IMPACT OF CLIMATE CHANGE ON FOOD PRODUCTION: OPTIONS FOR IMPORTING COUNTRIES

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Policy Brief

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Abstract

The imperative of climate change adaptation for a resilient food system requires institutional, technological and economic transformation not only in food exporting but also food importing countries. Furthermore, mitigation of greenhouse gas emissions in the agriculture and food sectors require costs that can lead to higher food prices from exporting countries, which may affect food consumers in all countries. Inaction and delays in mitigating and adapting to climate change can be catastrophic for food and agriculture.

Most of the studies on food systems under climate change are producer-centric. Adaptation policy in food and agricultural sectors need to be developed beyond unilateral efforts where every producing country resolves its own food affairs through self-sufficiency and/or trade. This RSIS policy brief identifies possible implications of climate change disturbances on crops and livestock in world production centers by 2030, 2050 and 2080. Policy recommendations for importing countries are discussed.

Introduction

Over the last 50 years since the Green Revolution, many Asian farmers have been able to cope with gradual climate variations through the use of technology and improved agricultural management practices. However, under climate change, brought about by the increase in greenhouse gases, the existing technology and crop management practices may no longer be adequate due to increasing uncertainty in climate behavior. Sustaining crop production can be a serious challenge for both farmers and policy makers, as climate change will affect both producers and consumers globally. Farmers in Southeast Asia lack the expertise and technology to respond to the increase in climate volatility and uncertainty.

Climate change affects agricultural crop, livestock and fisheries production by altering biotic stressors (for example, pests and diseases) and abiotic stressors (for example, change in precipitation, temperature, water loss, heat waves, warmer nights and so on). It will bring more perils than benefits in most current production areas. However, the distribution of climate risks varies across regions because different levels of vulnerability and exposure are shaped by bio-geophysical and socio-economic-political contexts.

There is an urgent need to examine how the many climate change variables will affect important commodities in the main production regions and exporting countries. While some global level studies have been conducted, meaningful policy action cannot be taken without an understanding of the local level impact of climate change (downscaled analysis). Downscaled climate analysis is imperative to inform farmers and policy makers of the adaptive options at the regional and national levels. However, little is known about the impact of climate change in key food production areas including key producers in the Southeast Asian region. This has repercussions on the formulation and implementation of local, national and regional climate change adaptation strategies, especially in relation to the production of food.

Under globalized and interconnected food systems, no country will be free from future climate impacts. For example, some key food producers in Southeast Asia such as Vietnam, Thailand, Malaysia and Indonesia are in fact food importers as they rely on wheat and livestock from other key producers in North America, South America and Australia. Therefore, climate adaptation imperative should be a shared interest of both importing and exporting countries.

Future Climate Change Impact on Food and Agriculture

The alarming rate of increase in total anthropogenic greenhouse gas (GHG) emissions in the last decade has altered the world's climate. Without a reduction of GHG emissions, further warming and changes in all components of the climate system will occur. As a result, the earth is very likely to have more warm than cold days and nights. Food production centers around the world have been experiencing climate change — from the Americas to Europe, Asia to Australia. Variations due to climate shocks are likely to become more intense and frequent. Future agricultural risks emanating from climate change can also result in unprecedented extremes, both through creeping disasters (for example, series of severe drought as recently seen in Australian rice-production centre — the Riverina region of southern New South Wales)[1] and sudden onset of extreme events (for example, tropical cyclones as seen during Cyclone Nargis in Myanmar 2008 or Typhoon Haiyan in the Philippines 2013). In some production regions, drought, dry spells, severe weather events and erratic rainfall will be altered under climate change, making it hard for the farmers to predict their occurrence.

Two factors determine the vulnerability and susceptibility of food production systems in different regions to climate change — (i) level of exposure, adaptation and resilience and (ii) geographic location. High exposure to climate shocks often leads to high losses and damages leading to catastrophe. Regions with lower levels of adaptation are more susceptible to climate impacts. Building resilience can create greater room for adaptive food systems and opportunities to offset climate impacts. For example, adoption of drought and flood tolerant seeds, improved water management, improved postharvest technology (better drying and storage infrastructure) can greatly reduce losses of rice in Southeast Asia, off-setting the reduction in yields due to climate change. However, biological factors such as crop tolerance to heat set the limits of adaptation.

Three time frames are used to characterize future climate trends — 2030, 2050 and 2080/2100 climate scenarios. The time frames allow one to assess climate impacts over time based on global greenhouse gas emission trends and climate sensitivity to the accumulation of these emissions.

Wheat crop failure under drought conditions in Navarre, Victoria, Australia in 2006

Source: David Kelleher/ flickr

1 Goh T and Lassa JA, Get ready for future crisis in food production in Southeast Asia, The Jakarta Post, 17 January 2015. Available at http://www.thejakartapost.com/news/2015/01/17/get-ready-future-crisis-food-production-southeast-asia.html

Climate Change Impact Scenarios by 2030

- By 2030, heat stress can cause significant reductions in rice production quantity in South and Southeast Asia. Incidents of warmer night temperatures have a greater negative effect on rice yield. +1°C above critical temperature (> 24°C) may lead to 10 per cent reduction in both grain yield and biomass.[2]

- Water stress, triggered by increasing temperatures, reduction in number of rainy days and increasing length of dry spells will likely impact rice and wheat production in Asia, the United States (Northwest and Central) and Australia.[3,4,5] Cost of livestock production, which is heavily dependent on water,[6] will likely increase due to higher water prices.

- Rice production systems in Southeast Asian deltas can be marred by flooding and storm surges, brought about by rising sea-levels and higher precipitation. By 2030, without adaptation, rice production in North-eastern Thailand can be reduced by up to 17.8 per cent from the present baseline.[7]

- Higher summer temperatures can lead to increase in livestock mortality, especially during transportation, and yield reductions if cooling measures are not implemented. Profitability of livestock business will decline at most sites due to increases in water price, energy price, carbon price and feed price.

- Water-stress is a major challenge for vegetable yield as vegetables consist of 90 per cent water.[8] On the other hand, high precipitation and flooding can result in submergence and soil erosion that destroys vegetable plots, resulting in yield reduction. However, marginal increases in temperature in temperate regions or regions of higher altitude may benefit leafy vegetable production as the temperature moves towards the optimum for seed germination.[9]

Vegetable farms in Cameron Highlands

Source: Edmund Yeo/flickr

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2 Peng S, Huang J, Sheehy JE, Laza RC, Visperas RM, Zhong X, Centeno GS, Khush GS, Cassman KG, 2004, 'Rice yields decline with higher night temperature from global warming', Proceedings of the National Academy of Sciences 101(27): 9,971−5.

3 Cairns JE, Sonder K, Zaidi PH, Verhulst PN, Mahuku G, Babu R, Nair SK, Das B, Govaerts B, Vinayan MT, Rashid Z, Noor JJ, Devi P, Vicente F. san, and Prasanna BM, 2012. Maize Production in a Changing Climate: Impacts, Adaptation, and Mitigation Strategies, Advances in Agronomy, 114:1-65.

4 Milly PCD, Dunne KA, Vecchia AV, 2005, Global pattern of trends in streamflow and water availability in a changing climate, Nature, 438: 347-350.

5 CSIRO, 2015, Chapter 7: Projections Atmosphere and the Land, in Climate Change in Australia, 90-141.

6 The computation of water consumption for livestock production includes water required for feed production. Regions which are highly dependent on feed from the same source country will be particularly vulnerable to water scarcity. Higher temperatures increase water demands for cooling to reduce the effects of heat stress.

7 Kuneepong P, Kongton S, Wangwachrakul V and Sumdin S. 2001. Modelling economic crop yield and climate change in Thailand. pp 709-714 in ModSim 1. International Congress on Modelling and Simulation. 10-13 December 2001. Modelling and Simulation Society of Australia and New Zealand, Canberra, Australia.

8 Pena R de la and Hughes J, 2007, Improving Vegetable Productivity in a Variable and Changing Climate, ICRISAT, 4(1)

9 Peet, Mary M. and Wolfe, David W. Crop Ecosystem Responses to Climatic Change: Vegetable Crops in Eds Reddy and Hodges. Climate Change and Global Crop Productivity.

Climate Change Impact Scenarios by 2050

- Water stress will likely be sustained and heat stress can impact some crops in the temperate regions due to higher surface temperatures. Without adaptation by 2050, crops and livestock are likely to experience significant reductions in production. For instance, India's climate is projected to increase by 2–4°C by 2050 with some marginal changes in monsoon rain in monsoon months and large changes in rainfall during non-monsoon months. An increase of 2°C in temperature could decrease rice yields by about 0.75 tonnes per hectare in the high yielding areas.[10]

- Rising global temperature will affect wheat production in all producing countries as wheat has a relatively low optimum temperature.[11] For tropical climate systems, extreme heat limits the length of the growing season. For example, in India, the Indo-Gangetic Plains could become significantly heat stressed by 2050s potentially causing losses of 50 per cent of its wheat-growing area.[12]

- Rice yield in the Mekong River Delta is predicted to decline by 6–12 per cent by 2050.[13] In Northeast Thailand, rice yield rate can experience a negative growth up to -22.9 per cent.[14]

- Increases in ocean temperature, ocean acidification[15] and changes in solar irradiation[16] in the coming decades can create volatility in fish production. By 2050, ocean fish catch potential in the Southeast Asian sea waters (and low latitude regions including Indian Ocean, Java Sea, and south of South China Sea) may be reduced by 40 to 60 per cent due to fish migration[17] responding to both warmer temperatures and ocean acidification. Aquaculture will also be affected, given the fact that fish feed (which constitutes about 30 per cent of world fish catch) are used for aquaculture[18].

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10 Chattopadhyay, N. 'Climate Change and Food Security in India', in Climate Change and Food Security in South Asia, eds. R. Lal et al. Amsterdam, Springer, 2011; See also Cruz, R. et al. 'Asia, Climate Change, 2007: Impacts, Adaptation and Vulnerability', Chapter 10 in Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, eds. Parry, M.L. et al. Cambridge: Cambridge University Press, 2007, pp. 469-506.

11 Asseng S, Ewert F, Martre P, Rotter RP, Lobell DB, Cammarano D, Kimball BA, Ottman MJ, Wall GW, White JW, Reynolds MP, Alderman PD, Prasad PVV, Aggarwal PK, Anothai J, Basso B, Biernath C, Challinor AJ, Sanctis GD, Doltra J, Fereres E, Garcia-Vila M, Gayler S, Hoogenboom G, Hunt LA. 2015. Rising temperatures reduce global wheat production. Nature Climate Change 5:143-147.

12 Porter JR, Xie L, Challinor AJ, Cochrane K, Howden SM, Iqbal MM, Lobell DB, and Travasso MI, 2014: Food security and food production systems. In: 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. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 485-533. Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap7_FINAL.pdf

13 World Bank 2010. Economic of Adaptation to Climate Change: Vietnam. Washington: World Bank Group.

14 Kuneepong P. et al. 2001, op cit.

15 Ocean acidification is the decrease in the pH (acidity) of the Earth's oceans caused by the uptake of carbon dioxide (CO2) from the atmosphere. An estimated 30% of the CO2 released by humans into the atmosphere dissolves into oceans. See https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-4-2.html.

16 The total amount of solar radiation energy received on a given surface area during a given time, often measured by an energy unit per square meter (e.g. megajoule per square meter).

17 Porter HO, Karl DM, Boyd PW, Cheung WWL Lluch-Cota SE, Nojiri Y, Schmidt DN, Zavialov PO, 2014. Ocean systems. In: 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. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 411 - 484 Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap6_FINAL.pdf

18 Merino, G., M. Barange, J. Blanchard, J. Harle, R. Holmes, I. Allen, E. Allison, M.C. Badjeck, N. Dulvy, J. Holt, S. Jennings, C. Mullon, L. Rodwell. (2012), Can marine fisheries and aquaculture meet fish demand from a growing human population in a changing climate? Global Environmental Change 22, Issue 4: 795-80.

Climate Change Impact Scenarios by 2080/2100

- Crops are likely to reach their biological limits in current producing regions, especially with temperature increases of 4ºC above current levels. For tropical climate systems, extreme heat limits the length of the growing season.

- Rice losses are likely to be associated with an increase in temperature (resulting in higher heat stress and higher evapotranspiration[19]), sea level rise and increased salinity in the deltas.[20] By 2080, North-east Thailand may experience negative yield changes from 8.6 to -32.2 per cent.[21]

- Under the worst case climate scenario,[22] it is likely that wheat yield will be reduced by -24.1±7.1 per cent between 2050 to 2080. In South-east Australia, warm temperatures can cause negative yield changes from -25 to -29 per cent. Due to uncertainty in rainfall, Indian wheat can experience delays in sowing period. A 10-day delay can result in losses up to 20 per cent of yield in Northeast India and 14 per cent in Northwest India.

- Warming in the tropics by 2100, combined with non-climate stressors such as unsustainable coastal and marine management practices, can cause local extinctions of particular fish species at the edges of their ranges and have serious negative impacts on fisheries. Coastal fisheries in tropical developing countries are likely to be vulnerable to climate change due to the decline of coral reef cover that may lead to declines in fish species dependent on coral reefs.[23]

Fish farm in Lake Toba, Medan, Indonesia

Source: Wilson Teo/ flickr

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[19] Crop water loss due to evaporation and transpiration.

[20] World Bank 2010. Economic of Adaptation to Climate Change: Vietnam. Washington: World Bank Group.

[21] Kuneepong P. et al. 2001, op cit.

[22] Also known as Representative Concentration Pathways (RCP) 8.5. The 8.5 refers to rising radiative leading to 8.5 Watt/m2 in 2100.

[23] Porter JR et al, 2014, op cit.

Key Issues for Importing Countries

Reduction in crop and livestock yields as well as fish catch

Climate change can result in a reduction in crop yields, livestock production and fish catch. This will place added stress on global food security and reinforce the existing challenges in food production. It is also likely that there will be greater volatility in food availability and price, as well as greater uncertainty and higher risks associated with access to food in international markets. This could encourage hoarding or greater speculative behavior, further destabilizing food markets.

Increase in food prices due to rising production costs

Food production costs are likely to increase due to increasing costs of climate adaptation and mitigation. Given the increase in temperature and drought occurrences, it is likely that feed prices will increase. Water scarcity, rise in feed prices and increase in demand for quality feed and energy for climate adaptation will drive up production costs. This will increase food prices and hence access to food.

Global commitment in mitigating climate change may alter the costs of energy and the way farmers farm their livestock. In Australia, and in all likelihood, the United States and Canada, mitigation costs will be borne by farmers, as they have to avoid business-as-usual production. In all regions including Southeast Asia, India and China, adaptation costs may increase. As a result, there will be an increase in cost of energy and water inputs.

Given the increase in temperature and drought occurrences, it is also likely that animal feed prices will increase. The implementation of carbon tax in exporting nations will also push up food prices. The use of biofuel as a substitute for oil may continue to artificially inflate demand for already reduced grain supplies. Carbon tax on high emissions from livestock production will also increase production costs, which may be transferred to consumers.

Shifting food production centres

To avoid higher costs of adaptation, agriculture and livestock production are likely to shift to regions with more favourable climate conditions — regions of higher latitude or altitude. This will change the global distribution of food production and export, potentially opening up new food source countries and new supply chains. The balance-of-power between food exporters and importers will shift, with repercussions for regional and bilateral relations.

Key Recommendations

An IRRI test field where saline resistant rice varieties are cultivated

Source: Deutsche Welle/ flickr

Exporting countries will prioritise local markets and needs if there are production failures, particularly as a result of climate change. Therefore, exporting governments will likely enhance export restrictions in times of food emergency. For importing countries, this could translate to reduced stability of food supply and access, and greater price volatility of cereals and vegetables, as well as increase in prices of meat and eggs. Specifically, price volatility can affect the availability of key commodities such as rice and wheat which are stockpiled by numerous countries. Against these scenarios, it is critical that importing countries adapt to future climate change by developing forward looking strategies:

1. Adopt a 'no-regrets' approach

Both exporting and importing countries should adopt a "no-regrets" approach to adaptation actions in food systems. "No regrets" approach refers to the need to take proactive adaptation actions. This is to preempt adverse conditions given the lack of accuracy in future climate projections. Most importantly, as climate impacts will affect domestic production, it is necessary for producing countries to identify potential impacts and possible adaptation actions on local production centres. Early identification of the impacts of climate change on current crop yields, livestock production and fish in producing countries will be important for these countries' food strategy decisions. For importing countries, such an approach ensures minimum supplies in the least and cuts down on fears of price volatility.

2. Adopt an 'adaptation without borders' approach

Food importing countries can also promote 'adaptation without borders'[24] (AWB) as a framework to continuously monitor global and regional food production and trade. AWB suggests that no country (either consumers or producers) can survive without looking beyond their borders. Importing countries that have the capacity to invest in research and development should provide long term support in scientific research and technological innovation to improve crop yields in potential or emerging producers and existing exporting countries. These include investments in the construction of better weather and climate monitoring and early-warning systems, both regionally and nationally. Importing countries should also provide the expertise or technology required for the construction of adequate drying and storage equipment and facilities to reduce postharvest losses which are about 20 per cent for rice in Southeast Asia,[25] making more food available for populations.

Capable Asian governments should also support international food research centres such as International Rice Research Institute (IRRI), International Livestock Research

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[24] Magnus Benzie, Oskar Wallgren and Marion Davis 2013. Adaptation without borders? How understanding indirect impacts could change countries' approach to climate risks. Stockholm Environment Institute. Available at: http://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-DB-2013-Adaptation-Without-Borders.pdf

[25] Lassa JA, 2012, Emerging 'Agricultural Involution' in Indonesia: Impact of Natural Hazards and Climate Extremes on Agricultural Crops and Food System in Sawada, Y. and S. Oum (eds.), Economic and Welfare Impacts of Disasters in East Asia and Policy Responses. ERIA Research Project Report 2011-8, Jakarta: ERIA. pp.601-640.

Institute (ILRI), International Maize and Wheat Improvement Center (CIMMYT) and the World Fish Centre. Collaboration with regional and international research centres can keep the importing country abreast with the latest developments in genotyping and technology, and allow for academic collaborations to further existing research.

3. **Diversify sources of food based on emerging climatic pattern**

   Policies encouraging diversification should consider similar climatic zones. Countries within the same climate and geographical region are likely to face the same climate impacts. The concentration of imports from a particular climatic region will not reduce the risks associated with climate change.

   For example, while Singapore imports fish from 46 countries, more than 80 per cent of this fish is from Southeast Asia. The tropical region of Southeast Asia may lose between 40 to 60 per cent of its fish catch potential due to climate-induced fish migrations,[26] as fish catch is likely to migrate away from the equator. Therefore, under a changing climate scenario, Singapore's fish import diversification policy needs to be re-explored. Importing countries also need to diversify imports based on early identification of future food crop and fisheries production regions. For example, Norway, Sweden and Western Africa are likely to enjoy some benefits from warming where fisheries can increase from 50 per cent up to more than a hundred per cent.[27]

4. **Identify options for adaptation financing and climate insurance markets**

   Importing countries and global financial hubs like Singapore, Japan and Korea can play bigger roles in identifying new financial mechanisms for climate insurance, adaptation and mitigation. These include endeavors to look for opportunities to use market mechanisms to promote risk management in food production sectors. In Asia, there is a huge potential market ranging from grain farmers (paddy and corn), to livestock and vegetable production and supply chains.

5. **Support regional cooperation for climatic disaster early warning and monitoring systems**

   Countries should work together to tailor early warning and climate monitoring systems for specific regions and crops. This can help to pool resources for common climate and cropping zones such as the Mekong River Delta. Importing countries will benefit from better knowledge of extreme weather events and early implementation of climate adaptation measures in the source countries that they import food from. On the other hand, producing countries can implement better adaptation measures based on these observed climate data. Continuing supports for regional cooperation on sharing an updated regional food security information system such as ASEAN Food Security Information Systems (AFSIS), which covers production and stocks, can be considered.

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[26] Porter HO et al, 2014, op cit

[27] Ibid ; Hoegh-Guldberg O, Cai R, Poloczanska ES, Brewer PG, Sundby S, Hilmi K, Fabry VJ, Jung S, 2014. : The Ocean. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA , pp. 1655-1731. Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap30_FINAL.pdf

6. **Participate in regional cooperation and dialogue on food production**

   In addition to identifying new financial mechanisms, importing countries can contribute by participating in regional and multilateral forums on climate adaptation in agricultural sectors — from platforms like ASEAN to the United Nations. Regional discussions are good platforms for importing countries to articulate their interests in terms of climate impacts on food production. Exchanges on expertise and technology, such as irrigation management and proper water harvesting techniques and technology can help source countries adopt best practices and hedge against possible yield reductions.

7. **Embark on robust food stockpiling system**

   Current public stockpiling policy is often developed based on short-term climate trends — anticipating short-term anomalies of the next harvest. For example, rice stockpiles are usually about 1.5 to 3 months, to ensure that there is sufficient stock in the event of a disaster, until the next harvest. Anticipatory stockpiling can help to reduce panic and volatility during poor harvests. Under climate change, double cropping in northern regions may become viable due to longer growing seasons and warmer winters. Crops may also grow faster under warmer temperatures,[28] allowing for mixed or double cropping. Countries can also improve their monitoring systems on both private and public stockpiling in order to anticipate climate shocks. Depending on the context, countries importing from temperate regions may thus consider adjusting the length of stockpiles. In the tropics, heat stress may limit the growing season and delays in planting due to changes in precipitation can change cropping cycles. In Southeast Asia, this means that ASEAN member states must develop better regional early warning systems in order to ensure robust stockpile systems nationally and regionally.

8. **Invest in food processing and storage**

   While it may not be cost-effective for importing countries to grow food locally, it may be economical to invest in the food value chain. Importing countries can develop local food processing and storage industries to increase the shelf life and safety standards of food, as food spoilage becomes an issue under warmer and more volatile weather conditions. This also gives importing countries a share in the global food system where food production may be more favourable for the North due to potential changes in climate.

[28] US EPA, 2013, Agriculture and Food Supply. Available at: http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html

9. **Build capacity in producing countries**

   Due to competing development agendas and lack of financial capacity, most governments in developing countries do not have the means to develop anticipatory adaptation in agriculture related sectors. These key agricultural production sources are unable to incorporate water and climate studies, as well as technological development, in their national development agendas. For example, Western African states may not be able to benefit from their potential increase in fish catch under climate change. Therefore, governments of importing countries can play a more active role in developing the capacity of citizens from source countries by providing graduate scholarships and PhD research grants. In the ASEAN context, ASEAN governments can make bold commitments to support existing initiatives such as SEARCA (Southeast Asian Regional Center for Graduate Study and Research in Agriculture).

Conclusion

The climate impacts on food security for importing countries cannot be overlooked. Importing countries have to face a myriad of challenges in gaining access to food in international markets, from the political dynamics of food trade and relations to shifting food production centres. They will also be at the receiving end of international food price hikes and volatility. Food price volatility and greater uncertainty under climate change will only unsettle the international food system and reinforce existing food security challenges. Importing countries need to exploit the potential benefits of climate change in order to navigate the challenges and safeguard national food security.

About the Authors

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Professor Teng has over 20 years of experience on food security issues, having held positions at the WorldFish Center, Malaysia; the International Rice Research Institute (IRRI); and Monsanto Company. He has extensively researched the role of plant diseases in causing epidemics and crop losses in several continents, working cooperatively with a network of national programme scientists. The work has led to over 250 journal papers, eight books and numerous conference papers, and recognition by peer organisations. His pioneering work on using system analysis and computer modelling techniques to quantify and predict biological phenomena, and conduct risk assessments, is still having impact today in the USA and Asian rice growing countries. More recently, he has devoted his time to researching science communication and science entrepreneurship, under the umbrella of “Innovation and Enterprise” and to meet the needs of new economies. Prof Teng has won awards such as the Jakob Eriksson Prize in Plant Pathology in 1987, given by the Royal Swedish Academy of Sciences every five years to a scientist who has made significant contributions to solving plant disease problems affecting developing countries. He is a Fellow of the Third World Academy of Sciences and the American Phytopathological Society, and was co-recipient of the 2001 CGIAR Excellence in Science Award for Outstanding Scientific Article. He has also been cited in the 1996–1997 ‘Marquis Who’s Who’ in Science and Engineering.

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The Centre serves as a networking hub for researchers, policy analysts, policymakers, NGOs and media from across Asia and farther afield interested in NTS issues and challenges.

The Centre is the Coordinator of the ASEAN-Canada Research Partnership (2012–2015) supported by the International Development Research Centre (IDRC), Canada. It also serves as the Secretariat of the initiative.

In 2009, the Centre was chosen by the MacArthur Foundation as a lead institution for its three-year Asia Security Initiative (2009–2012), to develop policy research capacity and recommend policies on the critical security challenges facing the Asia Pacific.

It is also a founding member and the Secretariat for the Consortium of Non-Traditional Security (NTS) Studies in Asia (NTS-Asia).

More information on our Centre is available at www.rsis.edu.sg/research/nts.

About the S. Rajaratnam School of International Studies

The S. Rajaratnam School of International Studies (RSIS) is a professional graduate school of international affairs at the Nanyang Technological University, Singapore. RSIS' mission is to develop a community of scholars and policy analysts at the forefront of security studies and international affairs. Its core functions are research, graduate education and networking. It produces cutting-edge research on Asia Pacific Security, Multilateralism and Regionalism, Conflict Studies, Non-Traditional Security, International Political Economy, and Country and Region Studies. RSIS' activities are aimed at assisting policymakers to develop comprehensive approaches to strategic thinking on issues related to security and stability in the Asia Pacific.

For more information about RSIS, please visit www.rsis.edu.sg.

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