©*The Pakistan Development Review*
55:4 Part I (Winter 2016) pp. 297–311

Sarfraz K. Qureshi Memorial Lecture

A Nexus Approach to Food, Water, and Energy: Sustainably Meeting Asia's Future Food and Nutrition Requirements

SHENGGEN FAN

Agricultural and food production systems in Asia must undergo a significant transformation in order to meet the concurrent challenges of increasing food, water, and energy demands amid on-going climate change. This is particularly true in countries in South Asia, including Pakistan, where hunger and undernutrition persist and natural resource are increasingly strained. Sustainable intensification with a focus on nutrition is particularly crucial to provide adequate and nutritious food for all without further damages to the planet. However, a silo approach to meeting the demands of a growing, increasingly urbanised, and wealthier population is no longer acceptable. Instead, capitalising on the inter sectoral linkages between food, water, and energy can more effectively minimise trade-offs and maximise synergies across concurrent efforts to improve water, energy, food, and nutrition security sustainably.

INTRODUCTION

Maintaining the status quo in Asia's agriculture and food systems is not sufficient to meet the expected food demands of the region in a rapidly transforming socioeconomic environment with dwindling natural resources, and a changing climate [FAO (2009)]. Amid parallel pressures from economic development, the ability of Asia's agricultural and food production systems to generate adequate food and nutrition over the coming decades will rely heavily on food production systems that can more efficiently use limited water and energy resources, while adapting to and mitigating climate change [FAO (2011); ADB (2013a)]. Many of the current policies and programmes in Asia across the food, water, and energy sectors are fragmented and uncoordinated, failing to account for the interconnections among these three sectors, and thus risking the sustainability of the region's natural resources—with adverse consequences for future food security and nutrition in Asia [ADB (2013a); UNESCAP (2015)]. For the region to make great headway toward achieving multiple Sustainable Development Goals, including ending hunger and undernutrition, major steps are needed to promote sustainable intensification of agriculture under a "nexus" food-water-energy approach.

Shenggen Fan is Director General, International Food Policy Research Institute (IFPRI), Washington, DC., USA.

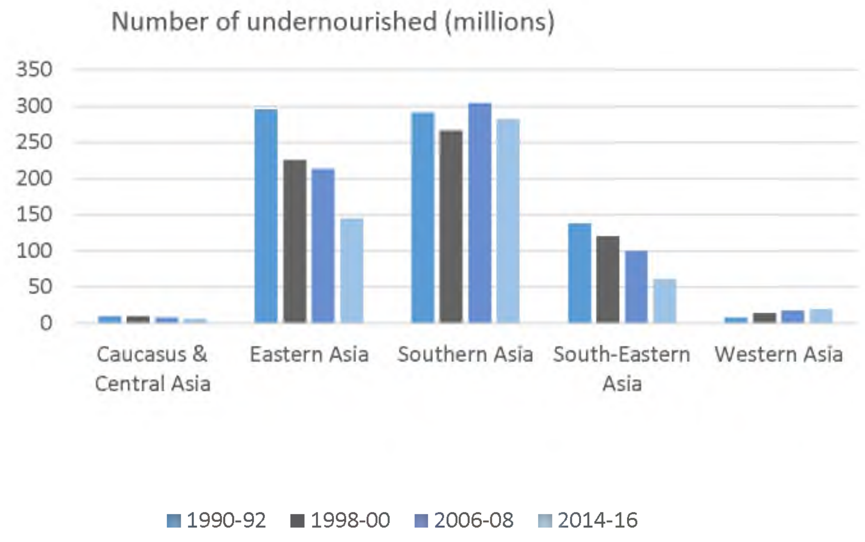
FOOD SECURITY AND NUTRITION SITUATION IN ASIA

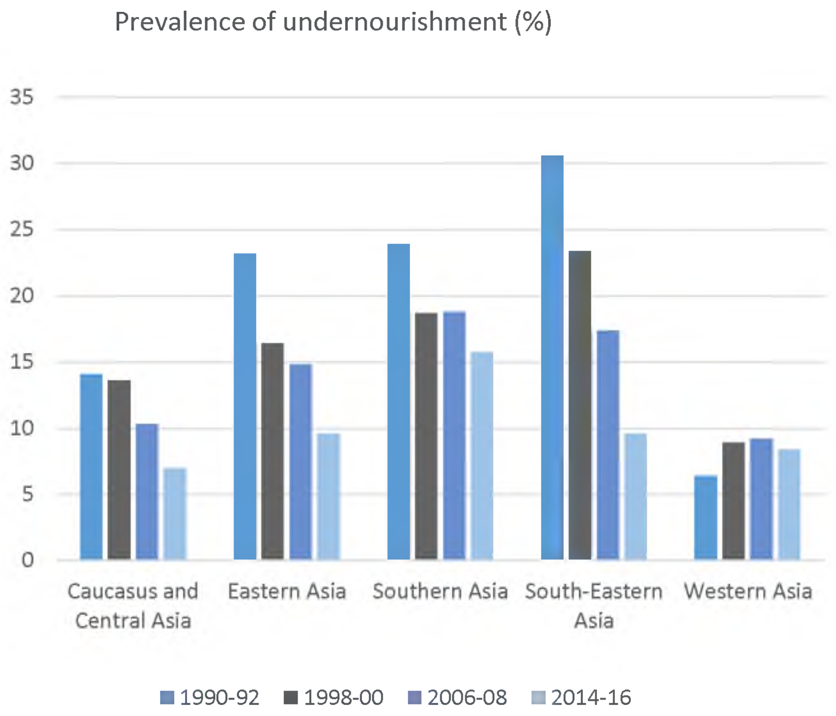
Hunger Remains Prevalent

As a whole, Asia is home to approximately two-thirds of the world's 795 million people who suffer from undernourishment, defined as the level of food intake insufficient to meet dietary energy requirements [FAO (2015)]. Over the last three decades, the number of undernourished people has steadily declined in the region, from 742 million in 1990-92 to 512million in 2014-16, the overwhelming majority of whom live in China and India. During the same period, the share of the population who suffers from undernourishment in Asia has been cut in half, from approximately 24 percent in 1990-92 to 12 percent in 2014-16—meaning that the region has achieved the Millennium Development Goal (MDG) of halving the proportion of undernourished people by 2015.

A more sub-regional breakdown reveals variability in hunger reduction (Figure 1). Eastern Asia (mainly China), the Caucasus and Central Asia, and South-Eastern Asia have experienced large declines in undernourishment in terms of both prevalence and absolute numbers, while hunger reduction has been much more muted in Southern Asia. In fact, the number of undernourished in Pakistan has increased by 44 percent from 1990 to 2015, and the prevalence of hunger has hovered from 22 to 25 percent in that time period [FAO (2015)]. Undernourishment trends are more discouraging in Western Asia, where the number of undernourished has more than doubled over the last three decades and the prevalence of undernourishment has hovered around 10 percent after increasing from 6 percent in the early 1990s, owing to a growing population combined with political instability and economic decline in a number of countries in the sub-region. Accordingly, both Southern and Western Asia have not matched the same level of success as East Asia and South-Eastern Asia in meeting the MDG goal of halving undernourishment.

Fig. 1. Undernourishment in Asia





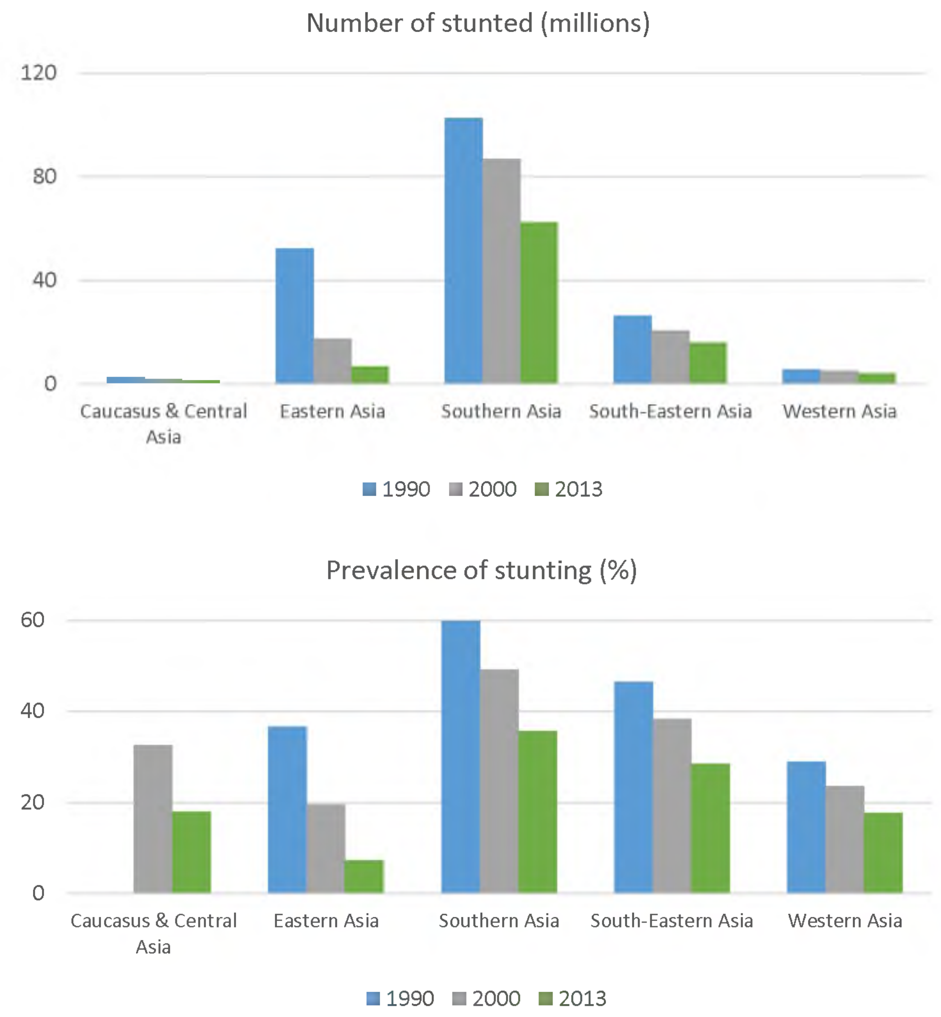
Source: FAO (2015).

Undernutrition is also Widespread

Going beyond a strict focus on caloric intake, indicators of nutritional outcomes help to paint a fuller picture of the food security and nutrition situation in Asia. Deficiencies in essential micronutrients among children are extremely widespread in Asia, including anaemia (50 percent), vitamin A deficiency (34 percent), and iodine deficiency (30 percent) [FAO (2013)]. This burden is especially evident in Southern Asia (in countries such as Afghanistan, India, Nepal, and Pakistan), where levels of micronutrient deficiencies are among the highest in the world. Such deficiencies have the potential to weaken the cognitive and physical development of children and adolescents and to reduce the productivity of adults due to illness and reduced work capacity. For example, the economic cost of micronutrient deficiencies in India has been estimated to be 0.8 to 2.5 percent of GDP, which equals US$5.8-26.8 billion [Stein and Qaim (2007)].

Another important indicator of nutritional outcomes is stunting (height-for-age), which captures the long-term effects of dietary deprivation (often beginning with maternal undernutrition). Asian countries have had significant success in reducing the prevalence of stunting among children (from 48 to 25 percent between 1990 and 2013—a decrease of approximately 100 million children) [UNICEF-WHO-World Bank (2015)]. However, significant variation exists across sub-regions (Figure 2), with Southern Asia continuing to have one of the highest incidence and number of stunted children in the world. For example, prevalence of stunting in Pakistan has remained at 43 to 45 percent from 1992 to 2012 [UNICEF-WHO-World Bank (2015)].

Fig. 2. Stunting among Children in Asia



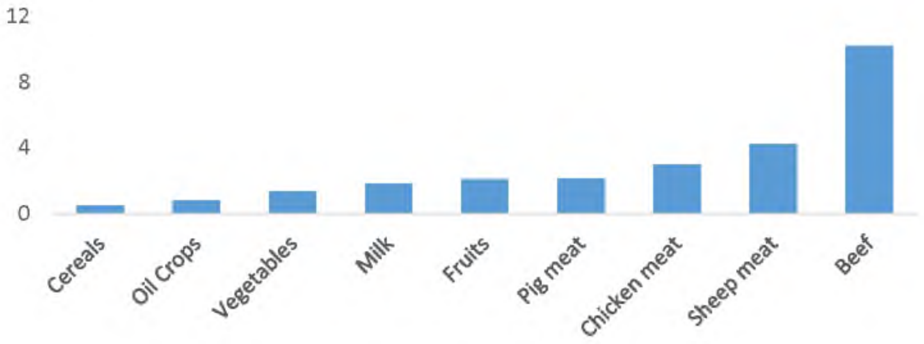
Source: UNICEF-WHO-World Bank (2015).

CHANGING PROFILE OF ASIA'S POPULATION

Continued global population growth and changing demographic patterns coupled with income growth will put increased pressure on food production systems. By 2050, the world population is projected to reach 9 billion, and nowhere is this trend more evident than in Asia, where the population has almost quadrupled from 1.4 billion to 4.3 billion between 1950 and 2014 and is projected to increase further to 5.2 billion by 2050 [UN Population Division (2014)]. Over the last several decades, this growth has come predominantly from urban areas. Current projections indicate that almost two-thirds percent of the population will live in urban areas by 2050 (compared to 18 percent in 1950 and 48 percent in 2014). At the same time, Asia's population is becoming wealthier, with per capita gross domestic product throughout emerging and developing Asia increasing from $566 in 1980 to $8,526 in 2013, and is expected to rise further to $13,132 in 2019 (current international dollars PPP) [IMF (2014)].

The transition toward a more urban and wealthier population in Asia—combined with the rise of supermarkets and emergence of modern supply chain in the region—has translated into changing patterns of food demand [Reardon and Timmer (2014)]. Consumption baskets throughout Asia are shifting from staple foods such as rice toward more high-value foods such as meat, dairy, fruit and vegetables, as well as toward more processed food [Pingali (2007); Timmer (2013)]. Over the next two decades, projections show that per capita consumption of meat, vegetables, and fruit is estimated to increase by approximately a third to a half in Asia, while the consumption of cereals will decrease [Msangi and Rosegrant (2011)]. Because meat-based food systems require more natural resources, such as water (Figure 3),than a vegetarian diet with equivalent nutritional value, this shift in food demand will have significant environmental implications. A closer look at a meat-based diet reveals that the water footprint varies across different types of animal production systems (ranging from grazing to industrial) and feed characteristics (such as how much and what the animals eat and the feed origin) [Mekonnen and Hoekstra (2014); Gerbens-Leenes, *et al.* (2013)].

Fig. 3.Water Footprint of Selected Food Products (Litre/Kcal)



Source: Mekonnen and Hoekstra (2014).

GROWING NATURAL RESOURCE DEMAND AND STRESSESIN THE FACE OF CLIMATE CHANGE

The increased and intensified use of many natural resources, including water and energy, has been critical in boosting global agricultural output in the past half century [FAO(2009)]. The expanded use and often poor management of these resources has contributed to their scarcity and degradation which threaten the capacity of agricultural systems to improve future food security and nutrition.

Water

Water is an indispensable component within agricultural production systems; as such, agriculture is vulnerable to water scarcity, but it also contributes to the problem. Asia is home to approximately a third of the world's renewable freshwater resources but per capita water resources throughout Asia were about a quarter of the global average, with the exception of Southeast and Central Asia, whose per capita water resources were greater than the global average [UNESCAP (2015)].

Asia is already facing substantial pressure on its water resources. Currently, Asia withdraws 22 percent of its internal renewable water resources annually (compared to the global average of 9 percent), a rate that leaves the region at significant risk of impending water scarcity [WWAP (2012)].In fact, looking at a regional disaggregation of water withdraw reveals that Western, South, and Central Asia use 56-62 percent of their water resources, which is above the "critical threshold" of 40 percent that indicates "unsustainable" water withdrawals and water-insecure river basins (Ibid.) In Pakistan, despite substantial water resource endowments, water demand exceeds supply, causing significant withdrawal from reservoirs such that their storage capacity is limited to a 30-day supply [ADB (2013b)].

Agriculture is by far the largest user of water in Asia, with water withdrawals for agricultural use ranging from 73 percent in developing countries in East Asia and the Pacific to 91 percent in South Asia [World Bank (2015)]. Currently, irrigated land accounts for 44 percent of cultivated land in Asia, and approximately 70 percent of the world's area equipped for irrigation is found in Asia (primarily India and China) [FAO (2015). In recent years, expanding irrigation systems have contributed to an increase in groundwater extraction in Asia, with current extraction rates 2-2.5 times their 1980 levels in China and India; groundwater currently supplies 55 percent and 30 percent of irrigation water in South and East Asia, respectively [WWAP (2012); FAO (2012)]. Since extraction rates often exceed natural replenishment in many areas, water tables have fallen in parts of Asia. Recent satellite data points to falling groundwater levels in major crop producing areas such as the Indus Basin aquifer between India and Pakistan as well as the Indian states of Rajasthan, Punjab, Tamil Nadu, and Haryana due to high irrigation and population demands, threatening future agricultural output and potable water supplies [Rodel, *et al.*(2009); Richey, *et al.*(2015); Chinnasamy and Agoramoorthy (2015)].

Water stress is already a reality in parts of Asia. According to the Asian Development Bank's (ADB) Water Security Index, three-fourths of countries in Asia are suffering from low levels of water security, especially in South Asia and parts of Central and West Asia [ADB (2013b)]. Under an assumption of business as usual practices, China and India will be home to 2.7 billion people in areas of high water stress by 2050 (compared to 1.4 billion in 2010) and will face a 25 and 50 percent gap respectively, between water demand and supplies in 2030 [Veolia Water (2011); WRG (2012)]. Water stress in Pakistan is projected to be extremely high in 2040, with the ratio of withdrawals to supply at over 80 percent, according to the World Resource Institute's Aqueduct Water Stress Projections [Lu, *et al.*(2015)]. Although, efficiency-promoting improvements and changes in cropping patterns (such as a shift from rice to wheat) will help Asia in reducing its use of water resources in irrigation, areas such as South Asia will continue to use critical levels of their renewable water resources for agricultural production [Alexandratos and Bruinsma (2012)]. Intersectoral competition for water will further complicate agriculture's access to water resources.

Energy

Efforts to meet the increasing demand for finite energy sources are indirectly and directly linked to Asia's food security and nutrition. With its high population and economic growth, Asia is increasingly at the centre of global energy consumption.

Between 2011 and 2040, global energy demand is set to increase by 37 percent, of which 60 percent will come from developing countries in Asia (primarily within the industrial and buildings sectors) [OECD/IEA(2014)]. For Pakistan, where electricity demand has increased exponentially in the 2000s alongside stable GDP growth, energy shortfalls have led to severe power cuts resulting in 2.5 percent GDP loss, unemployment for over half a million industrial labourers, and a loss of exports valued at US $1.3 billion [Perwez and Sohail (2014)]. Currently, the country is facing an energy crisis and the gap between energy demand and supply is widening over time [Naseem and Khan (2015)].

Rising energy demand and prices, in conjunction with growing interest in clean and renewable energy sources, have made biofuel production more profitable and attractive in recent years (underpinned by government mandates and subsidies). Asia is home to a growing market for biofuel, and China, India, Malaysia, the Philippines and Thailand are becoming the leading regional producers [OECD/FAO (2014)]. Continued biofuel expansion and increased competition with food crops for agricultural resources can have significant implications for food systems within Asia by increasing food prices and decreasing the consumption levels of key staple commodities, resulting in higher rates of undernourishment [Rosegrant, *et al.*(2010)].

Rising energy prices also have the potential to increase the cost of agricultural production, affecting both production costs and market prices. Critical components of the agricultural production process, such as irrigation, planting, and harvesting, are increasingly dependent on energy [von Grebmer (2012)]. Additionally, the price of energy is closely linked to the prices of inputs and post-farm gate services, such as fertilisers and transport.

Water use is another dimension to the relationship between energy and food systems as the water demands of energy and agriculture can often be in conflict. Increased hydroelectricity generation through the construction of dams in Asia has the potential to improve or worsen water availability for irrigation, depending on the location of agricultural activities in relation to the hydropower plants [WWAP (2014)]. Water-intensive coal production and demand will continue to dominate Asia's energy mix. Upward trends in Asia's coal production and consumption markets will have important environmental (and thus food security and nutrition) implications due to the high water requirements of coal mining operations, and their potential to degrade water quality [OECD/IEA (2014)]. Moreover, policies that promote government-subsidised energy provision in countries such as India have artificially deflated the cost of irrigation pumping for many farmers, leading to the unsustainable overdraft of groundwater in many areas [FAO (2012)].

Climate Change

Increased climate variability and extreme weather conditions are expected to severely affect agriculture in Asia—with floods and droughts predicted to increase in both magnitude and frequency accompanied by higher temperatures and sea level rise [World Bank (2013)]. These climatic variations are likely to affect agriculture in the region by degrading water and land quality (through saltwater intrusion) and altering cropping seasons, the spread of pests and diseases, and irrigation requirements. One of the "hot spots" in Asia for climate change vulnerability is the Mekong River Delta (a major rice producing area in Southeast Asia), where the projected rise in sea levels will result in rice production falling by about 11 percent over the next three decades. South Asia is especially vulnerable to extreme precipitation patterns due to its low per capita water storage capacity [ADB (2013b)]. While climate change will have varying effects on irrigated yields across Asia, potentially lower precipitation and warmer temperatures in South Asia are projected to decrease rice, wheat, and maize production by 14, 44-49, and 9-19 percent, respectively, compared to production without climate change [Nelson, *et al.* (2009)]. The effects of climate change in Asia are also projected to result in higher prices of major staple crops (rice, wheat, maize, and soybeans), lower calorie availability, and increased undernourishment among children. These impacts would be particularly harsh for low-income countries and poor people, who largely depend on agriculture as a source of food and income, and have limited capacity to adapt.

At the same time, it is important to note that food production systems also contribute to climate change through the generation of greenhouse gases (GHGs). Most significantly, the agriculture sector accounts for 24 percent of global GHG emissions, making it the second largest source of GHGs after energy production [IPCC (2014)]. Regionally, Asia is the greatest contributor to agricultural GHG emissions, accounting for 47 percent of global GHGs from agriculture, with the most agricultural emissions coming from South Asia [FAO (2015)]. While countries such as Pakistan through its Vision 2025 have made reducing emissions a priority, international climate finance, transfer of technology and capacity building will be needed to establish and implement commitments to climate change policy [WRI (2015)].

SUSTAINABLE INTENSIFICATION IS ESSENTIAL TO MEET ASIA'S FOOD AND NUTRITION REQUIREMENTS

Maintaining the status quo in agriculture is not sufficient to meet expected agricultural demands [Global Harvest Initiative (2014)]. For example, if agricultural productivity in East Asia continues to grow at the current rate then the region will meet only 67 percent of its food demand by 2030, while South and Southeast Asia will meet 87 percent of its food demand. According to a recent study, meeting food and nutrition requirements over the next several decades will require the more intense use of inputs, namely increased rates of crop water and fertiliser use, alongside increased productivity; however, such input intensification has the potential to come with a high cost to the environment [Grafton, *et al.* (2015)].

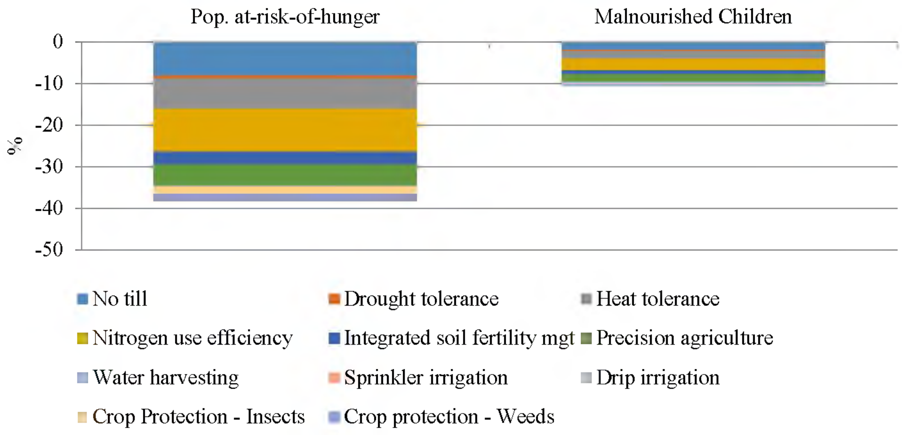
Sustainable intensification will thus be critical to meet Asia's growing demand for nutritious foods while preserving the region's natural resources while adapting to and mitigating climate change. In the recent years, a great deal of policy and research has been directed toward sustainable agricultural intensification, which is commonly defined as form of production in which "yields are increased without adverse environmental impact and without the cultivation of more land"[UK Royal Society (2009)]. Originally used in reference to low-yielding agriculture in Africa South of the Sahara, calls for more environmentally-friendly pathways within modern high-intensity food production systems have gradually become a more prominent feature in food security discourse since the early 1990s amid increasing population, consumption, and environmental pressures [Chen (1990); Tilman (1998); Garnett and Godfray (2012); Montpellier Panel (2013)].

However, because” sustainable intensification” is more of an aspirational framework rather than an endorsement of a particular agricultural production system, vigorous debate persists regarding what it will look like on the ground [Garnett and Godfray (2012)]. In recent years, discussions around sustainable intensification have shifted emphasis away from an overwhelming production-oriented perspective toward a greater balance between “sustainability” and “intensification” and the inclusion of both technological and socio-economic approaches regarding food demand, nutrition, governance, food losses and waste, distribution, and governance issues [Loos, *et al.* (20140; Garnett, *et al.* (2013); Garnett and Godfray (2012); Foresight (2011)]. This approach embodies the entire food system, for which new tools to understand it are in development. For example, the forthcoming Global Food System Index can provide accountability and help governments set priorities to tackle weak nodes in the system across six key dimensions: inclusive, nutritious and healthy, sustainable, climate-smart, productive, and business-friendly [IFPRI (2015)].

Whether or not countries embark on a more climate-smart pathway will have significant implications for food security and nutrition over the coming decades (Figure 1). The conventional world scenario assumes a business as usual approach without the use of climate-smart agricultural practices and technologies such as no-till and the use of drought tolerant varieties. In contrast, the climate-smart world scenario entails an approach that takes into account the use of such practices and technologies. In particular, the sustainable world scenario puts emphasis on water and energy conservation and climate change adaptation and mitigation through increased investments in practical and technological innovations.

Under a climate-smart world scenario in which all climate-smart practices and technologies are employed, for example, the number of malnourished children would decrease by over 10 percent compared to levels projected under the conventional world scenario. The population at risk of hunger decreases by nearly 40 percent in the climate-smart scenario compared to the baseline conventional scenario.

Fig. 1. Impacts of Improved Practices and Technologies on Food Security and Nutrition.



Source: Adopted from Rosegrant, *et al.* (2014).

WAY FORWARD—ADOPTION OF A FOOD-WATER-ENERGY NEXUS APPROACH TO ACHIEVE MULTIPLE SDGs

Efforts to improve food, water, and energy security for better nutrition and greater sustainability need to reflect the crucial linkages between all three sectors and their potential to promote or constrain growth in the other sectors. The issues and challenges that affect food, water, and energy in Asia are extensively interwoven. Food security and nutrition are simultaneously dependent and in competition with water and energy systems, through channels such as irrigation, mechanised agricultural production, biofuels, and hydropower [UNESCAP (2013); Rasul (2014)]. For example, poor water quality with high mineral and metal content (such as arsenic) combined with minimal energy resources and infrastructure for water treatment can result in reduced yields and contaminated food supplies that adversely affect the health of consumers [e.g. Talukder, *et al.* (2014); Bustingorri and Lavado (2014)].

In order to meet increasing demand for nutritious foods, countries in Asia need policies and investments that promote sustainable intensification of agriculture grounded in "nexus" thinking that capitalises on the inter-sectoral linkages between food, water, and energy. Adopting a nexus approach to dealing with concurrent food, water, and energy demands has the potential to promote cross-sectoral synergies and minimise the trade-offs more effectively than a more isolated, "silo-like" policy planning. A nexus approach will also be critical for countries in Asia and beyond to achieve national goals such as Pakistan's Vision 2025, as well as global goals such as the SDGs. For example, in order to end extreme poverty, hunger, and malnutrition (SDGs 1 and 2) while promoting sustainable production patterns (SDG 13) much attention must be paid to the intersection of the food, water, and energy sectors.

INCREASE NEXUS-RELATED KNOWLEDGE AMONG STAKEHOLDERS

Greater awareness and information on the water and energy implications of current food security and nutrition policies, and vice versa, are needed by all stakeholders, including farmers, different ministries, civil society, and the private sector. We have to move toward generating new data and metrics that measure the performance of food production and environmental systems in a holistic manner. This includes developing and using indicators such as nutrients per drop of water, or per kilowatt of energy. There is also a need for cost-benefit analysis of nexus-based versus business-as-usual approaches. In addition to collecting new data, mechanisms and platforms are also needed to share existing data in relation to agricultural production, energy generation, and water supplies and quality among stakeholders across the three sectors using a common language. Such efforts should also include sharing information on successful interventions through mechanisms such as online knowledge exchange platforms, allowing stakeholders to adapt and scale-up best practices. For example, the G20 Food Loss and Waste platform launched by IFPRI and FAO brings together information, advice and knowledge on good practices to reduce food loss and waste, making this information more easily accessible to countries and regions.

Promote Policies that Internalise Synergies between Food, Water, and Energy Security

More efficient and sustainable management of natural resources can be achieved through policies that provide consumers with the proper signals about the true value of resource provision required to produce foods. Economic incentives to promote resource-use efficiency include resource management pricing that internalises the social and environmental costs and benefits of agricultural production, including the gradual elimination of agricultural subsidies that encourage the overuse of agricultural inputs such as water and fertilisers. Additional policies to promote sustainable and healthy diets, such as converting subsidies from staple crops to investments for more nutritious crops, can help improve nutrition outcomes. However, because efforts to internalise the full cost of agricultural production can potentially raise food prices, a strong social protection system is needed to assist and compensate poor consumers and producers. In fact, better-targeted, more productive, and flexible social protection policies are needed both to ensure that poor consumers and producers are not priced out of accessing potentially more expensive food and natural resources and to offer long-term productivity-enhancing opportunities for the poor to escape poverty, food insecurity, and undernutrition.

Develop and Distribute Nexus-Promoting Agricultural Technologies and Practices

Increased investment in agricultural research and development should focus on new technologies and practices that raise food security and nutrition while enabling more efficient and location-specific use energy and water resources. Special focus should be especially placed on addressing the threat to food production from dwindling water supplies and more variable rainfall patterns through innovative tools that range from monitoring and early warning systems to water saving technologies and practices and risk management measures. Similarly, steps in the right direction to improve nutrient use efficiency include remote sensing by satellite and wireless communications. Crop bio-fortification and diversification efforts also offer the opportunity to increase yields and nutrition while allowing for more efficient use of inputs such as fertiliser and pesticides; however, biotechnology development should be accompanied by well-balanced and regulatory system that simultaneously promotes innovation and ensures the safety of consumers and the environment. High-quality and effective delivery and extension channels, alongside complimentary investment in infrastructure (such as roads, water storage, and irrigation) are needed to strengthen access to these technologies in developing countries—especially by smallholder farmers.

Develop Enabling Institutional Environment to Promote Nexus Approach

Institutional reforms at different levels and scales within and across food, water, and energy sectors have the potential to help producers, consumers, and policymakers to work together to make more well-informed decisions regarding natural resource management and provision while also increasing food security and nutrition. Cross-sectoral legal and regulatory frameworks that clearly define resource rights and targets should be accompanied by strong monitoring capacity, reallocation mechanisms (either market or administrative), and sanctioning and dispute resolution systems. Innovative mechanisms and governance processes that support vertical and horizontal collaboration among all stakeholders, from both the public and private sectors, can be a useful tool to integrate nexus thinking across the three sectors. At the same time, building and strengthening the capacity, accountability, and authority of existing coordinating mechanisms (both government- and market-led) to undertake integrated planning and cross-sectoral communication are needed to bolster the food-water-energy security nexus—allowing for bottom-up policy experiments with systematic monitoring and feedback processes to adjust policies and mechanisms.

CONCLUSION

Food, water, and energy security are crucial for better nutrition, sustainable long-term economic development, and human well-being and there are strong linkages between all three sectors. A food-water-energy nexus approach is key for the sustainable intensification of Asia's agricultural and food production systems. Interconnections between water, energy, and food sectors means that policies that benefit one area can translate into increased risks or co-benefits in another. It is therefore important to develop complementary solutions that minimise these trade-offs and promote synergies across efforts to improve food, water, and energy security, as well as nutrition and health. Achieving multiple SDGs depends on such an approach. Cross-sectoral benefits must be explored that promote winning solutions in all three areas, especially focusing on innovation in institutions, policies, information, and technologies. We can no longer afford to work in silos if we want to achieve truly sustainable development, food security, and adequate nutrition for all.

REFERENCES

Alexandratos, N. and J. Bruinsma (2012) World Agriculture Towards 2030/2050: The 2012 Revision. Rome, FAO. (ESA Working Paper No. 12-03).

Asian Development Bank (ADB) (2013a) Food Security in Asia and the Pacific. Mandaluyong City. Philippines: Asian Development Bank.

ADB (2013b) Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific. Mandaluyong City, Philippines: ADB.

Bustingorri, C. and R. Lavado (2014) Soybean as Affected by High Concentrations of Arsenic and Fluoride in Irrigation Water in Controlled Conditions. *Agricultural Water Management* 144, 134–139.

Chinnasamy, P. and G. Agoramoorthy (2015) Groundwater Storage and Depletion Trends in Tamil Nadu State, India. *Water Resources Management* 29:7, 2139–2152.

Food and Agriculture Organisation of the United Nations (FAO) (2015) FAOSTAT Database, available at http://faostat.fao.org/site/362/DesktopDefault.aspx?PageID=362

Food and Agriculture Organisation of the United Nations (2015) The State of Food Insecurity in the World. Rome: FAO.

Food and Agriculture Organisation of the United Nations (2013) State of Food and Agriculture 2013: Food Systems for Better Nutrition. Rome: FAO.

Food and Agriculture Organisation of the United Nations (2012) Irrigation in Southern and Eastern Asia in Figures. Rome: FAO. (FAO Water Report No. 37).

Food and Agriculture Organisation of the United Nations (2011) The State of the World's Land and Water Resources for Food and Agriculture (SOLAW)—Managing Systems at Risk. Rome and London: FAO and Earthscan.

Food and Agriculture Organisation of the United Nations (2009) How to Feed the World in 2050. Issue Brief for the High-Level Expert Forum on How to Feed the World in 2050, October 12-13. Rome: FAO.

Foresight (2011) The Future of Food and Farming. Final Project Report. London: The Government Office for Science.

Garnett, T. M. C. Appleby, A. Balmford, I.J. Bateman, T.G. Benton, P. Bloomer, B. Burlingame, M. Dawkins, L. Dolan, D. Fraser, M. Herrero, I. Hoffmann, P. Smith, P. K. Thornton, C. Toulmin, S. J. Vermeulen, and H. C. J. Godfray. 2013. Sustainable Intensification in Agriculture: Premises and Policies. *Science* 341, 33–34.

Gerbens-Leenes, P., M. Mekonnen, and A. Hoekstra (2013) The Water Footprint of Poultry, Pork and Beef: A Comparative Study in Different Countries and Production System. *Water Resources and Industry* 1–2: 25–36.

Global Harvest Initiative (2014) Global Agricultural Productivity Report. Washington, DC: Global Harvest Initiative.

Garnett, T. and C. Godfray (2012) Sustainable Intensification in Agriculture: Navigating a Course Through Competing Food System Priorities. Oxford, UK: Food Climate Research Network and the Oxford Martin Programme on the Future of Food, University of Oxford.

Grafton, R., J. Williams, and Q. Jiang (2015) Food and Water Gaps to 2050: Preliminary Results from the Global Food and Water System (GFWS) Platform. *Food Security* 7:2.

IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Field, C. B., V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

International Food Policy Research Institute (IFPRI) (2015) Global Food System Index Concept Note. Washington, DC: IFPRI

International Monetary Fund (IMF) (2014) World Economic Outlook Database. October. [2015-28-01]. http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/index.aspx

Loos, J., D. Abson, M. Chappell, J. Hanspach, F. Mikulcak, M. Tichit, and J. Fischer (2014) Putting Maning Back into "Sustainable Intensification". *Frontiers in Ecology and the Environment* 12:6, 356–361.

Luo, T., R. Young, P. Reig (2015) Aqueduct Projected Water Stress Country Rankings. Technical Note. Washington, D.C.: World Resources Institute.

Mekonnen, M. and A. Hoekstra (2012) Global Assessment of the Water Footprint of Farm Animal Products. *Ecosystems* 15, 401–415.

Montpellier, Panel (2013) Sustainable Intensification: A New Paradigm for African Agriculture. London.

Msangi, S. and M. Rosegrant (2011) Feeding the Future's Changing Diets: Implications for Agriculture Markets, Nutrition, and Policy. In 2020 Conference: Leveraging Agriculture for Improving Nutrition and Health. New Delhi, India.

Naseem, I. and J. Khan (2015) Impact of Energy Crisis on Economic Growth of Pakistan. *International Journal of African and Asian Studies* 7, 33–43.

Nelson, G., M. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, C. Ringler, S. Msangi, A. Palazzo, M. Batka, M. Magalhaes, and R. Valmonte (2009) Climate Change: Impact on Agriculture and Costs of Adaptation Santos, Mandy Ewing, and David Lee. Washington, DC: IFPRI.

Nelson, G. C., M. W. Rosegrant, A. Palazzo, I. Gray, C. Ingersoll, R. Robertson, S. Tokgoz, T. Zhu, T. B. Sulser, C. Ringler, S. Msangi, and L. You (2010) *Food Security, Farming, and Climate Change to 2050*. Washington, DC: IFPRI.

Organisation for Economic Cooperation and Development (OECD)/ International Energy Agency (IEA) (2014) *World Energy Outlook*. Paris: OECD/IEA.

OECD/FAO (2014) OECD-FAO Agricultural Outlook 2043. Paris: OECD Publishing.

Perwez, U. and A. Sohail (2014) Forecasting of Pakistan's Net Electricity Energy Consumption on the Basis of Energy Pathway Scenarios. *Energy Procedia* 61, 2403–2411.

Pingali, P. (2007) Westernization of Asian Diets and the Transformation of Food Systems: Implications for Research and Policy. *Food Policy* 32:3, 281–298.

Rasul, G. (2014) Food, Water, and Energy Security in South Asia: A Nexus Perspective from the Hindu Kush Himalayan Region. *Environmental Science and Policy* 39, 35–48.

Rasul, G. and B. Sharma (2015) The Nexus Approach to Water-energy-food Security: An Option for Adaptation to Climate Change, Climate Policy.

Reardon, T. and C. Timmer (2014) Five Inter-linked Transformations in the Asian Agri Food Economy: Food Security Implications. *Global Food Security* 3:2, 108–117.

Richey, A., B. Thomas, M. Lo, J. Reager, J. Famiglietti, K. Voss, S. Swenson, and M. Rodell (2015). Quantifying Renewable Groundwater Stress with GRACE. *Water Resources Research*, advanced online publication.

Rodel, M., I. Velicogna, and J. Famiglietti (2009) Satellite-based Estimates of Groundwater Depletion in India. *Nature* 460:20, 999–1003.

Rosegrant, M.W., C. Ringler, S. Msangi, T. B. Sulser, T. Zhu, and S. A. Cline (2008) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). Washington, DC: IFPRI.

Rosegrant, M., J. Koo, N. Cenacchi, C. Ringler, R.D. Robertson, M. Fisher, C.M. Cox, K. Garrett, N.D. Perez, and P. Sabbagh (2014) Food Security in a World of Natural Resource Scarcity: The Role of Agricultural Technologies. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Rosegrant, M. (2008) Biofuels and Grain Prices: Impacts and Policy Responses. Testimony for the U.S. Senate Committee on Homeland Security and Governmental Affairs. Washington, D.C.

Royal Society (2009) Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture. London: Royal Society.

Stein, A. and M. Qaim (2007) The Human and Economic Cost of Hidden Hunger. *Food and Nutrition Bulletin* 28:2, 125–134.

Talukder, A., C. Meisner, M. Sarkar, M. Islam, and K. Sayre (2014) Effects of Water Management, Arsenic and Phosphorus Levels on Rice Yield in High-Arsenic Soil-Water System. *Rice Science* 21:2, 99–107.

Timmer, C. (2013) Food Security in Asia and the Pacific: The Rapidly Changing Role of Rice. *Asia and Pacific Policy Studies* 1:1, 1–18.

United Nations Children's Fund (UNICEF)-World Health Organisation (WHO)-World Bank (2014) Global Health Observatory Data Repository. [24-01-2015] Http://apps.who.int/gho/data/node.main.NUTUNREGIONS?lang=en

UNEP (United Nations Environment Programme) (2012) *Global Environmental Outlook.*(Fifth Edition). Valletta: Progress Press Ltd.

United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP). (2015) ESCAP Statistical Database. [26-01-2015] http://www.unescap.org/stat/data/statdb/DataExplorer.aspx

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). (2013) The Status of the Water-Food-Energy Nexus in Asia and the Pacific. Thailand: UNESCAP.

United Nations (UN) Population Division. 2014. World Urbanisation Prospects: The 2014 Revision. [2015-1-26] http://esa.un.org/unpd/wup/index.htm

Veolia Water (2011) Finding the Blue Path for a Sustainable Economy. Chicago: Veolia Water.

von Grebmer, K., C. Ringler, M.W. Rosegrant, T. Olofinbiyi, D. Wiesmann, H. Fritschel, S. Badiane, M. Torero, Y. Yohannes, J. Thompson, C. von Oppeln, and J. Rahall (2012) Global Hunger Index 2012. The Challenge of Hunger: Ensuring Sustainable Food Security Under Land, Water, and Energy Stresses. Bonn, Washington, DC, and Dublin: Deutsche Welthungerhilfe, IFPRI, and Concern Worldwide.

World Bank (2013) Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience. Washington, DC: World Bank.

World Water Assessment Programme (WWAP) (2014) United Nations World Water Development Report 2014: Water and Energy. Paris: UNESCO.

World Water Assessment Programme (WWAP) (2012) United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk. Paris: UNESCO.

WRI (World Resources Institute) (2015) Pakistan—Intended Nationally Determined Contributions (INDCs). Washington, DC: WRI. Available at: http://cait.wri.org/indc/#/profile/Pakistan

WRG (Water Resources Group) (2009) Charting Our Water Future: Economic Frameworks to Inform Decision-Making. Washington, DC: WRG.

Yang, X., Y. Chen, S. Pacenka, W. Gao, M. Zhang, P. Sui, and T. Steenhuis (2015) Recharge and Groundwater Use in the North China Plain for Six Irrigated Crops for an Eleven Year Period. PLoS ONE 10(1): e0115269.