PROCEEDINGS OF THE APEC CLIMATE SYMPOSIUM 2017

BUILDING RESILIENT AGRO-FOOD SYSTEMS FROM PRODUCTION TO CONSUMPTION:
INTERDISCIPLINARY APPROACHES FOR SUSTAINABLE FOOD SECURITY USING CLIMATE INFORMATION

CAN THO, VIET NAM

AUGUST 18-20, 2017

This document summarizes the presentations and discussions from the APEC Climate Symposium (APCS) 2017, held in Can Tho, Viet Nam at the Muang Thanh Hotel on August 18-20, 2017

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APCC would like to extend its sincerest thanks to its invited speakers, honoured guests, and all participants for their contributions to the event's success.

Acronyms and Abbreviations

ABAC	APEC Business Advisory Council
AgMIP	Agricultural Model Intercomparison and Improvement Project
APCC	APEC Climate Center
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
BMKG	Indonesian Meteorological, Climatological, and Geophysical Agency
CCAFS	CGIAR Research Program for Climate Change, Agriculture and Food Security
CGIAR*	Consultative Group for International Agricultural Research
CIS	Climate Information Services
CIAT	International Center for Tropical Agriculture, CGIAR
CSA	Climate-smart agriculture
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GFCS	Global Framework for Climate Services
GGCM	Global gridded crop model
GHG	Greenhouse gas
GLAM	General Large-Area Model for annual crops
IFES	Integrated Food-Energy Systems
IFPRI	International Food Policy Research Institute
IRI	International Research Institute for Climate and Society at Columbia University, New York
KT	Korea Telecom
MAFFF	Ministry of Agriculture and Food, Forests and Fisheries of the Kingdom of Tonga
MOSAICC	Modelling System for Agricultural Impacts of Climate Change
NCHMF	National Center for Hydro-meteorological Forecasting of Viet Nam
NHMS	National hydrological and meteorological service (for any economy)
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PPSTI	APEC Policy Partnership on Science, Technology and Innovation
RIMES	Regional Integrated Multi-Hazard Early Warning System
TMS	Tonga Meteorological Service
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change

* CGIAR formerly stood for the Consultative Group for International Agricultural Research, but is now no longer an acronym

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Overview

1. The APEC Climate Symposium 2017 was conducted from August 18-20, 2017 at the Muong Thanh Hotel in Can Tho, Viet Nam. The meetings of the APCC Science Advisory Committee and the Working Group were also held in conjunction with the event.

2. The event was attended by nearly 130 participants from 23 economies – Argentina, Australia, Brazil, Chile, Chinese Taipei, Hong Kong, India, Indonesia, Italy, Japan, Korea, Malaysia, Mexico, Nepal, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Thailand, the United Kingdom, the United States of America, and Viet Nam. The participants included keynote and invited speakers, representatives from National Hydrological and Meteorological Services, government officials, private sector, media, non-governmental agencies, and academia. Experts from a diverse range of backgrounds, including climatology, agriculture, economics, and international development were invited to speak about and discuss the impacts of climate change on and the use of climate information for food security, agricultural production, and food systems as a whole. A complete list of participants can be found in Annex I.

Executive Summary

3. The APEC Climate Symposium, which focused on "Building Resilient Agro-Food Systems from Production to Consumption: Interdisciplinary Approaches for Sustainable Food Security Using Climate Information," addressed numerous aspects of food security from a food systems perspective, taking into account agricultural production, management of climate risk, consumption patterns, as well as the necessity of public-private partnership.

   In the opening and keynote sessions, speakers highlighted the importance of employing technology and data to bridge knowledge limitations and move towards an action agenda in tackling one of the most central concerns of the 21st century: food security. That climate change and variability contribute to chronic poverty and vulnerabilities in food insecurity was stressed, not just from crop loss but from also risk aversion, highlighting the need for more comprehensive risk management support. The critical role of two-way science-policy dialogue, a holistic consideration of whole food systems, as well as more user-focused and participatory approaches, were stressed as important factors in making sustainable progress. To help facilitate necessary collaboration within and between economies, information and model standardization were highlighted as practical tools for the way forward.

   The first session, *Increasing Sustainable Agricultural Production using Climate Information*, focused on the climate sensitivity of agricultural production and the use of climate information to build resilience. Speakers explored how climate information services and new technologies can best be developed, communicated, and employed in

agricultural applications. A number of initiatives and projects were presented, sharing lessoned learned, as well as expanding opportunities for collaboration with the telecommunications sector. They stressed that the involvement of the end users throughout this process is critical for the uptake of these tools.

The second session, *Beyond Growth: Building Resilient Post-Production Food Systems*, explored the vulnerabilities of agriculture and value chains to climactic variation and investigated how promoting climate resilience throughout food systems with the use of climate information can enhance food security. Speakers investigated the appropriate use of climate information tools, seasonal climate forecasts, climate-smart agriculture, and risk management. Again, the critical importance of using a user-driven approach rather than supply-driven was expounded, where useful tools can only be generated through collaboration and participatory consultation. This approach was exemplified in integrated landscape management, which seeks to include the complex considerations for value chains, ecosystems, and communities on a larger scale. Speakers also explored promising new technologies that will help increase agricultural production without increasing inputs such as labour, fertilizers, or pesticides.

Finally, large-scale and international approaches to climate change adaptation using climate information was explored in the third session, *Large-scale Holistic Approaches to Climate Risk Management*. Regional and international bodies and for were discussed, which brought together various economies for discussion of climate information or policy, including on climate information services and specific techniques for agricultural climate risk management. The components necessary for transformational change were explored, as well as political barriers to advances in climate smart agriculture and the promotion of techniques discussed at the symposium.

To close the event, a final panel session was held. Experts brought together their varied experiences and knowledge to build a more cohesive idea of what successful cross-sectoral collaboration would look like. The panellists linked the key outcomes above to their personal experiences in mediating the science-policy interface, and fielded questions on symposium outcomes and considerations of food security.

Opening Ceremony

4. The APEC Climate Symposium 2017 opened on Friday, August 18, 2017. The Opening Ceremony began at 9:00 am with Ms. Sangwon Moon, the head of the External Affairs Department at the APEC Climate Center (APCC), opening the ceremony and welcoming everyone to the event. She also thanked the co-hosts and partners from the National Hydro-Meteorological Service of Viet Nam, the Ministry of Natural Resources and Environment of Viet Nam, and the Ministry of Agriculture and Rural Development of Viet Nam for their help putting together the event. Ms. Moon then introduced Dr. Hong-Sang Jung, the Executive Director of APCC, for his Opening Remarks. Dr. Jung gave his Opening Remarks and spoke about the importance of this event. He concluded his speech by welcoming everyone to the symposium. He welcomed all of the participants, speakers, and special guests to the event. The Honourable Vice-Minister Nguyen Linh Ngoc of the Ministry of Natural Resources and Environment then gave his Welcome Remarks in Vietnamese followed by a translator. He spoke about the importance of food security for the larger goals of APEC and Viet Nam, and gave a warm welcome to all the participants. This was followed by Mr. Dao Anh Dung, Vice Chairman of the Can Tho People's Committee, who spoke about Can Tho as a breadbasket for Viet Nam and beyond. He expounded the importance of agricultural activities in the Mekong delta region, and listed some key regional crops including rice. Mr. Dung also gave a very warm welcome to participants on behalf of the city. The opening ceremony was followed by the presentation of commemorative plaques of appreciation from APCC to the Ministry of Natural Resources and Environment and the National Hydro-Meteorological Service of Viet Nam. The session was closed with a group photo.

Keynote Session: Fortifying Food Security with Climate Smart Food Systems

5. The Keynote Session commenced at 10:00 a.m. and consisted of keynote presentations by two distinguished food security specialists, which discussed the need for holistic solutions that address all dimensions of food security. The session was chaired by Dr. Jin Ho Yoo, the Head of the Climate Prediction Department at APCC.

6. **Dr. Jim Hansen, International Research Institute for Climate and Society at Columbia University, "Making Climate Services Work for Smallholder Agriculture: Innovations and Lessons from Across the Developing World"**

   Dr. Jim Hansen, who, in addition to his role as Senior Research Scientist at the International Research Institute for Climate and Society (IRI), works with the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS). His presentation investigated how climate services can help farmers to be more resilient, food secure, and prosperous. He began by addressing the multifaceted nature of the cost

of climate risk, which contributes to chronic poverty, vulnerability, and food insecurity. In addition to the well-documented downside risks that come with losses associated with climate shocks, there is also a heavy opportunity cost where farmers become increasingly risk adverse under increased climate variability or are unable to take advantage of opportunities provided by favorable conditions. This affects farmers, markets, the food system, and also through what he dubbed the "relief trap," the concentration of funds on response and aid, rather than long-term prevention and development. To address climate risk, effective climate services are required, which he defined as those that work for farmers, at scale, and sustainably. Hansen listed a number of options that are available to improve livelihoods of smallholder farmers, yet noted they cannot work without good climate information. These include matching crops and technical advisories to local climate, index-based insurance, participatory methods for developing and using seasonal forecasts, production or hydrological forecasts for planning, food security management, and detecting and understanding change to separate climatic effects from soil degradation and other processes.

Hansen then outlined five main challenges that obstruct the goal of climate services benefiting farmers at scale. These are: gaps in capacity to access, understand, and act on information; gaps in observations and historic data; gaps in the capacity of National Hydrological and Meteorological Services (NHMS) to provide actionable information; gaps in information relevance; and gaps in institutional, governance arrangements, and business models to sustain the co-development of services. He then gave examples of initiatives and tools that have aimed to bridge these gaps, including the CCAFS Participatory Integrated Climate Services for Agriculture (PICSA) program, a structured participatory communication approach, and the Enhancing National Climate Services (ENACTS) program, which enables NHMSs to customize, generate, disseminate locally relevant information without over-taxing limited human resources. He also highlighted the limitations of supply-driven climate services, noting that climate services are most useful when supported by partnerships that span generations, and ensure translation, communication and application.

In concluding his presentation, Hansen explained that effective climate services must be a part of the collective effort to help farmers to be resilient, food secure and prosperous in the face of a variable and changing climate. He stressed that making climate services work for smallholder agriculture, at scale, requires a lot more than just providing climate information; it requires finding solutions to the five challenges he presented. He ended his presentation on a hopeful note, recognizing that promising solutions to these challenges are under development but that more work is needed.

7. **Prof. Senthold Asseng, University of Florida, "AgMIP - Agricultural Production, Sustainability and Climate Change"**

Prof. Senthold Asseng began his presentation with a look at the challenges facing the agricultural community. In addition to the well-known FAO projection of the world requiring 60% more food to meet demand in 2050, he outlined other considerations.

While the population is increasing, the number of undernourished people has dropped by 100 million to 800 million over the last 14 years. However, he notes that there is still a huge amount of food waste, with one third of global food production lost or wasted annually. This waste occurs primarily in processing in developed economies or in harvest and storage in emerging economics. He highlights the combined issues of obesity and of the huge percentage of calorie production that goes into livestock feed. These calories if consumed directly, rather than inefficiently though meat products, could feed 4 billion more individuals. He noted that we must also increase the nutritional value of food as well as reduce environmental impacts. 70% of global water withdrawal is used in irrigation for agriculture and there is a high risk of surface pollution across the world from agricultural processes. He then noted the additional challenges posed by climate change, with temperature and atmospheric carbon dioxide concentrations increasing. By 2100 we expect more climactic extremes and even larger temperature increases.

With these complex issues to consider, how do we evaluate the quantitative impact of climate change on agriculture? Asseng proposed the use of crop simulation models, which can elucidate the role and impact of many factors of biophysical nature as well as crop management, including time dependency. He presented the Agricultural Model Intercomparison and Improvement Project (AgMIP), whose mission is to provide effective science-based agricultural decision-making models and assessments of climate variability and change and sustainable farming systems to achieve local-to-global food security. As a distributed climate-scenario simulation program, it enables historical model inter-comparison with the participation of multiple crop and agriculture models from around the world. He outlined the three main focuses: modelling for sustainable farming systems, coordinated global and regional agricultural assessments, and so called "NextGen Knowledge Products" with improved models and data. He emphasized that to have good models you need good experiments, and that we need to understand impacts before we can consider adaptation.

Asseng then moved onto an AgMIP Wheat case study, where they began with 4 pilot sites with contrasting conditions. From these results they could see a clear best and worst model. However, when they expanded with 6 other warm locations, the best and worst models switched, indicating that there is no single model that works best across multiple environments. Rather, it was the multi-model ensemble (MME) median that performed the best across all environments. This was also confirmed for maize, rice, and potato yields as well. He then addressed the question of a minimum number of models for sufficiently low error. MME results show that this depends on the changes in temperature – with increased temperatures the minimum number of models for the MME goes from 5 in 0-3 degrees, up to 12 with a 9 decree increase. He shared other results of AgMIP studies on yield impacts under climate change.

Finally, Asseng gave his concluding remarks, noting that AgMIP is the key international program for impact assessments, and that an MME provides the best predictor across multiple environments. Results show that global crop yields decline by 3-8% for each degree in global warming, and there is much more work ahead of us, including a need for regional impact assessments, better understanding of economic and

agricultural feedback, and addressing GHG emissions and sustainability issues together with impacts on production..

8. **Wrap-up and Discussion:**

The discussion session began with a question from Ms. Nurhayati from the Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG) for Hansen, on if he could expand on participatory methods, and Asseng, on the reason why Indonesia was not included in his slides for yield increase and temperature reason. Hansen said that there are few groups that have developed participatory methods, including various games to help farmers understand the tercile format used by many NHMSs, but he noted that due to issues with the tercile format he felt that it is better for to work with farmers on a probabilistic format instead. Asseng said that the data for Indonesia is quite good and projections are confident in the direction of temperature change as well as the amount of change for that region, it simply wasn't included in his slides.

Dr. Bin Wang from the University of Hawaii asked what the major reason was that every crop productivity is decreasing. Asseng noted that his work had showed the effects of temperature in isolation in his presentation, and did not take into account carbon dioxide or rainfall. This decrease is primarily driven by an increased rate of phenological development in higher temperature, where in irrigated crops this means fewer growing days – and thus light exposure – until harvest, resulting in less grain. These effects can be mitigated by having late blooming cultivars, but the additional heat stress must also be addressed. Wang noted that rainfall would have an important impact, and indeed Asseng agreed, yet noted that rainfall projections have significantly larger uncertainties, for while total rainfall may increase, so too may irregularity. Carbon dioxide has also been found to have positive impacts on yield, but it can also compound heat impacts by closing stomata and increasing capillary temperature.

Mr. Nicholas Brooke from the APEC Business Advisory Council posed a question for Hansen, in how he thinks business could contribute to a better understanding of mitigation and how they could play a larger part in reducing risk. Hansen acknowledged that much of the work thus far has been focused on the public sector and government, yet the development of value chains, rural development, and market access are some of the biggest constraints with poverty. He noted that while climate variability and change impacts the ability of farmers to become reliable providers, so too does economic security. He shared an anecdote of a company that realized some of their providers were very food insecure, and in helping to invest in staple crops actually made them more reliable providers.

Mr. Martin Obarra from the National Water Commission of Mexico shared a comment that the NHMS belongs to the Water Commission, and that they would like to share their information.

Dr. Jaiho Oh from Pukyong National University raised a question about the special resolution of the AgMIP models. Asseng noted that they are worried about points which may not represent a certain region. He said that, if they simulate every model cell – as opposed to using a point which represents a whole economy for example – they get

similar examples. Thus they try to determine spatial uncertainty for upscaling at AgMIP. When they simulate every cell, it requires more information which is difficult to obtain, such as crop management or historical data at each cell. So increased spatial resolution comes at a cost of input data uncertainty.

Session I: Increasing Sustainable Agricultural Production Using Climate Information

9. The afternoon session of August 18 commenced at 13:00. Session I discussed the vulnerability of agricultural system to climate variability and change as well as the opportunities and challenges for the utilization of climate information to increase agricultural production and help build food security. The Session was chaired by Dr. Jong Ahn Chun from the APEC Climate Center.

10. **Dr. Jong Ahn Chun, APCC, "Food Security Enhancement in Southeast Asia under Climate Change through Multi-Scale Crop Modeling"**

    Dr. Jong Ahn Chun started off the session with a presentation on how climate projections can be used with multi-scale crop modelling to enhance food security. He gave a brief overview of Southeast Asia, one of the regions deemed particularly vulnerable to climate change, noting the significance of rice and the various modelling studies that have been performed on the possible impacts of climate change on production. He noted that those at the global or regional scale, such as M-GAEX (Global Agro-Ecological Zones) model or GLAM (General Large Area Model), do not provide detailed management information that can advise on potential adaptation strategies. At the field-scale, CERES-Rice or ORYZA2000 cannot be used for large areas unless aggregating results, however this is input intensive and required data may not be available. Chun noted the diversity of needs in various stakeholders: while farmers need to know about management practices, government need to know about national policies and planning. To cover these two requirements Chun applied multiscale crop models to combine the advantages from each scale model to develop effective adaptation strategies for Cambodia, Laos, Myanmar, Thailand, and Viet Nam. GLAM Rice identified cells with the most reduced yield. Though some increase in rice yields may be seen in the 2040s in the north, the yield is simulated to decrease up to 45% by 2080s. In Myanmar, Viet Nam and Thailand, the reductions in rice yield can largely be explained by the increase in seasonal mean temperature, suggesting adaptation methods of shifting sowing date and planning heat tolerant varieties. While in in Cambodia and Laos, the decrease in rice yields was mainly due to the effect of rising mean temperature and the interaction of rainfall and temperature, suggesting mitigation strategies that focus on water management and storage. Chun went on to outline the mitigating impacts of irrigation and fertilizer, as well as take a look at farm-level case studies.

11. **Ms. Nurhayati, Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG), "Implementing Climate Information to Support Sustainable Agriculture in Indonesia"**

    Ms. Nurhayati began her presentation with an overview of Indonesia, noting that as the "maritime continent" it is exposed to many climactic influences and extreme weather,

and outlined the distribution of rice fields, of which most are irrigated (82%) and are on Java Island (40%). She also explained the vulnerability of Indonesia to natural disasters, with each province experiencing an average of 350 disasters over the last 7 years, more than half of which were hydrometeorological. Nurhayati then spoke about the climate information products of her institution, the Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG), including 6-month forecasts, monthly flood potential, dry and wet season onset prediction, and rainfall analysis. She then went on to address the strategies that BMKG uses to communicate this information, as she notes that weather forecasts do not seem to be sufficient for an appropriate public response, as evinced by Typhon Haiyan where, though warnings were accurate, not enough was done to mitigate the risks of the storm surge. She felt that, if the implications of the information such as knowledge of storm surge impacts were better understood, then users would be better equipped by this impact-based forecast. There is a need to increase the capacity of the climate information or to simplify it for better use. Nurhayati then discussed the users interface forums – though BMKG is responsible for the information production, they depend on other agencies for dissemination and on individuals to increase climate literacy. The National Climate Outlook Forum is periodically held amongst the climate application community, as well the Climate Field School, which bring together the provider, extension workers, and farmers. They produce and teach tools such as an integrated cropping calendar based on climate information and involve the whole harvesting process, for great impact on average yield increase in targeted areas. In conclusion, she felt that several strategies are needed to utilize and optimize use of climate info to increase production is needed and forums are also a good tool to inform and guide use and understanding of climate information services.

12. **Prof. Yuji Masutomi, Ibaraki University, "Regional Impact and Adaptation Assessment of Climate Change on Agriculture"**

Prof. Yuji Masutomi gave a presentation on a project in Indonesia, the first of Japan's Adaptation Initiative, which began in June 2015. The objectives of this project are to support regional adaptation planning, build capacity for sustainable planning and action on adaptation, and to develop an adaptation planning guideline that may be applied to other economies and regions. The phases of this project include an impact assessment, discussion with stakeholders, adaptation assessment, then discussion with stakeholders with revisions as necessary, and finally making adaptation scenarios. Masutomi then discussed the reasoning behind the input choices, noting that there were too many different climate projections, and it was not feasible to include all. With the ensemble mean showing low ability, as with some individual models, they devised a method to select a subset of climate models with high performance based on temporal and spatial errors and correlations. Temperature and rainfall results from the new ensemble mean, which showed better performance, were combined with a crop growth model for paddy rice (MATCRO) to simulate yields. Masutomi explained that, based on field validation, they found the model can accurately simulate growth. Results show a decrease in rice

yield in 2031-40, even if uncertainty is taken into account, showing a need for adaptive action. Discussion with stakeholders were held to prioritized adaptation and create an adaptation menu. He then explained that these adaptation practices are still under assessment, and it is important to investigate the impact of irrigation under future climate conditions. Finally, Masutomi noted that, since precipitation is important for rice production and that seasonal precipitation is linked to El Nino Southern Oscillation and the Indian Ocean Dipole predictions, these could be used as predictions for adaptive action.

13. **Mr. A. G. Kawamura, Solutions from the Land, "Envisioning an Agricultural Renaissance"**

Mr. A. G. Kawamura gave a presentation tracing the progress made in agricultural production and a look at where it might take us, all the while noting the importance of sufficient institutional support and enabling environment for farmers. He began by expounding the importance of agriculture, where historically the stability of society and the rise or fall of civilizations has been closely linked to food security issues. With great advances in the past 50 years including fertilization, mechanization, and breeding achievements during the Green Revolution, the world, for the first time in recorded history, has the collective logistic and production capability of feeding all of mankind. Kawamura noted that, with urbanization and development, an increasing percentage of the population is disconnected to the land, and through ignorance or negligence is unaware of how vulnerable global food systems are. He shared personal experiences during the recent drought in California and the following record-breaking rains. To help mitigate these risks, we turn to technology, yet the early adopters in farmers aren't always rewarded or even supported, forcing these critical pioneers to shoulder all of the risk. Policy and regulations should ensure that farmers are supported with proper management. Kawamura noted that much of the world does not have advanced machinery or technology, and that advances in farming need not be exclusively focused on larger and more intensive, but can be small and tap into different levels of productivity. He encouraged, in addition to advances in technology, the focus on fundamentals: soil quality, water systems, insects and pests. He strongly explained that agricultural labour is not unskilled, but requires a specialized type of knowledge. He feels that agriculture should not be drawn into ideological debates by politicians who are unfamiliar with the realities of farming, and that with knowledge and cooperation we should come together to support farmers properly and reduce uncertainty with intelligent policy.

14. **Mr. Jaheung Koo, Global Business Group, Korea Telecom, "Private Sector Participation in Building Resilient Agro-food Systems: Converging ICT & Agriculture in Rural Korea"**

Mr. Jaheung Koo began with an explanation of how a telecommunication company is involved with agriculture. With the market saturated in telecoms, Korea Telecom (KT)

has moved into converging business, the merging of Information and Communications Technology (ICT) with other areas such as health and agriculture, to find new opportunities. With the Korean Government eager to promote the Smart Farm industry, providing subsidies and other support to farmers adopting this, KT has moved to address traditional agricultural problems with innovative ICT. At the same time, the population of individuals returning to rural areas from urban areas is steadily growing in Korea. He defined Smart Farming is a Service using networks to actualize a convergence service in the agricultural field to cope with various problems, such as weather changes, growth condition of farm products, and diseases with the aid of information processing and autonomous control technologies of the information technology (IT) area. Koo then explained how, though nascent, Korea's Smart Farm industry is growing, especially with the support from the government in subsidies and favourable loans. He then explained the various components of KT's Smart Farm from sensing and automation to the Smart Farm platform covering big data based controls to the smart device enabling remote control and monitoring. The internally developed system by KT increases production and cultivation efficiency, while reducing labour costs and pest and disease incidence. He then shared a number of examples of KT's work in ICT convergence in the agriculture field, but also that they continue to explore and experiment. Koo went on to give a number of example KT corporate social responsibility projects, including the GiGA Island project which connects isolated areas to farming and market opportunities, a Smart Farm for the disabled, and developing an e-platform for local agriculture in Moheshikhali Island, Bangladesh. He then shared some lessons from ICT working in agriculture, where some farmers felt that few ICT people know enough about agriculture. Some farmers are resistant to a mass roll-out of Smart Farms, and their concerns should be taken into account.

15. **Dr. Hoang Phuc Lam, National Hydro-Meteorological Service of Viet Nam, "Seasonal and Sub-seasonal Prediction of Rainfall and Temperature for Viet Nam"**

Dr. Hoang Phuc Lam began his presentation with an overview of the forecasts procedure at the National Center for Hydro-meteorological Forecasting (NCHMF) within the Ministry of Natural Resources and Environment of Viet Nam. These steps include collecting data, analysis, forecasting (statistic and dynamic models), discussion, bulletins, dissemination, extra bulletins, and evaluating forecast performance. He explained that while NCHMF develops the forecast information on a range of natural hazards, there are many different organizations that distribute to end-user, including the Department of Disaster Management, the Ministry of Agriculture and Rural Development, and local governments. He outlined the structure of NCHMF then went on to explain their long to short term predictions, described in the "Ready, Set, Go" format, which include year and seasonal predictions, monthly to weekly rainfall and temperature predictions, and the detailed 10-day weather forecast. These climate predictions support agricultural decision makers for activities such as food safety management, forest pest control, and crop planting and harvesting schedule. Lam then

went on to share a recent project that showed the importance of studying climate impacts analyzing local conditions through the following steps: analyzing climate resources in the targeted locality, identifying the appropriate crop structure based on those climate resources, analyzing the future climate change impacts to target crop structures, identifying specific crops which adapt to local conditions and climates, and finally proposing solutions for livelihood and agriculture. Lam finished his talk by describing the development process for the seasonal outlook for Viet Nam, including for the El Nino Southern Oscillation, tropical cyclone predictions, and temperature and rainfall anomalies.

16. **Wrap-up and Discussion:**

Dr. Vladmir Kattsov from the Voeikov Main Geophysical Observatory in Russia posed a question for Masutomi, inquiring how sensitive his results are to differing selection processes for the models, noting that the way the models are chosen is extremely important as with different models we may come to different results. Masutomi explained that they are not sure if their method is the best, and they showed just one approach, which they want to address during the impact assessment stage. They are also considering what is a better way, though he felt there was no best way. Kattsov noted that he understood their situation well, and his intention was to draw attention to the important issue of using climate model information in this application since it is critical to try to evaluate uncertainty based on approach.

Dr. Prajal Pradhan from the Potsdam Institute for Climate Impact Research posed three questions. The first addressed the rice yield simulation, asking if it was actual yield or potential, and if it considered carbon dioxide fertilizer effects. Chun responded saying that the actual rice yield data was used for model validation and calibration and they did not include the fertilizer effect. The second question addressed smart farming, asking if there had been any mitigation studies done on the impacts of adopting these high-tech smart farming approaches. Masutomi replied saying that they have early warning and smart phone systems for their rice producers in Japan, while Kawamura noted that farmers will change cultivars and methods if they see successful demonstration as information accelerates change in agriculture, and finally Chun noted that for they study they worked closely with the Cambodian Agricultural Research and Development Institute, which set up two fields: experimental and development plots. The third question Pradhan inquired was about the technological options for less developed areas. Lam noted that their organization does not work directly with the farmers, which is something they are trying to address. Koo explained that, in the Korean context, most of the farms get their data from the Korean Meteorological Authority, but the quality is low because they are interested in the micro-level. While it would be good for farmers to collect this data, it would also be beneficial for the community at large. Kawamura noted that in the US they see discussions about this in silos, and an integrated approach looking at the food energy water nexus is critical. Nurhayati went on to share difficulties encountered when working with a culture that is resistant to climate information tools.

Senthold Asseng from the University of Florida then asked Kawamura what barriers to adoption do farmers have in making use of 10-day and seasonal forecasts in operational decision making. Kawamura noted that farmers wish to make use of forecasts when they are correct, and he is already making use of this information on his farms, but also that there is a large difference from the application with irrigated or rain fed agriculture. When asked to clarify his meaning for "correct" forecasts, Kawamura explained that they are looking for forecasts that are more accurate, as they experienced many years where ENSO prediction was wrong.

Dr. David Rogers from the World Bank Global Facility for Disaster Reduction and Recovery noted that the climate information communicated is moving away from any deterministic format towards an ensemble model. He explained that there will always be uncertainty, and this is something we must understand. There will be a risk, regardless, the farmer must accept the risk to use the information. Rogers felt that unrealistic expectations are created by a deterministic format, thus we should work together to develop a system where decisions are informed by the uncertainty and risk rather than ignorant of it. As a community, while we may not have expectation to make better forecasts in the future, but we can aim to make more useful forecasts.

An APEC Delegate from Indonesia asked what the largest barriers are for the older generations in the adoption of smart farms. Koo acknowledged this is one of the large difficulties they face, yet ICT development in Korea is one of the highest in the world. He shared an anecdote of how older farmers may not use the full system, perhaps just the CCTV, yet have used government subsidies to build a full smart farm.

Ms. Flaviana Hilario from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) asked a question regarding the models used in Chun and Masutomi's presentations. As PAGASA workers usually ask about the impacts of climate change on rice production – are these models enough to answer that question, can we provide good guidance on adaptive action? Masutomi noted that, while it is possible the most important variable, his assessment only considered temperature and that in the future they would consider others. Chun agreed that it is a difficult question, as we do not know what will happen. Lam shared his idea about the usage of ensemble forecast by providing end users a probability for different factors like rainfall, temperature and winds; this is a good option while we are waiting for a perfect model.

Session II: Beyond Growth: Building Resilient Post-Production Food Systems

17. The morning session of August 19 commenced at 09:00. Session II explored the vulnerabilities of value chains to climactic variation and investigated how promoting climate resilience throughout food systems with the use of climate information can enhance food security, and was chaired by Prof. Kyeong-Hwan Lee of Chonnam National University, Korea.

18. **Dr. Monica Petri, Food and Agriculture Organization of the United Nations, "Landscape Management for Resilient Value Chains"**

    Dr. Monica Petri began with an overview of climate change and the role of FAO. She presented the challenge ahead, where food production needs to grow in the face of climate change while addressing GHG emissions. She explained that, in the development of the Paris Agreement, it became clear that adaptation is the most pressing concern across all agricultural sectors. Water management, climate planning and policy, disaster risk reduction, forestry management and sustainable crop production are the main technical focuses. Petri then went on to discuss system trends in Southeast Asia in agricultural production and post-harvest, noting among other things that mechanization is spreading rapidly and the integration of ICT and other technology to enhance farm practices will lead to improved monitoring and new business opportunities. The risks posed by climate change can affect business through core operations, value chain, and also broader changes in the economy and infrastructure. She explained that focusing on the single value chain reduces the intervention trade-off and might disregard territorial socio-economic and environmental characteristics. In particular, some aspects of conservation goes beyond value chains, where farmers who invest in biodiversity bear a disproportionally large scale of costs, yet benefit from a smaller share of social benefits. Petri then expounded the benefits of climate smart landscapes for value chain resilience, where landscape thinking integrates the different elements of a landscape addressing potential trade-offs between production and conservation and enables an upscaling of success. The Integrated Landscape Management approach is multi-sectoral, multi-stakeholder, and multi-scale, balancing agro-environmental and governance interactions in both short and long term. She then gave an overview on various landscape initiatives working at multiple value chain levels in Asia, including FAO's composting urban food waste in Sri Lanka, conservation agriculture in Timor-Leste, and the expansion from one value chain to landscape inclusive development in Lao PDR. In conclusion, Petri explained that responding to climate change risks in agriculture requires an understanding of the broader system, considering both agro-environment and governance. She suggested a focus on value chains with landscape vision, with robust assessment of climate risks and stakeholder involvement, sufficient governance, at multiples scales and levels.

19. **Mr. Mitsuhiro Ogata, Weathernews, Japan, "Weather Risk Management: What WNI Can Do for Your Country"**

Mr. Mitsuhiro Ogata began with a history of Weathernews Inc. (WNI), and an overview of the 44 different markets covered by their services, including aviation, shipping, and agriculture, from the 19 economies they work in. He then explained that there are WNI Service and Support offices to the NHMSs of 14 of the APEC economies. In particular, they entered a partnership the NHMS of Viet Nam to support business weather risk management in 2015, and will work on enhancing data exchange, developing a forecasting system for heavy rain, and building new service models. Ogata then listed some recent hydrometeorological disasters across the Asia-Pacific region, explaining that they provided information for customer action in all of the events. The WNI Global Tropical Storm Forecasts process begins with analysis of existing conditions, forecast model output evaluations, and then forecasts based on speed, direction, and pressure. Ogata then discussed WNI's work on risk communication for agriculture with their Agriculture Weather Risk Management System, which brings together local observations, weather forecasts from various sources, downscaling methods to adapt forecasts to the plot level, and the development of an interactive web application. He then outlined their Water Level and Discharge Management System, which makes use of rainfall observation and forecasting, topography, and land cover data to forecast water level and discharge, as well as flood water levels. A similar system can be made for dam operation management. Ogata then gave information on their observation and database systems for their climate change control data platform, which he said is the world's largest database of weather, maritime conditions, and geological phenomenon. He then gave some examples of their observation infrastructure, including the launch of a satellite in Kazakhastan, explaining that the WNI Risk Communication Company plans to deploy more in the APEC region and work for APEC.

20. **Dr. Kwang-Hyung Kim, APCC, "A Model Project for the Establishment of Climate Information Services in Tonga to Enhance Food Security in a Sustainable Manner"**

Dr. Kwang-Hyung Kim gave a presentation tracing the origin, development, and implementation of a project employing climate information services (CIS) in Tonga to apply a holistic solution in increasing the resilience of the Tongan agricultural community with the Tonga Ministry of Agriculture and Food, Forests and Fisheries (MAFFF) and the Tonga Meteorological Service (TMS). The project ran from 2014-2016 and originated from a discussion at the 2014 Regional Consultation on Climate Services for Pacific Small Island States. Kim explained that it focused on building the capacity of the agricultural sector and expanding the role of TMS to build climate services for agriculture. The 5 main activities are as follows: the development of an agricultural database, the generation of agrometeorological information, the development and delivery of agro-climate services, continued assessment of users' needs and capacities, and finally research on the core relationships between climate and

agriculture through modelling and field trials. Kim then outlined the 5 main challenges they faced, and explained how they met them. The first challenge, that climate services should be based on stakeholder-driven portfolios, was addressed by developing a concept based on continuous stakeholder engagement and assessments on current capacity, needs, and farmer's desired features for such a service. This resulted in a selection of realistic, practical service options. The second challenge was that decision-making using the climate service should be supported by sound science. Kim explained how they developed various models, including disease spray models and statistical models for yield prediction linked to ENSO, for the climate services. These models, as well as traditional knowledge, weather and climate forecasting, a crop management simulator, and a farm diary data collection platform, were integrated into the resulting ICT-based agro-climate service, the Tonga Climate Services for Agriculture (ToCSA). He then explained that this service is deployed in a modular format, making it easily customizable to the needs to the users and local context, thus readily transferrable to other economies. The third challenge, improving agricultural data management was addressed through the development of a database, the Tonga Agricultural Information System within MAFFF, as well as ministry guidelines on data collection and management to ensure sustainable use. The fourth challenge, reaching as many end users as possible at community level, was addressed through collaboration with model farmers, extension workers, and NGOs. Finally, Kim outlined the last challenge, in mainstreaming climate services to increase long-term sustainability, which was met through official handover and operations agreements with high-level officials, the support of the AgroMet Working Group, contributions to the Tonga Agriculture Sector Plan, and connection to new projects.

21. **Dr. Prajal Pradhan, Potsdam Institute for Climate Impact Research (PIK), "Smart Food Systems to Mitigate Climate Change and to Attain Sustainable Development Goals"**

Dr. Prajal Pradhan began by acknowledging a global sustainability challenge – how to nourish a growing populations while reducing agricultural environmental impacts. Though we currently produce more than enough food to feed the global population, 800 million are undernourished and agricultural efforts cause severe environmental impacts and consume huge amounts of anthropogenic inputs. His work took a look at how to meet this sustainability challenge, using several freely available datasets and model results and then applying empirical and model based analysis at various scales from local to global. Pradhan then moved into dietary habits, where he explained that they vary across time and regions, with economies moving between them. With development, habits tend towards affluent diets, consuming a larger share of animal products, sugar, oil, and vegetables. This has important impacts on environmental footprint, with agriculture comprising a significant and increasing portion of global GHG emissions. He then noted that only 60% of crops are going directly to humans and the amount of crop fed to livestock in East Asia, North America and Europe would be enough to directly feed all of the 800 million currently undernourished, as an average

four calories of food crop are used to create one calorie of animal product. Pradhan then moved to take a look at food waste and food requirement, where we are already wasting over 20% of food globally. Since 1970s, we have seen a huge increase in food use per capita, yet not an increase in food requirement – this difference is going towards waste. This waste also represents avoidable GHG emissions. He then discussed the potential for agricultural expansion, which is limited and unevenly distributed among economies, and required strategies to close yield gaps between actual and potential yield, including fertilization. Fertilizer application efficiency needs to be improved in many world regions in order to limit the required fertilizer to close crop yield gaps. Pradhan also shared an analysis and projections of food transport GHG emissions, which are larger under extreme global trade. This look at urban food miles has critical implications for importance of local diets; the study concluded that food production needs to be diversified to meet local demand. Finally, he connected it to the UN Sustainable Development Goals, which should address the above components to sustainably pursue food security.

22. **Dr. Tran Dai Nghia, Ministry of Agriculture and Rural Development of Viet Nam, "Value Chain Approach and Gender Inclusion in Development of Climate Smart Agriculture: Experiences from Viet Nam"**

Dr. Tran Dai Nghia began with an introduction of the socioeconomic context of Viet Nam, where 16.3% of the national GDP in 2016 came from agriculture, indicating its importance. With a 94.4 million population in 2015, 69% of farmers were small holder, 66% of the population lived in rural areas, and 41.9 % were employed in agriculture (2016). He then took a look at the Climate Smart Agriculture (CSA) value chain, through input supply, production, collection, processing, market, and consumption. At the Ministry of Agriculture and Rural Development of Viet Nam (MARD), they look at all of the nodes of the chain to see what their sensitivity and exposures are, as well as their adaptive capacity. Nghia then explained the benefits of CSA with a value chain approach, outlining the economic aspects, which included the improvement of profits for every actor in the chain and risk spreading to mitigate individual risk, the social aspects, where both benefits and costs are distributed with more transparency and fairness, and the environmental aspects, which include more sustainable uses of natural resources and the reduction of GHG in the chain. He then shared an example of Integrated Food-Energy Systems (IFES) for the rice production chain and energy systems in the Vinh Binh community of the An Giang Province, where they reuse rice husks as fuel to dry the grain to reduce GHG emissions. Nghia followed this with another example, the ecological shrimp-mangrove forest approach in coastal provinces to sustainably increase farmers' income, protect the environment, and reduce GHG emissions. He also looked at their gender equality promotion strategy and principles in the development of CSA, which blends a number of approaches, highlighting awareness, advocacy, and activities. He then gave an example of gender inclusion with the Red Dao Women in sustainable natural forest management, where they have worked to protect 360 hectares of natural forests, while improving profits. He shared many key

elements and barriers to approaching CSA in Viet Nam. These included a need for concrete policies on climate change, which may focus more on disaster prevention and mitigation rather than non-structural adaptation measures like CSA, as well as vague links between currently existing CSA practices with mitigation and food security. He also outlined areas of cooperation, which included addressing the knowledge needs of the sector by linking public and private research, extension and advisory services to generate, manage, and blend and share indigenous and scientific knowledge, while facilitating learning processes and network-based innovation domestically and internationally.

23. **Prof. Kyeong-Hwan Lee, Chonnam National University, Korea, "Intelligent Agricultural Production System based on Climate, Crop, and Field Information"**

Prof. Kyeong-Hwan Lee began with a look at issues in agriculture, noting that future food demand of growing populations will be coming from Asia and Africa. However, current increases in food production are not enough to meet this demand, yet we also must balancing issues with food safety, reducing the use of pesticides and fertilizers, to meet growing demand for organic food. He explained that there are challenges in agriculture, an increase in quantity and quality, both in food and environment, as well as demands for competitive business models and improved quality of life for agricultural workers. To meet these challenges, he suggests the innovation of agricultural production systems using digital transformation technology, as part of the fourth industrial revolution in cyber-physical systems. Lee then moved into a discussion on intelligent agricultural production systems, which aims to maximize efficiency by unsupervised learning with minimum human involvement, and is organized into three sub-systems for monitoring, decision-making, and actuating, which he examined in turn. He described precision agriculture that uses site-specific variable technology based on field and crop conditions. He then described the range of monitoring systems from satellite all the way to biosensors, which, when combined with phenomics, can be used for the diagnosis of crop stress, disease, nutrient deficiencies at an early stage. He gave a range of examples where advanced monitoring systems can be used to maximize yield and quality with minimum input, in the whole life cropping life cycle: plowing, transplanting, disease and pest management, and harvesting. Addressing the second part of the intelligent agricultural production systems, Lee then described new decision-making systems that collect various data for weather, soil, and crop, use a big data based optimum model for input of agricultural materials, and can be calibrated for different environments. Finally, Lee took a look at actuating systems, showing videos of new technologies, such as an unmanned aerial vehicle (UAV) for the collection and inspection of crops, as well as self-driving tractors. In conclusion, he explained that cooperation between the automation related industry and agriculture is essential for the development of core technology, and suggested the adoption of new technology from related advanced industries.

24. **Wrap-up and Discussion:**

The discussion period began with a question from Prof. Senthold Asseng from University of Florida to Pradhan, inquiring what he thought was the most effective way to reduce food waste. Pradhan noted that he presented primarily on the user side, but many things can be done on the producer side for post handling techniques and transport, among others. He also explained how difficult behavioural change is, but it is possible, citing an example of groceries stores in France being forbidden from disposing of food.

The next question came from Dr. Chwen-Ming Yang from the Taiwan Agricultural Research Institute, who asked Lee to expand on the different technology used for the monitoring at different growth levels, from planting to harvesting. Lee then described this technology, first speaking about a camera mounted on a drone, which takes photos at around 10m, then they analyze the images, noting with accuracy the elevation. With transplanting, they take photos with very high resolution and technology, and finally with harvesting, similar, but the processing is different. This is still at the first stage of development, and they need to work more. He also explained that, during the growth stage, most people use spectroscopes and analyse the data, which is an indirect method of detecting. Usually, these images are taken from 100m, but the method they looking at, it is much closer, around 10m, which gives very precise and coloured information.

Dr. Pablo Impach, from the International Centre for Tropical Agriculture asked Kim about the agro-meteorological tool described for Tonga, wondering if it can be used in other settings and how the end user was involved in the design. Kim explained that the platform is modular, allowing a different delivery method and implementation, suited to the local context. The case study in Tonga was developed with a lot of discussion and consultation.

Dr. Govindarajalu Srinivasan from the Regional Integrated Multi-Hazard Early Warning System (RIMES) asked about the carbon footprint of high-technology approaches to these agricultural issues. Nghia agreed that this is an important issue, and Viet Nam along with other economies with UNDP are trying to develop a closed model to estimate this, including analyzing land use. Pradhan also agreed that the energy water food nexus is critical, and it would be good to use renewable energy to produce food. He noted the dichotomy between the use of livestock and low technology in most of South Asia and Africa, while we are also looking at automatic farms. Petri noted that there are many different challenges, so she does not see a conflict from those different technological solutions, but rather the point is that solutions should be developed with the end users to develop appropriate tools. She also noted that high-technology solutions may still be applicable in low development areas, citing an example from Mali, where local small scale enterprises merged drone imaging with government provided climate services to give personalized farming recommendations. Ogata agreed with the complexity of the issue.

Mr. Yeoh Yuan Xiang from Malaysia asked about the increasing use of fertilizer and pesticides to meet the rising demand for food. Pradhan noted that, if we reduce food waste, then such inputs may also be minimized. If food waste was an economy, it would be the third largest GHG emitter in the world, after China and America. Finally, we can increase the efficiency in fertilizer application.

Session III: Large-scale Holistic Approaches to Climate Risk Management

25. The afternoon session of August 19 commenced at 14:15. Session III discussed success cases to implement climate-related risk management measures at different scales will and was chaired by Dr. Govindarajalu Srinivasan from Regional Integrated Multi-Hazard Early Warning System for Africa and Asia.

26. **Dr. Hideki Kanamaru, Food and Agriculture Organization of the United Nations, "Towards Transformational Climate Change Adaptation in the Agriculture Sector using Climate and Agrometeorological Information"**

Dr. Hideki Kanamaru opened by sharing his personal goal – to bridge the gap between science and policy. For transformational climate change adaptation, good funding, long-term perspectives, a climate rather than general development focus, and innovative approaches are needed. He explained that transformational change is supported by evidence-based adaptation, linkages with policies, scaling-up and replication, capacity development and knowledge sharing, and an enabling environment. Kanamaru then went through each of these elements, beginning by explaining that any climate change adaptation programme should be supported by robust evidence, from historical data to future projections, and trials do demonstrate effectiveness of interventions. One such tool is the Modelling System for Agricultural Impacts of Climate Change (MOSAICC), an integrated system of tools and models to evaluate climate change impacts on the agriculture sector. To properly link with policies, he explained that FAO ensures that projects support and are integrated with national strategies that address climate change, agriculture, and food security. Kanamaru then noted explained that the third element, scaling-up and replication, is approached by FAO through a national level with sub-national disaggregation, which may be of interest to policy-makers. He emphasized an interdisciplinary approach, noting the narrow scope of presentations, focusing primarily at crops, yet foot security encompasses many things, including livestock and fisheries. MOSAICC, as an integrated modelling system, takes into account a range of biophysical, social, and economic factors. FAO promotes a national-driven approach, to internalize capacity and support long-term change. This means a focus on using national experts, with national knowledge, and capacity development. Finally, stakeholder involvement must be centralized, with FAO forming interdisciplinary working groups to equip policy makers with the fundamental information to guide national adaptation and food security policies. He then shared the results of various MOSAICC implementations in the Philippines and Peru. Kanamaru then expounded the benefits of combining top-down approaches employed by climate scientists, like MOSAICC, with bottom-up, like vulnerability assessments expected by agriculture practitioners. He then shared ongoing projects in Macedonia, Georgia, and Pakistan to predict plant disease risk. Finally Kanamaru explained that policy makers and project formulators are looking for information to underpin policies, the need to move beyond crops, to address appropriate scale, and that stakeholder involvement is critical.

27. **Dr. Govindarajalu Srinivasan, Regional Integrated Multi-Hazard Early Warning System for Africa and Asia, "Using Climate Knowledge to Create Sustainable Agricultural Systems"**

Dr. Govindarajalu Srinivasan began by giving a background of RIMES, which is an intergovernmental organization that links science with the generators and users of early warning information. He explained that sustaining agricultural production involves minimizing the impacts of adverse climate and capitalizing on favourable periods. Thus, more effective use of climate information supports the goals of sustainable development and food security. Climate knowledge is an entry point to bring sustainability, and he linked climate and weather decisions to impacts for sustainability. He then shared a project "Enhancing Utility of Seasonal Climate Forecasts and Managing Climate Change Risks" where RIMES and FAO implemented the climate component to develop a monsoon forum and manage climate change risks. He explained that a major achievement of the project was in bringing together the users and producers of the information in the Monsoon Forums. He felt that, in terms of linking information and decision making, a climate approach had the most potential impact, but this is still unrealized. Srinivasan then outlined their role in supporting the Global Framework for Climate Services (GFCS) project in South Asia, through supporting National Climate Outlook Forums, capacity building, and the development of sector-specific decision support systems. He shared a case study in the Krindi Oya basin in Sri Lank, to address challenges linked to water shortages in the dry season and floods in the monsoon season by bringing together weather and climate prediction data, water modeling, and observation data for improved management of the reservoirs. He then took a look at Specialized Expert System for Agro-Meteorological Early Warning for Climate Resilient Agriculture (SESAME), a decision-making tool for farmers, that integrates weather bulletins, real-time verification of forecasts, capacity building, and feedback, with delivery through email or SMS, as well as dynamic crop calendars for expert users. Finally, Srinivasan linked food security to the four pillars of food security: availability, access, utilization and stability. He then shared his concluding thoughts, where climate knowledge and information are pivotal for sustainable systems that ensure food security. That food security is linked to various key sectors like health and water and provides an ideal point for staring to use climate information, but also that past knowledge and emerging trends need to be innovatively used to move towards sustainable agricultural systems and food security.

28. **Dr. Pablo Imbach, International Center for Tropical Agriculture (CIAT-CGIAR), "Climate Information Services for Agriculture: from Big Data to Decisions"**

Dr. Pablo Imbach gave an overview of the Center for Tropical Agriculture (CIAT), with headquarters in Cali, Columbia, under the Consultative Group for International Agricultural Research (CGIAR), with a research focus on agrobiodiversity, soils and landscapes, and decision and policy analysis. He defined Climate Information Services

(CIS) to be the production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning. The challenges for CIS are to ensure tailored content delivered in time, accessible and equitable, farmer consulted, and successful dissemination. He stressed the need for scalable pilots as well as sustainable institutional arrangements, so that the initiatives will not fail after the case study or short term project ends. Imbach then explained how understanding the context in which the information will be used for decision-making is critical. The users should be centralized, taking into account their real and perceived understanding of climate information, priorities, how information should be tailored to community needs, and how it should be packaged and delivered. One should also understand input data, methodological needs, and institutional settings. He then shared two pilot studies that demonstrated how going from local to national level can overcome some of these challenges. Imbach then talked about the design of information products, where they evaluated the relevant stakeholders, used participatory and user-centred approach to develop the most usable information products, and took advantage of opportunities for improving delivery of information in communities with very limited resources. On a local-regional level, he explained how user profiles are important, for example rice and maize farmers differ on information access, satisfaction of agro-climate information, and levels of capitalization. He then noted that the flow of climate information is often simplified from producers to consumers, yet in reality there is and should be a complex relationship with information flowing both ways, and involving various institutions. CIAT supports this, though the goal is to eventually step out of the process. Imbach shared an example of stocktaking on networks and information products in Guatemala, where they found there was no thematic grouping, and only 1 in 18 products were tailored for farmers, without feedback mechanisms. He then spoke about harnessing the capabilities of Big Data to accelerate and enhance the impact of international agricultural research to solve development problems faster, better, and at greater scale. Finally, he shared some of CIAT's new activities.

29. **Ms. Imelda Bacudo, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), "ASEAN Initiatives in Building Resilience of Agriculture for Food Security"**

Ms. Imelda Bacudo spoke about the Association of Southeast Asian Nations (ASEAN) efforts to build agricultural resilience, describing the vulnerabilities of Southeast Asia, with its long coastlines and dependence on agriculture and other natural resource-based industries, to hydrometeorological events and climate change. She described the ASEAN Cooperation in Food, Agriculture and Forestry, which focused on a multi-sectoral approach, however it was not a success. She attributes this in part to a lack of ownership, where divisions occurred where cross-sectoral collaboration was needed. Bacudo then outlined the ASEAN Climate Resilience Network (ASEAN-CRN), which promotes agricultural resilience within the region through the scaling-up of identified CSA practices, as well as identifying common concerns and needs for regional support strategies. It works to develop and coordinate collaborative initiatives and bring in

various stakeholders, such as private sector and academia, to develop partnerships. She then explained the process of the identification of existing practices to promote climate resilience in agriculture and for the establishment and endorsement of the Regional Guidelines for Promoting CSA Practices. This was an iterative process which included the prioritization of various cropping practices by member states. Bacudo also noted the overlapping interests of the various ASEAN Member States, enabling regional exchange on good practices. She then outlined the progress of the ASEAN-CRN in major work areas, including the Brunei agreements on proposal development for packaging various CSA technologies and regional knowledge exchanges, listing a number of regional policies and events. She gave review of the ASEAN workshop on insurance from 2016 in Ho Chi Minh City. Developing a National Crop Insurance Program, which was important as some economies cannot yet start their own program. She also shared examples of some national level implementation of regional agreements, including in Cambodia with the promotion of stress tolerant rice varieties, and in Viet Nam with the next phase of an agricultural insurance program. The support of national level implementation is critical for the development and endorsement of regional agreements, and further on to global. Bacudo then talked about what should be done next, explaining that these meetings are absolutely necessary to not only gain consensus for these initiatives, but to bring together disparate sectors. She explained that the real challenge is approaching these issues in a well-organized manner.

30. **Wrap-up and Discussion:**

Ms. Christianne Aikins from the APEC Climate Center began the discussion with a question for Imbach, noting that the climate community is moving from a deterministic approach to one recognizing the probabilistic nature of climate information, asking to learn more about the participatory methods used in communicating the nature of climate information to the illiterate women mentioned in his presentation. Imbach explained that he was not involved with the implementation of that project, but in general they do a large amount of research on target groups to shape these approaches to the communities. Bacudo also gave some examples of information dissemination in the Philippines via radio broadcasting, which helps farmers know when to plant. She said there are many different ways to translate information from a meteorological approach.

Dr. Senthold Asseng from University of Florida inquired about the roadblocks for farmers in taking up this information. Imbach noted that, in some cases there is actually distrust towards the organizations disseminating the information, not necessarily because of the quality of the product but because of other factors. He cited an example from Guatemala, where there is high trust for climate information yet not towards crop information, possibly because it is produced on a national scale and not tailored – we need to develop the "ownership" of these products through consultation. Bacudo added that, from her experience, there is a large amount of information coming from NHMSs, but most of it is not tailored to the agricultural sector. For example, a complex system

with several species and varieties would have different forecasting needs, so the NHMS needs to expand. Another challenge relates to cultural barriers, such as planting outside of the traditional season, or a livestock being associated with wealth like in some parts of Africa. Dr. Monica Petri from FAO also added that, if farmers are not consulted in the production of data then it is just a flow, but when designed in partnership, then they will use it. It must be created in a manner that is easy to use and in a language they understand.

Mr. AG Kawamura from Solutions from the Land then said that all national agricultural ministry have roles to play regarding extension in reaching out to farmers. He asked if extension services are not working then why, and what is the general feelings about this. Srinivasan explained that where systems do exist, they are not always getting information at the right time or are equipped to understand or use it. Agricultural extension systems need to be strengthened through CIS. Kanamaru explained that ministries of agriculture are often severely underfunded with limited spatial coverage, and that he believes extension workers are doing their best within the information they have from NHMS, which is often not good enough to give tailored advice. Imbach noted that in Central America, extension roles have been diminished as the private sector has moved in. Climate variability has also wreaked the confidence of veteran extension workers. Kawamura followed up, suggesting to bring these discussions to the attention of agriculture ministers. Bacudo added that this is a problem of integration, and there is a need to bring agricultural and hydrometeorological services together. Mr. Nicholas Brooke from the APEC Business Advisory Council added that these discussions will indeed be brought before ministerial consideration during the 2017 APEC Food Security Week held in Can Tho after APCS.

Dr. Prajal Pradhan from PIK inquired about the difference between weather and climate services, if there is one. Kanamaru explained that, from his understanding, climate services include weather services, crossing the short time scale of weather to the long time scale of climate. Imbach added that the term depends on what user you are addressing and decisions that need to be made. Dr. Flaviana Hilario from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) explained that at the National Climate Outlook Forums, they also discuss weather forecasts, as well as use that opportunity to consult with farmers and stakeholders. The Global Framework for Climate Services also does include weather services, information, and forecasts. There is good linkage between PAGASA and the Department of Agriculture, yet also noted that a wrong forecast can damage the credibility of the information so the communication of the probabilistic nature of forecast is important. She also added a comment on FAO that national agencies must be involved for sustainability. Kanamaru agreed that sustainability is a large issue. He also added that many Automatic Weather Stations are installed in project areas then abandoned after it is completed, abandoning data. Many thousands are not connected to any network, and when we talk about diminishing numbers in the observation networks, there are many dormant.

Session IV: Wrap-up, Panel Discussion, and Closing Ceremony

31. The Panel Discussion and Wrap-Up Session on August 20 commenced at 09:00. The session was chaired by Dr. Mark Howden from Australian National University.

Session I: Dr. Jong Ahn Chun began with an overview of the purpose of Session I, highlighting the highly sensitive nature of agricultural production systems to climactic factors and the necessity of developing and using reliable climate information for food security. He then outlined each of the six presentations, where he discussed multi-scale crop modelling and rice yield in Southeast Asia under different GHG emission scenarios. Nurhayati looked at education programs for farmers, Masutomi presented on an adaptation initiative in Indonesia, Kawamura discussed future farming technologies and urban farming, Koo presented on KT development of smart farms, and final Lam presented on seasonal forecasting practices in Viet Nam. Chun then brought attention to the concept of how we can efficiently use climate information, noting that there was some discussion of the idea that "correct" information guarantees its useful application, which he disagrees with. The accuracy of the climate information is important, but it is a different story with application. He discussed this concept of usable vs useful forecasts, stressing that the user must be put first in the co-design and co-production between the scientific and adaptation communities. Finally he drew an analogy with learning languages, and noted that we mention bridging the gap between climate and application communities, but both areas must speak each other's language.

Session II: Prof. Kyeong-Hwan Lee also gave an overview of each presentation in turn, noting that Petri presented on integrated landscape management, and that Ogata had explained how WNI network can be used in APEC economies and they will install 200 Eagle radars over the Asia region. He explained how Kim presented on the Tonga AgroMet Project, with the development of climate smart technology with local knowledge and institutions, and discussed some highlights of Pradhan's presentation, which discussed the potential for reducing GHG emissions in agriculture through shifts in dietary patterns and minimizing waste, explaining how urban food miles is another aspect for optimization. Nghia had outlined the CSA experience in Vietnam through the economic, social, and environmental aspects of the benefits of using CSA with a value chain approach. Finally, he covered his own presentation which argued that the required increase in food yields requires a digital transformation, indeed the 4^{th} industrial revolution, applied to precision agriculture, which centers on optimizing timing and application of inputs to increase efficiency and outputs. He gave examples of monitoring rice crops through the whole life cycle using UAV and proposed a fully automated agricultural production as a potential future goal.

Session III: In collaboration with the absent Session III Chair Dr. Govindarajalu Srinivasan, Dr. Pablo Imbach gave the wrap-up, beginning with a brief overview of the four sessions. He then delved into Kanamaru's presentation on climate adaptation in

the agricultural sector, which argued that elements of transformational change need to be evidence based, linked to policy, capable of being scaled-up and replicated, involving capacity building and knowledge-sharing, and creating an enabling environment. Then addressing Srinivasan's presentation on climate knowledge for sustainable agricultural systems, he discussed the RIMES implementation of the WMO GFCS in South Asia, and that climate knowledge and information are pivotal for sustainable systems that ensure food security, which is linked to various sectors and may provide a springboard for CIS integration. Then Imbach gave an overview of his own presentation on CIS, which needs to be crop and practice specific that are integrated into farmers' usual activities, taking into account relevant institutions, extension services, and farmer capacity, and that we must harness the capabilities of "Big Data." He then gave a summary of Bacudo's presentation on ASEAN climate resilience initiatives, in particular noting that the ASEAN-CRN promotes regional agricultural resilience and that knowledge exchange events and policy guidance documents are critical. To close, Imbach drew some key points from the wrap-up discussion, which emphasized the need to strengthen agricultural extension systems to promote CSA using CIS and to develop interfaces to understand seasonal climate information and to scale-up activities like the farmer field schools and National Climate Outlook Fora to enhance the uptake of climate information. Finally, he noted the vision that climate services could serve as an overarching framework to support climate risk management including information on weather and climate on a continuum of time-scales.

32. **Panel Discussion: Dr. Mark Howden (Australian National University), Prof. Senthold Asseng (University of Florida), Ms. Imelda Bacudo (GIZ), Dr. Jim Hansen (IRI), Dr. Pablo Imbach (CIAT-CGIAR), and Dr. Monica Petri (FAO)**

Dr. Mark Howden opened the panel by inviting panellists to share some of their thoughts linking the outcomes of the symposium.

Petri began by highlighting the fact that, when wondering about the lack of uptake for a climate product, we may not have taken the socioeconomic or cultural considerations into account. Moving beyond the proposal of good practices or technology, we have to pay attention to how these are transferred at the field level. She highlighted the structured approach at FAO and others, where they first make assessments at a wide range of scales and planning is implemented in a way that respects interests of all relevant groups, prior to implementation.

Imbach followed up by taking a look at the various levels of integration of information and application, from high level technology with automated farms to low level interventions. He noted that these approaches must be adjusted to the local context yet balancing that with the need to make the tools and methods scalable. He believes that one of the big gaps is that they have not seen enough feedback mechanisms from the local to the national scale, but we need to explore how we can monitor the effectiveness of the CIS. While we are still learning how to do this, Imbach felt that a good approach to use in addressing this issue is to start from the regional level, and from there go

toward developing the information tools, communication methods, and data collection. By doing so, you can learn about systemized process and working on effective monitoring to understand the strengths of CIS.

Bacudo began by explaining her role, where her approach comes from a generalist point of view, looking at how science is engaged with policy makers and how these things are brought to a global scale. Some challenges she sees in engaging science and policy into the field is ministerial or departmental divides, and there is a disconnect for feedback. She highlighted the need to reverse certain inherent hierarchies in government and in our scientific practices. Bacudo explained that the promotion of CSA is often not science, but politics, and there is a need to find champions who will push for climate change mitigation and adaption.

Asseng noted that there has been a lot of interest on the impacts of climate change, the vulnerabilities of agriculture, and how to adapt. However, he noted that the approaches and use of scenarios, the choice of impact models, has important effects on the outputs. He feels that we need to coordinate the implementation of impact assessments, and such a coordinated framework may be offered by AgMIP. He suggested that an Asian or APEC regional AgMIP group be set up to promote a coordinated approach under this international framework used elsewhere.

Hansen began by noting it is both an exciting and challenging time for agriculture, and that in his career he as seen climate change go from an unrelated concern of agriculture development, to adaptation and risk management being central discussions. He explained that risk is a huge barrier to the adoption of innovation and technology and keeps farmers stick in subsistence agriculture and poverty, but now there are a lot of feasible options and considerably more investment. One of the biggest challenges they face with the proliferation of networks, donors, and projects is ensuring that projects build on existing knowledge and avoid duplication. There needs to be more done in keeping good lines of communications between climate and agricultural research organizations, even within the networks mentioned during the symposium, including RIMES and ASEAN.

Howden followed up reiterating the existence of an enormous amount of experiences to draw on. One thing as a society we see is the division between fields, for example where Bacudo sees politics, Asseng sees the standardization of information. He then asked them to explain how they would integrate the other's perspective. Bacudo explained how she thinks that the largest challenge is political and ideological, but also that there are agency politics, but the emphasis should be on getting people to work together. She went on to outline how her speciality, the art of collaboration, is not often regarded as a field in its own right, but that it should be highlighted given the need for integration of efforts. Asseng explained how actually the standardization of information through AgMIP is an important step in bringing people together, to allow them to work together, to compare and share data, and to quantify uncertainty.

Howden then asked about evidence-based decision making, which is often talked about but rarely done. Petri responded, explaining that there are actually many tools for

decision-making, which may seem like a simple thing to outline, but actually helpful in dealing with the complexity of ideology and abundance of stakeholders when trying to make a good decision, which means looking at the landscape scale. She also noted that this complexity is linked to the agenda of the international development community, with short projects impacting the effectiveness of what must necessarily be long-term interventions.

Howden then noted that, we often enter research with a value judgement that our research will make agriculture more productive, reduce risk, and increase resilience, but the evidence we have on that relationship is actually quite sparse. This can stress the relationship between researchers and target groups. He asked the panel to expand on this issue and what kind of monitoring we need to invest in to make this data a reality. Hansen confirmed this, saying that after a recent literature on technology innovations meant to reduce climate risk, he realized that, relative to other areas, the amount of investment on evaluation is quite low. Despite the challenges associated with measuring the impacts of information, this is a needed area of research to build the evidence base of climate information services. Bacudo also shared her experience of lack of funding for the monitoring and evaluation role in projects, which may stem from being considered less interesting to donors than other aspects of the projects. Imbach suggested this absence may in part be due to the origination of many projects from the bio-hydrogeological and modelling side, rather than the social science that specialize in looking at these impacts. If these projects are created in collaboration between fields, we might find ourselves better suited. In addition, this integrated approach should be emphasized in academic agendas. Petri shared some examples of extremely simple types of evaluation that can take place. Howden highlighted Bacudo's suggestion in making monitoring more attractive to close the circle, noting that unlocking the issues that arise locally and having a vision that is owned by the community is essential for success. He then opened the floor to questions.

Dr. Prajal Pradahn gave some comments, emphasising moving attention beyond production, suggesting that mitigation aspects be included in CIS information, and integrate with discussions on the UN Sustainable Development Goals. Bacudo noted that mitigation is actually a component of the definition of CSA, to harness the mitigation potential, and that, while not mentioned in the presentations, the Sustainable Development Goals are integrated into project descriptions.

Dr. David Rogers from the World Bank Global Facility for Disaster Reduction and Recovery shared his experience working towards sustainably coordinating government partners from global to national to stakeholder. They began an annual event to bring together donors to share experiences, and this has been replicated on smaller regional scales. This helps coordinate activities to minimize overlap. Rogers explained that there has also been changes in the approach, where now end users are not just beneficiaries, they are an integral part of the program and actually drive it.

Mr. Nicholas Brooke from the APEC Business Advisory Council, gave the final question, proposing two opposing views and asked the panel's opinions on them: the

first being that climate information is a public good and therefore should not be commercialized, while the second is that business do see this as an opportunity and should be able to commercialize it. Hansen says that, while he believes that the private sector is able to drive innovation faster than the public sector, there are serious challenges when companies are paid to go into communities and bypass NHMSs. The value of the private sector, the role of NHMSs, and the danger of undermining each other should be considered. He noted that in much of the developing world, while NHMSs are happy to provide weather forecasts as a public good, there are many complications and restrictions in sharing historical data. He suggests an important line of research would be to do a cost benefit analysis of selling this data versus giving it out. Imbach noted that the UK Met Office did a cost benefit analysis, and in 5-7 years the gains were higher in the approach that did not charge for data use. Bacudo noted that private-public-partnerships are another options where private sector distribute public data. Howden was careful to note that the community must be careful if we move towards commercialization, to avoid a decrease in quality and also that it does not contribute further to inequality.

Finally Howden closed the Panel Discussion by thanking all panellists and participants for their contributions.

33. Dr. Hong-Sang Jung, the Executive Director of the APEC Climate Center, concluded the symposium with a speech reiterating the key points of the symposium, while thanking everyone for their active participation. Mr. Nguyen Van Thang, Director General of the Viet Nam Institute of Meteorology, Hydrology, and Environment, then gave a speech thanking the participants, congratulating all on the success of the symposium, and linking the symposium outcomes to the larger APEC goals. Finally, Mr. Nicholas Brooke, the Principal Advisor to the APEC Business Advisory Council (ABAC) on the APEC Policy Partnership on Science, Technology and Innovation (PPSTI), gave his concluding remarks, noting that food security and safety is very high on the agenda of both ABAC and PPSTI. He congratulated the hosts APCC and the National Hydro-Meteorological Service of Viet Nam on a successful event and highlighted the appropriate topic of the symposium, linking to the Viet Nam's agenda for the year. He also noted that these discussions will be of great interest to the private sector, and he will work to ensure that events like these will have sufficient representation to help build collaborations. After this, the symposium came to a close.

ANNEX: APEC Climate Symposium 2017 Participants List

No.	Economy	Name	Affiliation	Gender
1	Argentina	Pablo Imbach	CGIAR International Centre for Tropical Agriculture	M
2	Australia	Mark Howden	ANU Climate Change Institute	M
3	Australia	Paul Gregory	Bureau of Meteorology/Climate Services of Australia	M
4	Australia	Senthold Asseng	University of Florida	M
5	Brazil	Antonio Moura	Brazilian National Institute of Space Research (INPE)	M
6	Chile	Alvaro Garrido	Chilean Agricultural and Livestock Service (SAG)	M
7	Chile	Ruth Alarcon Gatica	Sernapesca	F
8	Chile	Rommy Zuniga Pardo	Universidad Tecnológica Metropolitana	M
9	Chile	Enrique Garrido	Weather Service of Chile	M
10	Chinese Taipei	Shitephen Wang	Academic Sinica	M
11	Chinese Taipei	Tien-Chiang Yeh	Central Weather Bureau	M
12	Chinese Taipei	Chwen-Ming Yang	Taiwan Agricultural Research Institute	M
13	Hong Kong	Nicholas Brooke	APEC Business Advisory Council	M
14	India	Govindarajalu Srinivasan	Regional Integrated Multi-Hazard Early Warning System	M
15	Indonesia	Marjuki	Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG)	M
16	Indonesia	Nurhayati	Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG)	F
17	Italy	Monica Peteri	Food and Agriculture Organization of the United Nations	F
18	Japan	Yuji Masutomi	College of Agriculture, Ibaraki University	M
19	Japan	Hideki Kanamaru	Food and Agriculture Organization of the United Nations	M
20	Japan	Yoshiaki Sato	Japan Meterological Agency	M
21	Japan	Nishibayashi Masachika	Weather News Inc.	M
22	Japan	Mitsuhiro Ogata	Weather News Inc. Environment Weather Group	M
23	Korea	Christianne Miko Aikins	APEC Climate Center	F
24	Korea	Gyeongseok Jo	APEC Climate Center	M
25	Korea	Hong-Sang Jung	APEC Climate Center	M
26	Korea	Inja Jeon	APEC Climate Center	F
27	Korea	Jinho Yoo	APEC Climate Center	M
28	Korea	Jong Ahn Chun	APEC Climate Center	M
29	Korea	Kwang Hyung Kim	APEC Climate Center	M
30	Korea	Sangwon Moon	APEC Climate Center	F
31	Korea	Suhee Han	APEC Climate Center	F
32	Korea	Yonghee Shin	APEC Climate Center	M
33	Korea	Kyeong-Hwan Lee	Chonnam University	M
34	Korea	Heekyung Park	Korea Advanced Institute of Science and Technology	M
35	Korea	Seeungwan Ma	Korea Meteorological Administration	M
36	Korea	Sim Jung Park	Korea Meteorological Administration	F
37	Korea	Jaheung Koo	Korea Telecom	M

No.	Economy	Name	Affiliation	Gender
38	Korea	Jaeho Oh	Pukyong National University	M
39	Korea	Insik Kang	Seoul National University	M
40	Malaysia	Logeswary Kalyana Sundram	Department of Agriculture of Malaysia	F
41	Malaysia	Nor Adawiah	Malaysian Meteorological Department	F
42	Malaysia	Abdul Rahim Bin Harun	Malaysian Nuclear Agency	M
43	Malaysia	Yeoh Yuan Xiang	Ministry of Agriculture and Agro-Based Industry	M
44	Mexico	Martin Ibarra Ochoa	National Water Commission of Mexico	M
45	Nepal	Prjal Pradhan	Potsdam Institute for Climate Impact Research (PIK)	M
46	New Zealand	Brett Mullan	National Institute of Water & Atmospheric Research	M
47	Papua New Guinea	Joshua Ryan	Coastal Fisheries, National Fisheries Authority of Papua New Guinea	M
48	Papua New Guinea	Wille Kerenga	Coastal Fisheries, National Fisheries Authority of Papua New Guinea	M
49	Papua New Guinea	Petrus Dii URKA	Department of Agriculture and Livestock of Papua New Guinea	M
50	Peru	Americano Sihuas Aquije	Ministry of Agriculture and Irrigation of Peru	M
51	Peru	Frank Marvin Muller Figueroa	Ministry of Agriculture and Irrigation of Peru	M
52	Peru	Karim Quevedo Caina	National Meteorology and Hydrology Service of Peru (SENAMHI)	F
53	Philippines	Carlos Magnaye	Department of Agriculture of the Philippines	M
54	Philippines	Saturnina Halos	Department of Agriculture of the Philippines	F
55	Philippines	Elena B. De Los Santos	Department of Agriculture of the Philippines, RFO 5	F
56	Philippines	Leila C. America	Department of Science and Technology - The Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development	F
57	Philippines	Imelda Bacudo	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	F
58	Philippines	Danilo Santiago Hilario	Philippine Atmospheric Geophysical and Astronomical Services Administration	M
59	Philippines	Flaviana Hilario	Philippine Atmospheric Geophysical and Astronomical Services Administration	F
60	Russia	Evgeny Tsvetnov	MSU Center for Food Security, Russia	M
61	Russia	Vladimir Kattsov	Voeikov Main Geophysical Observatory	M
62	Thailand	Jintana Chancharoenrit	Ministry of Science and Technology of Thailand	F
63	Thailand	Pongpannee Poomikhet	Ministry of Science and Technology of Thailand	F
64	Thailand	Porrames Amatayakul	Thai Meteorological Department	M
65	Thailand	Songkran Agsorn	Thai Meteorological Department	M
66	Thailand	Sotharat Insawang	Thai Meteorological Department	F
67	UK	David Rogers	Global Facility for Disaster Reduction and Recovery, World Bank	M
68	USA	Chih-Pei Chang	Naval Postgraduate School	M
69	USA	A.G. Kawamura	Solutions From the Land	M

No.	Economy	Name	Affiliation	Gender
70	USA	James Hansen	The International Research Institute for Climate and Society, Columbia University	M
71	USA	Jo Leslie Eimers	U.S. Geological Survey	F
72	USA	Bin Wang	University of Hawaii	M
73	Viet Nam	Tran Thi Van	Administration Department, NHMS	F
74	Viet Nam	Huynh Van Khoi	Business Forum Newspaper	M
75	Viet Nam	Nguyen Ngoc He	Can Tho City	M
76	Viet Nam	Nguyen Thi Kieu	Can Tho City	F
77	Viet Nam	Le Sy Vinh	Can Tho Hydro- Meteorological Province Station, Southern Central Regional Hydro-Meteorological Center, NHMS	M
78	Viet Nam	Le Nguyen Minh Huyen	Can Tho Newspaper	F
79	Viet Nam	Do Tien Khang	Cuu Long Delta Rice Research Institute	M
80	Viet Nam	Doan Manh Tuong	Cuu Long Delta Rice Research Institute	M
81	Viet Nam	Tran Thi Kieu Trang	Cuu Long Delta Rice Research Institute	F
82	Viet Nam	Chau Minh Khoi	Department of Agriculture & Applied Biology,	M
83	Viet Nam	Tran Dai Nghia	Department of Agriculture and Rural Development	M
84	Viet Nam	Phan Thanh Truc	Department of Agriculture and Rural Development of Can Tho of Viet Nam	F
85	Viet Nam	Tran Thi Kim Thuy	Department of Agriculture and Rural Development of Can Tho of Viet Nam	F
86	Viet Nam	Nguyen Hieu Trung	Department of Environment & Natural Resources,	M
87	Viet Nam	Nguyen Thi Cam Uyen	Department of International Cooperation, MONRE	F
88	Viet Nam	Pham Phu Binh	Department of International Cooperation, MONRE	M
89	Viet Nam	Le Minh Nhat	Department of Meteorology, Hydrology and Climate Change, MONRE	M
90	Viet Nam	Tran Duy Hien	Department of Science and Technology, MONRE	M
91	Viet Nam	Truong Hanh Nguyen	Ethnic Minority and Development Newspaper	F
92	Viet Nam	Nguyen Linh Ngoc	Ministry of Natural Resources and Environment	M
93	Viet Nam	Hoang Phuc Lam	National Hydro-Meteorological Service of Viet Nam	M
94	Viet Nam	Do Quynh Hoa	National Hydro-Meteorological Service of Viet Nam	F
95	Viet Nam	Le Ngoc Quyen	National Hydro-Meteorological Service of Viet Nam	M
96	Viet Nam	Luong Huu Anh	National Hydro-Meteorological Service of Viet Nam	M
97	Viet Nam	Nguyen Quang Ha	National Hydro-Meteorological Service of Viet Nam	M
98	Viet Nam	Tran Hong Thai	National Hydro-Meteorological Service of Viet Nam	M
99	Viet Nam	Dao Anh Dung	People's Committee of Can Tho City	M
100	Viet Nam	Le Phuong Bang	People's Newspaper	M
101	Viet Nam	Tran Thi My Hanh	People's Newspaper	F
102	Viet Nam	Tran Thuan Phuong Thuy	Radio and Television of Can Tho City	F
103	Viet Nam	Huynh Van Xay	Rural Newspapers Today	M
104	Viet Nam	Tran Minh Truong	Saigon Liberation Newspaper	M
105	Viet Nam	Tran Hoai Phuong	Science and Technology Department of Can Tho	F
106	Viet Nam	Dinh Thai Hung	Science Technology and International Cooperation Department, NHMS	M
107	Viet Nam	Hoang Trong Thang	Science Technology and International Cooperation Department, NHMS	M

No.	Economy	Name	Affiliation	Gender
108	Viet Nam	Vu Thi Phuong Thanh	Science Technology and International Cooperation Department, NHMS	F
109	Viet Nam	Đoan Quang Tri	Scientific and Technical Hydro-Meteorological	M
110	Viet Nam	Pham Van Hao	Television Can Tho	M
111	Viet Nam	Tran Minh Khai	Television Vinh Long	M
112	Viet Nam	Tran Thuy Hang	Television Vinh Long	F
113	Viet Nam	Dong Huu Nghi	The Voice Of Ho Chi Minh City People	M
114	Viet Nam	Nguyen Huu Trai	The Voice of Viet Nam	M
115	Viet Nam	Pham Van Hai	The Voice of Viet Nam	M
116	Viet Nam	Do Thi Hoa Nam	Viet Nam Institute of Meteorology, Hydrology and Climate Change	F
117	Viet Nam	Le Van Phat	Viet Nam Institute of Meteorology, Hydrology and Climate Change	M
118	Viet Nam	Nguyen Van Thang	Viet Nam Institute of Meteorology, Hydrology and Climate Change	M
119	Viet Nam	Phan Thi Anh Tho	Viet Nam Institute of Meteorology, Hydrology and Climate Change	F
120	Viet Nam	Mai Van Khiem	Viet Nam Institute of Meteorology, Hydrology and Climate Change	M
121	Viet Nam	Tran Dieu Thuy	Viet Nam News Agency	F
122	Viet Nam	Nguyen Vu Can	Vietnam's Communist Party Newspaper	M
123	Viet Nam	Phan Van Anh	VOV (Media)	M
124	Viet Nam	Bui Lan Anh	VTC (Media)	F
125	Viet Nam	Nguyen Van Thuyen	VTC14 (Media)	M
126	Viet Nam	Tran Thanh Chuong	VTV Can Tho	M
127	Viet Nam	Quach Minh Ngoc	Weather News Inc.	F