SAFE, NUTRITIOUS, AND AFFORDABLE FOOD FOR ALL

ADB FOOD SECURITY FORUM 2016 DISCUSSIONS AND RECOMMENDATIONS

ASIAN DEVELOPMENT BANK

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Foreword

Food security challenges in Asia and the Pacific are constantly evolving with changes and transformations taking place regionally and globally. One of the lessons we have learned from the food price crisis of 2007–2008 is that food supply instability and price volatility can go beyond an increase in the incidence of hunger and malnutrition, affecting social and political insecurity. Evidence suggests that the crisis resulted in a temporary setback in the poverty reduction target, a fundamental objective of the Millennium Development Goals. Fortunately, multiple actions ranging from immediate food assistance to medium- to long-term assistance to increase supply and stabilize prices helped bring us back on track. Post-2015, the Sustainable Development Goals (SDGs) put food and nutritional security high on its agenda. SDG 2 aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

Climate change, economic transitions, and demographic transformations will have major influences on the future of food in the region. Climate variability and change will have significant effects on production and supply of food, and the prospect of sustainable agriculture in the region. Rapid urbanization and growth of middle-income consumers will result in dietary preferences requiring a restructure of the agricultural sector. The total population of Asia and the Pacific is likely to increase to 5.3 billion by 2050 from 4.5 billion in 2016, according to the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). More food is required to feed the additional population.

Tackling these challenges requires collaboration among governments, the private sector, civil society, and development partners. It is in this context that the Asian Development Bank's (ADB) Rural Development and Food Security Thematic Group organized the ADB Food Security Forum 2016 at its headquarters in Manila on 22–24 June 2016, in collaboration with a number of other organizations (Appendix 1).

Bannering the theme "Safe, Nutritious, and Affordable Food for All," the forum brought together about 400 participants including government leaders, representatives from private sector and civil society organizations, development experts and practitioners, farmers, and women and youth leaders for (i) knowledge exchange and dissemination, (ii) showcasing innovative and state-of-the-art technologies, and (iii) networking and partnership building. The discussion was forward-looking and oriented toward the development of new approaches and investment while consolidating existing advances and achievements to end hunger and malnutrition.

This report distills the depth of the discussions derived from the proceedings of this forum. ADB seeks to provide a better understanding of the food security challenges and opportunities to work in partnership with this report. We hope it will facilitate knowledge sharing, innovations, and partnership to invest more in the agriculture sector.

We are grateful to the development partners, civil society organizations, government leaders, private sector representatives, farmers, women, youth leaders, speakers, panelists, moderators, and other participants who made the forum a success and this report possible.

We hope this report can serve as a basis to forge effective partnership and collaboration to meet the need of the times: safe, nutritious, and affordable food for all.

Bambang Susantono
Vice-President, Knowledge Management and Sustainable Development
Asian Development Bank

Executive Summary

New challenges to end hunger and malnutrition are emerging. Hunger still exists and food security is yet to be achieved in the Asia and Pacific region. Farmers are facing new challenges every day, which are constantly evolving with changes and transformations taking place regionally and globally. If left unattended, these challenges will make the accomplishment of sustainable development goal (SDG 2: end hunger and malnutrition by 2030) difficult.

Despite population growth, the agriculture sector suffers from labor shortage. Asia and the Pacific is home to 61% of the world population which amounts to be about 4.5 billion in 2016 and projected to increase to about 5.3 billion by 2050. The region in general has a low land-to-population ratio. Additional 0.8 billion people will further reduce this ratio. This will require a paradigm shift to concentrate more on technology and nonland resources to produce food for its growing population. With the increase of total population, demographic composition will also take the shape of an inverse-pyramid implying relatively less working population. This will affect agriculture sector more than any other sector as a result of international and domestic rural-to-urban migration of young population. Agricultural sector in many countries of the region have already started suffering from shortage of labor and rising wages.

Economic transitions in the Asia and Pacific region can affect the food security of the poor. The ongoing economic transition in the region is going to affect the food security of the region. Two main features of this transition are rapid urbanization and growth of middle-income consumers. The region is projected to become 56% urban by 2030. The number of middle-income consumers is projected to increase to 3,228 million during the same period from 525 million in 2009. With these changes, the dietary preference of tens of millions of people will shift from grains to protein, fats and oils, meat and fish, pushing their price and production. The interlink between the price of food grains and nongrain foods will affect the food security of the poor by diverting more land to the production of the latter, and increasing the price of the former.

Climate change has become a new normal in Asia and the Pacific and the worst is yet come. Extreme events such as heat waves, droughts, tropical cyclones, prolonged rainfall, tornadoes etc. have become more intense and frequent. The occasional crop failures as a result of these natural calamities increase the risk of private investment in agriculture sector. Climate change also affects the availability and quality of natural resources, which in turn affects the long term agricultural productivity. According to an ADB study,[1] climate change may reduce yields of primary commodities (irrigated rice, wheat, and soybeans) by up to 9%–44%, increase commodity prices by up to 10%–50%, resulting in an increase of child malnutrition by up to 20% by 2050. The agriculture sector is not only a victim of, but also a significant contributor to climate change. Nitrous oxide linked to fertilization, carbon dioxide from fossil fuels used in the field as well as from across the whole food system continuum, such as food transport,

[1] ADB 2009. *Building Climate Resilience in the Agriculture Sector of Asia and the Pacific*. Manila.

storage, cold chains, processing, and methane from cattle farming and irrigated rice all cause greenhouse gas emissions. This spiral relationship between agricultural activities and climate change poses a great threat to the food security in Asia and the Pacific.

A new paradigm is needed to face the emerging challenges. Measures that have been applied so far to promote agricultural growth withstanding these challenges include mechanization of farming activities, building resilience of crop systems, managing genetic resources with appropriate traits and characteristics adapted to specific environmental context, and use of different technologies. In most cases, the main objective of these technologies have been to promote intensified use of land, labor and other natural resources. In the evolving reality, when land and other resources are declining, agricultural labor is shrinking, climate change is happening fast, the Asia and Pacific region needs departure from resource extracting technologies to resource saving technologies. It means simple improvements of existing technologies will not be adequate. Rather, high-level technologies (HLT) like innovative process and/or inputs that create opportunities for economies of scale, and maximize cross-sectoral synergies need to be introduced. Improvements are required at all segments of the agricultural supply chain.

Use of HLT in agriculture needs to be an integral part of the overall economic plan. Inconsistency among different sectoral policies affects the use of HLT. For example, protective trade regime shields the agricultural sector from external competition and thus works as a disincentive for farmers to use HLT to enhance productivity. Similarly, input subsidization, as practiced in many countries, results in increased use of inputs instead of HLT in order to increase agricultural yield. Harmonization of different sectoral policies and elimination of cross-border hurdles on the movement of knowledge and technologies at regional and international levels are required to create an enabling environment to develop and use of HLT. At national level a holistic development approach needs to be undertaken where sectoral policy will complement, instead of conflicting, each other. At international level, intellectual property rights need to be properly enacted while promoting cross-border transfer of technology.

Escalated investment and reorientation of agricultural research are crucial. The development of HLT has traditionally been poorly funded and suffers from inadequate private investment. Investment in agricultural research as well as reorientation of the focus of this research from increasing output per unit of land to output per unit of natural resources (e.g., output per drop of water) are essential. Such investments are also needed to remain ahead of the curve in climate change adaptation and mitigation. For example, given the average length of breeding cycles to develop a climate-resilient a rice variety, only two such varieties can be developed by 2030, which may not be enough to produce adequate food for growing population.

Farmers need to be reached out and supported to use HLT. The success of mainstreaming the use of HLT in agricultural sector depends on farmers' interest and willingness. One way to motivate the farmers to use HLT is to effectively disseminate the use and usefulness of this use through demonstration, consultation and training. Mainstreaming of use of HLT may also require aggregation of production through encouraging new institutional set up like producers' cooperatives where small and fragmented landholdings hinder the adoption of HLT. Investments in physical infrastructure like energy, road connectivity, transport, storage, processing and preservations, market and distribution centers, and overhauling of the obsolete infrastructure are also essential to make the use of HLT profitable for the farmers.

Agricultural credit needs to be enhanced. Farmers are constrained by lack of their access to finance. Due to asymmetric information, cumbersome traceability in case of default, missing credit history, and poor enforcement of contract, farmers are considered by the financial institutions as "high-risk" or "unbankable." On the other hand, farmers cannot access credit from the formal market as they do not have adequate tangible assets to use as collateral. The problem of collateral is further intensified by chaotic land management in most of the Asian countries. The farmers cannot use whatever land they own as collateral as land record and title are very complicated, where in most cases ownership in paper is collective or joint but operation in the field is fragmented. Traditional systems of inheritance and property including agricultural land have been predominantly patrilineal, which particularly affects the female farmers in obtaining finance from formal sources. Different models to derisk the agricultural financing by the private sector are currently being exercised in a limited scale. They need to be scaled up. Comprehensive approach to link the upstream activities with the downstream of the food sector to increase the resilience of the farmers to credit and market risks needs to be facilitated.

Market and supply chain needs to be improved. With the shrinkage of the farming community as a result of the outmigration of the young population from the agriculture sector, fewer farmers will have to produce more food to feed the growingly large population. This also implies that market has to play a significant role in the future to bring the food from farm to table. The number of middlemen involved in the agricultural supply chain needs to be reduced to check the dissipation agricultural profit. For that, small and unregulated markets need to be integrated into large market and distribution center with agrilogistics, safety and quality control infrastructure, where farmers can directly sell their products. Such centers will also help the government to monitor, detect and prevent food contamination.

Measures to deal with food market volatility have to be strengthened. In addition to increase in production and better management of overall agricultural supply chain, increased efficiency of social safety nets, improved public procurement and inventory management are also essential to promote food security in the Asia and Pacific region. There is evidence that use of ICT in the management of social safety net programs improved their efficiency and effectiveness. Therefore, use of an end-to-end ICT-based management system in social safety net program should be promoted. Barriers to international trade, both tariff and nontariff, should be eliminated to use international trade of food as a hedge against the volatility in domestic food market.

Abbreviations

ADB	Asian Development Bank
ANR	agriculture and natural resources
BAAC	Bank for Agriculture and Agricultural Cooperatives
CTI	Coral Triangle Initiative
DMC	developing member country
EIU	Economist Intelligence Unit
FAO	Food and Agriculture Organization
GCF	Green Climate Fund
GDP	gross domestic product
GIS	geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMS	Greater Mekong Subregion
HLT	high-level technology
ICT	information and communication technology
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
PRC	(the) People's Republic of China
SDG	Sustainable Development Goal
SIDC	Sorosoro Ibaba Development Cooperative
SPS	sanitary and phytosanitary
UN	United Nations
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
USAID	United States Agency for International Development
WFP	World Food Programme

Introduction

"No farmer, no food, no future." This is how a farmer summed up the essence of food security at the ADB Food Security Forum 2016.[1] Despite some visible progress made in the recent years, about 512 million people in the Asia and Pacific region still suffer from hunger. Farmers are facing new challenges every day, resulting from shrinking natural resources, degrading environments, and climate change and climate-induced disaster risks on one hand, and rising wages and declining workforce due to demographic changes, such as aging population, rural to urban migration along with increase in nonagricultural labor demand, on the other. Simultaneous to these supply-side challenges, demand-induced challenges in the form of dietary diversification and changing food preferences are also emerging from economic growth and urbanization. These latter factors have the potential to act as a "pull factor" for increased investment in production diversification and modernization, including value chains and agribusiness.

While these changes are unfolding, more rigorous targets have also been set under the post-2015 Sustainable Development Goals (SDGs) to rid the world of hunger, achieve food and nutritional security, and promote sustainable agriculture by 2030—Goal number 2 of the SDGs. Accomplishing the SDGs related to food security requires partnership and collaboration among the governments, private sector, civil society, and development partners in pursuit of their priorities and commitments. It is in this context that the Asian Development Bank (ADB), in collaboration with a number of development partners (Annex 1), organized the ADB Food Security Forum 2016 that brought together over 400 participants representing a wide range of stakeholders.

This report consolidates discussions summaries and main messages from the forum on good practices, innovations, and ways forward to ensure safe, nutritious and affordable food for all in Asia and the Pacific. A number of complex and challenging problems, such as climate change, market and financial access of small-scale producers, and quality, safety, and nutrition of food, were raised during a dialogue among development partners on the use and application of high-level technology to end hunger. A total of 20 organizations, clustered into four groups, took part in this dialogue (Appendix 2). Likewise, about 16 organizations exhibited state-of-the-art agricultural technologies and products that showcased emerging solutions (Appendix 3).

In panel discussions, food and agribusiness leaders, national and international policymakers, civil society representatives, and farmers discussed the changing agricultural landscape and recommended more comprehensive investments in technology, information services, infrastructure, and inclusive agribusiness financing for sustainable food security. This report ties these topics together to create a broader understanding of issues and recommendations, and share the output of the forum with a larger audience.

[1] ADB Food Security Forum 2016. Manila, Philippines, 22–24 June 2016.

Mirroring the forum sessions, the report delves into the following areas:

- **Emerging challenges of food security in Asia and the Pacific,** which focuses on challenges arising from economic transition (i.e., low-income countries becoming middle-income countries with increased urbanization); demographic shift (i.e., aging rural population, young people exiting from agriculture leading to the feminization of workforce); and climate change and natural resource degradation.
- **Mainstreaming the use of high-level technologies to end hunger,** which highlights the importance of technology and innovations, and identifies measure to scale them up through proper policy and institutional support.
- **Connecting farmers, agribusiness, and finance,** which takes stock of what is emerging in policy, technology, and the financing areas of the agriculture sector to identify the policy imperatives to connect farmers of all sizes with agribusiness in order to promote inclusive growth.
- **Sustainable entitlement to safe and nutritious food** through improvements in food safety and quality standards, trade of food, market facilitation, and social safety net programs.

The final section provides the summary and recommendations.

ADB

"I want to promote the food sector at ADB once again"—ADB President in the Leaders' Roundtable at ADB Food Security Forum 2016.

Emerging Challenges of Food Security in Asia and the Pacific

In 2000, when the United Nations Millennium Conference in New York set the eradication of extreme poverty and hunger as the number one objective for the next 15 years, about 617 million people were suffering from hunger in Asia and the Pacific. This number has decreased to 512 million from 2014 to 2016, according to the Food and Agriculture Organization of the United Nations (FAO), 2015a. Despite this progress, the region has witnessed one of the most the severe food crises since mid-1970s, in 2007–2008, along with the rest of the world due to food price hike. The crisis increased the number of people suffering from hunger by about 28 million (FAO, 2015b). The possibility of a similar event recurring cannot be ruled out if we do not act now.

According to the Global Food Security Index 2016 by The Economist Intelligence Unit (EIU), Asia and the Pacific is one of the lowest-scoring regions on food security, coming ahead of only sub-Saharan Africa. However, this low overall score disguises striking differences between wealthy and underdeveloped nations of the region. For example, the top five countries in the region, Singapore, Australia, New Zealand, Japan, and Republic of Korea, scored 83.9, 82.6, 81.1, 75.9 and 73.3, respectively. The bottom five countries, Nepal, Cambodia, Tajikistan, Bangladesh, and Lao People's Democratic Republic, scored 42.9, 39.8, 38.6, 36.8, and 32.7, respectively. While East and Southeast Asia have achieved Millennium Development Goal 1, the highly populous Southern Asia has failed (The Economist Intelligence Unit, 2016).

In terms of *availability* and *affordability* (EIU, 2014), the food security problem in the region is more pronounced in the case of the latter than the former. Thus, even though food production increases, affordability becomes a major obstacle to food security in the region. The region's economic growth remains inequitable and consequently, so does consumption.

> *If food prices will go up, what happens to the poor? If food prices do not go up, we are not going to get the supply response to increase food. So this is a central policy dilemma.*
>
> ADB Food Security Forum 2016

The complexity of food security in the region is also intensifying due to a number of emerging challenges, broadly grouped as (i) population growth and demographic transition; (iii) economic transition; (iii) competing uses of grains; and (iv) climate change, environmental degradation and shrinking natural resources. These are discussed below.

Population Growth and Demographic Transition

Asia and the Pacific is home to 61% of the world's total population. The People's Republic of China (PRC), India, and Indonesia account for 40% of the world's population (Swiss Re, 2013). The total population of the region is estimated at 4.5 billion in 2016 (ESCAP 2016)

and is projected to increase to 5.3 billion by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2015). The additional 0.8 billion people will directly create higher demand for food. Considering the stresses on rice, wheat, and maize, in terms of loss of land, scarcity of quality inputs, and impact of climate change, increasing agricultural yield to feed the additional population will be a daunting task.

Malnutrition, in terms of undernutrition and overnutrition, will intensify with the growth of population in the region. The escalated problem of micronutrient deficiency will also result in more cases of obesity. Thus, ensuring food security requires a large-scale solution involving biofortified crops, rice fortification, higher yields, efficient use of inputs, climate-resilient agriculture, and so forth. The growing population will make this large-scale solution even more challenging.

> *Before, when we talked about food security, it was largely ensuring that people got enough to eat. But now we are faced with at least recognition in terms of triple of burden of malnutrition.*
>
> ADB Food Security Forum 2016

Asia, in general, is a land-poor region. Population growth will compel many countries to resort to aqua-based food to ensure adequate food supply, which Indonesia is already considering. Research has already shown the potential of the marine environment to produce safe, nutritious, and affordable food. Many countries with relatively low land-to-population ratio will require a paradigm shift to concentrate less on land and more on the ocean to source food and nutrition. This will require a huge shift of focus in terms of policy and institutional setup.

With the increase in total population, the demographic composition will also change and the ratio of elderly population will increase. And more importantly, the agriculture sector will suffer from shortage of labor because of international and domestic rural-to-urban migration. For example, agricultural workforce in India declined by 30.6 million, dropping to 228 million in 2011–2012 from 259 million in 2004–2005 (International Crops Research Institute for the Semi-Arid Tropics, 2016). A similar situation prevails in other Asian countries like Bangladesh, the PRC, and Indonesia (Wiggins and Keats, 2014).

Along with these changes at the farm level, the agriculture sectors of different countries in the region are also advancing from one stage of development to another as shown in Appendix 4. With this vertical movement, a country also approaches "Lewisian turning point," a situation which implies exhaustion of surplus labor in the rural sector. At this stage, wages in the agricultural sector start to rise paralleling the wages in the nonfarm and industrial sector. As seen in Box 1, the share of agricultural employment in total employment in the Republic of Korea declined from 39.4% in 1965 to 2.3% in 2013. Annual agricultural value addition per worker became at par with the wages of the skilled and semiskilled nonagricultural worker by 2005, which implies the advent of the Lewisian turning point in the economy. There are indications of this happening in most of the countries in Asia and the Pacific. Other countries are also likely to experience the same situation soon.

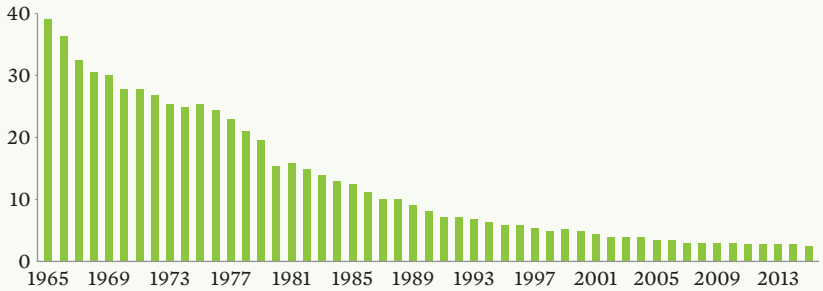
The response to labor shortage and rising agricultural wage has been dominated by support to mechanization of agriculture.[2] The PRC, for example, enacted the Law on the Promotion of Agricultural Mechanization in 2004. Since then, the country began to subsidize the purchase of agricultural machinery, which increased from $11.57 million in 2004 (in 2014 US dollar) to $3.9 billion in 2014. India has launched a Sub-Mission on Agricultural Mechanization in their 12th Five-Year Plan (2012–2017) with an estimated outlay of $350 million for the plan period. Malaysia approved the National Agro-Food Policy (2011–2020) with a component to promote continuous adoption and utilization of mechanization in agriculture. The Philippines enacted the Law on Agriculture and Fishery Mechanization in 2013.

However, labor shortage leads to the "feminization" of the agricultural workforce, which means that the current mix of skills, financing, and institutional arrangements will require major refurbishment to make them gender-friendly. Similarly, farm machineries and other technologies introduced to modernize agricultural sector need to be gender-friendly. Another

Box 1: Transition of Agriculture Sector in the Republic of Korea

The agriculture sector in the Republic of Korea accounted for 39.4% of the gross domestic product (GDP) in 1965, which decreased to 8.2% in 1990 and 2.3% by 2013.

Share of Agriculture in GDP in Republic of Korea since 1965



Employment in the agriculture sector accounted for about 58.5% of total employment in 1965 which decreased to 17.9% in 1990 and 6.1% in 2013. Per worker annual agricultural value addition (in constant 2005 US dollar) was 2,822 in 1980 and increased to 15,014.7 in 2005. Annual salary of a nonagricultural semiskilled worker such as a salesperson, garments cutter, baker, wood grinder, and carpenter in 2005 was $15,624, $11,520, $10,956, $13,256, and $16,200 respectively. This indicates the advent of Lewisian turning point in the Republic of Korea.

Source: World Bank. *South Korea: GDP Share of Agriculture. Cited in The Global Economy*. http://www.theglobaleconomy.com/South-Korea/Share_of_agriculture/ and Korea Average Salaries and Expenditures. http://www.worldsalaries.org/korea.shtml#average-salary-sector (accessed 28 October 2016).

[2] The PRC's "overall mechanization rate" increased from 35% in 2004 to 59% in 2012 (Bing, undated). The number of tractors increased from 600,000 in 1970 to 6 million in 2000 (Breuer et. al., 2015).

ADB

Participants listening to an expert during the Leaders' Roundtable at ADB Food Security Forum 2016.

challenge in case of female-led agricultural farms emanates from their poor access to collective efforts and common resources. It is difficult for a female head of the farm to be a part of any collective actions in rural areas, like access to water-user associations, credit groups, producers' cooperatives, and finances. These constraints also affect the modernization and mechanization of female-led farms, which eventually affect aggregate production.

Economic Transition

Two distinct features of the economic transition in Asia and the Pacific are *rapid urbanization* and *growth of middle-income consumers*.[3] The region was 45% urban in 2010. It is projected to become 56% urban by 2030 and further to 64% by 2050 (United Nations Department of Economic and Social Affairs, Population Division, 2012). The number of middle-income consumers was about 525 million in Asia and the Pacific region in 2009, more than the total population of the European Union. By 2020, this number is expected to increase to 1.74 billion, and further to about 3.23 billion by 2030. Global middle-income consumer population is projected to increase to 4.88 billion by 2030 (Ernst & Young, 2013).

With large populations and rapid economic growth, the PRC and India will become the powerhouses of middle-income consumerism over the next two decades. Assuming current growth performance and continued reforms, the number of middle-income consumers in the PRC is expected to increase to 500 million over the next decade. By 2030, about one billion people in PRC could become middle-income consumers—as much as 70% of its projected population. India's middle-income consumers are projected to increase to 200 million by 2020, further reaching 475 million by 2030 (Ernst & Young, 2013).

[3] The definition of middle-income consumer varies. For most businesses, a much more useful definition of middle class is people earning between $10 and $100 per day.

Historically, rising incomes around the world have changed the diets of millions of people by going beyond grains to eating more protein-rich food such as meat and fish. For example, per capita consumption of pork in urban PRC has increased from 16.7 kilograms (kg) in 2000 to 20.7 kg in 2010. During the same period, per capita consumption of dairy products increased from 11.6 kg to 18.1 kg.[4] Globally, annual meat production will need to rise by over 200 million tons to reach 470 million tons to meet the growing demand.[5]

There is evidence already that the surge in demand for meat in the PRC, especially pork, increases its relative price in the global market, creating an environment disfavoring the production of grains. It has indirectly contributed to the increase in the price of soybeans, which is used as feed for livestock, in the global market. This type of interconnectedness in the price of grains and nongrain food will continue to affect food security, particularly for the poor population of Asia and the Pacific, by diverting more land to the production of the latter.

While increase in demand for nongrain food brings opportunities for a range of producers, it can also marginalize small farmers who lack access to credit and ability to satisfy demand for volume, quality, and regularity (International Fund for Agricultural Development, 2014). In Asia and the Pacific, the average farm is less than 2 hectares.

> *Dietary aspirations as income grows are putting our natural resources endowment to additional stress, and this is going to evolve further in the same direction, intensifying for at least the foreseeable number of decades.*
>
> ADB Food Security Forum 2016

With the growth of the urban populations and middle-income consumers, demand for processed and fast-food will increase. If the current lack of legal framework for food safety continues, more consumers are likely to be exposed to food fraud,[6] food adulteration, and foodborne diseases. Foodborne diseases occur due to intentional food adulteration and contamination, as well as poor handling, processing, packaging, and storage of processed food. By increasing the susceptibility of the middle-income consumers due to their preference for processed and fast-food, urbanization can potentially have a negative effect on food safety.

In more developed countries, integrated market and distribution centers with storage, laboratory, and other infrastructure, or more commonly known as wholesale markets, play an important role in promoting supply of fresh and safe food. There are different ways of setting up and managing wholesale markets. The core elements of wholesale markets are legal and policy support, improved physical infrastructure, and skilled manpower. However, these elements are currently missing in most developing countries.

[4] Z. Zhou et al., 2012. *Food Consumption Trends in China*. Report submitted to the Government of Australia, Department of Agriculture, Fisheries and Forestry. http://www.agriculture.gov.au/SiteCollectionDocuments/agriculture-food/food/publications/food-consumption-trends-in-china/food-consumption-trends-in-china-v2.pdf

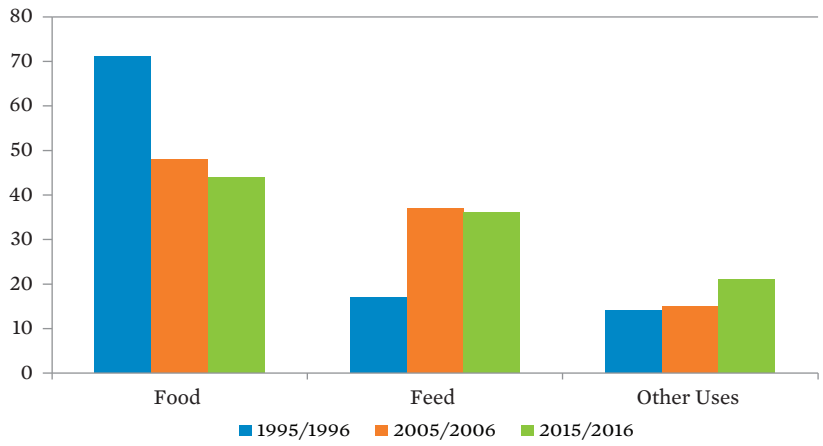
[5] FAO. 2009. How to Feed the World in 2050. Paper for the High-Level Expert Forum on How to Feed the World in 2050. Rome. 12–13 October.

[6] Food fraud typically has to do with one or more of three things: tampering the quality of the product, substituting or adding something cheaper, and faking the appearance of the product in order to fetch higher prices.

Competing Uses of Grains

Cereals are mainly used as food and animal feed, which together account for at least 80% of total cereal utilization. Other uses of cereals include as raw material for biofuels.[7] Food accounted for about 71% of total cereals in 1995–1996 (Figure 1). This declined to 48% in 2005–2006 and further to 43% in 2015–2016. On the other hand, the percentage of total cereals used as feed increased from 16% in 1995–1996 to 36% in 2015–2016. The demand for animal feed is a by-product of the demand for dairy products, poultry, and fish, which is likely to increase with the growth of urbanization and middle-income consumers in Asia and the Pacific.

Figure 1: Share of Different Uses in Total Cereal, 1995–1996, 2005–2006, and 2015–2016



Source: Food and Agriculture Organization. 1996, 2007, and 2016. Cereal Market Summary. Food Outlook: Global Market Analysis.

Other uses of cereals increased from 13% in 1995–1996 to 21% in 2015–2016, primarily due to the use of cereals in production of biofuels. According to a recent estimate by the German Renewable Energy Agency, 44% of total cereals is used as human food, 35% as animal feed, 6% as inputs for biofuel, and the rest for other purposes in 2015–2016. Although the use of grains to produce biofuel is currently only about 6%, its marginal effect on food price is significant. Increased use of grains for biofuels contributed to about 30% of the food price hike in 2007 (S. Wiggins et al. 2010).

Although Asia and the Pacific produced only about 5.6 million metric tons of biofuel in 2015, its production is projected to increase to 22.8 million metric tons in 2035 (Statista, 2016). Global energy requirement is likely to increase by 50% in 2030, with India and the PRC accounting for 45% (Tian et al., 2008), driven by economic growth. Demand for energy in these two countries will be the main reason for the increase in the production of biofuels in Asia and the Pacific.

[7] Biofuel is substitute for fossil fuel. Therefore, its production has a close relationship with the price and availability of fossil fuel. Oil price increases since 2003 led to the increase in the production of biofuel using maize, sugarcane, and vegetable oil.

Meeting this diversified as well as augmented demand for grains will become a huge challenge. For example, the European Union policy on biofuels, the Renewable Energy Directive adopted in April 2009, puts a premium on biofuel crops, especially oilseed, while the relative price of other crops declines (Laborde, 2011).[8] In this era of globalization, the effect of increased production of biofuel is easily transmitted across borders through trade channels. The most important question is whether the market can avoid any food price hike despite the increase in the production of biofuel. The answer depends on whether adequate cereals can be produced to meet not only the food demand of a growing population but also for animal feed and production of biofuels.

> *Our natural resource base is substantially more stressed today than it was in 1965. Then the green revolution was launched in a big way: we were just about 1.8 billion in this region. We are now 4.4 billion with less natural resources. Water is one big element.*
>
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Climate Change, Environmental Degradation, and Shrinking Natural Resources

Every aspect of food security is going to be affected by climate change. Many countries in the region are already experiencing frequent extreme weather events, such as heat waves, tropical cyclones, prolonged dry spells, intense rainfall, tornadoes, and thunderstorms. Coastal agricultural zones are inundated by salt water due to sea level rise. These events threaten the livelihood of farmers, particularly those who have limited capacity to adapt to the changing environment. Many countries in the region are already struggling with how to adapt with and mitigate the effects of climate change.

The increasing and unpredictable occurrence of natural calamities results in crop failures and damages. These short-term losses of production result in long-term problems for the agriculture sector. The occasional crop failure affects profitability. Profitability is already diminishing due to other problems like rising wages and shortage of workers in many countries. In such an uncertain situation, private investments shy away from the agriculture sector.

Climate change also affects the availability and quality of natural resource in the region. As observed by UNESCAP (2009), per capita water availability in Asia and the Pacific is the second-lowest in the world, at 5,224 cubic meters—way below the world average of 8,349 cubic meters—primarily as a result of high population. The situation is likely to get worse, not just in countries that had low levels of renewable resources like India, Maldives, Pakistan, and Uzbekistan but also in countries, such as Afghanistan and the Philippines, which have high population growth rates (UNESCAP, 2010).

At least three interrelated factors are going to deteriorate the situation. First, climate change is altering the water cycle. Global warming causes fewer yet more intense rainfalls, which

[8] D. Laborde. 2011. Assessing the Land Use Change Consequences of European Biofuel Policies. Final report for the Directorate General for Trade of the European Commission. http://trade.ec.europa.eu/doclib/docs/2011/october/tradoc_148289.pdf

means that water moves rapidly off the land where it is needed for agriculture. Second, the problem is also compounded by water pollution. For example, a national survey in the PRC indicates that agricultural water is now the source of the 67% fresh water pollution (ADB, 2015). Third, competing uses of water, especially for the production of energy, is on the rise. All these factors can seriously affect long-term agricultural productivity. According to an ADB study,[9] climate change may reduce yields of primary commodities (irrigated rice, wheat, and soybeans) by 9%–44% and increase commodity prices by 10%–50%, resulting to the increase of child malnutrition by up to 20% by 2050.

At the same time, the agriculture sector is not only a victim of, but also a significant contributor to climate change. Nitrous oxide linked to fertilization, carbon dioxide from fossil fuels used in the field as well as from across the whole food system continuum, such as food transport, storage, cold chains, processing, and methane from cattle farming and irrigated rice, all cause greenhouse gas emissions. Recent estimates suggest that agriculture and forestry and its associated land uses contribute to 20%–30% of the total anthropogenic greenhouse gas emissions (Tubiello et al., 2014, 2015). Therefore, farming practices which will neither become the victim of climate change nor contribute to the climate change needs to be promoted. Such farming can be regarded as "climate-smart" agriculture.

So far, the responses to climate change focus on building the resilience of crop systems and managing genetic resources. The resilience of crop systems relates to increasing and stabilizing productivity by practicing adaptive changes in crop management, especially timing of planting, choice of cultivar, and increased use of inputs. Adapting to increasing drought conditions and water scarcity by developing seeds with traits and characteristics appropriate to specific environmental context has been practiced. There are examples of proactive farmers who adopt these adaptive agricultural practices (Box 2).

In addition, better water management with water storage, improved access to irrigation and techniques, such as water harvesting, are also practiced depending on the local situation. One way to face these emerging water-related problems is to establish strong and clear water rights for farmers and other users. Voluntary trading systems, wherein farmers can sell stored water, needs to be introduced. However, these kinds of institutional reforms will be challenging. There is no alternative to increasing water efficiency. The main focus of agricultural research has been to increase output per unit of land. The focus needs to be reoriented to increase output per unit of water used.

> *With respect to water, it [intensification] means more crops per drop... the drive to curb the negative impacts of inappropriate farming practices and to grow the contribution of the farming sector to the formation of natural capital through environmental services.*
>
> ADB Food Security Forum 2016

Advances in breeding methodologies (e.g., molecular markers and sequencing) promise higher yielding cultivars suited to changing environments. However, to realize the benefit of these scientific developments, sophisticated information technology has to be introduced in agriculture. Precision farming, a system of site-specific management of cropping system based on geospatial information, will play an important role in maintaining financial viability of the agriculture sector in the wake of climate change. Sources of data for site-specific information

[9] ADB. 2009. *Building Climate Resilience in the Agriculture Sector of Asia and the Pacific*. Manila.

Box 2: Climate-Smart Farmer: Mang Reynaldo

Reynaldo San Jose (Mang Reynaldo) is no stranger to the grave impact of climate change on food producers in the Philippines. Mang Reynaldo has been a rice farmer and seed grower for over half a century in the Taytay municipality of Palawan province. In recent years, he has broken new ground for rice farming in a bid to wipe out the growing saltwater intrusion, which threatens over 25% of the rice lands in his municipality.

His determination to eliminate saltwater intrusion led him to the testing and combination of two rice varieties which grew and made his once salt-affected rice land prosper again. However, his thirst for innovation and discovery as a means of reversing the effects of climate change did not end there. He went on to test more varieties of rice developed by the International Rice Research Institute and disseminated through ADB's Coral Triangle Initiative (CTI)-Southeast Asia project, contributing to the development of climate-smart rice not only for this personal interest but also for all farmers affected by saltwater intrusion in his municipality.

His relentless efforts for sustainable rice farming led him to become a prominent figure in the promotion of climate-smart varieties. In the CTI-organized Farmers Day in Barangay Poblacion, his farm in Sitio Quilala served as an exhibition site for climate-smart farming. He is eager to pass on his expertise and knowledge to inexperienced, small-scale farmers in his municipality, determined to make the lands of his youth filled thrive again. He claims that his success is rooted in his openness to try new ideas. Many farmers affected by climate change today would find it in their own interest to follow his innovative example.

Source: ADB Food Security Forum 2016.

can be satellite imaging, aerial remote sensing, GIS mapping, field mapping, and derivatives of these technologies. Precision farming also requires machine and equipment with the capacity for variable-rate applications like precision planters, sprayers, fertilizer applicators, and tillage instruments. Increased use of these techniques and machineries would require appropriate policy and institutional support.

New and modified genetic resources so far have played an important role to withstand the effects of climate change on agriculture and will continue to remain important. However, a major challenge will arise from the mismatch between the speed of climate change and our response to it. For example, about 70% of the rice germplasm used in Asian crops is derived directly from the International Rice Genebank, which is maintained by the International Rice Research Institute (IRRI). It typically takes seven years to create a new major crop variety. This means that there are only two breeding cycles left before 2030 to produce a rice variety that is adapted to the climate change. Because of this, the choices and investments made today will profoundly affect the ability to meet the future challenges of climate change and natural resource degradation.

Mainstreaming the High-Level Technologies for Food Security

Importance of High-Level Technology

Agricultural growth has been driven by technology. In most cases, the main objective of these technologies is to promote augmented use of labor and other natural resources to extract more rent from land which "possesses some original and indestructible powers" (Ricardo, 1817). Whether such extractive technologies can meet this objective is a different issue. The agriculture sector is currently in a crossroad; land and other resources are declining and agricultural labor is shrinking. Old extractive technologies will not be adequate to enhance agricultural yield. As defined and explained in Box 3, agricultural growth depends on (i) the intensification of agricultural labor, (ii) augmented use of natural resources like water, (iii) fertilizers, and (iv) the use of high-level technology (HLT).

Land: Fertility of the arable land is declining. About 25% of arable land around the world is degraded already (J. von Braun et al., 2012). Agricultural land is also declining in favor of other uses and due to salinization (FAO, 2011) as well as desertification. While a few countries

Box 3: Importance of High-Level Technology in Agriculture

Total agricultural output can be shown as:.

$$Q = L.Y(l, i, f, T)$$

where Q represents total output, L is total cultivated land, T is technology, and Y is rate of yield per unit of land. Y depends on amount of labor (l), use of natural resource (such as water) (i), fertilizer (f), and technology (T). The extractive technologies are embedded in (i). Rather than intensifying the use of natural resources, the new technology (T) itself is a contributor to agricultural yield. T includes any technology and/or method that can improve the efficiency and productivity of operations; address climate mitigation, adaptation, and resilience to disaster risk; and introduce innovative process, creates opportunities for economies of scale and maximizes cross-sectoral synergies. Thus T can be identified as high-level technology (HLT).

Growth of agricultural output can be written in additive form as:

$$\%\Delta Q = \%\Delta L + \%\Delta Y$$

that is, growth of agricultural output has two potential sources; growth of cultivated land and growth of yield. However, the scope for the growth of cultivated land in Asia and the Pacific is very limited to nil. Growth of yield depends on (i) the intensification of agricultural labor, (ii) augmented use of natural resources like water, (iii) fertilizers, and (iv) the use of HLT. Of these, the scope of first three is more or less exhausted as explained below. It essentially implies the importance of HLT for agricultural growth.

in Latin America and sub-Saharan Africa have areas that can be converted into arable land in theory, Asian and the Pacific countries are mostly land-scarce.

Labor: Increasing the labor force can contribute to the growth of agricultural yield to some limited extent. However, as mentioned earlier, the agriculture sector is currently facing labor shortage. With the growth of other sectors of the economy, such shortage will become more binding in the coming years.

Natural resources: Along with land, water utilization has exceeded sustainable levels, threatening to reduce global food supply by a quarter by 2050. Eighty percent of freshwater in Asia is consumed by irrigation (ADB, 2011). Fifty-eight percent of irrigated land around the world is confronting high or extremely high water stress (World Resources Institute, no date). Surface water scarcity is compounded by the rapid depletion of groundwater aquifers due to unregulated abstraction and increased competition for scarce water between agriculture and other industries, between industrial and domestic use, and between rural and urban residents.

Fertilizer: The unintended costs of using fertilizer to the environment and human health have been substantial. These costs imply a ceiling on the desirable level of fertilizer use in agriculture. While sub-Saharan Africa still has some opportunity to increase soil fertility by applying more fertilizer, the Asia and Pacific region, in general, has already exhausted such opportunity. For example, farmers in the PRC use more fertilizer than required and some experts demonstrated nitrogen fertilizer use could be cut in half without loss of yield (M. Shwartz, 2009).

> *There may be one last mile left to cross for ending hunger but our ability is already stressed thin. Besides, our gains are also relapsed due to emerging challenges like climate change and degradation of natural resources. This calls for new technology to gain control of this compassionate voyage.*
>
> ADB Food Security Forum 2016

Schultz's (1964) postulation that the introduction of some relatively simple improvements in traditional inputs will not be sufficient to modernize agriculture sector is probably more pertinent now more than ever. It would require a new approach including modern capital inputs and farmers with the right skills to convert these inputs into profitable income streams. This is why the use of HLT is the viable option left to increase total agricultural production in the future.

Examples of High-Level Technologies

Some HLTs are currently being promoted by different organizations not only to increase agricultural output but also to improve the nutritive value and safety of food.[10] These include a wide range of operations and solutions like innovative approaches to agricultural extension services, product modifications, drone mapping tools, and other technology solutions (Box 4).

[10] This section is exclusively based on the ADB Food Security Forum's Partnership Dialogue held on 22 June 2016. It includes an illustrative rather than an exhaustive list of HLTs currently being used.

Box 4: High-Level Technology Techno Show

A total of 16 organizations—including international agricultural research centers, United Nations agencies, bilateral organizations, development agencies, and private sector companies—exhibited agricultural products and programs classified into three categories: innovative approaches, modified and advanced products, and tools and technology solutions.

Innovative approaches include initiatives by organizations that aim to fund poverty alleviation (Asian Partnership for the Development of Human Resources in Rural Areas), provide auxiliary agricultural services (Centre for Agriculture and Bioscience International), support food and nutrition security (GIZ), and assess a country's capacity to address food security challenges (Asia BioBusiness and Syngenta).

Modified and advanced products include protein-reduced rice varieties suitable for those suffering from chronic kidney disease (BioTechJP), Ultra Hermetic storage for dry agricultural products (GrainPro), and Agro-Weather Tool (RMSI).

Tools and technology solutions include drone mapping for disaster preparedness (FAO), nuclear/isotopic techniques to check food contamination (International Atomic Energy Agency), solutions for building climate-resilient agrifood system (International Center for Tropical Agriculture, International Centre for Integrated Mountain Development, and the Centre for Environment and Agriculture Policy Research, Extension and Development, and the International Potato Center), local solutions to cope with climate change (World Agroforestry Centre and IFAD), biointensive gardening technology (International Institute of Rural Reconstruction), 3D models of postharvest processing technologies (Murdoch University), climate-smart and water-saving technologies, climate change-ready rice varieties and ecological engineering (IRRI).

Source: ADB Food Security Forum 2016.

The International Center for Agricultural Research in the Dry Areas is applying HLTs to improve pulse production in areas of Asia where malnutrition is prevalent. These technologies are delivering access to knowledge-sharing services and helping to replace local varieties of pulses with high-yielding and nutrition-rich varieties in Bangladesh, India and Nepal.

HLTs have also been successful in aiding research using gene banks. For example, a World Vegetable Center project has made a vegetable gene bank of 65,000 samples from over 150 countries and 450 species accessible to the research community. It is also working on different crop varieties (such as tomato, pepper, onion, mung bean, and soybean) that have high resistance to biotic and abiotic stresses and resilient to climate change. The International Maize and Wheat Improvement Center is developing climate-resilient germplasm, including drought-tolerant wheat and maize, and water-logging right maize. This organization is also working to develop satellite and/or drone technology to better predict and prepare for extreme weather events such as heat waves affecting a geographical area.

The International Potato Center is also applying HLT to create climate-resilient crop varieties, improve soil and water management, and develop accurate crop disease models. HLTs to address the effects of climate change are also driving innovative approaches to natural disaster reduction and management. FAO is using drones to produce aerial maps immediately following natural disasters to provide real-time critical data that can be used to assess the

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Exhibits of high-level and innovative agricultural technologies in the Techno Show organized at the ADB Food Security Forum 2016.

damage to agricultural systems. These data can also feed into early warning systems and help with farm-level advisory services and agricultural intervention planning.

A collaborative project between Murdoch University (Perth, Australia) and Imperial College London is making advances in the use of *iKnives* for food security applications. If successful, it can detect pesticide and antibiotic residues. This technology can also check for food fraud and may also be used to reduce food waste by providing real-time safety tests. This is particularly important as food fraud is likely to become more prevalent as climate change affects food security.

Another example of a collaborative initiative is the partnership between the United States Agency for International Development (USAID) and Cornell University. To strengthen its capacity to develop and disseminate genetically engineered eggplant in Bangladesh and the Philippines, the Government of the United States has awarded Cornell University a 3-year grant worth $4.8 million. The award supports USAID's work under Feed the Future, a global initiative by the US government to fight hunger and improve food security using agricultural science and technology. Under the Feed the Future South Asia Eggplant Improvement Partnership, Cornell University will protect eggplant farmers from yield losses and improve their livelihood in partnership with the Bangladesh Agricultural Research Institute and the University of the Philippines at Los Baños, Laguna province.

The Centre for Agricultural and Bioscience International is using an innovative approach, known as the Plantwise Program, to promote plant health. The program has 5,000 plant doctors working in 2,000 clinics all over the world. It also acts as a global knowledge resource with a web-based tool on plant health diagnosis. GrainPro developed "hermetic" storage, which reduces storage loss from 5% to 10%.

The World Food Programme (WFP), in collaboration with Global Pulse and the UN Secretariat, uses voice recognition and mobile data for quicker assessment of vulnerability. The WFP also uses biometrics to ensure the effectiveness of the delivery of social safety nets and social protection.

The Japan International Cooperation Agency (JICA) is promoting HLT in three areas: gnome technology, space technology, and information technology. JICA is working with IRRI and Nagoya University to develop salt-tolerant and drought-resistant rice. It is also working with Indonesia to promote weather index-based agricultural insurance. JICA is likewise working with the Government of the Philippines to develop a market transaction management system and a cultivation condition management system.

High-Level Technology in ADB's Operation in the Agriculture and Natural Resources Sector

To maximize the impact and sustainability of its operation in the agriculture and natural resource (ANR) sector, ADB recognizes that it needs to help its developing member countries (DMCs) in using HLTs. ADB is currently using state-of-the-art technology wherever possible in its operations within the ANR sector. Some of these technologies are described below:[11]

Satellite-Based Remote Sensing

A number of water resources management projects in Pakistan (Pehur High-Level Canal Extension Project), Cambodia (Uplands Irrigation and Water Resources Management Sector Project), and Viet Nam (Water Efficiency Improvement in Drought Affected Provinces Project) are using remote sensing and satellite imaging for geographical identification of water shortage and the duration of dry periods, irrigation infrastructure mapping, crop areas monitoring, evapotranspiration, and water demands forecasting. This technology will also be used to monitor food security (particularly rice production) under the Greater Mekong Subregion (GMS) Core Agriculture Support Program.

Geographic Information System

ADB is currently using geographic information system (GIS) in its operations, particularly in water resource management to visualize, analyze, and interpret data to understand relationships, patterns, and trends to provide better water services to DMCs. This technology is being used in a number of ADB projects in the ANR sector for monitoring and evaluation during project implementation. GIS is also being used to develop Water Resource Information System in Balochistan (Balochistan Water Resource Development Project) and Punjab (Institutional Transformation: Punjab Irrigation Department to Water Resources Development) provinces of Pakistan. It is also being used in the Greater Mekong Area (Implementing the GMS Core Agriculture Support Program: Phase 2) to identify areas suitable for application for biochar to promote climate-friendly agriculture.

[11] The list is illustrative, not exhaustive.

Internet Plus and Application of Big Data

Internet plus technology is used to provide demand, weather and other agriculture-related information to stakeholders along the agricultural value chain in Pakistan (Deploying ICT for Agricultural Efficiency in Pakistan and Tajikistan). It is also used to strengthen food quality management and transparency of food supply chains using "e-traceability" of livestock and poultry in Viet Nam and fresh vegetables in Thailand (Implementing the GMS Core Agriculture Support Program, Phase 2). ADB is also preparing to develop "big data" platform and capacity for its applications. Big data will be captured by mobile applications. An internet plus-based socialized agricultural service system is being developed in Gansu province in the PRC to provide online and offline production and management services to farmer cooperatives. Distribution and processing infrastructure will be upgraded with sensors for real-time data collection to enhance coordination and traceability of products and value chain stakeholders along the production, processing, and marking steps of agricultural value chains. (PRC Gansu Internet-Plus Based Socialized Agricultural Service System Development Project).

Integrated Engineering System

To take account of the multidimensional impact of development intervention, particularly in water resource management, ADB is now using an "integrated engineering system" in its operations. The system has been introduced in barrage gate operation in Pakistan (Punjab Irrigated Agricultural Investment Program, Tranche 3) by linking together different computing systems and software applications, physically or functionally, to act as a coordinated whole. This increases the precision and timeliness of barrage gate operations. A similar technology is being used in Afghanistan (Kabul Managed Aquifer Recharge Project) for ground water recharge and management.

Water-Saving Irrigation (Drip Irrigation)

ADB is now reaching out to the areas where farmers struggle with cold temperature of the irrigation water by introducing drip and sprinkle irrigation. The Shanxi Integrated Agricultural Development Project in the PRC is one example. ADB introduced drip sprinkler irrigation in the area combined with warming ponds in greenhouses. Cultivation of prickly ash shoots, a local delicacy, got a boost. Aside from irrigation, this system also washes down the remaining aphids and prevents the soil from being saturated with water (PRC: Shanxi Integrated Agricultural Development Project).

Constraints to Scale Up Successful High-Level Technologies

HLT is not developed by the agriculture sector. Rather, it applies technologies developed by other branches of science. However, the application of HLT is not automatic. Appropriate policy, along with institutional and financial support, is required for the development of HLT and its use in the agriculture sector. Several factors hinder the development, dissemination, and widespread adoption of HLTs in ANR sector.

a. **Policy inconsistency.** The use of HLT is constrained by inconsistent policies among different sectors of the economy. For example, highly protective trade policy shields the agriculture sector from external competition and thus works as a disincentive to use HLT in the sector to enhance productivity. Similarly, current policy on input subsidization, such as subsidy for water, fertilizer, pesticides, and others, results in the increased use of these inputs to increase agricultural yield rather than using HLT. Any kind of preferential policy always creates distortion in the incentive structure and deters the market forces from promoting use of HLT.

b. **Lack of public–private cooperation.** A clearly conducive interphase between the private and public sector in agricultural research is yet to emerge. The areas of basic and applied research are yet to be demarcated. Thus, it is not clear where the handoff between the two should be placed. There is no ideal model that has been developed, let alone being practiced, to distribute the gains from the innovative technologies between the government and private sector. Similarly, a public policy to regulate the price of innovated technologies and inputs is required in the interest of both innovators and users.

c. **Cumbersome regulatory environment.** Regulatory systems governing scientific research are complex and vary between countries. Some, such as the use and movement of genetic resources, are becoming increasingly restrictive, which can hinder the development and adoption of HLTs. Genetic research can continue to deliver new varieties of crops that are better adapted to a changing environment, but a consistent regulatory environment is needed to fully realize the potential of this type of HLT.

> *We are seeing now, for example, the use and exchange of genetic resources is becoming more restrictive globally as we enter a post-Nagoya protocol world. Regulatory regimes that cover varietal releases, seed quality introductions are insufficient to meet the rapidly changing global and domestic market conditions.*
>
> ADB Food Security Forum 2016

d. **Poor enforcement of intellectual property rights.** In many countries, intellectual property rights remain unenforced or are poorly enforced. This results in lack of introduction of HLT and deters private research and development investment in developing countries.

e. **Lack of adequate financing.** The development of HLTs has traditionally been poorly funded, and does not benefit from any private sector funding. Currently, a large share of financing for HLT comes from climate change research funding, which can be administratively burdensome to access. It is perhaps a mistake to depend so much on this source of funding.

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Experts discussing how to promote high-level technology in the agriculture and food sector during the Partnership Dialogue at the ADB Food Security Forum 2016.

Measures to Promote High-Level Technology in the Agriculture and Natural Resources Sector

Several recommendations emerged from the forum on how to promote the use of HLT in the ANR sector. These include the following:

a. **Priority setting.** It must be noted that failed innovation comes at a price. The reasons for failure may include disrepair, limited application to a complex problem, lack of capacity to scale up, or lack of regulatory and institutional support. Therefore, proper prioritization and sequencing when applying resources to promote the use of HLT in the different segments of agricultural value chain, and in different activities within the agricultural sector, is required. To ensure immediate gains from HLT-supported activities, which will encourage private sector involvement, areas that can benefit the most from HLT must be identified.

b. **Build partnership.** A heterogeneous group of organizations—private, public, regional, and international—are working to end hunger. A symbiotic partnership among these organizations will accelerate the promotion of HLT in the ANR sector. Areas for collaboration and partnership include sustainable intensification of aquaculture, improving nutrition through biofortification, minimizing food waste and loss, better surveillance and prevention of food crisis, agricultural conservation, remote sensing, developing agricultural weather index, and so forth. The provision of commercially viable technology and machineries, financing, risk management, postharvest value addition, and loss minimization are some of the core partnership activities from a practical point of view. Partnerships between organizations during the learning process, such as pilot implementation and demonstration activities, is important

before scaling up the use of any HLT. Along with knowledge sharing, cofinancing is another important area for partnerships between stakeholders.

c. **Dissemination and demonstration.** The success of mainstreaming the use of HLT in the ANR sector crucially depends on farmers' interest and their willingness to use them. One way to motivate farmers to use HLT is to effectively disseminate the economic benefits of these technologies through effective demonstration. Complementary to this, the required inputs and services should be made available to them as well. An innovative use of new and old methods of agricultural extension is also vital to ensure HLTs are understood and adopted by farmers.

d. **Financial flexibility.** Developing new technology requires a higher tolerance for failure and a less risk-averse approach. Project management budgets need to reflect this, allowing more flexibility for failures, so that good ideas can have more space to develop. Therefore, financial flexibility is essential to develop and mainstream the use of HLT in the ANR sector.

e. **Resorting to new windows of finance.** To mobilize more resources for HLT, all possible windows should be exploited. The Green Climate Fund (GCF) is one potential window. Organizations that do not qualify for the GCF but can contribute to promote HLT in the ANR sector can work in partnership with organizations which are qualified for the fund. Since country ownership and implementation capacity is a prerequisite to access GCF, organizations need to identify the target country before developing a full-fledged proposal. In fact, it will be better to involve the target country in identifying the key HLT that the proposed project will develop and/or promote.

Connecting Farmers, Agribusiness, and Finance

Different Modalities of Connecting Farmers with Agribusiness

Farmers, particularly smallholders, need to be connected with agribusiness in order to make farming financially viable. Agribusiness will also benefit from such connections. Three distinct models to connect farmers with agribusiness have been discussed during the forum.

Comprehensive Model with Upstream and Downstream Integration

In the upstream, the firm is involved in farming and production. In many cases, the firm manages its own farming. In addition to owning the produce, the firm also sources from a network of individual farmers and farmers' cooperatives. The relationship is based on mutual trust and reciprocity, a form of social capital developed over time.

In the downstream, the firm converts the collected agricultural products into value-added products. Olam International, which manufactures tomato paste from tomatoes and peanut paste from peanuts, is one example of this model (Box 5).

Box 5: Olam International

Olam International selectively integrates to the various segments of the value chain. Upstream integration is characterized by ownership of plantations and management of perennial tree crops (e.g., palm and rubber plantations in Africa, almond plantations in Australia and California; coffee plantations in Tanzania, Ethiopia, and Lao People's Democratic Republic; cocoa plantations in Indonesia), engagement in peanut farming in Argentina and South Africa, rice farming in Nigeria, dairy farming in Uruguay and Russia, and the management of hardwood forest concessions in Africa. The company also sources agricultural raw materials from a network of about four million farmers and growers, village-level cooperatives, and village-level agents. It stores these raw materials; processes them into primary products; and transports, distributes and markets them to their destination.

In the midstream of the value chain, Olam adds value to the products it grows and sources through its more than 200 manufacturing facilities (e.g., blanching of peanut shells; manufacturing of peanut paste, tomato paste, soluble coffee; processing of cocoa; milling of wheat and sugar; refining of palm oil and sugar). Finally, Olam also links to the downstream segment of the value chain by producing, franchising, and distributing fortified branded food products in the African market and a fertilizer manufacturing and distribution venture with the Republic of Gabon.

Source: ADB Food Security Forum 2016.

Development Cooperative

The difference with a private enterprise is that this is a cooperative. Unlike a civil society organization or nongovernment organization, a development cooperative is a profit-making entity founded through the equity contribution of its member farmers. It conducts farming and other activities mainly through its members. It also involves nonmember farmers on the basis of profit sharing. Development cooperatives also provide financial assistance to members at an affordable interest rate. Sorosoro Ibaba Development Cooperative in the Philippines is an example of a development cooperative (Box 6).

Box 6: Sorosoro Ibaba Development Cooperative—A Success Story

Sorosoro Ibaba Development Cooperative (SIDC) in the Philippines was established in 1969 and currently has 24,000 members and an asset base of P2.2 billion. With operations in Northern Luzon, CALABARZON,[a] MIMAROPA,[b] Panay Island, and Bicol, SIDC has an annual turnover of more than $76 million and employs over 600 workers. Economies of scale allow SIDC to manage 1,500 hectares of rice and corn fields, 300,000 heads of livestock, and 85,500 broiler chickens. The cooperative produces 21.6 million eggs, 2 million bags of feed, 85,000 heads of chicken, 30,000 bags of rice, and 15,000 bags of organic fertilizers annually. This level of production allows SIDC to run its own feed mill, rice mill, and corn processing plant. It also runs consumer markets and community animal husbandry operations for smallholder livestock farmers, and offers rural finance and insurance at competitive rates.

As a cooperative, SIDC negotiates with markets from a stronger position, delivers technical assistance to its members, operates research and development projects, guarantees prices to growers, provides advocacy and marketing services, and shares its profits among its members. SIDC also extends social services to its members, such as medical assistance, memorial loans, mortuary benefits, scholarships, among others.

[a] Also known as Region IV-A. The acronym CALABARZON stands for the provinces that comprise the region, namely Cavite, Laguna, Batangas, Rizal and Quezon.
[b] Also known as Region IV-B. The acronym MIMAROPA stands for the provinces that comprise the region, namely, Occidental Mindoro, Oriental Mindoro, Marinduque, Romblon, and Palawan.

Source: ADB Food Security Forum 2016.

Contract Farming and Inclusive Business

Contract farming is carried out by the agribusiness firms through an agreement which provides guaranteed sale of their products. In most cases, the contracting firm provides financial support, inputs, technology, and logistics to the farm to reduce production risks. Contract farming has many modalities but it can be used as a tool for inclusive growth by targeting smallholders and other disadvantaged groups. Lal Teer Seed is an example of this model (Box 7).

Box 7: Lal Teer Seed Limited

Lal Teer Seed Limited is the first private research-based seed company in Bangladesh since 1995. The company is engaged in developing, producing, processing, and marketing high-yielding seeds. It aims to develop a sustainable foundation for agriculture and food security in the country. It develops nutritious and ecologically sustainable crop varieties and supplies these in different sizes of packets so that even small can afford them. At present, Lal Teer is marketing 131 varieties of 33 vegetable crops in Bangladesh. The Product Development Service Group conducts countrywide adaptation trials in 30 agroecological zones to determine sustainability of its crop varieties in different climate conditions.

About 6,200 contract growers along with 28,173 workers (of which 80% are women) in 14 different production zones are producing the quality vegetable seeds under the direct supervision of highly skilled and well-trained agriculturists. The contract growers are trained and provided with inputs by the company. The company has an independent training wing through which about 500,000 farmers, 5,500 contract growers, 22,000 mobile seed vendors, and 15,000 dealers and retailers have been trained. The company also conducts exchange meetings among farmers.

Source: ADB Food Security Forum 2016.

Agricultural Financing

Two main problems in agricultural financing were discussed in the forum: asymmetric information and lack of collateral. While these are general problems observed in the financial market, they are more binding in the case of agricultural credit. A number of innovative approaches have been identified to circumvent these problems.

To minimize the risk that emerged from asymmetric information, group-based lending is exercised by different entities including private firms and banks. Under such an arrangement, a sequential approach is followed to grant loans to group members, where one member gets the loan provided that the previous borrower from the group repaid his/her loan. As a result, other members of the group always exercise pressure on the fellow-borrower to repay his/her loan in time for their own interest. This group pressure works as a substitute for collateral. Olam International provides short-term loans to farmers organized in groups from whom it source agricultural produce. So far the firm has recorded no bad debts among the short- and medium-term loans provided to 350 farmers valued at $186 million.

The Bank for Agriculture and Agricultural Cooperative (BAAC) of Thailand uses a similar approach. The bank provides individual lending under the umbrella of joint liability where farmers are organized into groups and each group is jointly responsible to repay the loan. The second method used by the BAAC is cooperative banking. In this case, money is lent to the cooperatives using their assets as collateral and the cooperatives in turn lend that money to its members. Social capital accumulated in the form of mutual trust and norm of reciprocity gradually serves as partial substitutes for physical assets used as collateral. Social capital also helps family-oriented enterprises as it helps to mobilize finance from traditional sources (Box 8).

Box 8: Family Business Helping Local Farmers: The Panopio Family Enterprise

Tradition and a family-oriented enterprise lay close to the heart of Alfonso Panopio: making chocolate, the tablea type, which he started in the town of Bauan in Batangas province, Philippines. His passion for chocolate was passed on to his grandson Modesto Panopio, who, along with his wife Emilia, established Mely's Pure Chocolate in 1949. The company, half a century later, was transferred to the current owner Alfonso Panopio Jr.

Today, Panopio's chocolate-coated dream has turned JAMLA Corporation into one of the biggest processing companies of cacao beans in the Philippines. Its success lies in the sustainability in the harvesting and production of the cacao bean. The business also helps local farmers.

Through their family business, Lourdes (Lulu) Panopio, senior vice-president of JAMLA, preaches that "happiness is actually in making others happy." by improving the lives of JAMLA farmers and employees. By buying their produce at a reasonable price, she aims to encourage them to plant more. She also places importance on her employees' well-being, and hopes that through their employment with JAMLA, they will be able to afford housing and send their children to school. For Lulu, cacao manufacturing is much more than a profitable family legacy; it is an enriching way to change the lives of the farmers and the unemployed in local communities.

JAMLA believes in its chocolate business as a catalyst for change, as the corporation's current expansion aims to provide widespread employment in the country.

Source: ADB Food Security Forum 2016.

Another approach used to circumvent the problem of asymmetric information is the use of warehouse receipt as collateral to secure a loan. This enables the farmers to receive credit by using their harvested produce deposited in a registered warehouse. In addition to reducing postharvest losses, warehousing can also work as a conduit of agricultural credit. However, the significance of this conduit depends on the availability of affordable storage facility. This system also enables a farmer to defer the sale of his/her produce until the price is not acceptable.

Although not so much exercised yet in the agriculture sector, the use of "receivables" as collateral can increase the flow of agricultural credit. Contract farming in most cases involves a guaranteed sale and definite or estimated receivables.

Another important tool to provide credit to agriculture sector is factoring, which is yet to be used to its full potential. Under this system, a farmer can sell its contract of sales of goods at a discount to a third party, called a factor. Thus, the third party pays the farmer total value of the contract of sales minus an agreed amount as discount and collects the receivables when due.

Promoting Agribusiness in Asia and the Pacific

To promote agribusiness, ADB works along the entire value chain—from provision of inputs and logistics to processing and branding. During the last 4 years, it approved 15 private sector agribusiness projects with financing of about $1 billion, directly benefiting at least 200,000 small farmers. ADB supported the establishment of a large cold chain facility and an international best practice warehouse and logistics management in Tianjin, PRC. Upgrading food value chain facilities is expected to expand shelf life and reduce spoilage of agricultural produce, including Mongolia's export of meat and dairy products to the PRC, projected to increase by 25% from 2013 to 2017.

ADB co-invested $3 million in a company in Bhutan that is promoting hazelnut production by small farmers for export to the PRC and Europe. Fifteen thousand contract farmers involved in the project are expected to double their income. ADB is helping provide 6,000 dairy farmers access to formal credit from a local bank, disseminating essential farm management technologies, and engaging the farmers to be part of quality dairy supply chains that cater to urban markets.

Support is also being provided for a leading Indian spice processing company to invest in new processing facilities, including an extraction plant in Cambodia, and expand its contract farming with 5,000 additional smallholder farmers in India and Cambodia. In Samoa, a project established a risk sharing arrangement with two participating commercial banks to enable agribusinesses to avail of finance and provide essential business support services to develop supply value chains for agriculture exports.

ADB enables private investments to promote agribusiness through direct financing, credit enhancements, and risk mitigation instruments. It provides direct funding assistance through loans and equity investments. Some of the companies with ADB's direct investments to promote agribusiness are shown in Figure 2.

Figure 2: ADB's Private Sector Investment to Promote Agribusiness, 2012–2016

PRAN, Bangladesh— $12 milliion loan for liquid glucose plant (2012)

RG Brands, Kazakhstan— $40 million loan for milk and juice processing (2013)

Tedahang Cold Chain, PRC— $24 million loan for cold storate (2012)

Yoma Strategies Holdings, Myanmar— $100 million loan for logistics and other infrastructure (2014)

Akay Flavours & Aromatics, India and Cambodia— $6 million equity for spice farming, processing (2014)

Mountain Hazelnuts, Bhutan— $3 million equity, $1.5 million technical assistance for hazelnut production (2015)

Legaga, PRC— $80 million A loan, $60 million B loan for greenhouse vegetables (2014)

Saikexing, PRC— $63 million A loan, $63 million B loan for sustainable dairy farming (2016)

Source: ADB.

Sustainable Entitlement to Safe and Nutritious Food

Sustainable food entitlements require reliable supply of safe and nutritious food. This requires a major focus on production, food standards and a quality control infrastructure, supply network, and social safety net programs.

Food Standards and Quality Infrastructure

The multiplicity of standards without clarity for food producers and processors affects the supply of safe food. Aspects of food standards are spread across various stages of food value chain: production, transportation, consumption, and disposal. Since agricultural production is dominated by small and medium farmers in the Asia and Pacific region, thousands of farmers and middlemen are involved in the supply chain and are collectively responsible to ensure food safety. This collective responsibility can easily create a problem known as the "tragedy of commons," a situation when a collective responsibility is never accomplished in absence of government action.

Monitoring of food safety and quality, due to its cross-cutting nature, is the responsibility of multiple ministries and departments. Many countries have instituted different forms of collaborating mechanisms—such as acts, decrees, high-level committees, and so on—and established single authority to conduct monitoring in a coordinated way. Such authorities need capacity building both in terms of skilled manpower and quality control laboratories and testing facilities.

To reduce the incidence of food fraud (e.g., tampering with the quality of food, substituting or adding something cheaper, and faking the appearance of the product in order to fetch a higher price), it is important to shorten the supply chain, wherever it is feasible. Two important things need to be done to accomplish this. One is to maintain rigorous documentation. The second is to enable traceability. Some progress has been made in many countries in Asia and the Pacific region in terms of traceability, but a lot more needs to be done. One big challenge in implementing traceability is overcoming the anarchy in the supply chain as a result of numerous intermediaries.

International Trade

Trade is the most basic tool to move food from surplus to deficit areas. Thus, it can play a significant role in food entitlement. More importantly, trade is also a hedge against the variability in the domestic supply of food. If the world was just a single country, then all trade is internal and smooth. However, restrictions on trade at the border and over the border are omnipresent. These restrictions are even strengthened in times of crisis. Many countries even banned the export of food during the food price crisis from 2007 to 2008, which intensified

the crisis even more. This may be an extreme case but various restrictions are in play which affects the international trade of food.

The use of nontariff barriers, when increased significantly, affects the trade of food. There were about 1,000 sanitary and phytosanitary (SPS) concerns raised to World Trade Organization in 1999, which increased to 8,000 in 2010 and growing exponentially. SPS measures are important because they contribute to food safety, but the key issue in this context is the design and implementation of these measures. These measures need to be designed and implemented in a coordinated way to enable countries to avoid unnecessary disparities and unintended deterrence on the movement of food. SPS measures also need to be transparent and scientific.

The average tariff on agricultural products is high and depends on the level of product transformation. So, with the movement from primary product to an advanced product, tariff goes up. This is even more obvious in the case of South–South trading relationship; trade taking place among the developing countries. The Association of Southeast Asian Nation countries have made notable progress in overall trade integration, but the same level of progress is not observed in the case of agrifood products.

Supply Network (Wholesale Market)

The current agricultural supply chains in developing countries are unable to support reliable supply of fresh and safe food to the growing population of urban consumers. These channels are mostly dominated by *thousands* of unregulated intermediaries who collect the produce from *millions* of farmers and then sell to *millions* of consumers. Due to the dispersed nature of farming activities, lack of coordination with logistic providers, and asymmetric information, the transaction cost of delivering agricultural products directly by farmers to consumers is high. The outcomes of the current supply chain include (i) multiple local equilibrium prices with glut in one area while scarcity in another area at the same time; (ii) significant differences between farm-gate and consumer price; (iii) unreliable and volatile supply of agricultural produce, creating frequent price instability; (iv) difficulties in monitoring quality and safety standards; and (v) low *expected returns* from agriculture due to price risks, which in turn affect agricultural finance and investment.

However, if suppliers are linked to larger distribution channels and market infrastructure, the supply of fresh food will improve. It will also make it easier for regulatory authorities to monitor, detect, and prevent food contamination. One of the major elements of the food distribution channel is a fresh food wholesale market. The wholesale market can potentially make a difference by adding an efficient and better-managed route in the current agricultural supply chain in developing countries. Wholesale markets will connect the producers, suppliers, logistics providers, and end users. Producers and other intermediaries sell their products to the wholesale market, where they will be sorted, graded, and checked and certified for safety and nutritional standards.

There are examples of such wholesale markets in Europe and other parts of the world that connect the producers, suppliers, logistics providers, and end users. These markets rent stalls to small- to medium-sized companies and family businesses that sell fresh food like fruit, vegetables, fish, and meat. The concentration of high volumes of products in one physical marketplace has several benefits. Food safety control can be concentrated in a small area

and official inspection bodies and a laboratory can be housed on-site. Prices are stabilized through the combination of many buyers and sellers and the large volume of trade. Also, the supply, as well as the variety of produce is made more stable because of the large turnover of a wholesale market.

The leveraging effect of the markets is important in enabling participating producers to scale up and invest in mechanization to produce greater volumes or even to become private retailers. Wholesale markets also encourage better interaction with professional organizations, with a concentration of information and extension services in one area where large numbers of producers gather. The markets are profitable and encourage positive interactions with private companies.

The operation of the wholesale market is summarized below:

Orientation	Focus	Objective
Collection of products	Build a supply network involving producers, intermediaries, and logistic providers	Ensure a smooth and undisrupted supply to ensure profit for all players involved.
Value addition	Test and certify for safety and quality, sort and grade, preserve scientifically to maintain nutritive value, and maintain inventory.	Ensure quality, safety, and nutritive value of agricultural products and price stability in market.
Sales and marketing	Remain vigilant on the dynamics of needs of different end users and match them by taking necessary measures. Preempt impact of urbanization and growth of middle-income consumers, and other probable short-term demand and supply shocks.	Ensure undisrupted, sustainable, and financially viable supply of safe, quality, and nutritive agricultural products to end users.

Social Safety Nets

When local production and exchanges in markets fail to ensure adequate food supply, governments need to provide for those who are economically challenged. This requires procurement and safe preservation of food, and distribution to those who need it most. This requires financing, infrastructure, technology, and policy.

> *We have many examples of countries producing surplus food and yet have a large portion of their population that are not secure.*
>
> ADB Food Security Forum 2016

Different transfer modalities of social safety net programs—food, cash, or a combination of both—are currently being implemented in different countries. The success of any social safety net program, regardless of the transfer modality, depends on proper targeting and stoppage of pilferage. Social safety net programs need to be *"shock-responsive"* to promote overall food security. An example is the Cambodia Emergency Food Assistance Project, which not only resolved the food crisis in 2008 but also eventually enhanced the country's ability to produce more food (Box 9).

Box 9: Sustainable Food Security in Cambodia

In 2008, ADB initiated the Cambodia Emergency Food Assistance Project in response to the food crisis that severely threatened food security for millions of farmers in the Tonle Sap Basin. The project attracted additional financing from the Global Agriculture & Food Security Program in 2012. Having started as an emergency assistance with a vision for sustainable food security, the project established a national system to respond to natural disasters.

It is also geared toward enhancing productivity by closing yield gaps through dissemination of existing technology (introduction of better rice varieties), seed value chain development and establishment of quality seed industry in Cambodia under a public–private partnership (seed-producing farmers' groups under a production contract with a local seed distribution company). The project also directly addressed household nutrition insecurity by diversified household agricultural productions, providing better nutrition for poor households.

The project, spanning a 7-year period and covering over 100 communes across 10 provinces, focused on sustainable food security in Cambodia. Thousands of households benefited from livelihood and food security training; widespread distribution of rice seed, fertilizer, and other crop seeds; and rehabilitation of poor infrastructure.

Agricultural training provided by the project also placed value on the importance of gender equality and women empowerment in the workforce; more than 60% of those trained were women. The project targeted beneficiaries based on a national identification system, which applied asset-based selection followed by community consultation and self-evaluation). In effect, the project builds a food safety net system for well-targeted poor households in the project area.

Cambodia's need for emergency food assistance has now turned over a new leaf, because of the contribution of the project, reducing the risk of malnutrition for thousands of Cambodians and contributing to a significant increase in productivity and income for many food-insecure farmers.

Source: Emergency Food Assistance Project (efap.org.kh).

In terms of institutional setup, shock responsiveness would mean a departure from the current practice of maintaining a reserve of food for natural disasters that happen in a long interval, such as earthquakes that happen once in every 100 years or a devastating flood that occur once in every decade. It may be better to build regional and/or global support centers to address this kind of uncommon events.

> *Even governments with strong social protection legislation such as in the Bangladesh, Pakistan, and the Philippines perhaps should not consider building and maintaining systems for very uncommon events.*
>
> ADB Food Security Forum 2016

One aspect of a shock-responsive social safety net program is continuity. Emergency assistance provided after an uncommon natural calamity is temporary in nature. It has little to do with the restoration of livelihoods back to normal situation. If beneficiaries are embedded within the national social protection system, the chance of long-term support becomes much higher without any extra effort.

The use of information and communication technology (ICT) helps resolve some of the challenges involved in a social safety net program. India, home to more than a billion people, has one of the largest social safety net programs in the world. More than 800 million people are now covered by different programs, which cover about 75% of the rural and about 50% of the urban population. Nearly 60 million tons of grains were distributed among the beneficiaries through 500,000 fair price outlets. This requires procurement from farmers, bulk storage before distribution, transportation to distribution areas, and intermediate storage before transporting to outlets.

A range of initiatives have been used in the program, including a mix of policy intervention and ICT integration. An online management system is used to estimate how much food can be procured from a region. The system also indicates ideal collection points. Similarly, farmers can also see online the set price, names of the collection centers, and the date and time of collection. They are also paid online which ensures the highest-level transparency and no need for intermediaries.

The Government of India is now working to introduce an end-to-end computerization system. At the warehouse level, the system will provide real-time information about food inventory. The system will link to fair price outlets to track how much food has been provided and how much has been distributed to beneficiaries. Biometrics will be used to properly identify beneficiaries. The system will also provide information on the amount of food received (against the allocation of a beneficiary) and thus reduce leakages from the social safety net program.

Conclusion and Way Forward

Climate change, economic transitions, population growth, and change in demographic structure presents difficult challenges to achieving the goal of ending hunger and malnutrition by 2030 (SDG 2) in Asia and the Pacific. These challenges continue to evolve as a result of the relationship between climate change and farming activities, increased urbanization and growth of middle-income consumers, increase in the ratio of elderly population, and outmigration of young people from the agriculture sector.

With the shrinkage of arable land and natural resource agriculture in the Asia and Pacific region needs to shift from resource-extracting technologies to resource-saving technologies, and from labor-intensive to knowledge-intensive practices, which need to be climate-resilient as well. Simple improvements to existing technologies will not suffice; high-level technologies (HLTs) that create opportunities for economies of scale and maximize cross-sector synergies need to be introduced. Improvements are required at all segments of the supply chain.

Three interrelated actions are required to promote the use of HLT. First, the harmonization of different sector policies at the national level, and elimination of cross-border hurdles on the movement of genetic resources at regional and international levels, is required to create an enabling environment to develop and promote the use of HLTs. At the national level, a holistic development approach needs to be undertaken where sector policy will complement each other. At the international level, measures on intellectual property rights protection need to be properly enacted while promoting cross-border transfer of technology.

Second, more investment is required to support the development of HLTs. Investment in agricultural research and reorientation of research focus, from increasing output per unit of land to output per unit of natural resources (e.g., output per unit of drop of water), are essential. In agricultural research, the objective is to remain ahead of the curve in climate change adaptation and mitigation. For example, given the average length of breeding cycles to develop a climate-resilient rice variety, only two such varieties can be developed by 2030, which may not be enough to produce adequate food supply for a growing population.

Third, the use of HLTs by the farmers needs to be scaled up. Food security in Asia and the Pacific in the next few years will depend on the investment in cost-effective development, effective demonstration, and rapid dissemination and use of HLTs by farmers of all sizes. The aggregation of production through producers' cooperatives may encourage the adoption of HLTs. Investments in physical infrastructure such as power and energy; road and transport; food storage, processing, and preservation; and market and distribution centers are also essential to make the use of HLTs profitable for farmers.

Farmers are also constrained by lack of access to financing. Thus, innovative models of agricultural financing that reduces risks for the private sector need to be facilitated. In particular, there is a need to leverage accumulated wisdom from microfinance to promote agricultural finance through group-based lending. The missing link between smallholders and agribusiness is another problem. A comprehensive approach to link upstream and

downstream activities in the food sector to insulate farmers from credit and market risks is also needed. Government, meanwhile, needs to provide policy and institutional support to private sector to enable this approach.

As the farming community shrinks in population due to younger workers opting out of the agriculture sector, farmers need to increase their production while aiming to make profit by selling the produce in market. The number of middlemen involved in the agricultural supply chain needs to be reduced to curb the dissipation of profit. Integrating small, unregulated markets into larger distribution centers with logistics, safety, and quality control infrastructure, will allow farmers to sell their products directly. These distribution centers will also help the government monitor, detect, and prevent food contamination.

Finally, in addition to increase in production and better management of overall agricultural supply chain, increased efficiency of social safety nets and improved public procurement and inventory management are also essential to promote food security. There is evidence that the use of information and communication technology in the management of social safety net programs improved efficiency and effectiveness. Barriers to international trade, both tariff and nontariff in nature, should be eliminated to reduce volatility in domestic food markets.

APPENDIX 1

Forum Partners

1. Asian Farmers' Association for Sustainable Rural Development (AFA)
2. Centre for Agriculture and Bioscience International (CABI)
3. City of Pasay, Family-Based Ecological Diversion and Recycling of Waste Program (FEDROW)
4. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
5. Food and Agriculture Organization of the United Nations (FAO)
6. Government of Australia, Department of Foreign Affairs and Trade (DFAT)
7. Global Agriculture & Food Security Program (GAFSP)
8. GrainPro
9. International Center for Agricultural Research in the Dry Areas (ICARDA)
10. International Food Policy Research Institute (IFPRI)
11. International Fund for Agricultural Development (IFAD)
12. International Maize and Wheat Improvement Center (CIMMYT)
13. International Potato Center (CIP)
14. International Rice Research Institute (IRRI)
15. Japan International Cooperation Agency (JICA)
16. Murdoch University
17. Olam International
18. Syngenta AG
19. United States Agency for International Development (USAID)
20. World Food Programme (WFP)
21. World Vegetable Center (previously Asian Vegetable Research and Development Center)
22. WorldFish Center

APPENDIX 2

Partnership Dialogue: Participating Organizations

1. Asia BioBusiness (Rice Bowl Index)
2. Asian Farmers' Association for Sustainable Rural Development (AFA)
3. Centre for Agriculture and Bioscience International (CABI)
4. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
5. Food and Agriculture Organization of the United Nations (FAO)
6. Global Agriculture & Food Security Program (GAFSP)
7. Government of Australia, Department of Foreign Affairs and Trade (DFAT)
8. GrainPro
9. International Center for Agricultural Research in the Dry Areas (ICARDA)
10. International Food Policy Research Institute (IFPRI)
11. International Fund for Agricultural Development (IFAD)
12. International Maize and Wheat Improvement Center (CIMMYT)
13. International Potato Center (CIP)
14. International Rice Research Institute (IRRI)
15. Japan International Cooperation Agency (JICA)
16. Murdoch University
17. United States Agency for International Development (USAID)
18. World Food Programme (WFP)
19. World Vegetable Center
20. WorldFish Center

APPENDIX 3

Techno Show Exhibitors

1. Asia BioBusiness (Rice Bowl Index)
2. The Asian Partnership for the Development of Human Resources in Rural Areas (AsiaDHRRA)
3. BiotechJP Corporation
4. Centre for Agriculture and Bioscience International (CABI)
5. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
6. Food and Agriculture Organization of the United Nations (FAO)
7. GrainPro
8. International Atomic Energy Agency (IAEA)
9. International Centre for Integrated Mountain Development (ICIMOD) and the Centre for Environment and Agriculture Policy Research, Extension and Development (CEAPRED)
10. International Institute of Rural Reconstruction (IIRR)
11. International Center for Tropical Agriculture (CIAT)
12. International Potato Center (CIP)
13. International Rice Research Institute (IRRI)
14. Murdoch University
15. RMSI
16. World Agroforestry Centre (ICRAF) with the International Fund for Agricultural Development (IFAD)

APPENDIX 4

Stages of Agricultural Development in Some Asia and the Pacific Countries

	Countries in 1980	Description	Countries in 2010
Beginning	Bangladesh, Cambodia, Nepal, Viet Nam	Low-income countries; agricultural labor productivity only $240. Agriculture output share 37%, and employment share 66%	Nepal
Agricultural surplus	Bhutan, People's Republic of China, India, Indonesia, Kyrgyz Republic, Lao PDR, Pakistan, Papua New Guinea (PNG), Sri Lanka, Samoa, Uzbekistan	Low-income countries; agriculture output share ranges from 19% to 36%; employment share from 33% to 85%. Agricultural labor productivity ranges from $434 to $947	Bangladesh, Cambodia, Kyrgyz Republic, Lao PDR, Pakistan, PNG, Tajikistan
Integration (early)	Armenia, Philippines, Tajikistan, Thailand, Vanuatu	Middle-income countries; agriculture labor share ranges from 33% to 52%, output share ranges from 10% to 21%. Agricultural labor productivity ranges from $367 to $1,100.	The PRC, India, Indonesia, Philippines, Sri Lanka, Thailand, Viet Nam
Integration (middle)	Georgia, Republic of Korea, Malaysia	Middle-income countries. Agricultural labor productivity $2,800, output share 20%, employment share is 38%.	Georgia, Samoa, Uzbekistan, Vanuatu
Integration (late)		Middle-income country; agricultural labor productivity $7,000, output share 10%, employment share is 14%.	Armenia, Malaysia
Industrialized	Japan		Japan, Republic of Korea

Source: R. Briones and J. Felipe. 2013. Agriculture and Structural Transformation in Developing Asia: Review and Outlook. *ADB Economics Working Paper Series*. No. 363. Manila: Asian Development Bank, p. 15.

APPENDIX 5

Forum Schedule

Day 1: Wednesday, 22 June 2016

2 p.m.–5:30 p.m.	**Partnership Dialogue: High-Level Technology to End Hunger**
2 p.m.–4:05 p.m.	Opening Remarks: **Stephen P. Groff**, vice-president, Operations 2, ADB
2:05 p.m.–2:15 p.m.	Stage-Setting Presentation: **Mahfuz Ahmed**, technical advisor, Rural Development and Food Security, ADB
2:15 p.m.–2:55 p.m.	**Part A** Chair: **Stephen P. Groff**, vice-president, Operations 2, ADB **Cluster 1** • International Center for Agricultural Research in the Dry Areas (ICARDA) • International Food Policy Research Institute (IFPRI) • International Maize and Wheat Improvement Center (CIMMYT) • International Potato Center (CIP) • International Rice Research Institute (IRRI) • World Vegetable Center (AVRDC)
2:55 p.m.–3:35 p.m.	**Cluster 2** • Asian Farmers' Association (AFA) • Centre for Agriculture and Bioscience International (CABI) • GrainPro • Murdoch University • WorldFish Center
3:35 p.m.–3:50 p.m.	**Break**
3:50 p.m.–4:30 p.m.	**Part B** Chair: **Bambang Susantono**, vice-president, Knowledge Management and Sustainable Development, ADB **Cluster 3** • Food and Agriculture Organization of the United Nations (FAO) • Global Agriculture and Food Security Program (GAFSP) • International Fund for Agricultural Development (IFAD) • Asia BioBusiness (Rice Bowl Index) • World Food Programme (WFP)

4:30 p.m.– 5:10 p.m.	**Cluster 4** • *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) • Government of Australia • Japan International Cooperation Agency (JICA) • United States Agency for International Development (USAID)
5:10 p.m.– 5:30 p.m.	**Closing Remarks:** **Bambang Susantono**, vice-president, Knowledge Management and Sustainable Development, ADB
5:30 p.m.– 7:30 p.m.	**Participant Registration** **Cocktail Reception for Forum Participants** ADB Auditorium

Day 2: Thursday, 23 June 2016

8 a.m.– 9 a.m.	**Participant Registration**
9 a.m.– 9:10 a.m.	**Introduction of the Forum: Mahfuz Ahmed,** technical advisor, Rural Development and Food Security, ADB
9:10 a.m.– 10:10 a.m.	**Leaders' Roundtable: The Future of Food, Panel 1** Moderator**: Farhana Haque Rahman,** director general, Inter Press Service Panelists: **Takehiko Nakao**, President, ADB **Sikandar Hayat Khan Bosan**, federal minister, National Food Security and Research, Pakistan **Musdhalifa Machmud,** deputy minister, Coordinating Ministry for Economic Affairs, Indonesia **Kundhavi Kadiresan**, additional director general and regional representative for Asia and the Pacific, FAO **Phouang Parisak Pravongviengkham**, vice-minister, Ministry of Agriculture and Forestry, Lao PDR **Sunny Verghese**, cofounder and group CEO, Olam International, Singapore
10:10 a.m.– 10:30 a.m.	**Opening of the Techno Show**
10:30 a.m.– 10:50 a.m.	**Photo Session**
10:50 a.m.– 11 a.m.	**Break**
11 a.m.– 12 noon	**Leaders' Roundtable: The Future of Food, Panel 2** Moderator**: Farhana Haque Rahman,** director general, Inter Press Service Panelists: **Uttam Kumar Bhattarai**, secretary, Ministry of Agriculture, Nepal **Rob Bertram**, chief scientist, Bureau for Food Security, USAID **Erkinbek Choduev**, deputy minister, Ministry of Agriculture, Kyrgyzstan **Tin Htut**, permanent secretary, Ministry of Agriculture, Livestock and Irrigation, Myanmar

	David Kaatrud, director, Asia and the Pacific, WFP **Hoonae Kim**, director, Asia and the Pacific, IFAD **Matthew Morell**, director general, IRRI **Ma. Estrella Penunia**, secretary general, AFA **Feng Yong,** deputy director general, Foreign Economic Cooperation Center, Ministry of Agriculture, PRC
12 noon–1 p.m.	**Lunch**
1:10 p.m.–3 p.m.	**Session 1: Meeting Asia's Agricultural Transformation Challenges** Chair: **Deborah Stokes**, vice-president, Administration and Corporate Management, ADB **Key Issues**: Shrinking agricultural labor and rising wage; mechanization of agriculture and farm consolidation; feminization of agricultural workforce and its implications; climate change and extreme weather conditions; efficient resource management (water, land, forests and coastal areas).
	Keynote speaker: **Jikun Huang**, professor, Peking University, PRC Panelists: **Fabrizio Bresciani,** lead regional economist, IFAD **David Dawe**, senior economist, Regional Office for Asia and the Pacific, FAO **Mark W. Rosegrant**, director, IFPRI **Kamel Shideed**, additional director general, ICARDA **Sonomi Tanaka,** technical advisor, Gender Equity Thematic Group, ADB **Qingfeng Zhang,** director, Environment, Natural Resources, and Agriculture, ADB
3 p.m.–3:15 p.m.	**Break**
3:15 p.m.–5:15 p.m.	**Session 2: Value Chain Financing and Promotion of Agribusiness** Chair: **Diwakar Gupta**, vice-president, Private Sector and Cofinancing Operations, ADB **Key issues**: Innovative financing instruments; postharvest loss reduction; derisking private financing and promoting inclusive business; collaboration between micro, small, and medium agrienterprises and corporations; value addition and promotion of agroprocessing; role of governments.
	Keynote speaker: **Sunny Verghese,** Co-Founder and Group CEO, Olam International, Singapore Panelists: **Adolfo Brizzi,** director, Policy and Technical Advisory Division, IFAD **Bruno Carrasco,** director, Public Management, Financial Sector and Trade, ADB **Martin Lemoine,** agribusiness investment unit head, ADB **Fiona Lynn,** director, Agricultural Productivity and Food Security, DFAT, Australia **Abdul Awal Mintoo,** cofounder, Lal Teer Seed, Bangladesh **Iftikhar Mostafa,** senior agriculture economist, GAFSP/World Bank

Day 3: Friday, 24 June 2016

8 a:m:– 9:45 a:m:	**Farmers' Roundtable: Voices from the Field** Moderator: **Ma. Estrella Penunia**, secretary general, AFA Panelists: **Bon Ian Dela Roca,** Sorosoro Ibaba Development Cooperative (group-based production and marketing) **Aynal Haque,** Bangladesh (modern seed production) **Lourdes Panopio**, JAMLA Corporation, Philippines (small-scale agribusiness) **Reynaldo San Jose,** Philippines (climate-smart agriculture) **JonJon Sarmiento,** PAKISAMA, Philippines (community resilience building) **Luck Wajananawat,** Bank for Agriculture and Cooperatives, Thailand (agri credit)
9:45 a:m:– 10:30 a:m:	**Knowledge Product Launch** Chair: **Amy Leung**, deputy director general, East Asia Department, ADB **Book:** *Improving Logistics for Perishable Agricultural Products in the People's Republic of China* **Presentation:** **Yun Kang**, operations researcher, RAND, USA **Wang Wei**, deputy director general, Development Research Center of the State Council, PRC Discussant: **Qingfeng Zhang**, director, Environment, Natural Resources, and Agriculture, ADB **Book:** *Developing and Disseminating Water-Saving Rice Technologies in South Asia* **Presentation: Arvind Kumar**, plant breeder, IRRI Discussant: **Jiangfeng Zhang**, director, Environment, Natural Resources, and Agriculture, ADB
10:30 a:m:– 10:45 a:m:	**Break**
10:45 a:m:– 12:45 p:m:	**Session 3: Sustainable Food Entitlement** Chair: **Marlene Ramirez**, secretary general, AsiaDHRRA **Key issues:** Price and supply stability; efficient supply chain and logistics for safe food; digital shopping outlets; tariff and nontariff barriers to agricultural trade; public procurement and inventory management of food; social safety net programs.
	Keynote speaker: **Vinod Thomas**, director general, Independent Evaluation, ADB Panelists: **Mark Bell,** director, International Learning Center, University of California-Davis **Gerd Fleischer,** head, Agricultural Innovation and Sustainability Standards Section, GIZ **Jared Greenvile,** senior agricultural policy analyst, OECD **Siemon Hollema,** senior regional programme and policy adviser, WFP

	Subhasish Panda, joint secretary, Department of Food and Public Distribution, India **Shashi Sareen,** senior food safety and nutrition officer, Asia and the Pacific, FAO
12:45 p.m.– 1:45 p.m.	**Lunch**
1:45 p.m.– 3:45 p.m.	**Session 4: Safe, Quality and Nutritious Food: Are We Eating Right?** Chair: **Mark W. Rosegrant**, director, IFPRI **Key Issues**: Public policy and institutions; responsible private sector; nutritious and health promoting food; integrated supply facility for cost-effective monitoring of safety issues; frontier technology for food safety; role of development partners.
	Keynote speaker: **Marco Ferroni**, executive director, Syngenta Foundation for Sustainable Agriculture Panelists: **Mubarik Ali,** member, Food Security and Climate Change, Planning Commission, Pakistan **María González Pastor,** consultant, *Direccion de Operaciones en el Exterior,* MERCASA **Najat Mokhtar,** director, Division of Asia Pacific, International Atomic Energy Agency (IAEA) **Akmal Siddiq,** director, Environment, Natural Resources and Agriculture Division, ADB **Paul P.S. Teng,** senior fellow, Nanyang Technological University, Singapore **Marco Wopereis,** Director General, AVRDC
3:45 p.m.– 4 p.m.	**Break**
4 p.m.– 5:20 p.m.	**Actions and Recommendations** Moderator: **Mahfuz Ahmed**, technical advisor, Rural Development and Food Security, ADB Panelists: **Nichola Dyer**, program manager, GAFSP **Hoonae Kim**, director, Asia and the Pacific, IFAD **Takashi Matsuo,** director, Environment, Natural Resources and Agriculture, ADB **Akmal Siddiq,** director, Environment, Natural Resources and Agriculture, ADB **Jiangfeng Zhang**, director, Environment, Natural Resources, and Agriculture, ADB **Qingfeng Zhang**, director, Environment, Natural Resources, and Agriculture, ADB

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Safe, Nutritious, and Affordable Food for All

ADB Food Security Forum 2016 Discussions and Recommendations

In 2000, 617 million people in Asia and the Pacific were suffering from hunger. Although the number decreased to 512 million in 2016, food security challenges continue to evolve. A lesson learned from the 2007–2008 food price crisis is that food supply instability and price volatility not only increase the incidence of hunger and malnutrition but also affect social and political insecurity. About 400 farmers, development practitioners, women and youth leaders, and representatives from government, the private sector, and civil society gathered at the Asian Development Bank Food Security Forum 2016 to discuss new approaches to and consolidate advances in the fight against hunger and malnutrition. This report distills the discussions from that forum.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to a large share of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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