, improving the yield of high-quality traditional varieties through breeding, improvements in milling technologies, the promotion of healthy rice products such as brown rice, rice bran and bran oil, the use of processing technologies such as parboiling to conserve nutrients and compliance with food safety standards.

Value chains and post-harvest operations

Tremendous opportunities exist for improving food quality, diversity and safety as well as reducing post-harvest losses through enhancements of rice value chains. Rice value chains may be traditional or modern export chains. Traditional value chains are characterized by a low level of vertical integration and coordination, with rice being mostly locally processed and consumed within the local production areas. On the other hand, vertically integrated modern value chains mainly supply rice to large urban centres or to export markets. These modern value chains are rapidly emerging in Asia although traditional value chains are still important components of the overall rice supply chain.

Major opportunities for improving the value chain and reducing post-harvest losses are the mechanization of post-harvest operations; improved drying, storage and milling of harvested paddy; secondary processing of rice to enhance consumer convenience; the use of rice biomass to generate energy or to produce animal feed; and improved vertical coordination and shortening of the rice value chain for greater efficiency. Transportation and storage infrastructure may be critical in determining chain characteristics, including production methods, market opportunities and the level of production.

Table waste of rice (i.e. cooked rice that is never consumed) is also an increasing concern in the region. There is therefore a need to make rice available in more convenient forms through value addition (rice cakes, rice snacks, etc.) to provide diversified options to rice consumers and to raise consumer awareness of table waste.

Policies on rice price, trade and stock

Price, stock, and trade and price policies can be used to achieve different objectives such as higher farmer income, improved welfare of consumers, price stability and self-sufficiency. Other key options are futures markets and the provision of market information. These various policies affect the rice sector directly as well as through their indirect effects on overall economic growth. These direct and indirect effects may benefit producers and consumers differentially and may also involve trade-offs regarding short-term vs long-term impacts on food security.

Strategic choices surrounding rice trade policies are governed mainly by domestic rice policy objectives, and these choices differ among exporters and importers. For importing countries, tariff protection is an option, but it raises the domestic price and makes rice less affordable to the poor, as well as creating inefficiencies. Other options for importing countries are Tariff Rate Quotas (TRQs), import licensing and import monopoly of parastatals. Large countries whose import requirements can be large in the event of even a small supply shock are less able to rely on trade than small importers. For rice exporters, WTO rules are not seen as a constraint to the policy space. The best policy for maintaining a stable world market is to avoid export restrictions, and use rules-based instruments such as variable taxes and TRQ-like policies only when some management of exports is perceived as essential.

Regional cooperation on rice

Regional cooperation arrangements among rice-producing countries can take place at several levels: bilateral, multilateral, regional and global. Regional cooperation has large potential to add value by exploiting potential for synergy. Cooperation is easier to establish on less divisive issues such as sharing of technologies/information, food safety and harmonization but difficult on more divisive issues such as trade liberalization, policy coordination and positions on WTO. Considerable progress has been made on the first set of issues and examples are rice information systems under ASEAN, the regional food reserve (APTERR) and AMIS. Strengthening and expanding collaboration on less divisive issues could be an important strategy to build mutual trust for making progress in the more divisive areas such as export restrictions and farm subsidies.

Food and nutrition security in the Pacific Island countries (PIC)

Despite the current low level of rice consumption in the PIC, the quantity consumed has increased over time, supported mainly by increased imports as rice production in the PIC is currently low by Asian standards. The major traditional staples of the PIC are root crops such as sweet potato, cassava, yam and taro. The key questions for the PIC are (1) How can they build a resilient and sustainable food security system that integrates rice with traditional food crops? (2) What is the economically optimal level of domestic production of rice vis-à-vis imports? and (3) What public investment and policy framework will promote long-term food security?

A major option for the PIC is to increase the productivity of rice by developing and promoting improved technologies. Ample opportunities exist to transfer suitable technologies available in Asia and carry out adaptive research where needed prior to dissemination. Another important option for the PIC is to integrate rice with traditional crops to promote sustainability and resilience in the larger food system.

The way forward

Wider consultations with stakeholders will be needed to translate the broad vision and strategic objectives into specific measurable targets and an implementation plan. Priorities across the six objectives may vary across countries, depending on the specific context and national development strategies. Complementarities/trade-offs across objectives will need to be considered while setting priorities. The suitability of specific options similarly depends on the country/context and the choice of the best option or a combination of options falls within the ambit of national policy-making. Clearly, member nations and international organizations such as FAO have important roles in facilitating wider consultations for developing an implementation plan that includes dimensions of both regional coordination and country-level policy.

As the next step, while promoting regional coordination and networking, national initiatives will be needed to translate the regional strategy into country-level actions by refining existing national rice strategies or formulating new ones as needed. Efforts in this direction could focus initially on a few pilot countries. Current initiatives such as the Regional Rice Initiative, a pilot initiative implemented in 2013 by FAO, could be considered as synergistic components of the regional strategy.

Based on the broader analysis presented, the following four major areas of action are suggested:

1. Investment in R&D for inducing and supporting technological innovations in all stages of the rice value chain for productivity and efficiency gains, better quality and nutritional value, greater resilience and environmental protection.

2. Promotion of technology and knowledge transfer and Information and Communication Technologies (ICT).
3. Policy and institutional innovations to promote rural income growth and the rapid spread of improved technologies, and to develop a robust food security system that is stable and accessible to all.
4. Investment in rural infrastructure.

The overall approach presented here is consistent with important elements of the Zero Hunger Challenge that strives to achieve its objectives by 2025. National rice strategies or policies, once formulated, would be implemented within the framework of the Zero Hunger Challenge.

Technological innovations and investments in R&D

A number of potential technological options were identified earlier for raising the productivity of rice-based systems through sustainable intensification. Increased investment in R&D is clearly needed not only to translate scientific innovations into specific technologies but also to carry out research in promising scientific areas such as rice functional genomics, developing C4 rice, bio-prospecting of genes and allele mining and engineering rice with biological nitrogen fixation, and resilience measures to address climate change. Other important avenues for impact include biofortification, rice fortification, raising input efficiency through better agronomic practices, precision farming, mechanization and improvements in post-harvest value chains for efficiency gains and loss reductions.

The private sector is now an important player in rice R&D and in technology dissemination. The growth in private sector investment clearly provides the opportunity to encourage the development of public-private partnership for substantially augmenting the amount of investment in these areas.

Promotion of technology and knowledge transfer and ICT

The benefits of agricultural research will not be fully harnessed unless effective linkages between agricultural research and extension are created including the promotion of the use of ICT and e-Agriculture as well as SSC. Modern ICT can be used for the large-scale dissemination of information (e.g. weather forecasts and market opportunities) and new technologies. Differences in available rice technologies, R&D capacity and ICT developments across countries clearly point towards opportunities for impact through improved South-South Cooperation (SSC) for technology development and transfer. The constitution of a network among countries to share experiences and approaches is of high priority in this regard.

Policy and institutional innovations

Policy and institutional environments determine farmers' decisions on rice production and the overall transformation of the rice sector. Hence, suitable policies and institutional innovations are needed to encourage the adoption of improved technologies. These include policies on price support and subsidies, public expenditure on public goods such as infrastructure, regulations on limiting farm size and land rental markets and security of tenure. These policies affect incentives for technology adoption, mechanization, investments to improve irrigation and soil fertility and the pace of structural transformation of agriculture.

A new organization of the farm will also require new skills that could be provided through targeted education programs, especially to a new generation of young farmers and women. Similarly, programs could be designed to incorporate the special role of women in food security in Asia. Programs that provide economic incentives to farmers/rural communities involved in dynamic conservation of biodiversity and rice heritage could also be developed through using facilities such as Globally Important Agricultural Heritage Systems and Geographical Indicators. The promotion of organic farming as a part of an organic value chain provides another avenue for the protection of heritage and income generation. Local development and community-driven approaches will promote broad-based rural development and diversification of income by empowering the rural poor, and disadvantaged and vulnerable communities.

Smallholder farmers need to be able to reap the benefit of scale in production and marketing by being organized in institutions that reduce transportation costs and increase overall efficiency. Such institutions include group farming, contract farming, community organizations and farmer cooperatives. Capacity building and the empowerment of such farmer organizations are hence needed to increase the efficiency of smallholder agriculture and connect smallholders effectively with markets to promote income generation.

Robust food security systems could be developed by managing price volatility through a combination of stock, marketing and trade policies. For the poor and vulnerable, farm-level activities that integrate various sectors such as rice-fish, rice-livestock and rice-horticulture can be a part of such safety nets.

Investments in rural infrastructure

Investments in rural infrastructure (such as rural roads, electricity, schools and health facilities) promote overall rural development and have not just economic value but social value as well. Increased investments in rural infrastructure are hence needed to promote market opportunities to raise rural income and improve the food security of the poor.

BACKGROUND AND APPROACH

In 2012, FAO member states in the Asia-Pacific region, on the occasion of the 31st Session of the FAO Regional Conference for Asia and the Pacific (APRC) convened in Hanoi, Viet Nam, requested the Organization to coordinate the formulation of a regional rice strategy. This request was the culmination of increasing discussions within and outside FAO, notably in Asia and especially in the wake of the food crisis of 2007/08, on a number of prospective issues surrounding rice, ranging from productivity and resource use efficiency to policy, trade and the future demand outlook. A special task force was formed for this purpose by the FAO Regional Office for Asia and the Pacific by mobilizing internally available technical expertise, and an advisory group of eminent experts was constituted. This Expert Rice Advisory Group (ERAG)[1] met twice to provide advice to the task force for the preparation of the rice strategy.

It is important to recognize that, although rice strategies and policies are country-specific, national strategy is best formulated when guided by insights and parameters identified within a framework on regional and global assessment of the situation and outlook. This is important in view of the increasing interlinkages of the various factors that affect the rice sector and the economy as well as national and regional food security. A single regional rice strategy does not capture the diversity that exists in rice production systems and policy priorities across countries in this large and diverse region. However, several aspects related to trade policy, regional cooperation, managing price volatility and technology development can benefit from a common framework. Beyond these common areas, it would be more useful to consider policy/strategies in the context of country-specific situations.

The main aim of this strategy document is to provide evidence-based strategic guidelines to member nations to help them (1) develop/adjust their rice sector strategies in the light of broader regional/global trends and national priorities and (2) choose among key strategic options while considering the implied trade-offs (or consequences). The outputs are presented here in the form of strategic options and the implied trade-offs (or consequences) instead of being prescriptive. The intention here is to enrich the strategy and policy formulation processes of member nations for achieving sustainable food security.

[1] The ERAG is composed of an eminent group of scientists and development experts and is chaired by Dr M.S. Swaminathan.

CHALLENGES AND OPPORTUNITIES IN REGIONAL RICE SECTOR DEVELOPMENT

The Asia-Pacific region is one of great diversity and dynamic change. It is a wide and heterogeneous region – physically, socially, culturally, politically and economically. It has large and populous countries such as China and India that are experiencing rapid economic growth; island countries such as the Philippines, Indonesia and the Pacific Island countries (PIC) that are historically rice importers; major rice-exporting countries such as Thailand and Viet Nam; emerging rice-exporting countries such as Cambodia and Myanmar; and South Asian countries such as Bangladesh with high population density. Accounting for about 60 percent of the world population, the region is large and has a total population of 4.3 billion.

Rice is the staple of Asia and it is central to the food security of about half of the world population. Asia accounts for more than 90 percent of world rice production and consumption. Rice production is an important source of livelihood for around 140 million rice-farming households and for millions of rural poor who work on rice farms as hired labour. For poor consumers in Asia, rice accounts for nearly a fifth of the total household expenditure on average. The low price of rice thus directly contributes to poverty reduction of these poor consumers. Rice is a strategic commodity as the overall economic growth and political stability of the region depend on an adequate, cheap and stable supply of this staple crop.

The strong economic growth in the region over the past decades has resulted in major gains in poverty reduction and food security. Rapid agricultural growth, especially the substantial increase in rice production resulting from the Green Revolution, has brought about substantial poverty reduction by raising farm income while keeping the price of this staple crop low and affordable to poor consumers. The low price of rice has also kept the wage rate low, thus fueling industrial growth.

Despite this impressive historical performance of the region, a number of challenges face the rice sector that will determine further progress in reducing hunger and poverty. More than 600 million people in Asia and the Pacific are still poor and over 500 million people are hungry and undernourished (UN 2013a, FAO 2012a). The rice price crisis of 2007/08 worsened this situation, with the rice price still remaining above the pre-crisis level. Expenditure on rice accounts for a substantial proportion of poor people's income; hence, a price rise generally increases the incidence of poverty and hunger.

Population growth in Asia is continuing and the Asian population is projected to reach 4.9 billion by 2030. With more mouths to feed, Asia needs to continue to increase rice production even if rising income and urbanization will result in some decline in per capita consumption. Added to the fact that Asia is a net exporter of rice accounting for more than two-thirds of world exports, food security of the poor in other parts of the world, especially in Africa, where the demand for rice is increasing, will also depend at least in the near term on Asia's ability to continue its rice exports.

Environmental degradation associated with intensive rice production systems is an increasing concern. Inappropriate and excessive use of agro-chemicals (fertilizers, pesticides) and increasing water use have resulted in an unsustainable level of water depletion, water pollution, soil erosion and downstream silting. Important ecosystem functions provided by rice fields are being compromised. The decline in biodiversity and loss of rice culture and heritage are other important manifestations of damage to ecosystem functions sometimes resulting in a resurgence of pests that significantly threatens national production.

Global climate change is an important challenge, in terms of both adaptation and mitigation. Rice production in many of the low-lying productive deltas is likely to be adversely affected due to sea-level rise resulting from global warming. Similarly, the increased frequency and intensity of extreme events such as drought and flooding and the rise in temperature that are likely to result from global climate change will strongly affect rice production. At the same time, rice contributes to global warming through emissions of greenhouse gases.

The growth in rice productivity will continue to remain important in the future for reducing hunger and poverty. However, rice productivity growth has slowed considerably and even failed to keep pace with population growth during the past decade. Several reasons explain this slowdown in productivity growth but an important one is the slowdown in investment in R&D in the 1990s and the 2000s before the food price crisis.

Unlike in the past, future growth in rice productivity must occur in the context of several new factors. Asian economies are undergoing structural transformation, which involves the movement of resources out of agriculture to the non-agricultural sector. Rice production has to adjust to this resource squeeze as land, labour and water are increasingly drawn out from the farm to the non-farm sector. Urbanization and changing dietary habits are inducing crop diversification at the farm level and this has increased the competition for resources that were traditionally available for rice.

Demographic changes and migration are altering the demographic composition of labour in rural areas. As young people move to cities in search of better employment opportunities, the rural population is "greying." Agricultural tasks are becoming less gendered as male outmigration has increased the feminization of agriculture. At the same time, economic and social changes in rural areas are undermining the important roles women have traditionally played in rice farming and the conservation of biodiversity.

The composition of rice demand in the future is also likely to change. It is not just the matter of producing a larger quantity of bulk rice but also meeting the rising demand for specific varieties (such as aromatic varieties) and high-quality and safe rice (free from contaminants and hazards to health and the environment). Similarly, the demand for industrial quality low-grade rice for animal feed and industrial use will also likely increase with increased demand for meat and livestock products. Hence, future rice production systems will need to respond to this demand diversification.

The structural transformation means that the organization of rice production must also change. Labour scarcity and the need to mechanize will make larger farms economically more efficient. This will also require changes in the arrangements on how farm labour is organized. Adjustments to these factors are rapidly occurring through new forms of production organization in countries with faster economic growth such as China, Malaysia and Thailand.

An important development is the modernization of the rice value chain. Urbanization has increased the geographic distance between rice production and consumption centres. Dietary transition resulting from urbanization and income growth is increasing consumer demand for high-quality rice and diversified rice products that also enhance consumer convenience. Rice farmers are now increasingly connected with urban consumption centres through rice mills and supermarkets. Vertical integration in the rice value chain is also emerging. As a result, a considerable amount of value addition takes place in these modern value chains after paddy leaves the farm gate.

Commercialization increases the interconnectedness between rice and other sectors of the economy. As a result, the rice economy will be increasingly affected by forces that originate outside agriculture. The increasing association of the price of energy with the price of rice is a case in point. Transmission of external shocks through increased interconnectedness with the rest of the economy can result in increased instability in rice prices. Similarly, the trade policy of major exporting countries can destabilize the supply and world market price as demonstrated by the crisis of 2007/08.

Despite the many old and new challenges mentioned above, several new opportunities also exist to sustainably increase the impact of the rice sector on hunger, malnutrition and poverty reduction. These include the accelerated genetic improvement of yield, quality and adaptability; improving rice quality through better post-harvest management; reducing post-harvest losses; adding value through secondary processing; raising incomes; and stabilizing the market supply through value chain improvements. Similarly, there is an increasing realization that responsive/responsible domestic market and trade policies are needed to stabilize the rice price and avoid a repeat of the 2007/08 food crisis in the future.

Modern scientific approaches and new technologies, such as biotechnology, are also making it possible to increase rice productivity in a sustainable manner, add nutritive value to rice, reduce losses from drought/flood, add new products derived from rice and its by-products, reduce the environmental footprint and make rice production systems "climate smart." In contrast to the reliance on public sector investments in agricultural R&D and in infrastructure, opportunities now exist to promote "partnership for agricultural prosperity" with the private sector, which is already significantly investing in these areas, and this has great potential for future development. Certifications for assuring or demonstrating quality are on the increase, which have additional costs but also increase acceptability in both domestic and international markets.

Sustained reductions in hunger and poverty remain at the top of the unfinished development agenda of the Asia and the Pacific region. Even when the MDG goal on poverty reduction is achieved in 2015, there will still be 970 million people in extreme poverty, with more than 600 million poor being in the Asia and the Pacific region. Similarly, the number of hungry and undernourished people in the Asia and the Pacific region is projected to surpass 500 million. Thus, considerable challenges remain in overcoming these chronic poverty and hunger problems. Although multi-sectoral approaches will be needed to overcome chronic hunger and poverty, the rice sector can contribute in important ways to the post-MDG agenda as rice remains the staple crop of Asia.

Overall, the major strategic issues for the region now are how to modernize and transform the rice sector, given the various emerging challenges. Asian economies are undergoing transformation and there is now a clear need and major opportunities for the rice sector also to transform itself. By undergoing such transformations, the rice sector can contribute even more to hunger and poverty reduction in a sustainable manner while contributing to the enhanced prosperity of rice producers and consumers. However, the business-as-usual approach of the past may no longer suffice. Forward-looking and innovative solutions must be found and a major strategic re-orientation of the rice sector is needed.

These challenges and opportunities are broadly applicable to the Pacific Island countries also where root crops, not rice, are traditional staples. Rice consumption is, however, increasing rapidly in the PIC mainly by increasing imports as domestic production is limited. Given this, the specific strategic issues for the PIC are (1) how to build a resilient and sustainable food security system that integrates rice with traditional food crops and (2) what is the economically optimal level of domestic rice production vis-à-vis imports?

A VISION FOR THE REGIONAL RICE SECTOR

Given the challenges and opportunities, the vision of the rice economy is that of *food-secure, better-nourished and prosperous rice farmers and consumers in the Asia/Pacific region who benefit equitably from a vibrant, innovative and transformed rice sector that is more productive, efficient and environmentally sustainable by 2030*.

The ultimate aim as described in the vision statement above is to make rice consumers and farmers in the region prosperous, food-secure and better-nourished. Prosperity is a broader term that includes at its core poverty reduction with equitable income growth. A more productive, efficient and environmentally sustainable rice industry is a cornerstone for achieving this vision. The concept of a rice "industry" will be more relevant in the future as rice production systems are becoming more commercialized and the importance of modern post-harvest value chains is increasing. The rice industry includes not only farmers but all actors collectively grouped as "producers" along the value chain. It is also important that prosperity be shared equitably by all actors along the value chain and by consumers. The growth of the rice sector takes place in the context of overall economic growth and the rice industry needs to transform itself as the Asian economies undergo structural transformation. Innovations (including technological, institutional and organizational) are envisaged as the main mechanisms through which such transformations are to be achieved.

Implicit in this vision statement is the role of Asia in improving world food security as Asia is a net exporting region accounting for 70 percent of world rice exports. The traded volume of rice is small and accounts for only about 7 percent of total world consumption. Nevertheless, trade plays an important role in enhancing the food security of importing countries, including those within the region itself. As Africa is currently a major destination for Asian rice exports, the food security of Africa at least in the near term will depend on Asia's ability to maintain its exportable surplus, although production within Africa is likely to increase over time.

The suggested time frame for achieving the vision is 2030. A 15-year time period commencing in 2015 is a reasonable time frame for making significant progress towards achieving the vision. This time frame is also consistent with the time frame chosen by the World Bank for its goals to "End Extreme Poverty and Promote Shared Prosperity" (World Bank 2013) and by the UN for the post-MDG development agenda, "New Global Partnership" (UN 2013b).

The broad vision outlined here needs to be translated into objectives and specific measurable targets to guide the development of an implementation program. Although six strategic objectives are suggested in the next section, the development of measurable targets and an implementation plan, including the financing strategy, will require additional deliberations and consultations with all stakeholders. This strategy document is an initial step in this direction.

GLOBAL RICE CONSUMPTION AND TRADE OUTLOOK

Medium- and long-term outlooks for global consumption, supply and trade are periodically produced by FAO and various research organizations. The main driver of future consumption for rice is population growth, which together with outlooks on changing per capita consumption provides the overall demand estimates. Supply estimates are derived based on projected production growth considering the past trend and likely future scenarios. Projecting variables for long periods is fraught with uncertainties regarding various parameters and forecast ranges in alternative scenarios often tend to be wide. With this caveat, some currently available major outlook results are summarized in Table 1.

Table 1: Compilation of projected global rice consumption levels from various perspective studies (in million metric tonnes)

	2020	2025	2030	2035	2050
FAO World Agriculture Towards 2015/30 study (2002)			535		
FAO World Agriculture Towards 2030/50 study (2006)			503		449
FAO World Agriculture Towards 2030/50 study (2012 revision)					465
Timmer, Block & Dawe (2010)					
Best judgment	450	440	430		360
Rapid income growth		414	390		255
Slow income growth	466	469	466		404
Rejesus, Mohanty & Balagtas (2012)					
Point forecast (middle)	491	517	544	570	651
Lower forecast interval	437	446	457	469	504
Upper forecast interval	545	588	630	672	797
GRiSP (2010)	496		535*	555	

* Obtained through linear interpolation of consumption estimates for 2020 and 2035.

Various outlooks for 2030 from FAO and from IRRI indicate demand to be in the range 503-544 million metric tonnes. These broadly represent the mid-point values. The Timmer et al. (2010) projection is generally below this range and the difference may be partly due to the difference in methodological aspects. Taking the GRiSP projection as the basis, the outlook is for total consumption to increase to 496 million tonnes by 2020 and further increase to 535 million tonnes by 2030. This is equivalent to the average growth rate of approximately 1 percent per year relative to the total consumption of 439 million tonnes in 2010.

Asian rice consumption is projected to account for close to two-thirds of this total increase in demand by 2030 (GRiSP 2010). Additional demand will arise from export markets and the projected increase in exports from Asia in 2022 relative to 2013 is in the range of 5-7 million tonnes, with additional imports into Africa being 2-3 million tonnes (Table 2).[2]

Overall, the outlook for 2022 is for world rice trade of about 46 million tonnes, which represents an expansion of 8-9 million tonnes relative to the projection for 2013. The 2022 trade amounts to 8.2 percent of consumption, which is up from 7.5 percent in 2013. Sub-Saharan Africa (SSA) accounts for about 30 percent of trade, with projected imports being 13-14 million tonnes. However, the actual imports by SSA will depend critically on the extent to which rice production will increase as a result of major production initiatives being implemented in Africa.

[2] OECD-FAO Agricultural Outlook (2013) is the most recent updated consumption/trade outlook from OECD-FAO.

Asian exporting countries (Thailand, Viet Nam, India, Pakistan, Cambodia and Myanmar) are projected to export a total of 31-36 million tonnes in 2022, with Thailand exporting the most. This is obviously based on the model assumption that the current Thai policy of rice price support will not continue to 2022. Both Thailand and Viet Nam are projected to expand exports relative to 2013. On the import side, the OECD-FAO outlook is for the imports by five major importing Asian countries (Philippines, Indonesia, Malaysia, Bangladesh and China) to total around 7 million tonnes. The USDA outlook indicates this total to be much higher at 11 million tonnes, with the major difference being for the Philippines and Indonesia. The difference in assumptions in these two outlook studies about the extent to which these two countries are able to make progress towards rice self-sufficiency drives this result.

Table 2: Rice trade outlook 2022

Importers	OECD-FAO Outlook		USDA Outlook	
	2022 projection	Change from 2013	2022 projection	Change from 2014
	Million metric tonnes		Million metric tonnes	
Philippines	1.0	-0.2	2.5	0.9
Indonesia	1.3	0.1	4.0	1.5
Malaysia	1.3	0.3	1.4	0.3
Bangladesh	1.8	1.1	1.3	0.7
China	1.5	-0.3	1.9	0.0
Iran + Saudi	3.7	1.0	5.1	0.7
SSA total	12.8	1.9	13.8	3.5
Others	21.6	4.7	17.0	1.9
World imports	**45.0**	**8.5**	**46.9**	**9.5**
Exporters	**OECD-FAO Outlook**		**USDA Outlook**	
	2022 projection	**Change from 2013**	**2022 projection**	**Change from 2014**
	Million metric tonnes		**Million metric tonnes**	
Thailand	12.2	3.4	13.0	4.2
Viet Nam	9.7	2.0	8.8	1.3
India	5.3	-1.0	6.8	-0.1
Pakistan	4.1	0.6	5.0	0.9
Cambodia	n.a.	n.a.	1.6	0.5
Myanmar	n.a.	n.a.	1.1	0.4
U.S.	3.8	0.8	4.2	1.3
Latin America	4.0	0.4	3.5	0.7
Others	5.8	2.3	3.1	0.3
World exports	**45.0**	**8.5**	**46.9**	**9.5**

n.a. = not available.

STRATEGIC OBJECTIVES

The following six strategic objectives that member nations may wish to achieve result from the vision and the demand outlook scenario described above. These objectives are not listed in any specific order of priority as the relative priority among various objectives will most likely differ by country. It is hoped, however, that these broader strategic objectives adequately capture what member nations in the region are aiming to achieve for ensuring sustainable food and nutrition security.

Objective 1 (O1): Increase the productivity and nutrition value of rice sustainably to meet the increasing global demand (**Increase productivity, nutrition value and sustainability**).

Objective 2 (O2): Enhance the rice value chain by improving food quality, diversity and food safety while reducing post-harvest losses (**Enhance value chain and reduce post-harvest losses**).

Objective 3 (O3): Improve mitigation/adaptation of rice farming to climate change and improve farmers' capacity to cope with risk (**Mitigate/adapt to climate change and reduce risk**).

Objective 4 (O4): Minimize the environmental footprint of rice production and enhance the ecosystem functions of rice landscapes, including the protection/promotion of rice heritage and culture and landscape management (**Conserve environment and heritage**).

Objective 5 (O5): Improve the efficiency, reliability and fairness of domestic and international rice markets for stabilizing rice price and supply, ensuring equitable access by the poor and promoting regional collaboration (**Promote fair and efficient markets and trade**).

Objective 6 (O6): Enhance the well-being and livelihoods of smallholders, women and the new generation of rice producers by improving adjustments to long-term changes in demography, farm size and labour supply (**Improve organization of production, and empower youth and women**).

It is to be noted that these six strategic objectives are not independent of each other and there are interlinkages that result in complementarities and trade-offs. This is especially the case with Objective 6 regarding adjustments in the organization of production. The adjustment path followed will affect technology adoption, input use and the nature of the value chain, which in turn affects the pace of adjustment. The basic idea is to identify win-win options when possible while taking explicit account of the trade-offs when national development goals indicate certain specific priorities across these objectives.

Objective 1 (Increase productivity, nutrition value and sustainability)

The possibility to significantly expand rice area is limited in Asia; hence, the main strategy has to be to increase rice yield per unit area. The projected yield growth required for meeting the rising demand is 1.2-1.5 percent per year (GRiSP 2010), taking into account the likely future reductions in rice area due to increasing competition for land from other uses (e.g. crop diversification, urbanization and industrial development). The growth rate of rice yield in Asia has, however, shown a declining trend over the past two decades and has been mostly around 1 percent per year.

Given the above, the main strategy for Asia has to be to further intensify rice production and achieve a higher growth rate in yield. But, unlike in the past, it is critically important to ensure that intensification is environmentally sustainable. For sustainability, intensification of rice production must increase not only yield but also total factor productivity while minimizing the depletion of water, soil erosion, downstream silting, salinity buildup, erosion of biodiversity, resurgence of rice pests and pollution caused by agro-chemicals. As rice is typically a component of the farming system, it is important to exploit opportunities to raise system-level productivity by considering the linkages between rice production and other components of integrated systems such as rice-fish,[3] rice-legume or rice-livestock. This requires greater exchange of technologies and knowledge among developing countries through networking and SSC.

The sustainable intensification of rice production (SIRP) requires the integration of novel, genetic and agronomic improvements into an ecosystems approach that enhances nature's contributions to crop growth (e.g. soil fertility, water and biocontrol of pests) to achieve higher productivity, profitability and resource use efficiency of the rice production system, while protecting the environment. This reflects a paradigm shift from the earlier Green Revolution to make it greener and is fully consistent with the "Save and Grow" approach launched by FAO in 2011.

Although rice is a major source of calories, new scientific developments have opened up opportunities for biofortification of rice to increase its nutrient value. The density of important micronutrients such as iron and zinc in rice grains can be increased through the use of modern breeding tools. Similarly, "Golden Rice" enriched in pro-vitamin A provides a new opportunity for overcoming blindness that afflicts millions of poor children. Rice fortification similarly offers another opportunity for increasing nutrient value.

Within this broader principle, the specific types of interventions vary by rice ecosystems and include improvements in rice varieties, crop and resource management practices and farmers' access to information, inputs and markets; and policies to promote technology development, transfer and adoption. Significant changes in ways that the whole rice value chain is understood are required and will call for extensive public information.

Objective 2 (Enhance value chain and reduce post-harvest losses)

Tremendous opportunities exist for improving food quality, diversity, nutritional value and safety as well as reducing post-harvest losses through enhancement of the rice value chain. Rice value chains in many parts of Asia are modernizing, with supermarkets playing an increasing role in supplying rice to urban areas. Paddy is being increasingly milled by large commercial mills that source the supply directly from farmers instead of the traditional chain of village traders, local collectors and bulking intermediaries. These mills are also often supplying directly to supermarkets without the usual chain of intermediaries. These changes are revolutionizing ("quiet revolution") the overall supply chain that links rice farmers to urban consumers. In the process, new opportunities are arising for value addition in the form of quality control, branding, packaging, certifications and product diversification. Diversification of rice products can be an important way of reducing table waste (i.e. cooked rice that is never consumed), which is becoming an increasing concern in the region.

There is considerable scope to improve post-harvest operations and reduce the loss in harvested grain in terms of both quantity and quality. When using traditional methods, losses occur during threshing, drying, storing and milling of paddy. Although it may not be financially profitable to reduce some of these losses when viewed one at a time, an increase in efficiency resulting from modernization of the value chain (e.g. shortening and streamlining of the value chain) can lead to an improvement in product quality and an overall reduction in post-harvest losses.

Considerable variations exist across countries in value chain operations depending on factors such as farm size, mode of production, rural labour availability, transportation infrastructure, the level of spatial integration of rice markets and consumer dietary habits. Low-income consumers will continue to procure rice in traditional markets while higher-end consumers will seek higher quality rice and diversified rice

[3] Rice-fish systems encompass the wide range of aquatic species (including finfish, crustaceans, mollusks, reptiles, insects, amphibians and aquatic plants) used for consumption and/or sale and integrated farming systems (concurrent, rotational, side-by-side using the same water resources) being practiced in various intensities of input use from the harvesting of wild fish to the introduction of cultured fish.

products from modern and niche markets. Hence, suitable interventions for value chain improvements will also vary across countries and even within countries.

Objective 3 (Mitigate/adapt to climate change and reduce risk)

Global warming and climate change are predicted to have a major impact on rice production. Rice production is not only affected by global warming but it also contributes to the emission of greenhouse gases that contribute to global warming. Thus, both adaptation and mitigation strategies are relevant.

Rice farmers have to contend with multiple sources of risk, with the major sources being instability in rainfall and market prices. Large swings in production can arise from insufficient or excessive rainfall, especially in rainfed areas. Farmers not only risk losing their food and income but also their livelihood as consecutive stress events (droughts/floods) can deplete their meagre asset base rapidly. Instability in rice price is another source of risk, especially for farmers who sell part of their rice output.

Given the intrinsic nature of these risks, farmers have developed various coping mechanisms to avoid or reduce the impact of risk. However, studies have shown that these traditional coping mechanisms are inadequate to prevent consumption shortfalls and the depletion of productive assets in stress years. As a result, production shocks push farmers deeper into poverty, thus making it more difficult for them to escape poverty. New interventions that enhance social protection targeting the poor and augment and complement the existing coping mechanisms are thus needed.

Objective 4 (Conserve environment and heritage)

Rice fields contribute to overall environmental protection by providing important ecosystem services. These ecosystem services include provisioning services (rice and other rice-field products), regulatory services (e.g. flood buffering, control of soil erosion), supporting services (wet rice fields are sources of rich biodiversity and habitat for bird populations) and cultural services (e.g. rice culture and heritage). It is critically important to maintain and augment this multifunctional role of rice farming for broader environmental resilience. However, the intensive production of rice based on the misuse of agro-chemicals and depletion of water is resulting in environmental degradation and impairment of these important ecosystem functions. It is important that the environmental footprint of rice be minimized while augmenting ecosystem and landscape functions, including the protection of rice heritage and conservation of biodiversity.

Objective 5 (Promote fair and efficient markets and trade)

Rice is among the basic food products subject to a relatively high level of policy interventions that affect farm incentives and consumer prices, in both developed and developing countries. These policy interventions are applied to both domestic markets and trade. The aims of these interventions are to increase farmer income, improve consumer welfare, increase price stability and achieve high self-sufficiency. Policy tools frequently used are subsidies, trade controls, price stabilization and buffer stock operations.

The first major effort at liberalizing trade policy, including domestic support measures, was the WTO URAA in 1995. The basic architecture of rice policy from that Agreement largely remains today despite the progress made recently in the Bali Ministerial Meeting. The 2007/08 rice price spike was an important event in the evolution of rice policy. It is widely held that this event halted or even reversed the process of gradual liberalization of rice markets, with increased occurrences of autarkic policy regimes among importers and more frequent export restrictions by exporters.

The challenge is to identify strategic choices and policies that enhance the efficiency and reliability of domestic and international rice markets without undermining food security and the livelihood roles that rice plays in the Asian countries. Marketing information systems such as AMIS can contribute to this process through efficient and timely dissemination of price information.

Objective 6 (Improve organization of production, and empower youth and women)

The process of structural transformation leads to a decline in the importance of agriculture relative to the overall economy as industrial and service sectors grow. This is an inevitable consequence of economic growth. A major issue of policy relevance is how to manage this process of structural transformation without compromising the food security of the poor. Slow structural transformation is often an important reason for chronic poverty and food insecurity in rural areas.

Structural transformation means that the organization of rice production must also change. A major factor inducing changes in the organization of rice production is labour, which becomes increasingly scarce with the expansion of the non-farm sector. The exit of labour out of agriculture in the process of structural transformation induces major changes in the agrarian structure. These include changes in farm size, mechanization, labour employment and gender roles. “Greying” of the rural population occurs as young people move to cities. Similarly, male outmigration leads to changes in gender roles in farming while providing significant remittances to diversify income flows. The farm management and agribusiness skills demanded by the new generations of young farmers and women who remain on the farm will be very different from those in the past. The challenge is to identify policy and institutional interventions that make the process of adjustment less painful to the poor. Local development and community-driven approaches have a leading role in this endeavour.

KEY THEMES AND OPTIONS

The following section provides a discussion of the major themes derived from the strategic objectives and options for attaining those objectives together with trade-offs implied in the choice of one or a combination of options. A thematic structure is followed as it permits a sharper focus on a set of interrelated key issues. Several of the themes discussed below are of a cross-cutting nature and span one or more strategic objectives. Hence, the mapping of objectives into themes is not a simple one-on-one. However, a broad summary of linkages among objectives and themes is captured in Table 3. Themes that are a major component of a specific strategic objective are highlighted in bold letters but linkages with other objectives are indicated without bold. One of the themes is of a geographic nature and covers the Pacific Island countries, where current rice consumption, although low by Asian standards, is increasing rapidly. This theme spans across all six objectives.

Table 3: Mapping of objectives (Os) and themes

	Themes/objectives	O1	O2	O3	O4	O5	O6
1.	Sustainable intensification of rice production	**X**	x	x			
2.	Climate change mitigation/adaptation and risk management	x	x	**X**	x		
3.	Environment and rice heritage	x			**X**		
4.	Water and irrigation	**X**		x	x		X
5.	Smallholder farmers and farmer organizations	**X**	x	x	x		X
6.	Gender roles and empowerment of youth and women	x	x				**X**
7.	Food quality, safety and nutrition	x	**X**				X
8.	Value chain and post-harvest management		**X**				X
9.	Policies on rice price, trade and stock	x			x	**X**	
10.	Regional cooperation on rice	x			x	**X**	
11.	Food and nutrition security in PIC	**X**	**X**	x	**X**	**X**	X

Sustainable intensification of rice production

Background

Of the total rice area in Asia of 144 million hectares, rice ecosystems are differentiated with approximately 60 percent as irrigated, 34 percent as rainfed lowland (including coastal saline and deepwater areas) and 6 percent as rainfed upland. In irrigated ecosystems, rice is grown in bunded fields with assured irrigation for one or more crops per year. In rainfed lowland, rice is grown in bunded fields without irrigation and is subject to drought and/or flooding in the cropping season; in uplands, fields remain dry for most of the growing period. The coastal ecosystem is a low-lying area near the coast affected by salinity or tidal flows. The major technological options for each of these environments can be grouped into three types: those that are related to improved rice varieties, those that involve better management of crops and inputs and those that involve changes at the cropping/farming systems level.

As described in Strategic Objective 1, the sustainable intensification of rice production (SIRP) is critically important for improving food security. To achieve SIRP in each rice ecosystem, technological options best adapted to the ecosystems and locally specific conditions are needed. SIRP involves the integration of technologies of genetic and agronomic improvements as well as mechanization into an ecosystems approach to achieve higher productivity, profitability and resource use efficiency, while protecting the environment.

Science-based technologies that take advantage of ecosystem services to increase input use efficiency, raise productivity and reduce the cost of production per ton generally tend to produce "win-win" solutions with the least trade-offs. Nevertheless, some trade-offs may eventually arise in the form of externality effects of the use of specific technologies or practices.

Options for irrigated ecosystems

Because of favourable growing conditions, rice yields in irrigated areas are higher than in other environments. However, the yield ceilings of improved varieties in irrigated areas have largely remained stagnant despite the development of many new varieties. An important scientific challenge is hence to develop a new generation of rice varieties with higher yield ceilings.

The main varietal options currently available for irrigated environments are hybrid rice and several inbred varieties with pes tresistance and with improved grain quality. Currently available hybrid rice produces 15-20 percent higher yield relative to inbred varieties but newer generation hybrid rice varieties with a higher yield advantage and superior grain quality are being developed. Hybrid rice has spread mostly in China, accounting for more than 50 percent of the total rice area. It has also spread to some extent in India and Viet Nam and is spreading in Indonesia, Bangladesh and the Philippines. But, in other parts of tropical Asia, its spread remains rather limited. Some of the main constraints to a wider adoption of hybrid rice are the consumer perception of poorer grain quality while newer hybrids with superior grain quality have not yet been disseminated widely; the high cost of seeds, which need to be purchased every year; and the still complicated seed multiplication process. Overcoming these constraints requires further research and development.

A promising option for irrigated areas is a set of improved varieties known generically as "Green super rice." These high-yielding varieties are being developed by pyramiding multiple desirable traits for stability of high yield, multiple pest tolerance and higher resource use efficiency. These varieties, when fully developed and released, will provide promising options for yield improvement in irrigated environments.

A number of crop and resource management practices designed to improve input use efficiency, save input costs and reduce the environmental footprint of irrigated rice production are now available for farmer adoption. These include site-specific nutrient management (SSNM), integrated pest management (IPM) and water-saving technologies such as alternate wetting and drying (AWD) and aerobic rice systems. Other related options are laser-levelling of rice fields, direct seeding and zero tillage, and the System of Rice Intensification (SRI). Some trade-offs are likely to be involved, however, in the use of these technologies. For example, AWD may save field-level water use but this can result in a higher use of agro-chemicals (herbicides) for controlling potential increases in weed infestation. It may lead to increased emission of nitrous oxide – a potent greenhouse gas. AWD may also reduce the environmental services provided by wetland paddies.

At the cropping systems level, diversification of intensive double or triple cropping of rice per year by including other crops, particularly leguminous crops, in the system could improve soil fertility, break the pest cycle and increase farmer income. Rice-fish agriculture or rice-fish alternate farming provides an option to reduce rice monoculture and increase nourishment values of the system. In intensive cereal systems such as the rice-wheat systems of South Asia, system productivity can be increased through interventions such as zero tillage and direct seeding of rice. Private-sector-driven "organic" or "green" rice producers may already provide important models to be mainstreamed.

Options for rainfed lowland ecosystems

The major constraints for rainfed lowlands are the high incidence and intensity of drought and submergence during the cropping season. As a result, farmers mostly grew traditional rice varieties that tolerated these abiotic stresses but produced low yield, except in some areas where field conditions were suitable for growing high-yielding varieties. The situation has now changed recently with the development of rice varieties that tolerate these abiotic stresses. Submergence-tolerant varieties are now available for farmer adoption in a number of countries and newer varieties that combine submergence tolerance with other desirable traits are being developed. Similarly, several drought-tolerant varieties are also available for drought-prone areas. Extension campaigns together with seed production programs are needed to promote the adoption of these varieties in various countries.

Currently, farmer demand for improved crop management technologies such as those developed for irrigated areas is low due to generally low input use in rainfed systems. However, the demand for such technologies can be expected to increase with potential productivity gains from new improved varieties, particularly for favourable rainfed lowland areas.

Promising options also exist in cropping systems interventions. In rainfed areas with a unimodal pattern of monsoon rainfall, land is mostly left fallow after rice because of a lack of soil moisture. These areas offer an excellent opportunity for growing a second crop (mostly legumes) that provides cash income in addition to being a source of protein to farmers. Short-duration rice varieties that are harvested earlier facilitate the establishment of such crops using the residual soil moisture. Rice-livestock and rice-fish systems similarly provide promising alternatives.

Options for upland ecosystems

The upland rice ecosystem represents a unique production system because of its association with mountainous landscape and ethnic minority groups. Although it accounts for a small proportion of rice area, this ecosystem has a significant role in food security in the mountainous region where food access from markets is difficult and the incidence of poverty is high. Farmers traditionally grew upland rice using shifting cultivation to meet their food needs. Improved market access in recent years and changes in government policies have promoted commercialization and farming diversification in these upland systems. As a result, the area under upland rice has decreased. Although economic profits and farmer incomes have increased to some extent, these changes have also contributed to increased food insecurity of ethnic minorities, environmental degradation including a decline in soil fertility, increased soil erosion and loss of biodiversity.

In these upland systems, proper incentives or regulations could limit the negative impacts of commercialization trends. For upland rice, opportunities exist to increase productivity to compensate for area reduction. The advent of high-yielding aerobic rice varieties provides a promising sustainable intensification option. These varieties are as drought tolerant as traditional upland rice but can produce high yields when moderate quantities of fertilizer are used. Terracing of upland area is another intervention that can increase upland productivity. A successful example of this is found in the southern mountains of Yunnan Province of China, where high-yielding aerobic rice varieties have spread. In more adverse upland environments, locally adapted traditional rice varieties with stable yield and quality specialities can be selected and maintained. Organic rice production can further add value when using these varieties. In addition, such traditional rice varieties with unique characteristics and high market value can be integrated with horticulture crops as in Chiang Mai, Thailand. Such land use systems can provide environmental benefits in the form of watershed protection and prevention of downstream flooding. They will also help conserve rice biodiversity and protect rice heritage.

Other options include growing upland rice as an intercrop or in rotation with other suitable crops or trees and the use of conservation technologies such as zero/minimum tillage, mulching, hedgerow alley planting and cover crops. Such farming systems can provide agro-environmental benefits such as the prevention of weed invasion, soil nutrient decline and soil erosion, and protection of the watershed.

Options for coastal saline areas

Coastal rice area is limited to some countries and changes in land use have resulted in a reduction in rice area in the coastal zone. Salinity is a main constraint to rice production in the coastal zone although other constraints include submergence and problem soils (acid sulphate or sodic soils). Rice can be grown in the wet season when salinity is low but salinity becomes a serious constraint in the dry season. The main options in these areas are rice varieties with salinity tolerance. Several improved salinity-tolerant varieties are now available for these areas. Tidal water control in estuaries through suitable operation of sluice gates can improve the management of salinity and the high cost of this infrastructure could be justified if other income-generating activities such as fish/shrimp farming can be a part of the rice system. The rotation of rice (in the wet season) with shrimp in the dry season facilitates organic or ecological farming in this ecosystem.

Climate change mitigation/adaptation and risk management

Background

Global warming and climate change are likely to affect rice production through the following key mechanisms:

- Increased frequency and severity of drought/submergence.
- Loss of productive delta areas due to submergence/intrusion of sea water.
- High temperature resulting in reduced grain production per rice plant.
- Increased carbon dioxide fertilization resulting in a positive yield effect.
- Increased incidence and widening spread of crop pests and diseases.
- Long-term shifts in comparative advantage across countries/sub-regions as weather patterns change.

These various factors interact in a complex manner to affect rice yield and production. The extent of further greenhouse gas emissions, warming, changes in precipitation, and sea-level rises remains a subject of great uncertainty, particularly regionally and nationally. Quantitative assessments of the net effects on rice production are indeterminate with the model results varying widely, depending on the nature of the relationships and the accuracy of parameters captured in these models. Nevertheless, precautionary and “no regrets” steps must be taken to ensure that any adverse effects on rice production are minimized.

Rice production is not only affected by global warming but it also contributes to global warming through emissions of greenhouse gases. Thus, both adaptation and mitigation strategies are relevant. The effect of rice on climate change is the net result of emissions from rice fields of greenhouse gases, including methane, nitrous oxide and carbon dioxide. Flooded rice fields sequester carbon dioxide but emit methane, which is a more potent greenhouse gas (25 times more potent relative to carbon dioxide). On the other hand, rice fields also emit another potent greenhouse gas, nitrous oxide (300 times more potent than carbon dioxide), during the period when the soils remain dry.

Options and trade-offs

Major technological options for adaptation include the following:

- Short-duration rice varieties that "escape" drought or submergence.
- Rice varieties tolerant of multiple stresses such as drought, submergence, salinity, insects/ diseases and high temperature.
- Agronomic practices such as improved water management and pest management that save water and prevent pest outbreaks.
- Cropping systems changing from double rice cropping to rice-wheat rotation, rice legumes or rice-upland crop rotation.

Similarly, major technological options for mitigation include the following:

- Alternate wetting and drying practice (AWD) and mid-season drainage to reduce methane emissions.
- Site- and season-specific nutrient management (SSNM) to reduce nutrient loss and emission of nitrous oxide.
- The proper use of rice straw for energy generation and animal feed instead of the common practice of disposing of it by burning in open fields.

The net effect of a specific mitigation intervention or a combination of interventions on emissions, however, is dependent on local soil and climate factors, including the nature of the production system.

Some of these technological options were discussed in some detail in the theme "Intensification options for different rice ecosystems." Technological options related to varietal improvements generally have the least trade-off issues as the required traits are incorporated in the seeds themselves. As a result, farmers generally do not require major changes in crop agronomy other than replacing seeds. On the other hand, changes in crop management practices and/or changes in cropping systems may involve some trade-offs:

- Water-saving practices such as AWD may result in an increase in weed infestation, requiring additional farm-level investments in chemical or mechanical weed control. An increased use of chemical weed control may increase the environmental footprint of rice production.
- Water-saving practices such as AWD may also reduce the groundwater recharge and environmental services provided by flooded paddies. In addition, these practices will reduce methane emissions but will increase emissions of nitrous oxide, which is a more potent greenhouse gas.
- Changes in cropping systems from rice-rice to rice-wheat, rice-maize and rice-upland crops will reduce methane emissions but will increase emissions of nitrous oxide.

Considerable scientific progress is being made in developing and evaluating these options under varied conditions. However, increased investments in R&D are needed to conduct anticipatory research, to further develop and refine technological options, to identify geographic domains/production systems suitable for each and finally to disseminate suitable options to farmers. More research is also needed to integrate these technologies and cropping options to develop Climate-Smart Rice Farming Systems (CSRFS) in which non-rice crops such as pulses and millets could also play an important role.

Obviously, farmers will adopt these practices only if they are able to obtain economic gains as a result (through yield increase, cost reductions, stabilization of yield or income compensation). So, it is important to ensure that economic returns to farmers in terms of gains in average income and/or stabilization of income are adequate.

Beyond these changes in agricultural technologies and practices, broader policy interventions that reduce production and price risks are also relevant as adaptation mechanisms. These interventions can be targeted at the farm level or nationally.

Some key options are (1) the provision of timely and reliable weather forecasts and climate information to farmers, (2) improving access to institutional credit and finance to farmers for income stabilization, (3) the provision of crop insurance, (4) investments in rural infrastructure to promote crop/income diversification in rural areas, (5) managing rice stock and trade to smoothen total market supply, and (6) social protection targeting the poor. Timely and reliable weather forecasts help farmers adjust their production plans and input decisions to avoid/reduce losses in poor seasons, and, more importantly, to make income gains in good seasons. Ready access to institutional credit will similarly help income and consumption smoothing so that the consequences of risks on farmer welfare decrease. The poorest farmers should be supported through the provision of agricultural inputs and other means to cope with extreme shocks. Crop insurance provides protection to farmers in the event of a loss. Although traditional forms of crop insurance have not been successful in protecting rice farmers, new forms of insurance such as rainfall insurance hold considerable promise. Crop and income diversification similarly help reduce farm income instability – policies that promote such diversification are hence likely to improve adaptation. Finally, wide swings in production that may result from climate change can be managed better by trading more and not less as trade flow helps even out surplus and shortfall across countries.

The above implies that it is important for governments to incorporate the latest research and development results into their rice sector strategies and promote capacity building in adopting climate-resilient varieties/practices that are in line with UN principles for green growth. Similarly, policy reforms to promote rural income diversification, improve trade flows and efficiently manage production and marketing risks are equally important. Increased communication and sharing of information and technologies among countries will similarly improve the effectiveness of various interventions in addressing this global concern.

Environment and rice heritage

Background

The primary function of rice production is to supply rice grain for food but other products such as rice straw, husks and bran are also produced together with rice. In addition, rice production generates important ecosystem services that protect and conserve the environment. Ecosystem services broadly include provisioning services (rice and other rice-field products), regulatory services (e.g. flood buffering, control of soil erosion), supporting services (wet rice fields are sources of rich biodiversity and habitat for bird populations) and cultural services (e.g. rice culture and heritage). The last three types of ecosystem services are also known as externalities (or non-commodity outputs) as they are not fully valued by free and open markets.

These environmental externalities can be considered negative or positive depending on whether they damage or augment environmental services. Intensive production of rice based on an excessive use of agrochemicals and water typically results in negative externalities such as environmental pollution. Rice production also contributes to the emission of greenhouse gases, depletion of groundwater aquifers and improper use of pesticides, which can result in health problems. On the other hand, well-maintained rice terraces generate positive externalities by contributing to flood buffering, mitigation of soil erosion and biodiversity conservation.

Rice heritage is a specific ecosystem service that is of high cultural significance. Building on accumulated knowledge and experience, traditional rice systems have resulted in resilient ecosystems, maintenance of biodiversity and valuable cultural inheritance capable of sustaining the provision of food and livelihood over generations. Rice heritage thus represents a food, livelihood and cultural system that has evolved as a result of co-adaptation of communities with their environments. These systems are rich in traditional knowledge, biodiversity and cultural identity.

The augmentation of ecosystem services, including the protection and promotion of rice heritage, is, hence, essential for the long-term sustainability of rice production systems. However, increasing intensification pressure on rice lands, increased use of agro-chemicals, changes in farm income structures, demographic changes and broader changes in cultural and social values in rural areas are threats.

Options/trade-offs

The ecosystem services provided by rice fields are not priced in the market but are valuable to society. The continued provision of these services thus requires some form of intervention by the public sector to compensate farmers who generate these positive externalities. Targeted approaches that directly link compensation with the production of these externalities are almost always more efficient than those that provide a general support to rice farmers through blunt but popular instruments such as rice price support.

Practices that promote SIRP, as discussed in Strategic Objective 1, contribute to a reduction in the environmental footprint of rice production by increasing the efficiency of input use. Such technological options discourage excessive and wasteful use of agro-chemicals. Such practices also indirectly contribute to environmental protection by reducing the intensification pressure in fragile and marginal lands as the sustainability of rice production in intensive rice bowls of Asia is improved.

The impacts of different practices and policies on the environment, however, tend to be spatially variable and dependent on local factors and the specific context of rice production (e.g. various rice ecosystems). These result in important trade-offs and full considerations of various consequences are important in judging the impact. For example, in upland areas with poorly defined property rights to land, rice technologies that raise yield can encourage the expansion of rice farming in steeply sloping areas, resulting in increased soil erosion or other forms of land degradation. Similarly, flood mitigation is a benefit from terraced rice land but not from upland.

Reducing the environmental footprint requires changes in rice production practices at the field level but many interventions such as control of soil erosion, flood control and watershed protection are more effectively implemented at the landscape/watershed level. Similarly, the protection of rice heritage and biodiversity generally requires community-level approaches and landscape management. Thus, scale issues are important in designing/implementing interventions.

Some key options for reducing the environmental footprint of rice production, augmenting ecosystem functions and protecting rice heritage follow:

- Water-saving technologies such as alternate wetting and drying, saturated soil culture and aerobic rice can result in water saving at the field level. However, a trade-off in using these technologies is a possible reduction in rice yield depending on soil type and production system. These practices may also result in a reduction in groundwater recharge and compromise of ecosystem functions that depend on rice fields remaining flooded. Another trade-off is increased weed infestation, which may encourage more use of herbicides.
- Integrated pest management practices based on an ecologically sound approach that involves the use of a combination of biological, cultural and mechanical methods, together with pest-resistant varieties and judicious use of pesticides, can reduce pesticide use and also the overall loss due to pests. A range of options suited to different ecosystems and local circumstances are available but these may need to be further refined through adaptive research.

- Avoiding excessive use of chemical fertilizers by applying integrated nutrient management.
- Policies to promote the adoption of these input-saving technologies.
- Piloting and refining schemes (such as Payment for Environmental Services) that provide compensation to producers of environmental services.
- Identification and protection of important rice heritage sites beyond those such as the Ifugao rice terraces in the Philippines, the Hani rice terraces in Yunnan Province (China) and the Wannian rice culture systems in Jiangxi Province (China). The Ifugao rice terraces are already included not onlyin the UNESCO World Heritage Sites but also in the Globally Important Agricultural Heritage System (GIAHS) initiated by FAO. National governments could similarly identify unique heritage sites and provide the required protection and support so that such heritage sites are adequately protected.
- The promotion of eco-tourism and the development of "rice products with cultural identity" that can be marketed will generate income and incentives to farmers to maintain their traditions so that they can continue their role as stewards of heritage sites. Traditional rice varieties with specific geographic origin and/or having unique quality characteristics can be similarly branded and promoted through the use of Geographical Indicators (GI) for niche markets for income generation.
- Infusion of science-based innovations that are built on traditional knowledge to promote the dynamic evolution of rice heritage.

Water and irrigation

Background

Water is a critically important resource for rice production. In Asia, irrigated rice accounts for more than 50 percent of the total rice area and over 70 percent of the total production. Thus, food security of the poor in Asia depends critically on irrigated rice. Around 60 percent of agricultural water withdrawal in Asia is used in rice production, so rice production is the single largest user of water. With economic growth, water availability for rice production faces increasing competition from other uses such as from increasing demand for high-value crops and from urban and industrial uses. Water availability for rice production is becoming scarcer both physically and economically. In addition, inappropriate agronomic and irrigation practices leading to water depletion, deterioration of water quality and contamination by toxic metals such as arsenic are important concerns.

The ecosystem services (see Strategic Objective 2) provided by rice fields depend critically on water availability. Thus, water availability affects not only rice production but also the environmental functions of rice paddies. As most large-scale irrigation systems provide services for multiple uses (for example, domestic use, hydropower, groundwater recharge, agricultural and industrial uses, and environment), it is important to consider priorities across all these uses while developing broader policies on irrigation development and water use. Priorities across these sectors are not static but change in the process of structural transformation.

The challenge, in the context of rising scarcity and multiple use of water, is to identify key options to increase water productivity in rice production while ensuring that the water quality and environmental services provided by irrigated rice fields are not compromised. The suitable options vary across countries and localities depending on the trends in farm size, mechanization, the extent of crop diversification, the nature of rice production systems and other related factors that are linked with the structural transformation of agriculture. In addition, broader issues related to investments in water resource development for a country, including trans-boundary issues, are also important as these define the total availability of water resources for various economic and environmental uses. Broader national development strategies and priorities that go beyond agriculture will govern these issues on water resource development.

Options/trade-offs

Focusing on rice, the major options for addressing the challenges mentioned above include the following:

- Improved on-farm water management for raising crop water productivity,
- Modernization of irrigation systems, and
- Conjunctive use and management of surface water and groundwater.

The most efficient option or a combination of options will obviously vary across countries and even among locations within a country, depending on local factors and the nature of the rice production system. The choices naturally involve important trade-offs.

Water accounting at different scales is critically important in designing strategies and guiding the choice among various options. The accounting of how water flows spatially and temporally through ecosystems is essential as it provides a comprehensive view of water supplies, demand and uses in the context of multiple scales and multiple uses.

Improved on-farm water management for raising crop water productivity

Agronomic practices to narrow the gap between attainable and actual crop water productivity could provide a set of cost-effective options for sustainable rice production. Yield could be improved through varietal improvements and numerous crop and water management techniques. In the irrigated regime under water scarcity, water-saving technologies such as alternate wetting and drying (AWD), aerobic rice and saturated soil culture can be implemented to raise water productivity. In rainfed systems, rainfall efficiency can be improved through the use of short-duration varieties and direct seeding.

These practices, however, can result in some important consequences (or trade-offs), which include a potential reduction in yield depending on management and field conditions; additional investments in water control needed for AWD of rice fields compared with the current practice of continuous flow irrigation; an increase in labour use for water management; increased weed infestation requiring the use of more herbicides; a decline in groundwater table due to reduced recharge from seepage and percolation; a reduction in ecosystem services as less water is retained in paddy fields; and an increase in nitrous oxide emissions although methane emissions decrease due to drier field conditions.

The location-specificity of the extent of the increase in water productivity and the trade-off effects implies that the options suggested require proper testing and evaluation.

Modernization of irrigation systems

The performance of large-scale irrigation systems is deteriorating over time because of years of neglect and must be improved through modernization. Service-oriented modernization is needed to facilitate flexibility and reliability to meet the irrigation needs of rice and of evolving diversified cropping systems. System modernization, however, can require high investment costs and it needs to be accompanied by governance restructuring and capacity building.

Institutional reforms in irrigation management are very much an integral part of the modernization process. It is important to look beyond the usual participatory irrigation management (PIM) and irrigation management transfer (IMT) approaches. A new alternative such as the public-private partnership using business models that is more compatible with the service-oriented approach to irrigation modernization and economic systems sustainability could be promising in this regard.

Groundwater management and conjunctive use

Irrigation systems that heralded the Green Revolution were mainly surface schemes based on dams and canals supplying water through gravity flow. The wide-ranging changes that are taking place in Asian agriculture have made the future of such systems questionable. These schemes are now considered to be relatively costly, having large negative environmental effects when supported by big dams, being difficult to maintain and manage, and being relatively inflexible to provide timely irrigation for supporting crop diversification, which is occurring in many parts of Asia due to rising incomes. On the other hand, groundwater schemes based on privately owned pumps are increasing in importance and have expanded substantially throughout Asia during the past two decades. The evolution of groundwater markets has enabled the purchase of irrigation in small quantities according to the needs of smallholders. Thus, groundwater schemes are now emerging as the mainstay of smallholder agriculture. However, overexploitation of groundwater leading to receding groundwater tables, rising pumping costs and deterioration of water quality are also becoming serious where groundwater development has occurred too fast and without a planning framework for sustainable use.

A major option where a surface-water diversion and delivery system is also available within the same area is to promote a conjunctive use and management of groundwater and surface water. This is happening to some degree by default with farmers investing in private tubewells in canal command areas to partly take advantage of groundwater recharge that occurs by seepage/percolation from rice fields and from canals. Governments can give a major boost to this by incorporating the principle of conjunctive use in the management of existing surface irrigation schemes and by promoting groundwater development in areas where such conjunctive use is feasible.

In addition, opportunities exist for improving the efficiency of pumps used for extracting groundwater. Rural electrification will promote the use of electrical pumps instead of diesel pumps, which are more expensive to run and are less energy efficient. Similarly, mapping and zoning of aquifers will facilitate better planning and devise regulations to prevent groundwater overdraft.

In the case of rainfed environments (mainly rainfed lowlands), key water management options include rainwater harvesting and more effective use of rainwater through proper tillage and mulching. Supplemental irrigation through groundwater use may be applicable in areas with a shallow groundwater table.

Smallholder farmers and farmer organizations

Background

Smallholder farmers dominate in the Asia-Pacific region, with the average farm size (measured in terms of operational holdings) being less than 2 hectares. A majority of the rice farmers in densely populated countries such as Bangladesh, China, India, Indonesia, the Philippines and Viet Nam operate on farms of less than 1 hectare. Farm size is not only small but is also decreasing over time due to increasing population pressure and the limited exit of labour from rural areas in some of these countries.

Small farms were earlier considered to have a higher yield per unit area than large farms, indicating the existence of an inverse relationship between farm size and yield. However, recent empirical evidence indicates that such an inverse relationship holds only in agrarian societies with surplus labour. The inverse relationship disappears or becomes considerably weaker as wage rates increase with increasing scarcity of rural labour in the process of economic growth. In fact, the rising scarcity of labour induces mechanization, which in turn induces an expansion of farm size. Whether or not farm size will actually increase depends on the nature of land markets, land tenure policy, regulations governing farm size, rural employment opportunities and the availability of custom-hiring services for farm machinery. These factors partly explain the increasing size of operational holdings in countries such as Thailand and Malaysia but the decreasing size in countries such as Bangladesh and India.

Given the current small average farm size, rice production in much of Asia will be largely carried out by smallholders in the foreseeable future even though there will be some pressure towards the expansion of farm size. Smallholder farmers will, hence, continue to remain central to rice farming. Smallholder farmers can, however, reap the benefit of scale in production and marketing by being organized in institutions that reduce transaction costs and increase overall efficiency. Such institutions include group farming, contract farming, community organizations and farmer cooperatives. Considerable experience exists in the functioning of such farmer organizations in Asian countries and SSC will be an important way of benefiting through sharing of such experiences.

Options/trade-offs

The major options discussed below relate to interventions that reduce the transaction costs for small farmers in relation to access to technology, information and markets, and improve the efficiency of farm operations.

- Improvements in the legal/institutional framework of contracts: Contract farming provides an opportunity to smallholders to benefit through participation in the modern value chain. Improving the legal and institutional framework of contracts by reducing transaction costs will enable smallholders to enter into such formal arrangements. In addition, such a framework will provide protection to smallholders from unscrupulous contractors.
- Promotion of custom-hiring services for agricultural machinery: Custom hiring is an important way through which most smallholders access services of agricultural machinery. Except for very small agricultural tools, large machinery such as tractors, harvesters and threshers is mostly used by smallholders on a custom-hiring basis. Such services are efficiently provided by the private sector – hence, a suitable regulatory framework and support policies to attract private sector investment for providing such custom services are needed.
- Promotion of farmer organizations/cooperatives: Farmers' groups and cooperatives could be empowered through local development and community-driven approaches and through support for capacity building in various aspects of farm and agri-business management, provision of preferential access to institutional credit and institutional reforms to recognize such entities as key agencies in agriculture.
- Provision of production and market information to smallholders through modern information and communication technologies.
- Development and promotion of technologies that are less risky and within the investment capacity of smallholders.
- Reducing farmers' production and market risks and providing safety nets (see the theme on climate change mitigation/adaptation and risk management).

Although these interventions are needed to empower smallholder farmers and increase their productivity and income, care must be taken not to rely on directly subsidizing farmers or their organizations. Subsidies are mere transfer payments that increase the fiscal cost and result in inefficiencies without necessarily making smallholder agriculture or farmer organizations economically viable. Care also must be taken not to slow down the process of structural transformation by directly or indirectly limiting options for rural labour to engage in non-farm employment.

Gender roles and empowerment of youth and women

Background

Women have always played critically important roles in agriculture in general and in all aspects of rice that include rice cultivation, consumption, conservation and commerce. Women's labour contribution in rice cultivation is generally well established and recognized. However, their roles in promoting healthy food consumption patterns in the family, in conserving rice biodiversity and in promoting rice commerce, although quite important, are often not recognized fully.

Food and nutrition security in the future will depend in important ways on ensuring that gender roles are integrated well into the food security system. In addition, it is important that women be empowered adequately to carry out these critical roles effectively in rural economies that are undergoing rapid transformation. Mainstreaming of gender dimensions in all aspects of the rice economy is thus important for ensuring the stability and sustainability of rice farming systems.

The rural youth of today are farmers of tomorrow. They represent a huge potential resource for rural development but they are migrating to urban areas due to a lack of profitable economic opportunities in rural areas. Such migration of young people will not only result in "greying" of the rural workforce, but also contribute to growing urban unemployment. Young people have enormous potential for the innovation and risk-taking that are often the core of smallholder agriculture. However, they face particular constraints in gaining access to land, credit and new technologies relative to their older peers. Investing in young people living in rural areas is a key to enhancing agricultural productivity and food security, boosting rural income and reducing rural-to-urban migration. When young people begin to see that smallholder farms can be transformed into dynamic innovative modern businesses, they will be encouraged to choose agriculture as a career path.

Options/trade-offs

Major options for empowering women follow:

- Mechanization to increase labour productivity and reduce the drudgery involved in various farm operations such as transplanting, weeding, harvesting and threshing. The drudgery involved in some of these operations may also be decreased by changing the method itself, for example, a switch from transplanting to direct seeding, and a shift from manual weeding to the use of herbicides for weed control. Although these activities will have a positive impact on women's labour productivity and their welfare generally, women may lose their income in more traditional systems in which labour-intensive operations such as transplanting of rice and weeding are their important sources of income and employment. In such cases, it will be important to provide alternative employment opportunities to women.
- Targeted training programs to build the capacity of young people to access and effectively use new technology and information for rice production and for making managerial decisions. This is particularly important for women heads of households and *de facto* farm managers. Future rice farming and post-harvest operations will be more knowledge-intensive and there is a need to train youth to take on these roles effectively through tertiary education and vocational training.

- Promotion of women farmers' participation in farmers' meetings, on-farm demonstration trials, farmer field schools and participatory experiments/evaluation of rice varieties and other technologies.
- Collection, compilation and analysis of gender-differentiated data (labour, income, decision making, access to assets and control of resources) to increase awareness among research managers, extension agents and policymakers to help reduce gender inequalities in access to resources and economic opportunities.
- Legislative changes to assure women's property rights to farm and other related assets. Legal entitlement to land will also facilitate women's access to institutional credit.
- Development of programs that incorporate the special role of women in food security systems in Asia, including culturally appropriate ways of interacting with women.

Food quality, safety and nutrition

Background

Quality is not always easy to define and it depends on the consumer and the intended use. What is considered to be high-quality rice in a particular social setup or country may not be considered high-quality rice in another. Quality indicators include directly observable parameters such as moisture content, softness, grain colour, chalkiness, shape and size, aroma and taste, and also extraneous matter and defective kernels. These are partly determined by underlying chemical characteristics such as gelatinization temperature and gel consistency, and partly by milling processes and grading aspects. Important scientific progress is being made in identifying and isolating genes responsible for such quality traits that are very promising for new varieties with significantly improved grain quality.

Safety is determined by the presence/absence of substances hazardous to consumers. High concentrations of residues and contaminants can make rice unsafe. Standards have been laid down both in Codex and ISO to cover safety parameters such as pesticide residues, heavy metals (arsenic, cadmium), aflatoxins and quality parameters. In addition, as per the Sanitary and Phytosanitary (SPS) Agreement, countries can impose additional requirements.

Grain quality and safety, hence, depend not just on the rice variety but on the production environment, production practices and post-harvest operations. Thus, the production of good-quality rice that meets safety parameters requires controls right from the stage of seed to in-field crop management, harvesting, drying, milling, storage, transportation and retailing. Following Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP) and good storage and fumigation practices *is* essential for food safety but certification may be needed to assure or demonstrate compliance with the standards set. Countries may have their additional set of safety standards based on their broader safety concerns. Fumigation is also an important issue both as a hazardous substance and for its impact on the environment. It is important to use gases that are non-hazardous to humans and the environment.

Although rice is a major source of calories, new scientific developments have opened up opportunities for biofortification of rice to increase its nutrient value. The density of important micronutrients such as iron and zinc in rice grains can be increased through breeding (or biofortification). Similarly, "Golden Rice" that is enriched in pro-vitamin A provides a new opportunity for overcoming blindness that afflicts millions of poor children. Rice varieties with low glycemic index enable better management or prevention of Type II diabetes. Rice fortification, which involves the addition of micronutrients to increase the level of specific nutrients or to restore nutrients lost during processing (e.g. milling), provides another important complementary option.

Unpolished or less polished brown rice has a higher nutrient value due to a higher content of protein and vitamins relative to well-polished rice. Other products with health benefits are rice bran, bran oil and parboiled rice. The overall nutritional value of rice can thus be increased by the development and marketing of these products.

Options/trade-offs

Thus, various options available to improve the quality, safety and nutritional value of rice follow:

- Improve the yield of high-quality traditional varieties such as Basmati rice through breeding to incorporate traits that result in higher yield. A particularly successful example is Pusa Basmati 1509 released in India in 2013. Additional work along this line may be desirable.
- Biofortification of rice varieties with micronutrients (iron, zinc, etc.) and rice fortification.
- Development and marketing of healthy rice by-products such as rice bran and bran oil rich in protein and micronutrients.
- Popularization of processing technologies and options such as parboiling and germination to conserve or improve nutrients.
- Consumer education and awareness to shift consumption from polished white rice to nutrient-rich brown rice and also towards healthy dietary diversification.
- The use of Good Agricultural Practices (GAP) throughout the production cycle and strict monitoring of compliance with accepted food safety standards with possible assurance and demonstration through internationally accepted certification schemes.

Although the above lists some of the major options specifically related to rice, other key factors such as maternal health, sanitation and health of a child in the first 1 000 days since conception are other major determinants of nutritional outcome. Broader reforms outside rice and agriculture are hence also needed to generate positive nutritional outcomes.

Value chains and post-harvest systems

Background

The rice value chains across the region can be broadly characterized as "traditional" and "modern export chains." Both categories of chains operate in parallel in practically all countries of Asia. Traditional value chains are characterized by a low level of vertical integration and coordination. The adoption of mechanized operations such as harvesting, threshing and drying in these chains has been relatively slow, resulting in inefficiencies in the post-harvest system and poor-quality outputs. In the case of modern value chains, organizational innovations including improved coordination and vertical integration have increased efficiencies, promoted mechanization and resulted in high-quality outputs.

The efficiency and quality of post-harvest handling operations strongly affect the quality of rice and the amounts of loss across the post-harvest system. The major post-harvest operations for rice are threshing, drying, storing and milling. There is a great diversity in the way these operations are carried out depending on the market and transportation conditions across Asia. Accordingly, the amounts of qualitative and quantitative post-harvest losses vary depending on the practices used.

Reliable quantitative estimates of post-harvest losses in diverse conditions in Asia are currently not available. But, the information available indicates that these losses could be substantial and a reduction in these losses, even by a few percentage points, can increase the availability of rice substantially. However, the cost-effectiveness of such loss reduction options varies and some options may not be financially viable.

Qualitative and quantitative losses can occur at all stages in the post-harvest chain. Hence, opportunities for reducing losses also need to be considered throughout the post-harvest system. Often, it is also important to consider the way rice is grown as this can affect post-harvest losses. For example, farmers often use "mixed" seeds containing several varieties from the previous harvest and post-harvest losses associated with such mixed harvested grain also tend to be high. Such losses can be avoided by using uniform standardized seeds.

Table waste of rice (i.e. cooked rice that is never consumed) is also an increasing concern in the region. There is therefore a need to make rice available in more convenient forms through value addition (rice cakes, rice snacks, etc.) to provide diversified options to rice consumers and to raise consumer awareness on table waste.

Options/trade-offs

Major options follow:

- Seed standardization: Planting standardized rice seeds of high quality to avoid higher harvest/post-harvest losses that typically occur when mixed seeds of different varieties are used.
- Harvesting and threshing: The traditional practice of manual harvesting and threshing is being largely replaced by mechanization in intensive rice bowls of Asia. Mechanization of one or both of these operations provides opportunities to decrease losses and improve quality through increasing efficiency in post-harvest operations and through suitable management and operation of these mechanical devices.
- Drying: Mechanical dryers of different types are now available. These range from small-scale farm-level dryers to flat-bed dryers and advanced continuous-flow dryers for handling large quantities.
- Storage: Hermetic storage, use of commercial silos.
- Milling: Modern commercial mills.
- Secondary processing of rice to enhance consumer convenience in the context of increasing demand for convenience food.
- The use of rice biomass (straw, husk) to generate energy (e.g. gasification) and animal feed or to produce economic products using innovative processing technologies.
- Shortening of the value chain through improved vertical coordination for increased efficiency.

Overall, these approaches are based mainly on mechanization as it provides opportunities for better control of individual operations. A suitable mechanization strategy, however, will depend on the nature of the value chain. Thus, strategies for quality improvement and reducing post-harvest losses need to be considered within the context of market requirements and wider transportation investments.

In a relatively simpler traditional value chain where rice is locally processed and consumed largely within the local production area, small-scale equipment to process the output may be adequate. In such circumstances, the mechanical devices may be individually owned or shared through suitable contractual arrangements involving cooperatives or the private sector. This strategy is suitable in areas with poor connectivity, fragmented markets and low production volumes.

In intensive rice bowls of Asia, the rice value chain is undergoing rapid transformation, with vertical integration taking place in the production-processing-marketing chain. These modern value chains mainly supply rice to large urban centres or to export markets. Modern mills play a key role in these systems in collecting paddy from farmers, drying, milling and supplying processed rice to urban consumers or to export markets. Benefits from quality improvement and reduced post-harvest losses in these systems largely accrue due to the shorter lengths and increased efficiency within these chains, coupled with good milling capacity. In addition to mechanization, the quality and safety improvement of rice hinges greatly on improved efficiency in the post-harvest system through improved horizontal and vertical coordination in the value chain, which contributes to better control of operations and decreased losses.

What are the public policy options for reducing post-harvest losses in these two types of value chains? For the first, the role of the public sector will be mainly in R&D to identify options suited to local conditions and promote identified suitable options. Partnership with the private sector will be important as the private sector has a comparative advantage in providing these post-harvest services efficiently. For the second, the public sector role will be mainly to create an enabling environment for private sector investment through institutional innovations that include group/contract farming for realizing economy of scale, establishing suitable standards and monitoring compliance.

Policies on rice price, trade and stock

Background

Governments have many different objectives in the rice sector, some of which are higher farmer income, improved welfare for consumers, price stability and self-sufficiency. Because rice is the most widely grown crop in most countries, and the single most important item of expenditure for the poor, the level and volatility of domestic rice prices will strongly affect the above objectives. Managing the level of prices is a particularly difficult problem, as high prices hurt many poor consumers but low prices hurt many poor farmers.

Rice stock and trade policy choices differ among exporters and importers, and are largely driven by the relative importance of the domestic rice policy goals noted in the previous paragraph. WTO rules on agriculture, mainly the Uruguay Round Agreement on Agriculture (URAA), and country-specific commitments made at the WTO, are other important parameters that constrain strategic and policy choices on rice trade. While some policies are not allowed at all, for example, import bans and variable tariffs, the WTO rules provide ample space for deciding national rice policy. For example, most countries have adequate space to subsidize rice production and have scope to vary tariffs within the relatively high bound levels. This space is likely to shrink gradually with further rounds of trade agreement, such as the Doha Round, but this is not a serious issue currently.

Rice attracts considerable attention in the WTO Committee on Agriculture in view of the range and depth of interventions in rice markets throughout most of the world, and notably in Asia. One of the national policy responses to the 2007/08 price crisis has been increased support to rice production as well as enhanced policy interventions such as higher price support, increased procurement and export restrictions. Although WTO rules generally provide ample policy space in most cases, some countries felt constrained in implementing food stockholding programs. In response, a group of WTO members proposed some adjustments to the current rules so that more space could be provided to upscale food stockholding programs. The proposal was taken to the Bali WTO Ministerial Meeting in December 2013 where a Ministerial Decision was made in favour of a “peace clause” under which other WTO members would not legally challenge such programs for four years even when WTO-allowed subsidy limits were breached.

Options/trade-offs

The major options for managing the level and volatility of rice prices include trade policy, stock management, domestic support prices, futures markets and the provision of market information.

Trade policy

Policies that affect international trade have an important effect on the level of domestic rice prices, and thus on the above objectives. Many countries control trade with tariffs and formal or informal quantitative restrictions. When these trade controls serve to raise domestic prices, there are several advantages. Higher prices mean more income for farmers, and also give them increased incentives for raising productivity. But, higher prices have many negative effects as well. Analysis shows that they often increase poverty, as the people with the lowest incomes tend to buy more rice than they sell. Higher rice prices also have a negative impact on nutrition, as they reduce the effective purchasing power of poor consumers and make it more difficult for them to afford foods such as meat, dairy products and fruits and vegetables that are crucial sources of micronutrients. Higher domestic rice prices also impede crop diversification, lead to higher wages that reduce industrial competitiveness vis-à-vis other countries and lead to more wheat imports as consumers substitute into wheat and away from rice.

Options and consequences for importing countries

For countries pursuing a given degree of rice self-sufficiency, whether 100 percent or lower, the role of trade policy is to prevent import surges that may undermine domestic farm prices and production. For this, the most common instrument is tariff protection, up to the level bound at WTO. Some countries have access to Tariff Rate Quotas (TRQs) that allow imports up to a pre-determined level (quota) at a low tariff, followed by a high tariff beyond that volume. Some Asian countries also have access to a Special Treatment in the URAA that enables them to control imports even more tightly. Restrictive import-licensing regimes and import monopolies by government parastatals are other instruments used by some countries.

Irrespective of the availability of these options, an important consideration that has been debated for years within countries is the choice between a rules-based import regime and one in which policies and instruments are changed occasionally on an ad hoc basis. An example of the former would be the TRQ regime, with no further intervention. For example, a country that has an 85 percent self-sufficiency policy would set the TRQ such that imports covering 15 percent of consumption take place at zero or a low tariff. A variable tariff, with which tariffs vary automatically with changes in world market prices, would have been another such rules-based regime, but this has been ruled incompatible with WTO rules. The main argument in support of a rules-based regime is that this provides predictability and leaves space for the private sector to be involved in rice business along the supply chain. Studies have shown that rice supply chains have suffered in terms of investment and efficiency relatively more than the supply chains of products for which policy interventions are fewer and less intense. There is a clear trade-off here with predictable consequences.

Strategic choices on trade policy also vary by country size. Large countries, that is, ones whose import requirements in the event of even a small supply shock can be very large relative to the size of the world market, are less able to rely on trade than small importers. The argument is that when a large importer buys supplies on the world market, world prices can surge, thus undermining the buffering capacity of the world market for such countries.

Options and consequences for rice exporters

Broadly, rice exporters in Asia can be categorized into two groups in terms of the policy choices exercised and the drivers of those policies. For regular exporters with consistent surpluses far in excess of self-sufficiency, exporting rice is mainly a commercial matter, that is, of maximizing export volumes and earnings. This is also the case for specific types of rice that are not considered important for food security, such as aromatic rice in South Asia. In such circumstances, there is little need to resort to trade-restrictive measures. However, exporters who are closer to self-sufficiency or are occasional exporters, are concerned about the food security consequences that may arise when exports surge due to a high global price, thus reducing the supply and raising the price at home. They may need to have in place mechanisms to monitor exports and to have instruments (quotas, variable export tariffs or even outright export bans) ready to manage export surges.

Current WTO rules are considered weak when it comes to exports and are not seen as a constraint to the policy space. Nevertheless, there can be important economic consequences to export restrictions, especially ad hoc export restrictions that undermine private sector investment in the export supply chain, raise uncertainty for farmers and cause a price surge in international markets.

Trade controls can reduce exposure to international markets, thereby helping to stabilize prices. But, if the trade controls are not implemented well, they can also lead to more domestic market instability in response to domestic production fluctuations. In order to manage domestic market instability, countries also use stocks as a complement to trade controls.

Stock management

Cereal stocks can be characterized according to their major purpose. Working stocks for planned distribution programs are typically held by national institutions responsible for food-based safety nets. The volume of stocks needed for these programs is based on relatively straightforward calculations based on the timing and location of planned distribution, as well as the time needed to replenish stocks from sources of supply. Emergency food reserves are used to enable a quick response to food needs following natural disasters or major disruptions to supply. To the extent possible, these reserves are pre-positioned in warehouses near the location of intended beneficiaries. Estimates of the appropriate size of emergency reserves are far less straightforward than calculations of working stock requirements, as they require an assessment of the likelihood and scale of future natural or human-made disasters, along with an estimate of how quickly stocks can be replenished in the event of potentially major disruptions to transport. More controversial and most problematic for management are stocks for price stabilization purposes. Here, the size of the stocks required depends in part on the desired level of price stabilization to be achieved (with greater price stability requiring larger stocks); the source, timing and price of supplies for stock replenishment (from domestic procurement, international commercial markets, food aid or government-to-government transactions); storage losses; and other storage costs (including interest costs).

Substantial research has been done on optimal price stabilization and buffer stock policy showing that, on average, some reliance on international trade can reduce the costs of price stabilization substantially. These modeling results derive from the fact that holding stocks entails substantial cost, in terms of both interest and quality deterioration over time. The extent to which trade-based price stabilization policies are superior to holding national cereal stocks depends on the degree of stability in international prices and availability, however. Because production outcomes and market conditions vary substantially from year to year, the relative contribution of stocks and trade to price stabilization can change over time.

International rice stocks have been tried by both the South Asian Association for Regional Cooperation (SAARC) and ASEAN (the Association of South East Asian Nations), but to date these reserves have had limited impact. Current efforts at international rice reserves are too small to make a difference for price stabilization in international markets, though they could conceivably help small countries in the event of a serious supply disruption.

Domestic support prices

Many countries use support prices to help increase farmer income and/or increase the level of self-sufficiency. In some cases, the support price is meant to serve as a floor price below which market prices should not fall. In other cases, it serves mainly as a procurement price to ensure that the government can obtain needed supplies.

For a support price to serve as an effective floor price, the government needs to have a large line of credit, in case there is a large domestic harvest and a large quantity of supplies needs to be purchased in order to prevent prices from falling. Many governments alternatively specify a fixed amount of money that can be used for procurement that effectively limits the quantity of rice that can be procured. In such cases, it will not in general be possible to keep market prices above a floor. The difference between the support price and the market price is also an important issue. If it becomes negative, then the government will not be able to procure supplies. But if the support price is far above the market price, the government can lose very large amounts of money that threaten the government's investment budget and even the continuation of the support price program itself.

Futures markets

Futures markets are also advocated by some as a way to make it easier to cope with price volatility. National futures markets exist in several countries, including China, India and Thailand. However, all of these markets are relatively small, and do not seem to have a major influence on the rice economy as a whole. A regional futures market, perhaps based in Singapore, has been suggested as one option to reduce the risks associated with rice trading, with possible spillover benefits to rice producers and consumers. However, one obstacle to a vibrant regional futures market is that domestic rice prices do not correlate very well with prices on the world market (due to government policies). This means that domestic producers, traders and consumers would not be able to use a regional market as a hedge against price risk, although such a market might be of some benefit to international traders. A regional market based in Singapore would also be far away from the major sources of rice supply and demand, thus missing out on one of the key advantages that has made futures trading so strong in Chicago.

Market information

The sharp increase in rice prices in international markets in 2007 and 2008 shook the confidence in international markets of many national policymakers and made increases in stocks an attractive option. In the case of rice, the world rice market has actually been quite stable since the mid-1980s, with the exception of the 2007/08 crisis. This crisis was not due to a shortage of supplies, but rather to government export and import policies that changed suddenly and without notice. Had government policy shifts been more gradual and predictable, and been made in consultation with the private sector, the price spike might not have occurred. Additional market information, especially on the level of stocks held by the private and public sectors, would help both governments and private traders to make more rational decisions and be less prone to panic. FAO is doing work through the Agricultural Market Information System (AMIS), a multi-agency initiative, in order to improve the information base on which sound policy decisions depend.

It is possible that larger domestic stocks would have stopped governments from these sudden changes in trade policies. Thus, holding moderate national stocks will likely remain the best option for providing insurance against short-term disruptions in trade and a tool to calm domestic markets in times of heightened market uncertainty. Together with medium-term policies to promote technical change and efficient domestic production, a combination of stocks and trade will likely remain the best option for ensuring food availability nationally.

Regional cooperation on rice

Background

The main question asked is where are the added values from bilateral, regional and global cooperation on rice? What would be some strategic choices for individual countries in this area?

A review of the past and current regional cooperation arrangements that are relevant for rice shows that such cooperation takes place at several levels: bilateral and pluri-lateral; regional, notably within Regional Economic Organizations (REOs); multi-REOs; and the global pluri-lateral level. One common thread connecting these various levels seems to be trade relations, and so cooperation at the WTO level is also relevant for this discussion.

As regards the areas of cooperation, an inventory of past and current arrangements shows the following: sharing of technology and knowledge, infrastructure and connectivity (e.g. Mekong), market information systems and policy fora (e.g. the AMIS), trade and stocks/reserves.

In each of these areas of cooperation, progress has been uneven as constraints to cooperation vary a lot owing to the extent of the divisiveness in the areas of cooperation. A rough categorization of this would be as follows:

Relatively less divisive issues (relatively easier to cooperate)

- Sharing of technology, knowledge (e.g. IRRI-NARES, within REOs)
- Infrastructure, connectivity (e.g. Mekong, GMS)
- Food safety, harmonization (e.g. within ASEAN)
- Information system (e.g. AFSIS)
- Reserves for emergencies (APTERR, SAARC Food Bank)
- Rice futures market (ASEAN region)

Relatively more divisive issues (relatively difficult to cooperate)

- Trade liberalization (ATIGA, SAFTA) – rice is on the sensitive list and has many non-tariff barriers (NTBs)
- Bilateral supply/price assurance agreements (e.g. government-to-government sales of rice)
- Policy coordination (effective ASEAN Rice Trade Forum)
- Positions on WTO

As regards the first list, a considerable amount of cooperation exists in these areas and much progress has been made in some areas. For example, a number of initiatives on rice have advanced within the Greater Mekong framework, including on technology and connectivity. Likewise, the rice information system is advanced under ASEAN's AFSIS. Regional food reserves have been set up in both the ASEAN and SARC areas (APTERR and Food Bank). Considerable discussions have taken place on rice futures – the problem has been technical, not a lack of willingness to cooperate.

In contrast, regional cooperation has been considerably more difficult in the case of the more divisive issues. Rice remains a sensitive product for some countries within ASEAN's ATIGA as well as in SAFTA, with several NTBs. Discussions on food reserves to address price risk have stalled completely. The idea of a framework for rice policy coordination and harmonization among ASEAN countries remains on paper only. Countries have pursued G2G rice sales arrangements bilaterally rather than making progress in enhancing trust in the open rice market. Cooperation at the WTO level with common negotiating positions has also been difficult as the interests and positions of the Asian countries diverge considerably, for example, on issues of farm subsidy and export restrictions. Finally, international pluri-lateral cooperation arrangements on rice, for example, with a global commodity agreement or globally coordinated rice stocks to respond to events as in 2008, have not made any progress.

Options

Given the recent experiences, what would be some strategic and policy choices for the consideration of individual countries in the case of rice? The first point to note is that, with increased integration of countries in the region, regional coordination has large potential to add value to what could be achieved without it. For this purpose, sharing technologies and knowledge among developing countries through SSC should be promoted. There are synergies in most areas that can be exploited by countries working together. In some cases, this is obvious, for example, restraining the spread of trans-boundary pests, food safety regulations, common and acceptable quality and safety certification mechanisms, sharing knowledge and enhancing connectivity.

One strategy would be to recognize that, in order to make progress in the more divisive areas, countries need to begin by intensifying regional cooperation on the less divisive or non-divisive arrangements to help build trust. For this, formal bodies may need to be created, such as the ASEAN Rice Trade Forum (the Rapid Response Forum, the policy coordination arm of the G20's AMIS, is a similar example), which has been effective in promoting dialogues on divisive policy topics on rice such as self-sufficiency and trade.

Several avenues exist on trade liberalization, notably the NTBs, from within the REOs. The REOs could also be the main bodies for addressing concerns such as the reliability of rice supplies from exporters. WTO remains the main body to work towards resolving some of the most divisive issues such as food export restrictions and farm subsidies. Lastly, it is also a matter of strategic consideration to recognize the limits to some of the regional cooperation desired or envisaged, for example, creating rice reserves, whether regionally or internationally, for offsetting global price volatility and risk of supply disruption.

Food and nutrition security in the Pacific Island countries

Background/issues

Like with the countries in Asia, the Pacific Island countries are making progress in improving food security and reducing malnutrition. However, the lack of reliable quantitative information on indicators of food security and nutrition makes it difficult to assess the progress made towards meeting the corresponding MDGs.

The major traditional staples of the PIC are root crops such as sweet potato, cassava, yam and taro. These traditional unprocessed foods are being increasingly substituted by imported rice and wheat. Increasing consumption of rice is mainly due to its higher calorie content than the traditional root crops as well as the convenience of storing, cooking and good taste. The dietary composition is changing from local traditional food to imported food, including rice, with some important implications for food and nutrition security. Increased dependency on processed imported food has contributed to increased incidence of obesity due to an unbalanced diet.

Local production of rice is limited although opportunities exist for increasing it. The production of rice in Fiji, Papua New Guinea (PNG) and Solomon Islands in 2012 totaled 15 000 tonnes, with the total area being 4 000 hectares (FAOSTAT). Fiji accounts for more than two-thirds of this total. With a combined population of 8 million, the per capita rice production in these three countries is less than 2 kg.

The domestic production of rice has remained historically low because of several constraints. Rice is grown in the PIC mainly in rainfed lowland and upland conditions due to limited irrigation development. Rice yields are low and variable as a result. Returns to labour using traditional methods of rice production, which is labour-intensive, are low relative to the production of root crops for food and cash crops for income. This has made domestic rice production economically uncompetitive. Other constraints are limited milling options, limited support services such as extension, credit and transport, a lack of suitable high-quality seeds and traditional land tenure. There have been numerous efforts and revitalizing programs over the past decades, but the economy-wide impacts of such rice programs appear to be minimal.

Total imports of rice in these three countries in 2010 were approximately 240 000 tons, with PNG importing two-thirds of this amount. Overall, rice consumption in the PIC mainly depends on imports.

The shift in dietary patterns from locally produced food to imported rice and other imported food items has major implications for food and nutrition security in the PIC. The dependence on imports can weaken the traditional food security system and make people vulnerable to supply disruptions or price spikes of imported goods. This happened during 2007/08 when the rice price spike sharply increased the import cost, thus severely compromising the food security of those who depended mainly on rice.

The key questions for the PIC are hence: (1) How to build a resilient and sustainable food security system that integrates rice with traditional food crops? (2) What is the economically optimal level of domestic production of rice vis-à-vis imports? and (3) What public investment and policy framework will promote long-term food security?

Options and consequences

The changing dietary composition in the PIC obviously means that rice will increasingly assume a greater importance in the future. Thus, a key policy option is to increase the market availability of rice at a price that is low and affordable to the poor. Subsidized domestic sales of high-priced imported rice, although often a popular policy, are unlikely to be sustainable on budgetary grounds.

Another option is to meet a larger proportion of the consumption requirement of rice from domestic production while importing only to cover shortfalls. This import-substituting policy requires an increase in domestic production. Input subsidy and rice price support are often promoted as key policy instruments for expanding production. Such policies, although justifiable in some specific circumstances, mostly lead to inefficiency by distorting the price signals and the budgetary costs can be prohibitive. In addition, such subsidy/price support schemes merely transfer resources to farmers but do not result in increased farm capacity to achieve efficient production in the long run.

A better option, as described in Strategic Objective 1, is to increase the productivity of rice through the development and use of improved technologies. Increased investments in R&D to develop productive technologies that raise both rice yield and labour productivity are needed. Improved rice varieties that are flood, drought and salinity tolerant are now available in Asia and these could be suitably adapted to the conditions of the PIC through adaptive research. Similarly, biofortification of rice with micronutrients and vitamin A could contribute to nutritional improvement. A suitable mechanization strategy will help increase labour productivity. Together with increased investments in rural infrastructure, these interventions could be expected to promote the emergence of a dynamic and efficient rice sector that could enhance food and nutritional security in the PIC.

Should the PIC attempt to meet their rice requirement mainly from domestic production and replace imports? The answer to this question really depends on the economic comparative advantage of the PIC in producing rice (import substitute) vis-à-vis export crops. Increased investments in R&D for rice will tend to shift this comparative advantage in favour of rice. But, whether or not such shifts will be large enough to justify a substantial reduction in the current dependency on rice imports will depend on many other factors and the results will most likely vary across countries. In addition, it may take several years to develop improved technologies adapted to the PIC and for those technologies to be widely adopted. In the meantime, the PIC will likely have to continue to rely on imports. Given this, it will be important for the PIC to carry out a detailed analysis of the extent to which increased domestic production is economically justifiable by considering the price of imported rice and economic returns from alternative crops.

A third but complementary option is to integrate rice with traditional crops in the food systems. Although of increasing importance, rice in the PIC will most likely remain only as a component of the overall diet, which consists of many indigenous food items. Thus, the achievement of food and nutritional security will depend on interventions that promote sustainability and resilience of the larger food system.

THE WAY FORWARD

The strategic objectives and key intervention options, including the trade-offs involved in the choice of options to achieve the proposed 2030 vision for the rice economy, were discussed in the previous sections. Wider consultations with stakeholders will be needed to translate the broad vision and strategic objectives into specific measurable targets and an implementation plan. Although regional coordination may be important for some objectives (e.g. trade policy, information and technology sharing, food safety standards and certification, and trans-boundary management of water), others fall largely within the national policy-making arena (e.g. taxes/subsidies, technology development/extension and domestic market reforms). Priorities across the six objectives may vary across countries, depending on the country-specific context and the national development strategies. Complementarities and trade-offs across objectives will need to be considered while setting priorities. The suitability of specific options similarly depends on the country/ context and the choice of the best option or a combination of options falls within the ambit of national policy making. Clearly, member nations and organizations such as FAO have important roles in facilitating wider consultations for developing an implementation plan that includes dimensions of both regional coordination and country-level policy.

As the next step, while promoting regional coordination and networking, national initiatives will be needed to translate the regional strategy into country-level actions by refining existing national rice strategies or formulating new ones as needed. Efforts in this direction could be focused initially on a few pilot countries. Current initiatives such as the Regional Rice Initiative (RRI), a pilot initiative implemented in 2013 by FAO, could be considered as synergistic components of the regional strategy.

Based on the broad analysis presented, the following four major areas of action are suggested:

1. Investment in R&D for inducing and supporting technological innovations in all stages of the rice value chain for productivity and efficiency gains, higher quality and nutritional value, greater resilience and environmental protection.
2. Promotion of technology and knowledge transfer and ICT.
3. Policy and institutional innovations to promote rural income growth and the rapid spread of improved technologies, and to develop a robust food security system that is stable and accessible to all.
4. Investment in rural infrastructure.

The overall approach presented here is consistent with important elements of the Zero Hunger Challenge that is composed of five pillars: (1) 100% access to adequate food all year round; (2) zero stunted children less than 2 years of age; (3) all food systems are sustainable; (4) a 100% increase in smallholder productivity and income; and (5) zero loss or waste of food. The Asia-Pacific Zero Hunger Challenge was launched in May 2013 and strives to achieve its objectives by 2025. National rice strategies or policies once formulated would be implemented within the framework of the Zero Hunger Challenge.

Technological innovations and investments in R&D

Technological innovations are often the prime mover of agricultural transformation. The Green Revolution that led to a rapid growth in the production of food grains in Asia in the second half of the twentieth century is an excellent example. Technological innovations require sustained investments in R&D. However, public investments in R&D from domestic and international sources have been not just low but also declining during the past two to three decades. It is only after the food crisis of 2007/08 that there has been some upward trend in such investments. A strong case clearly exists for providing a substantial boost to

R&D investments as expected returns measured in terms of improvements in food security of the poor and poverty reduction continue to remain high. This is especially important for developing suitable adaptation and mitigation strategies in the context of global climate change. A complementary aspect is the development and dissemination of new technologies for the rainfed systems that would bring real transformational change to the food security and prosperity of the people living in these environments. Rice varieties and related technologies that perform well under stress conditions (such as drought, submergence and salinity) of rainfed environments also improve adaptation to climate change, resulting in a "win-win" situation.

The promising rice technological options that are ready or almost ready for farmer adoption include a new generation of hybrid varieties with higher yield potential and inbred varieties with multiple tolerance of abiotic (drought/submergence/salinity) and biotic stresses. Some of these require adaptive research while others may require some additional development to improve grain quality (such as with hybrid rice). Advances in scientific tools (e.g. biotechnology and genomics) have also led to the development of micronutrient-rich rice varieties and rice varieties that are enriched in pro-vitamin A. Rice fortification similarly provides an important option to increase the nutritional value of rice. Exciting long-term research on substantially boosting the yield of rice by altering its physiological mechanism from the C3 to C4 photosynthetic pathway could open up a completely new frontier. Similarly, increased international and national investments in R&D are needed in some promising frontier scientific areas such as rice functional genomics, bio-prospecting of genes and allele mining, engineering rice with biological nitrogen fixation and apomictic rice. The collection and conservation of fast-eroding wild rice are another high-priority area for public investment.

In addition to genetic improvement of rice, considerable opportunities exist for raising input efficiency and total factor productivity through better agronomic practices. Precision rice farming and the use of nano products hold great promise for enhancing productivity and sustainability in some areas. Similarly, investments are needed to develop resilience measures to address climate change and the sustainable management of natural resources. New developments in rice mechanization throughout the various stages of rice production need further government support and the involvement of the private sector.

Improvements in post-harvest value chains for improving quality, reducing losses, raising efficiency and adding value are important aspects that are receiving greater recognition more recently. High payoffs can be expected in countries where value chains are undergoing rapid modernization. Even in situations in which largely traditional value chains continue to supply the region's poor and undernourished, government support for technological and organizational improvements is needed to enhance food security. A number of potential technological options exist to improve post-harvest operations (such as threshing, drying, storing, packaging and transporting) but some of them may need further development through adaptive research. This is an area where suitable models for "partnership for prosperity" between the public and private sector could bring in large dividends.

Unlike in the past, private sector investment in R&D in rice is now increasing. This growth in private sector investment clearly provides an opportunity to encourage the development of public-private partnership for substantially augmenting the amount of investment in R&D. Obviously, mechanisms for sharing of both the costs and benefits through licensing or other suitable arrangements would need to be developed and countries can draw lessons from several existing models.

Promotion of technology and knowledge transfer and ICT

The benefits of agricultural research will not be fully harnessed unless effective linkages between agricultural research and extension are created, including the promotion of ICT and e-Agriculture as well as SSC. The current weak link between research and extension and between research and development investments severely constrains the spread of innovations. This needs to be overcome by capacity building and by promoting diverse learning and dissemination approaches that involve researchers, extension agents, civil society organizations (e.g. NGOs, farmer organizations) and the private sector. The power of modern information and ICT could be harnessed for the large-scale dissemination of information (e.g. weather forecasts and market opportunities) and new technologies. Differences in available rice technologies, R&D capacity and ICT developments across countries clearly point towards opportunities for impact through improved SSC for technology development and transfer. The constitution of a network among countries to share experiences and approaches is of high priority in this regard. Public information on the new opportunities in technologies and value chains is critical for generating public support for new investments and policies.

Policy and institutional innovations

Rice production takes place in the context of specific policy and institutional environments. Accordingly, policy and institutional innovations can facilitate the desired transformation of the rice sector. Economic incentives to adopt improved technologies depend critically on these policy and institutional factors. For example, subsidies on fertilizers, pesticides and irrigation that are often provided to farmers discourage the adoption of technologies that save these inputs. Similarly, long-term farm-level investments such as for improving irrigation and soil fertility are discouraged by insecure tenancy. The removal of such subsidies and making tenancy secure will encourage the adoption of these practices.

Structural transformation in which labour moves out of the farm sector induces a major reorganization of rice production. Labour scarcity induces mechanization but mechanization in most cases becomes efficient only when the farm size or operational holding increases. Where regulations limit farm size, the expansion of operational farm size can be facilitated by promoting group farming (or cooperatives) or by removing restrictions on the operation of land rental markets.

Given the small average farm size in several major rice-growing countries in Asia, rice production is likely to be carried out mainly by smallholders in the near term despite the underlying pressure for an expansion of farm size. For efficiency, smallholder farmers need to be able to reap the benefit of scale in production and marketing by being organized in institutions that reduce transaction costs and increase overall efficiency. Such institutions include group farming, contract farming, community organizations and farmer cooperatives. Capacity building and empowerment of such farmer organizations and farmer groups are hence needed to increase the efficiency of smallholder agriculture and connect smallholders effectively with the market for income generation.

Farmers will also require new skills in farm management and agri-business, which could be provided through targeted education programs, especially for women who are increasingly taking on the role of farm managers. The new generation of farmers who are young and innovative could similarly benefit from such targeted training programs. Programs could also be designed to incorporate the special role of women in food security in Asia. Similarly, programs that provide economic incentives to farmers/rural communities involved in dynamic conservation of biodiversity and rice heritage could also be developed using a framework such as Geographical Indicators (GI) and Globally Important Agricultural Heritage Systems (GIAHS). The promotion of organic farming as indicated in a joint declaration by FAO and the International Federation of Organic Agriculture Movement (IFOAM) could help develop organic value chains. Local development and community-driven approaches will promote broad-based rural development by empowering the rural poor and disadvantaged and vulnerable communities.

Institutional innovations for raising crop water productivity and ensuring adequate availability of water for environmental uses are very important for the future of rice farming. A number of such innovations were presented in the previous section. A key challenge, however, is to design mechanisms that promote adaptive institutional responses as priorities in the use of water change in the process of structural transformation.

Income from non-farm rural activities is an important source of income in rural areas. This consists of economic activities that can be broadly characterized as retail trade, manufacturing and services. Policies that strengthen the rural non-farm economy through investments in infrastructure, health, skill building and market development and improving access to credit will raise income and also facilitate the process of farm reorganization.

The food security system can be considered to be robust if it is able to (1) avoid wide fluctuations in the price and supply of rice and (2) provide an effective safety net to vulnerable people. Several options to manage price volatility through a combination of stock, marketing and trade policies were discussed earlier. Again, the right mix of these options will be country-specific but regional fora such as the ASEAN Rice Trade Forum can provide useful mechanisms for information exchange and promoting dialogues on rice trade that are needed to build trust in trade following the food crisis of 2007/08.

Regarding the safety net, possible interventions include conditional cash and food transfers, maternal and child health and nutrition programs, public works and insurance schemes. In addition to these broader safety net programs, the promotion of farm-level activities that integrate various combinations such as rice-fish, rice-livestock and rice-horticulture will help protect the rural poor by providing diverse livelihoods.

Investments in rural infrastructure

Investments in rural infrastructure area key to improving connectivity with markets and with the rest of the economy. Rural infrastructure such as electricity and roads has been shown to generate substantial benefits by promoting forward/backward linkages and the development of the rural non-farm sector. For example, many farmers are constrained by a lack of all-weather roads that can bring in cheaper inputs and make it easier to sell farm produce to outside markets. By making a village a larger part of the market, improved connectivity generally helps improve local food security as shortfalls in production caused by local factors can be overcome by purchases from the larger outside market. The increasing availability of mobile phones (which has been provided by the private sector) enhances the value of rural roads, and will continue to be a key development in the coming years. Other infrastructure includes schools and hospitals, which produce much broader impacts by improving the health and skills of the rural population. Investments in this rural infrastructure have both economic and social value. These investments promote overall development. Increased investments in rural infrastructure thus have high priority.

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