

# PROCEEDINGS OF THE APEC CLIMATE SYMPOSIUM 2018

OVERCOMING THE CHALLENGES OF AN UNCERTAIN FUTURE WITH ENHANCED CLIMATE  
INFORMATION AND SERVICES

PORT MORESBY, PAPUA NEW GUINEA

AUGUST 21-23, 2018

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This document summarizes the presentations and discussions from the APEC Climate Symposium (APCS) 2018, held in Port Moresby, Papua New Guinea at the International Convention Center on August 21-23, 2018

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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.*



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## **Overview**

1. The APEC Climate Symposium 2018 was conducted from August 21-23, 2018 at the International Convention Center in Port Moresby, Papua New Guinea. The meeting of the APCC Working Group was also held in conjunction with the event.
2. The event was attended by more than 170 participants from 20 economies – Australia, Chile, China, India, Indonesia, Japan, Korea, Malaysia, Mexico, Nepal, Papua New Guinea, Peru, the Philippines, Sweden, Chinese Taipei, Thailand, United States of America, Turkey, Vanuatu, 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, water resources, energy, economics, international development, and decision-making were invited to speak about and discuss the impacts of climate change on and the use of climate information for food and water security and decision making process. A complete list of participants can be found in Annex I.

## **Executive Summary**

3. The APEC Climate Symposium 2018, which focused on “Overcoming the Challenges of an Uncertain Future with Enhanced Climate Information and Services,” aimed to improve understanding and utilization of climate science and applicability in ensuring water food security with theme of regional scale climate forecast information and services.

In the opening and keynote, speakers highlighted the importance of employing science and technology to bridge the gap between climate and application and between scientists and policy-makers to manage climate change. Special focus on *Climate Change and our Challenges* was dealt in keynote session which provided overview of regional and global issues of enhancing climate forecast and service and promoting the utilization of climate science in various sectors. Also the importance of climate information and services to policy-making process was highlighted in the face of climate change.

The first session, *Enhancing Climate Information Applications*, focused on the challenge and success for more accurate climate forecast information and the efforts for producing region-specific climate forecast information to be applicable to agricultural and water resource sectors and decision-making practices.

The second session, *Improving Water and Food Security with Climate Information and Services*, discussed the strengths and limitations of current climate forecast systems with respect to various application sectors and a wide variety of application status of climate information and services for water and agricultural sectors in various regions.

Finally, in the third session of *Linking Climate Information and Decision Making*, topics connecting climate information and decision-making from frameworks to region-specific application that enables utilization of uncertain climate information in policy development were discussed.

To close the event, a final panel session was held. Experts brought together their varied experience and knowledge to build a more cohesive idea of how to employ climate science and technology to strengthen regional water and food security. The panelist also suggested the ways of linking climate information to decision making process by giving statements.

## **Opening Ceremony**

4. The APEC Climate Symposium 2018 opened on Tuesday, August 21, 2018. 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 Papua New Guinea National Weather Service, Climate Change and Development Authority of Papua New Guinea, Papua New Guinea Science & Technology Council Authority, the Central Weather Bureau of the Chinese Taipei for their help putting together the event. Ms. Moon then introduced Prof. Dong-In Lee, the Chairman of Board of Trustees of APCC, for his Opening Remarks. Prof. Lee 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 John Thomas Pundari, Minister of the Ministry of Environment & Conservation and Climate Change of PNG had his Welcome Remarks. He spoke about the importance of timely, high quality and accessible information in decision making process to manage climate change for Papua New Guinea, and gave a warm welcome to all the participants. This was followed by the Congratulatory Address by Ambassador Ivan Pomaleu, APEC 2018 Senior Officers Meeting Chair, who highlighted the connectivity between science and technology and well-informed decision making under the theme and priorities of APEC 2018. He also welcomed all participants to the meeting to have a fruitful discussion. Then, Dr. Tien-Chiang Yeh, Director-General of Central Weather Bureau of the Chinese Taipei gave a Congratulatory Address with the emphasis on the importance of climate information and services to manage the uncertain future especially to the Asia-Pacific region where the natural disasters prone to occur and the need of all member economies efforts as a group to benefit all. Dr. Yeh also thanked APCC and PNG government for organizing the event. The opening ceremony was followed by the presentation of commemorative plaques of appreciation from APCC to the Climate Change and Development Authority under the Ministry of Environment & Conservation and Climate Change of PNG, Papua New Guinea National Weather Service under the Ministry of Transport and Infrastructure of PNG, Papua New Guinea Science & Technology Council Secretariat, and Central Weather Bureau of the Chinese Taipei. The session was closed with a group photo.

## **Keynote Session: Climate Change and Our Challenges**

5. The Keynote Session commenced at 10:30 a.m. and consisted of the speeches by two distinguished experts on climate change and institutional collaborations. The main theme discussed by the two speakers and the participants was how to efficiently connect scientific knowledge and actions to cope with climate change impacts. The

session was chaired by Dr. Jin Ho Yoo, the Acting Director of the APEC Climate Center.

**6. Prof. Mark Howden, Director of Climate Change Institute, Australian National University, “Climate Change: Connecting knowledge and Action”**

Showing the rising temperatures and agricultural risks to the audience, Professor Mark Howden, the Director of Climate Change Institute at the Australian National University, began the first keynote speech about challenges in linking between scientific knowledge and actions. He listed several reasons why humans have limited capability to perceive the risk of climate change. Despite clear signals of the globally rising temperatures and increasing climate extremes (e.g., flood and drought), humans seem to perceive climate change as distant and abstract risks when comparing to other confronting and urgent issues in their societies. He also pointed out the substantial economic and societal costs that have prohibited formulating actionable strategies to cope with climate change impacts. By comparing it to the climate-driven frameworks that have been commonly employed in the scientific community, Prof. Howden introduced the decision-centric framework that enables clear visualization of climate change risks. He emphasized that paradigm shifts from the climate-centered knowledge production to value-centered platforms would lead to participatory researches, thereby connecting the scientific community to real-world problems and actionable strategies. It was also highlighted that climate forecasts should be utilized with careful consideration of sociological, psychological, and institutional aspects together with their limitations so as to encourage humans to deliver proper actions for reducing climatic risks. He ended up his speech with a re-emphasis on integration of climate sciences and action plans from participatory, strategic, and proactive decision-makings for efficient risk reduction.

**7. Mr. Edward Vrkic, Senior Advisor – Climate Change of United Nations Development Programme, “Is It Time to Think about Climate Change as Weathernomics?”**

Beginning the second key note speech, Mr. Vrkic left a short comment on the UNDP’s keen interest and difficulties in mitigating climate change impacts in the developing world. He provided a metaphoric anecdote about the failure of economists to predict the 2007-2008 financial crises. The cultural and inter-historical prediction was that the British would not be hit by the economic hurricane, while, in reality, the U.K. was badly damaged by the economic hurricane. He pointed that weather, climate, and economic forecasts rely on data, interpretation, and instincts to provide us early warnings about impacts of upcoming issues. He exemplified the evolution of the APEC economy to show the importance of balance between social and human development and energy consumptions. The APEC economy has been rapidly growing for past twenty years and became a valuable economic region. The GDP of the APEC accounts for approximately a half of the world GDP. 41% of the world

population is living in the APEC region. However, in response, energy consumptions across the APEC region also rapidly increased together. The question arose here is how to balance between human development and impacts of climate change. He indicated that the APEC region is particularly vulnerable to natural disasters during the period of the rapid development. Mr. Vrkic commented that the United Nations has been a good partner for searching innovative approaches to overcoming challenges, emphasizing that the key is how to translate different perspectives and knowledge into actionable strategies. He also argued that non-traditional paths and financial sources would be required for overcoming non-traditional challenges. Mr. Vrkic urged to collaborate between private and public sectors to find economic sources for upcoming climatic challenges. To find long-term and sustainable solutions, he encouraged to move beyond the past narratives. We clearly have scientific evidence of climate change sufficiently, but what we are missing is actions that can boost people's perception of climate change risks. At the end, he re-emphasized the point that individuals cannot easily grasp the climate change risks, and thus the concept of climate change should evolve over time together with related policies toward leading people to better understanding of what climate change is and what are its consequences. It was commented that the better human stories will be helpful for the challenging goals.

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

The discussion began with a question from the audience asking how to connecting stakeholders under their changing interests and surrounding conditions. Prof. Mark Howden answered that fast technological innovations and environmental conditions should be appropriately adopted in the policies with consideration of traditional perspectives. The social norms are sometimes very strong, and prohibit employing new technological innovations. However, he commented that social norms also change slowly with time, and thus approaches posing acceptable changes in social norms will be available and applicable. The second question was in a similar context with the first question what if the transformational changes roll back and/or cannot be made. Prof. Howden agreed that the social changes can be very difficult and be made in destructive ways. For example, converting energy productions from non-renewable sources to renewable ones can destruct existing energy industries. He recommended cautious approach by balancing between existing environments and the innovations for climate change by providing an example of the efforts coping with the mega droughts in Australia. Mr. Vrkic also commented on the difficulty in the transformational changes. He mentioned that there may be long term strategies for slow societal changes rather than short-term big movement. Following questions from the audience were how to encourage participatory research, how to make organizations departments cohesive to make action plans, and how to make stories about climate changes more interesting thereby improving people's the perception of climate change risks. As a reply, Mr. Vrkic listed some requirements, for example, simplifying messages from scientific research and clearly identifying what actions are

required in societies. Prof. Howden added some more requirements such as monitoring people's evaluations about the action plans and policies that allow valuation of action plans. He also recommended that probabilistic forecasts for weather and climate in a defensive manner would prevent wrong deterministic forecasts. Another question followed was what the APEC economies should do for weathernomics. In addition, the audience and Mr. Vrkic had a little discussion on the weathernomics for the APEC economies that can encourage leading discussion between sectors into actions. The audience and the two speakers had some discussion on psychological aspects of climate change perception and difficulties to demonstrate effectiveness of policies. Prof. Howden commented that sometimes detailed analysis and data are unnecessarily required for big decisions despite their importance. One more question from the audience was given and ask how stakeholders should negotiate. Prof. Howden made a comment that urged conversations between stakeholders to disentangle complicated matters. He emphasized conservatism in social values rather than conservatism in actions, which may become a philosophical solution. In addition, Mr. Vrkic emphasized socialization and simple messages again. The last question was to ask advices to use available climate data. The two speakers commented challenges in researches on climate change and disaster management (e.g. poor data accessibility). The value change in climate data and services was listed as an important arena for research sectors. Finally, Dr. Jin Ho Yoo closed the keynote session with his gratitude to the audience and the two speakers.

## **Session I: Enhancing Climate Information Applications**

9. Session I started at 13:30 of August 21. This session discussed about enhancing climate information applications. In the perspective of the climate information producer, how the climate information can be provided effectively, satisfying the requests of the end-users. This session was chaired by Prof. Simon S. Y. Wang from the Utah State University.
10. **Dr. WonMoo Kim, Research Fellow of APEC Climate Center (APCC), “Gaps and Opportunity in climate information services”**

Dr. WonMoo Kim started his presentation from stating that current climate prediction system can provide useful prediction information for sectoral applications over the subseasonal, seasonal, and climate projection time scales. And Dr. Kim introduced about the efforts of the APCC in climate information services. The APCC are providing seasonal prediction information (global temperature, precipitation, and ENSO, etc) from APCC MME system whose predictive skills are continuously improved and also exploring the prediction potential of the MME for important climate variables, including BSISO, MJO, and Ural Blocking, on the subseasonal time scales. He also introduced that APCC also performed some projects on the application of the seasonal prediction information to the application sectors. There has been noticeable progress in climate prediction information over the subseasonal, seasonal, and climate projection time scales. However, there are rooms to fill including the poor understanding of uncertainty and huge gaps between the climate information and its application in sectoral levels. Particularly, he noted that the gaps could cause the climate information to be incorrectly transferred to the application sectors, resulting in misleading their policy and decision making. APCC is making great efforts to bridge climate information and interdisciplinary application. Furthermore, APCC performed the various climate services in the Pacific regions where the prediction skills are highest but it is less utilized. Pacific islands are very vulnerable to hazardous climate events over subseasonal-seasonal-climate projection scale. Among the APCC climate services, PICASO is a tailored seasonal prediction system for the national meteorological services in the Pacific, sectoral applications in agricultural and water management and it can provide not only the various climate prediction information but also how to interpret the information. PICASO can provide climate prediction information with higher reliability than both dynamical and statistical models. APCC also held some workshops and training programs for building their own capacity to produce the climate prediction information. In conclusion, he noted that what we learned from success and failure in APCC climate services is that the climate information should reflect the end-users' needs, utilize cutting-edge science and technology, and should be produced, understood, and maintained by the users.

**11. Prof. Simon S. Y. Wang, Associate Professor of Utah State University, “Enhancing climate prediction information by capturing where people aren’t looking”**

Dr. Wang listed things where people aren’t looking in climate prediction information. These are Processes of extremes, sources of predictability, and education. Then, Dr. Wang highlighted that the one solution to enhancing climate prediction information lines in education. In other words, we should build some academic degrees for climate forecaster or climate communicator. He noted that there are gaps between provider and end-user in terms of climate information. He noted that climate prediction can be done over the various time scales (e.g., weather, subseason to season, decades) regarding climate prediction. He also noted the future projection of extreme events as a climate prediction, with introducing some extreme events occurred in Korea and Japan in 2018. He stated that the goal of the climate prediction is approximately same as that of climate information. He introduced how the U.S does regarding climate prediction information. He stressed the climate information should be based on “bottom-up information development”, citing statements by some scientists. He noted that the more localized climate information should be provided in the U.S to meet user needs, although the US have regional centers to handle and deliver climate information. Furthermore, he noted that good translators, who have both localized knowledge and meteorological professionalism, to connect between climate information producers and end-users are needed for enhancing climate information. For good translators, he stressed that degrees in more various climate-related fields such as climate science, climate communication, and climate informatics, should be opened in the university.

**12. Mr. Philip Malsale, Climatological Officer of Secretariat of the Pacific Regional Environmental Programme (SPREP), “Dynamical, statistical and traditional climate forecasting in the Pacific Island Countries: What we do now and challenges for future”**

Mr. Philip Malsale noted that SPREP tailored some statistical models (e.g., SCOPIC) and dynamical models (Clik-P, PICASO) through various projects and provided to the national meteorological services (NMSs) in 11 Pacific Island Countries (PICs). SCOPIC is a first statistical seasonal forecasting system which has been used in the PICs since 2000s. The main dynamical models that use in the PICs include POAMA by BOM, Australia, and CLIK-P and PICASO by APCC, Korea. He also noted that The dynamical models overperformed the statistical models and it is expected that the future increase in prediction accuracy is possible with dynamical models when new science, better modelling techniques, more observations and greater computer power are introduced. He introduced how the traditional knowledge (TK) on climate indicators in the PICs can be incorporated in the climate information from the models. He stressed that combining the TK with the climate forecast information could be more effective for communicating with the PICs communities because they have

relied on the weather and climate forecasts based on the TK. The NMS that have benefited from using the tools can now provide better climate forecast information than the previous. He concluded that challenges for the future is use of higher resolution models, data sharing, more observing sites, and combination of traditional knowledge and modern science for weather and climate forecasts.

**13. Dr. Rebecca a. Bolinger, USA, Colorado Climate Center, Colorado State University, “Developing a regional drought outlook product using seasonal forecast information”**

Dr. Rebecca Bolinger introduced that the US is operating the US drought monitoring system which is used to activate state and local level drought response plan. She noted that because the drought, in terms of definition, indicators, and impacts, is different greatly from region to region, the regional Drought Early Warning System (DEWS) was created and increased regional drought monitoring has led to improvement in drought early warning. She also noted that in terms of seasonal prediction of early warning, NOAA releases national monthly and seasonal drought outlook products but this information is a little far from the usefulness for decision making. She highlighted that we should communicate climate outlooks in a way that is meaningful to the climate information users and we need products that show the probable range of outlooks, communicate uncertainty, give historical context (historical extremes, normal etc.) that people understand, orient people to identify what’s normal and what’s extreme, and provide the information in a way that people can use it to better understand and/or make a decision.

**14. Prof. David Letson, Professor of University of Miami, “Agroclimate for climate – smart agriculture”**

Prof. David Letson introduced AgroClimate which is an innovative web-resource for decision support and learning, providing interactive tools since 2005. It is dedicated to translate climate and weather information (e.g., monitoring/weather forecast, seasonal climate outlook, and long-term climate projections) into decision to help producers reduce risk. Considering the impact of the ENSO on rainfall and temperature in the US, the AgroClimate provides climate information (rain, risk factors in planting) based on ENSO phase (El Nino, neutral, La Nina). He noted that Agroclimate can be extended for economies with no station-based weather data or field trial results widely available. He also noted that the whole website is easily managed and even by person who has no computer programing experience and it works very well in the locations with limited internet.

**15. Prof. Alberto Troccoli, Co-founder and Managing Director of World Energy & Meteorological Council, “What can European climate services offer to the energy and water resource sector”**

Prof. Troccoli started his talk with the intimate relationship between energy and climate over various time scales. He noted that the relationship makes meteorological/climate forecasts allow to be utilized for energy use and energy decisions. He also noted that the energy systems are already experiencing sizable climate impacts, which are likely to become more severe. Therefore, the goal of the WEMC is to enable improved sustainable energy, resilience of energy infrastructures, and efficiency under changing weather and climate of energy systems. He mentioned that climate services regarding seasonal climate forecast, climate projections, but also reconstructions of the past are emerging as useful tools for energy planning, and operations/maintenance. He introduced a demonstrator which was developed by C3S ECEM to assess how well different energy supply mixes in Europe will meet demand, over different time horizons, focusing on the role climate has on the mixes. He showed some examples of services obtained from the demonstrators and also showed prediction skills of seasonal forecasting systems used in C3S ECEM. Other than the utilization of the climate information in the energy sector, he also stated the use of seasonal climate forecasts in water industry. He concluded the presentation stating that the despite emerging use of climate in energy sectors, there is a strong need to improve knowledge of meteorological data and processes and to improve access to meteorological and energy data for improved products.

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

First, each speaker of the Session I mentioned important points from their presentations and all highlighted again when the climate information is provided, provider should consider how meaningfully and effectively the information could be utilized for people in various sectors from relevant stakeholders to end users.

An audience posed two questions for Prof. Wang. The first one addressed extension service, inquiring how the extension system presented, including main actor and management works. Prof. Simon responded saying that although there is a certain limitation to educate students as school faculty has a large amount of works in university; the US is working effectively by separating their faculty's task clearly. It gives them an opportunity to interact with people in climate-related field and build capacity of work as climate communicator. The second question was about the climate informatics, asking whether it is already applied in the field. Prof. Wang explained that big data has been a great item a few years ago in the US and climate being one of initial purpose, they made efforts to develop the climate informatics with programmers. He encourages promoting climate informatics by bringing multiple disciplines together to advance climate informatics as a way forward.

Another audience posed three questions. The first addressed CLIK-P forecast tool, asking which region CLIK\_P can be applicable to. Dr. WonMoo Kim from the APEC Climate Center responded saying that although the CLIK\_P is dedicated for pacific region, its general version with the global scale which is CLIK can be applicable to APEC member economies. The second was about AMO (Atlantic multidecadal oscillation), asking if AMO has been considered in his project on ArgoClimate. Prof.

David Letson from the University of Miami explained that AMO does not exert as powerful influence. However, they reported seasonal outlooks and discussion of tropical cyclone due to relevance of tropical cyclone activity to AMO.

One of the APEC representatives from the Ministry of Agriculture and Rural Development of Viet Nam highlighted that economies like Viet Nam are more concerned about forecasting extreme weather events and; thus, asked a question about the means of effective communication to translate the forecast information to end-users, especially farmers more effectively and possibility of using drought monitoring and early warning system. Dr. Bolinger from the Colorado Climate Center replied that it will be more valuable to provide forecast measure to specify threshold of information each users require rather than providing the average as extreme forecast information each individual seeks may be different from one another. Prof. Wang added that by considering region's specific characteristic and regional weather system, coupled with seasonal forecast will help provide forecast information for extreme weather event.

An audience noted that Pacific Island States need more information on climate change to better understand what climate change means to people in a long term rather than climate variability. Dr. Bolinger mentioned that there are demands for short-term climate information as well as long-term climate information like climate change depending on region. So they strive to turn climate information into useful information for respective demands.

One of participants noted that it is very important to translate climate information to economic point of view relevant to agriculture and food production to benefit agricultural sector by enhancing economic gain. In doing so, climate information interpreter or translator will have an important role in the future; thus, Met. Services of each economy are encouraged to work towards boosting climate extension to bridge the gap.

Session chair concluded this session highlighting that we need to build capacity of fresh graduates to be a good communicator to connect the climate information to the end-users.

## **Session II: Improving Water and Food Security with Climate Information and Services**

17. The morning session of August 22 commenced at 09:00. Session II discussed various adaptations for the enhancement of water and food security. Diverse theoretical and practical approaches were introduced in this session from crop physiology to glacio-hydrology or from a leaf-scale to global-scale. The Session was chaired by Dr. Jong Ahn Chun from the APEC Climate Center.

**18. Dr. Toshichika Iizumi, Senior Researcher of National Agriculture and Food Research Organization (NARO), “Global Crop Yield Forecasting Using Seasonal Climate Information from a Multimodel Ensemble”**

Dr. Toshichika Iizumi started off the session with a presentation on how climate change and variability can affect global crop production. He gave a brief overview of global food demand as well as global production changes of the four major crops (Maize, Wheat, Rice, and Soybean) including major production economies from 1980 to 2008. He noted that the yield growths of the four major crops at the global-scale would stagnate with global warming and displayed this yield growth stagnation with the four warming ranges (i.e., warming > 1.8°C, warming > 2.7°C, warming > 3.2°C, and warming > 4.9°C). He also noted that warming effects would lead to an increase in crop yield variabilities. Iizumi noted that climate extremes could contribute to food price spikes through a graphical description. He introduced several monitoring systems including Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM) and the Agricultural Market Information System (AMIS). Iizumi introduced a joint research between NARO and APCC on seasonal climate forecast data for global crop forecasting, after he suggested that crop forecasts could be an option to reduce the negative impacts of climate change and variability on crop production. He showed that reliable within-season predictions of yield variability are feasible in 25—38% of global harvested area, enabling us predicting national average yield variability for a substantial portion (24—36%) of the crop-producing economies. He expected that these findings lead to an operational global crop forecasting service and noted that NARO and APCC are preparing for test operation of crop forecast in 2019/2020.

**19. Dr. Dennis Timlin, Research Soil Scientist of United States Department of Agriculture (USDA) - ARS Adaptive Cropping Systems Laboratory, “Incorporating CO<sub>2</sub> Responses into Crop Simulation Models”**

Dr. Dennis Timlin began his presentation with an overview of changing climate conditions in the USA, noting that increases in temperature, precipitation intensity, and atmospheric carbon dioxide concentrations lead to changes in growing seasons and precipitation and increases in flood and drought events. He explained the brief

“history” of crop model and addressed potential uses and limitations of crop models. He also listed several reasons why new crop models are required to develop: 1) Theories and data for many of the current models from 30-40 years ago, 2) Necessity of calibration for any new situation, 3) New technologies to better quantify plant and soil processes, and 4) Theoretical advances in our understanding of plant physiology and environmental physics. He then introduced facilities, the Soil-Plant-Atmosphere-Research (SPAR) chambers, to improve understanding of photosynthesis and canopy development in response to water and temperature stresses, and CO<sub>2</sub>. He also explained the characteristics of those SPAR chambers. The SPAR chambers use natural sunlight and soil volume (larger units), control and monitor aerial and soil environments, monitor whole canopy gas exchange (Photosynthesis, Respiration, Transpiration), and measure gas leakage rates with a N<sub>2</sub>O system to maintain accuracy. Finally, he gave a few findings from those SPAR chambers and applications of crop models. For examples, he showed experimental results leaf addition rates in Potato as a function of temperature and leaf areas simulated by the MAIZESIM model.

**20. Dr. Ramakrishna Akkinapally, Deputy Director-General of PNG National Agricultural Research Institute (NARI), “Adaptation Options for Climate Sensitive Development”**

Dr. Rmakrishna Akkinapally began an explanation with global climate change by noting rising average temperatures, precipitation pattern changes, and sea-level rise. He then discussed the impacts of climate change on coastal ecosystems, agricultural crop, livestock and forest productions, and water resources. Akkinapally proposed the five key components of new and innovative adaptation measures to climate change: 1) Changes in agricultural practices to improve soil fertility and enhance carbon sequestration, 2) Changes in agricultural water management for more efficient water use, 3) Agricultural diversification toward enhanced climate resilience, 4) Agricultural science and technology development, 5) Agricultural advisory services, and information systems; and risk management and crop insurance. He also emphasized on several approaches to build resilience through resource-conserving technologies, the promotion of research and development, and the support knowledge exchanges. Akkinapally discussed efficacious ways to disseminate adaptation strategies to climate change in PNG and noted several tactical approaches to enhance farmers’ capacity to resilience. He addressed an issue on how to efficaciously disseminate those information and agricultural advisories from an information center to remote areas such farming and rural communities. Lastly, Akkinapally also noted water security and proposed an integrated management system to effectively distribute water resources with an upland reservoir, gravity-fed and drip irrigation systems, and lowland reservoir.

**21. Prof. Nüket Sivri, Professor of Istanbul University - Cerrahpasa, Environmental Engineering Department, “Impacts of Climate Change on Turkey's Water Resources”**

Prof. Nüket Sivri began a presentation with an overview of Turkey, noting Turkey's special water resources and impacts of climate change. She also explained main adaptation steps to mitigate effects of climate change on water availability in Turkey. Sivri introduced basic and general statistics on Turkey (e.g., geographical location, total area of the economy, population, brief history, and administrative districts). She showed a map which depicts surface water resources such as lakes and rivers in Turkey. However, she noted that most of those surface water resources are classified as brackish water, saline water or soda water, because of the three seas surrounding the economy. Sivri noted that economically exploitable water amount in Turkey is limited by showing a diagram. Even though the mean annual precipitation in Turkey is approximately 501 km<sup>3</sup>/year, the diagram displays that the usable water per year is only 112 km<sup>3</sup>/year. She also emphasized that due to growing population, rapid urbanization and industrialization, the economy is projected to be a water-stressed economy by 2030. She gave examples which show climate change impacts on water resources in Turkey. For example, the surface area of salt lake has been decreasing mainly due to climate change. She introduced weather extreme events (e.g., extreme precipitation) to cause natural disasters including flood or damages to infrastructures including a bridge.

**22. Prof. Rijan Bhakta Kayastha, Associate Professor of Kathmandu University, “Use of Climate Information in Nepal for Water and Food Security”**

Prof. Rijan Bhakta Kayastha began his presentation with a brief overview of Nepal, showing the five physiographic divisions (Terai: <500m, Siwalik Hills: 500-1000m, Mid-Hills: 1000-2000m, High Mountains: 2000-5000m, and High Himalaya: >5000, geographical location, and climatic conditions. Especially, he provided more detailed hydrological and meteorological information including monitoring networks for weather and stream flows in Nepal. The glacierized-sub river basins in Nepal were also presented and explained by him. He noted that the annual maximum and minimum temperature trends were +0.056 and 0.002 °C/year from 1971 to 2014, respectively and explained decreases in glacier area (24% from 1977 to 2010) in Nepal using those warming trends. He presented several pictures to show the decreases in glacier AX010 in Shorong Himal. Interestingly, he also explained that these decreases in glacier can cause increases in the surface area of a lake with an example of Tsho Rolpa Glacial Lake (Dolakha). Kayastha introduced a flood early warning system in Nepal by integrating satellite based monitoring and ground-based monitoring networks. An early warning system in Banke district was given as an example of this system. He also gave an example for agricultural sector, Agriculture Management Information System (AMIS). The eight pilot districts for the AMIS system were presented: Dhankuta, Sunsari, Siraha, Bara, Kavre, Rupendhei, Jumla, and Banke.

**23. Prof. Joon Ha Kim, Director of International Environmental Research Institute, Gwangju Institute of Science & Technology, “New Era of the 4th Industrial Revolution & Climate Change”**

Prof. Joon Ha Kim began his presentation with an overview of greenhouse gases impacts on species reduction. He explained how climate change makes “FEW” issues by providing interesting statistical data for Food, Energy, and Water. He also gave examples which “imagination” will be “realized” with the two pictures in 1900. Then he introduced the definition of the 4th industrial revolution by referring to World Economic Forum: “The 4th revolution is characterized by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres.” He emphasized on a role of big data with other key technologies for the 4th industrial revolution: IoT sensors, 3D printing, Virtual reality, Bio-tech, Drone, and AI robot. Kim showed several very interesting video clips on self-driving car and AI robot. He gave an example of adaptation to climate change using big data. In a climate big-data connected smart city, a few systems associated with weather and climate are proposed: Integrated disaster management system, Urban heat circulation design and management, Smart farm based on high-quality weather data, Water disaster prevention system, Early warning system, and Integrated water resource management. Kim then explained those systems in detail. For example, an integrated disaster management system may consist of database construction, early warning system for city disaster, monitoring system based on IoT, and disaster response decision support system. Finally, he suggested that “connectivity”, “convergence”, and “communication” are required for the era of the 4th industrial revolution climate change, new-normal, post-human, and intelligence connected society.

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

Prof. Alberto Troccoli from the World Energy & Meteorology Council posed question to Dr. Dennis Timlin from the United States Department of Agriculture on how he predicts the crop yield with climate variability using the simplified crop modeling. Dr. Timlin responded that they simulate topography of land as well as temperature variation on small pieces of lands which will be aggregated to larger pieces and have them interacted to each other and come up with the crop yield. In aggregating the results, they are facing challenges of some variations of predictions and MME will be able to put more strength to the results. Also, Dr. Iizumi from the National Agriculture and Food Research Organization of Japan added that there exists still a large gap between large and more detailed scale-based approach to understand crop growth. He explained that his global scaled crop yield study is principally based on knowledge from crop modeling such as in which crop growth stage climate condition is more sensitive to form the crop yield, etc. due to current seasonal climate forecast being reliable at aggregate scale on 3 months average, while detailed crop modeling, analyzing day to day variability is more influential for crop growth.

Dr. Marjuki from Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) made a comment to Dr. Ramakrishna Akkinapally from the National Agriculture Research Institute of PNG that BMKG and PNG National Weather Service(NWS) collaborated and developed a drought monitoring system on November 2017 for PNG. This System contains GIS map and displays forecasts of rainfall for 1 month and 3 months and currently being improved with new features. He advised to connect and share information with PNG NWS. Dr. Akkinapally agreed on his points and added that 3 months is very long duration and shorter time scale down to 15 days to 1 week is what he would like to have for more effective drought monitoring in PNG.

Dr. Elisabeth Simelton from the World Agroforestry Center noted that the importance of water quality in addition to water quantity for agriculture in South East Asia and advocated crop modellers to take that factor in count and Dr. Timlin agreed on that.

One of audience shared her concern on how to balance between rapid changing innovative technology and our adaptation which takes some time. Dr. Joon Ha Kim from Gwangju Institute of Science and Technology explained it is a role of government to narrow down the gap between innovative technology and people's daily lives by articulating social policy and regulation set up. Another question posed from the floor was about controlled-environment for agriculture. Dennis mentioned that the controlled-environment for agriculture will bring a number of benefits to the society by protecting the crop from disease or insects as well as maintaining optimal growing conditions for the crop growth. For instance, some of the industrial factories are growing vegetables with low sodium to be provided to people in hospitals in Japan. Currently, limiting factors of growing plants indoors is the cost for electricity, lights and heating and this does not make it more compatible. Once cost goes down, he sees its potential to be very positive.

### **Session III: Linking Climate Information and Decision Making**

25. The afternoon session of August 22 commenced at 14:00. In Session III, the five speakers in various disciplines discussed about institutional activities and case studies that highlighted the importance of actionable decision making against increasing climatic risks. The session was chaired by Dr. Chalapan Kaluwin from the University of Papua New Guinea.

26. **Dr. Elisabeth Simelton, Climate Change Scientist & CCAFS Project Manager, World Agroforestry Center, “Closing Actionability Gaps of Climate Services for Farmers, Agriculture Planners and Advisors – Southeast Asian Examples”**

Dr. Simelton opened her presentation by introducing the agro-advisory activities provided by the research program on the Climate Change, Agriculture and Food Security (CAAFS). The projects across Southeast and South Asia, Africa and Latin America were to develop services and useful tools that linked between climate information and agricultural practices. The outcomes from the projects included systems for real-time spatial crop monitoring, participatory integrated agricultural climate services, supporting activities to meteorological offices in the Southeast Asia. She illustrated a 4-steps value-chain, namely “Production-Translation-Transfer-Use”, which has been traditionally employed in the Climate Partnership. Dr. Simelton argued that disconnections in the process are often from supply-driven, one-way knowledge transfer to end-users. The limited actionability or usability of the climate services can be attributed to gaps and inefficiencies in the value chain. To improve the actionability of the services, she accentuated the five points: availability of, easy access to, timely, understandable, and useful climate information. Together, it was emphasized that one-sided value-chain should be two-sided for all the four steps to encourage participatory scenario planning that enables to connect planners, meteorologists and local stakeholders. She argued that the skill of weather forecasts would become below 50:50 within one or two days, implying low importance of prediction skills of supply-driven deterministic climate forecasts. Rather, demand-driven forecasts considering farmers needs could improve predictability and usability of the climate services. She showed an example that includes participatory scenario planning in Vietnam. The program gathering meteorologists, extension, farmer champions, and organizations together shed light on new insights on preferences in data usage (e.g., different preference by gender). It also showed that the local farmers wanted to have timely information useful for resources management. She re-emphasized the importance of engaging local actors in climate services and building cost-sharing and participatory models, and ended up her presentation.

27. **Prof. Hojeong Park, Professor of KU-KIST Green School, Korea University, “Robust Decision Making Process under Scientific Uncertainty on Climate Change”**

Prof. Park began with an introduction to ECO2NOMICS, which is a new concept for identifying benefits and costs and future values and uncertainty in CO<sub>2</sub> abatement investments. He presented the first to the third generations of decision-making theory under uncertainty, showing specific equations for each one of them. The economic valuation in the first generation pursued the positive net present value (NPV), while the second generation adjusted the NPV by the risk costs. The third generation approach, namely the real option analysis, considers the waiting values in real options, and incorporates uncertainty and irreversibility into economic decision-making processes. He contrasted the definitions of uncertainty and risks to indicate that climate change is a risk rather than uncertainty, because probabilities of unknown outcomes can be measured or learned at least. Subsequently, he showed the 4th generation approach for decision-making with ambiguity, highlighting that earlier investments on the CO<sub>2</sub> abatement are necessary with the ambiguity aversion considering uncertainty on uncertainty. The ECO2NOMICS is a framework within no-regret principle (i.e., precautionary one). Based on the framework, costs for CO<sub>2</sub> abatement are substantial and irreversible. Showing a case study for Cambodia, he argued that immediate investments are necessary to reduce CO<sub>2</sub> emissions when considering ambiguity aversion. For robust decision makings for climate change, it was emphasized that incorporating social costs in market system is crucial. Since well-organized systems are more vulnerable to small stresses, he urged to build flexible systems by embracing the data-driven technology and new frameworks in energy policies..

**28. Prof. Jagath J. Kaluarachchi, Professor of College of Engineering, Utah State University, “Linking Climate to Water Scarcity: Case Studies from the Western Desert of Egypt and the Ganges Delta Region of Bangladesh”**

Introducing that climate change impacts and socio-economic conditions co-develop and pose treats to fresh water availability and societal growth, Prof. Kaluarachchi started his presentation about two case studies for regions with different climates: Siwa Oasis, Egypt (arid) vs. Ganges Delta of Bangladesh (humid). He described the geophysical, climatological, and socio-economical characteristics of the Siwa Oasis, Egypt, and identified the problems in the oasis. Increasing salinity in groundwater, excessive crop water uses, decreasing crop yields have been challenges. The irrigation requirements are expected to increase until 2100 in the Siwa Oasis under a stabilized CO<sub>2</sub> emission scenario (RCP4.5), while much higher and rapidly increasing water uses were expected under a severe emission scenario (RCP 8.5). It was highlighted that crop water uses could affect non-renewable water sources in the Nubian Aquifer, thereby posing threats to water security in the region. Prof. Kaluarachchi presented another case study for the Ganges Delta of Bangladesh that showed the effects of climate variability on fresh water availability. He illustrated the spatial and temporal patterns of climate within the study area, comparing before and after construction of the Farakka Barrage. It was indicated that extreme temperature events (i.e., heat

waves) have been significantly increased, intensifying drought conditions. He also showed that the Farakka Barrage seemed to limit streamflow to the Ganges Delta of Bangladesh, aggravating the decreasing freshwater availability by climatic changes. Together, increasing actual evaporation in the region was listed as a key factor for declining streamflow. In conclusion, Prof. Kaluarachchi summarized the key findings from the case studies for both regions. He also emphasized that proper evaluations are needed before making policies against climate change rather than prejudging with common knowledge. While drying climate is seemingly a problem to the Egyptian Oasis, overexploitation by humans was the main cause of water insecurity. The Ganges Delta of Bangladesh where floods are expected to pose challenges had reducing water availability from climatic changes.

**29. Prof. Chalapan Kaluwin, Professor of University of Papua New Guinea, “Climate Change, Variability and Sea Level Changes Poses Long Term Disasters in Achieving Responsible Sustainable Development in the APEC and Pacific Island States”**

At the beginning, Professor Kauwin asked a question to the audience which planet is the warmest among Venus, Earth, and Mars. Venus with a thick atmosphere containing 95% of CO<sub>2</sub> has a surface temperature of 420 °C, while Mars with a thin atmosphere has very cold surface temperature of -50 °C. He highlighted that CO<sub>2</sub> plays a crucial role in maintaining the earth’s temperature to be within the range for sustainable ecosystems although it accounts for only 0.3% of the earth’s atmosphere. He commented on the increasing atmospheric CO<sub>2</sub> that has been posing the greatest challenges to human-kind as well. The sea surface temperatures and the ocean acidification were illustrated as treats to the Pacific regions. Dr. Kauwin also showed the impacts of the El-Ninō Southern Oscillation (ENSO) on the Pacific regions. Papua New Guinea has been warming since 1945. The sea level rises significantly have reduced land availability, and people’s livelihoods are being physically affected by global warming. He additionally presented the images of climate change impacts on biodiversity, people, water, fisheries, tourism, and forestry and agriculture. By showing pictures of shoreline protective structures and lost biodiversity in the Pacific islands, he again emphasized the impacts of global warming. Dr. Kauwin presented an established approach to deal with hazard and risk management to identify and visualize the risks associated with the climate change. Together, he proposed to apply resilient and sustainable development for the earth’s future. He argued that understanding human vulnerability to climate change and actionable policies are crucial and should be achieved from active communications between stakeholders. Dr. Kauwin ended up his presentation with a suggestion that science, sustainable development, and government policies should be aligned with new emerging issues of “No regret” options.

**30. Hen-I Lin, Director of Center for Science and Technology Policy Evaluation, Chung-Hua Institution for Economic Research, “Connecting Users’ Needs for**

## **Climate Information with Climate Services by Using Economic Benefit Evaluation: the Experiences in Chinese Taipei”**

Dr. Hen-I Lin started this presentation with an introduction to his institution for economic research whose roles are to become a think-tank for government and international polices. He highlighted the organization and human resources of the institution as well. An introduction to geographical environment of Chinese Taipei was provided. Typhoons and rainfall events intensified by warming temperatures were commented as challenges to agricultural communities. Dr. Lin added the cold surges could also influence human health and agricultural productivity. The roles of his team were showed in the presentation: (1) to assist to strengthen the collaboration between government agencies, (2) to develop seamless weather services, and (3) to establish a successful pilot case study for domestic end-users. As a case study, he provided a statistical valuation of weather services. The case study included participatory activities of local agricultural representatives, and suggested the willingness to pay for weather services. The pilot study embarked in 2013 has been developed from the economic valuation to mobile software and agricultural application in 2016 by collaborations between more than 120 participants. He presented several photos to describe the extension and outreach activities of the CIER as well as the mobile application. The economic valuation efforts of the CIER were being extended to energy, health, water resources management, disaster reduction among many other areas. He ended up his presentation with overall outlook of the benefit evaluation project beyond 2020.

### **31. Wrap-up and Discussion:**

The discussion after the five presentations started with a question from the audience asking how to properly deal with economic risks associated with climate change using the concept of ambiguity. Prof. Hojeong Park responded to the question. He told that the concept of multiple uncertainties is a new emerging topic in the economics. The ambiguity is generated by a set of uncertainties, and should be controllable by individual decision-makers. Though the decision-makers can be either pessimistic or optimistic to the ambiguity, they may have risk-aversion behaviors towards extreme cases. However, in theory, the attitudes toward the ambiguity can dependent on decision-makers’ perspectives. While Dr. Park agreed to an opinion from the audience that both individual and the society can show ambiguity-aversion behaviors, he made a comment that a collection of individuals can exhibit different behavior patterns from each individual.

The audience from the Climate Change and Development Authority of PNG asked another question on how to improve the governance of climate change issues. Dr. Simelton provided an answer explaining that working closely with representatives from ministries directly involved in climate services such as Ministry of Agriculture and/or Ministry of Environment and local stakeholders is an important factor. She emphasized that it is important to show them that it makes difference then; both

authorities and stakeholders could open their mind to solve confronting problems via participatory activities. She told that it was vital to show the clear evidence of climatic risks and vulnerability so that both sides could sufficiently perceive those risks and thereby make efforts to developing actionable policies (e.g., consultation for adaptation measures). Additionally, she provided –an example of multi- economy agreements through an ASEAN White Paper on agroforestry with guidelines that the ASEAN-Swiss Partnership on Social Forestry and Climate Change and the World Agroforestry Centre supported the development of, and suggested APEC economies might be able to do the similar activity for reducing climate vulnerability.

The last question from the audience was how to encourage stakeholders and authorities to gather together for capacity building better adapt to climate change. Dr. Hen-I Lin answered the question. He told that educating local farmers are very difficult as most of farmers are part-time farmers rather than commercial farmers, and; thus, the government of Chinese Taipei attempts one by one education for them. After Dr. Lin's response, Prof. Kaluwin closed the Session III with his sincere gratitude to the speakers and the audience.

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

32. The Wrap-Up and Panel Discussion Session on August 22 commenced at 09:00. Each session was summarized by the session Chair, Prof. Simon S. Y. Wang from Utah State University for Session I, Dr. Jong Ahn Chun from APEC Climate Center for Session II, and Prof. Chalapan Kaluwin from University of Papua New Guinea for Session III.
33. For Session I entitled Enhancing Climate Information Applications, Prof. Simon S. Y. Wang invited all the speakers of Session I to the stage for the additional comments from each speaker after two days of presentation and discussion. Firstly, Prof. Wang made a few statements starting that the main topic through the session was climate change and projections versus variabilities at different time scales. The important part of the projected increase of CO<sub>2</sub> and global warming is to change the physics of atmosphere in a way to change extreme events. Throughout the session, presenters talked about climate services, extension, systematic approach, drought information, climate information tool through webpages, and so on. And the important question is how to secure financial support to push further to benefit the communities. Prof. Wang suggested that, in terms of extending services, the government and universities which have produced climate information for many years connect to the APCC, for example, where the services are provided to become an entity with to develop high technique tool, and then bring it to the communities. Then, universities could take a step forward by educating the next generations in order them to understand and utilize climate information to the practice. Prof. Troccoli stressed that the immediate action is needed to make the best use of climate forecasting information in everyday life and industry to prepare the next season rather than waiting on next 50 years. Also, for example in Europe, many funding opportunities go to research and innovation, which means the project needs to have actual users from the industry not just the potential ones. Dr. Bolinger provided an observation that, with the initial emphasis on communicating with the users from her presentation, there are many cases where researchers and institutions have taken bottom-up approach trying to communicate with users and stakeholders. Then, she raised two questions for further stage of utilization of climate information; how do we assess the concrete benefits of what the researchers and institutions have provided and how do we ensure that the information is being used in adapting and even mitigating climate change issues. Dr. Kim emphasized that the APEC Climate Symposium is not the final report of the climate prediction and utilization but the start-up and, as for the sustainability aspect, a capacity building component has to be importantly considered when coordinating any project. Prof. Letson provided remarks over the session talks that the predictability of climate change has to be looked into firstly, which would help engaging the decision makers. Also he stated that climate change is deep uncertainty rather than just risk and there are vast amount of works to do ahead of us. Mr. Malsale stated that SPREP is emphasizing on informing and empowering the community with climate information incorporated with traditional knowledge (TK), which is believed as a

missing link between different climate models and scientific information and employing to decision making. After the short statements from each presenter, Prof. Wang opened the floor for questions. A government officer from the Department of Agriculture of PNG raised one question where the climate scientists can predict for example migration of insects or birds in a economy or regional level and climate models can predict the economic loss or benefits of such movement. Prof. Wang appreciated the question and highlighted that the sectoral collaboration is needed to identify the issue and find the resolution. Dr. Bolinger added that climate change affects possibly every other aspect and it is vital to seek out collaboration with other sectors to tackle the issue. Prof. Wang also suggested an online platform such as social media for climate scientists, stakeholders, decision makers, and many more where people could share the comments or discussion. Then, he appreciated the speakers and audience for the active participation once again and ended the first wrap-up.

34. For Session II entitled Improving Water and Food Security with Climate Information and Services, Dr. Jong Ahn Chun provided a few wrap-up points of the presentations given throughout the session. As the theme of the session indicates, the presenters focused on the application sectors, mainly agriculture and water resources sectors and he gave a broad overview of each talk. Dr. Iizumi discussed global crop issues with yield variability. He introduced joint research with APCC and it is hoped that the outcome would be available in a couple of years. Dr. Dennis Timlin works in a laboratory which precisely controls CO<sub>2</sub> concentration and temperature. With such experiment and computer modeling, they could improve crop models. Dr. Ramakrishna Akkinapally introduced several points regarding PNG especially in terms of climate issues that PNG faces. While there is information available, the dissemination to the users in need is very difficult especially in water and agriculture in PNG. Dr. Chun also made an observation that, from the two presentations by Prof. Sivri and Prof. Kayastha, the water body of Turkey's lake is decreased while the water body of Nepal's lake becomes bigger due to climate change, and raised an assumption that, in a global sense, the water mass could be stable. Prof. Joon Ha Kim introduced AI and 4th industrial revolution in terms of climate change. He also proposed a solution with optimum conditions for agriculture and human society. Then, Dr. Chun stated that there are many agro-climate models: some of them are complex and some of them are simple. Regional scale models do not provide field scale information while field scale models are complex and needs more resources. Parameters and variables related to the agriculture are very hard to obtain especially in developing economies, and it would be insufficient if there are many assumptions as inputs to the models. And there are diverse needs from stakeholders. Farmers want to know what happens to their farms while national government officers would focus on national policy planning. In such sense, Dr. Chun introduced multi scale model crop approach is to use the complexity of different models. The idea is that, for larger scale simulation, it uses simple model while for looking into focus on a hotspot, it uses complex models for detailed simulation in a small scale. He showed an example

conducted in 5 economies from Vietnam to Myanmar. And then Dr. Chun ended the wrap-up with great appreciation to audience.

35. Session III entitled Linking Climate Information and Decision-Making, Prof. Chalapan Kaluwin highlighted that the case studies introduced by the speakers from the session were invaluable sharing from various parts of APEC economies. The first one by Dr. Simelton targeted Vietnam and Southeast Asia provided an opportunity to consider, while addressing issues of climate variability to apply to various sectors, how one gets the data from and how to apply the data to the sectors such as water resources and agriculture. Also, in Bangladesh and Vietnam, the community level issue became a governmental issue, which guided, when the data is available, how to take the information to influence the community and sectors in need. The case study that Utah State University conducted was an important example to address how to attract various sectors such as public, sectors, and engineers to tackle climate variability and climate change since, in most cases, including climate change and variability issues into developing infrastructure is difficult to obtain. Prof. Kaluwin emphasized the importance of including climate change information in long term in the development stage and has encouraged PNG to include such climate sensitivity into designing infrastructure when making decisions. But how the sectors take in climate information? While the data is available worldwide and in region, sectors still do not utilize it into planning stage. This is a challenge the climate community including APEC Climate Center faces, Dr. Kaluwin stated. Dr. Kaluwin also stressed that we have a long way to go to connect the national information to applying it and it is a matter of who you partner with. And he finally stated that the efforts should be together in a collective way because we would benefit together as well. Dr. Kaluwin finalized the wrap-up with thanking all the audience and speakers once again.

**36. Panel Discussion: Prof. Alberto Troccoli (World Energy & Meteorology Council), Dr. Rebecca A. Bolinger (Colorado State University), Dr. Dennis Timlin (United State Department of Agriculture), Dr. Ramakrishna Akkinapally (National Agriculture Research Institute of PNG), Dr. Elisabeth Simelton (World Agroforestry Center), Prof. Jagath J. Kaluarachchi (Utah State University)**

This panel discussion session was chaired by Prof. Alberto Troccoli. Before the discussion, there were some statements from the panels about the discussion topic of how climate science and technology be employed to strengthen regional water and food security and provide insights into developing relevant scientific and socioeconomic policy. First, Dr. Rebecca Bolinger stated that Colorado has very-well-drought response plan. Scientists analyze data and monitor drought indicators and this result is transferred to the decision making to mitigate the drought. She stressed that the important role of the climate scientists is to deliver the climate information for driving policy.

Dr. Dennis Timlin noted that the food security is underrepresented in the news media relative to temperature change under climate change. We need to see how food

security is affected by the temperature rise. Each economy should have a program to train crop modellers. From this program, they can develop models to utilize effectively their own climate data and to face their own situation related to the food security. Each economy needs more research for the food security impact from the climate change, something like how diseases spread with increase in temperature or impacts of saline water on plants with rise in SLH.

Dr. Ramakrishna Akkinapally noted that concerning about food security and water security in PNG the early warning system is needed. For the system, he noted that firstly we need to strengthen weather station data and its relevant information. Secondly, we need the station data networked for sharing them effectively. He also noted that more capacity building and more education about climate science in university, particularly, in PNG are needed.

Dr. Elisabeth Simelton noted that multifunctional farming systems help farmers to select the appropriate crops and to mitigate the impact from the extreme events. She also stated that we need more direct communication with farmers. Particularly, information related to the crop production from farmers could be utilized for improving climate prediction. She lastly stressed about the need of more fund resources.

Prof. Jagath Kaluarachchi highlights that making a good policy for climate change we needs good communication between the various sectors. Science provides good information to policy makers leading to making good policy by policy makers. Most importantly, science should convince the policy makers what the climate information is meaning.

After that, importance of education extension was more discussed, and an audience recommend that we needs some platform to communicate among various sectors from developing and developed economies to share effectively climate information. From audiences some issues and problems in terms of climate information services are also commented and one of panels answered the comments. He noted that we need leadership that understand important issues. Then, it is necessary that recognize the problems, proves the causes of the problems using all the existing available resources, and convince the relevant decision makers to solve the problems. There are additional comments by the session chair for sharing and exchanging the climate information between various sectors in terms of building the platform. Additionally, one of a panel stressed that scientist should be proactive on how to figure out the potential impacts from extreme climate events in advance.

Finally, this session was completed with final statements from a panel as listed in the following: 1) In addition to the research, scientists need to communicate effectively and differently with different sectors for making them understand what and how important climate scientists are doing and what the climate information is meaning and for sharing the climate information to meet the end-users' needs. 2) We need to collaborate to exchange information, communicate between sectoral levels, and coexist to recognize problems and issues. 3) Scientists should communicate with farmers in the field and also understand the previous knowledge on different impacts of different extreme events on various crops and plants. 4) There are three important

things; we communicate between various sectors, scientist has to be proactive, and education for next-generation of scientist.

Finally, Prof. Troccoli closed the Panel Discussion by thanking all panellists and participants for their contributions.

37. Prof. Dong-In Lee, Chairmen of Board of Trustees 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. Samuel Maiha, Director of the PNG National Weather Service then gave a speech with special focus on collaborations among agencies, scientists, policy makers, and stakeholders, and then thanking the organizers, partners, and participants congratulating all on making APCS 2018 as a memorable event. After this, the symposium came to a close.

## **ANNEX: APEC Climate Symposium 2018 Participants List**

<b>No.</b>	<b>APEC Economy</b>	<b>Name</b>	<b>Affiliation</b>	<b>Gender</b>
1	Australia	Emily Edwards	Australian High Commission (Port Moresby)	F
2	Australia	Mark Howden	Australian National University	M
3	Australia	Nige Kaupa	Australian High Commission	M
4	Australia	Alberto Troccoli	World Energy & Meteorology Council / University of East Anglia	M
5	Australia	Edward Vrkic	United Nations Development Programme	M
6	Chile	Oscar Alfredo Bustamante Cuevas	Ministry of Agriculture	F
7	Chile	Camila Fernández Silva	Ministry of Agriculture	F
8	Chile	Enrique Osvaldo Garrido Segovia	Dirección Meteorológica de Chile	M
9	Chile	Maritza Silvia Jadrijevic Girardi	Ministry of the Environment	F
10	China	Zunya Wang	National Climate Center, China Meteorological Administration	F
11	India	Ramakrishna Akkinapally	National Agricultural Research Institute	M
12	Indonesia	Woro Estiningtyas	Indonesian Agro-climate and Hydrology Research Institute	F
13	Indonesia	Marjuki	Indonesian Meteorological Climatological and Geophysical Agency	M
14	Indonesia	Joko Budi Utomo	Indonesian Meteorological Climatological and Geophysical Agency	M
15	Japan	Toshichika Iizumi	National Agriculture and Food Research Organization	M
16	Japan	Yoshiaki Sato	Japan Meteorological Agency	M
17	Korea	Kuh Hee Cho	Korea Meteorological Administration	M
18	Korea	Jong Ahn Chun	APEC Climate Center	M
19	Korea	Suhee Han	APEC Climate Center	F
20	Korea	Inja Jeon	APEC Climate Center	F
21	Korea	Kyeongseok Jo	APEC Climate Center	M
22	Korea	Daeha Kim	APEC Climate Center	M
23	Korea	Joon-Ha Kim	Gwangju Institute of Science and Technology	M
24	Korea	Seon Tae Kim	APEC Climate Center	M
25	Korea	WonMoo Kim	APEC Climate Center	M
26	Korea	Dong-In Lee	Pukyung National University	M
27	Korea	Yunjeong Lee	Korea Meteorological Administration	F
28	Korea	Sangwon Moon	APEC Climate Center	F

<b>29</b>	Korea	Hojeong Park	Korea University	M
<b>30</b>	Korea	Jin Ho Yoo	APEC Climate Center	M
<b>31</b>	Malaysia	Ahmad Fairudz Bin Jamaluddin	Malaysian Meteorological Department	M
<b>32</b>	Malaysia	Nani Dzulkarnain Bin Mohd Yunan	Ministry of Agriculture and Agro-based Industry	M
<b>33</b>	Malaysia	Mohd Rezza Mohd Yusof	High Commission Of Malaysia	M
<b>34</b>	Malaysia	Yeoh Yuan Xiang	Ministry of Agriculture and Agro-based Industry	M
<b>35</b>	Malaysia	Muhd Irfan Zulkurnain	High Commission of Malaysia	M
<b>36</b>	Mexico	Maria Tereza Cavazos Perez	Centro de Investigación Científica Y de Educación Superior de Ensenada B. C.	F
<b>37</b>	Nepal	Rijan Bhakta Kayastha	Kathmandu University	M
<b>38</b>	Papua New Guinea	Eileen Aitsi	APEC Secretariat	F
<b>39</b>	Papua New Guinea	Lahui Ako	PNG APEC Secretariat	M
<b>40</b>	Papua New Guinea	Ruth Apuqahe	PNG National Weather Service	F
<b>41</b>	Papua New Guinea	Scott Arikapu	Department Of Transport	M
<b>42</b>	Papua New Guinea	Rolynne Asik	PNG APEC Secretariat	F
<b>43</b>	Papua New Guinea	Andrew Asmann	Department of Transport	M
<b>44</b>	Papua New Guinea	Jonah Auka	Climate Change & Development Authority	M
<b>45</b>	Papua New Guinea	Sonia Baine	Climate Change & Development Authority	F
<b>46</b>	Papua New Guinea	Sergie Bang	Department of Agriculture & Livestock	M
<b>47</b>	Papua New Guinea	Lawrence Baro	RSTS	M
<b>48</b>	Papua New Guinea	Soldier Buruka	Department of Agriculture & Livestock	M
<b>49</b>	Papua New Guinea	Gavera Chris	PNG APEC Secretariat	M
<b>50</b>	Papua New Guinea	Francis Daink	Department of Agriculture & Livestock	M
<b>51</b>	Papua New Guinea	Reuben Daniel	Ministry Of Environment Conservation And Climate Change	M
<b>52</b>	Papua New Guinea	Petrus Dii Urka	Department of Agriculture & Livestock	M
<b>53</b>	Papua New Guinea	Shirley Drew	Department of Agriculture & Livestock	F

54	Papua New Guinea	Eunice Dus	Climate Change & Development Authority	F
55	Papua New Guinea	Marie Eorage	PNG APEC Secretariat	F
56	Papua New Guinea	Jacklyn Gigimat	PNG APEC Secretariat	F
57	Papua New Guinea	Jimmy Gomoga	National Weather Service	M
58	Papua New Guinea	Anna Herry	Climate Change & Development Authority	F
59	Papua New Guinea	Heai Hoko	Department of Agriculture & Livestock	M
60	Papua New Guinea	Kasis Inape	Australian Bureau of Meteorology	M
61	Papua New Guinea	Jealchris Inji	Climate Change & Development Authority	F
62	Papua New Guinea	George Iramu	Climate Change & Development Authority	M
63	Papua New Guinea	Mirzohaydar Isoev	Climate Change & Development Authority	M
64	Papua New Guinea	Imelda Kachau	UNDP	F
65	Papua New Guinea	Cecilia Kagen	Department of Agriculture & Livestock	F
66	Papua New Guinea	Morgan Kai	Climate Change & Development Authority	M
67	Papua New Guinea	Chalapan Kaluwin	University of Papua New Guinea	M
68	Papua New Guinea	Paul Kandu	NFA	M
69	Papua New Guinea	Billy Kang	Climate Change & Development Authority	M
70	Papua New Guinea	Shirley Kangol Albert	Department of Agriculture & Livestock	F
71	Papua New Guinea	Nime Kapo	Department of Agriculture & Livestock	M
72	Papua New Guinea	Mame Kasalau	Department of Agriculture & Livestock	M
73	Papua New Guinea	John Kendiga	Department of Agriculture & Livestock	M
74	Papua New Guinea	Timothy Kepou	NISIT	M
75	Papua New Guinea	Willie Kerenga	CIDA	M
76	Papua New Guinea	Hera Kevau	PNG APEC Secretariat	F
77	Papua New Guinea	Johnson Kilis	Climate Change & Development Authority	M
78	Papua New Guinea	Anna Kimam	Department of Agriculture & Livestock	F

<b>79</b>	Papua New Guinea	Brown Konabe	Department of Agriculture & Livestock	M
<b>80</b>	Papua New Guinea	Joanne Koyabina	PNG Tourism Promotion Authority	F
<b>81</b>	Papua New Guinea	Darren Kuama	PNG APEC Secretariat	M
<b>82</b>	Papua New Guinea	Jacinta Kull	Climate Change & Development Authority	F
<b>83</b>	Papua New Guinea	Velma Kulukulu	PNGFA	F
<b>84</b>	Papua New Guinea	Francis Kuluwah	Department of Transport	M
<b>85</b>	Papua New Guinea	Daisy Lepon	Department of Agriculture & Livestock	F
<b>86</b>	Papua New Guinea	Samual Maiha	National Weather Service	M
<b>87</b>	Papua New Guinea	Nidatha Martin	Climate Change & Development Authority	F
<b>88</b>	Papua New Guinea	Teatulohi Matainaho	PNG Science and Technology Secretariat	M
<b>89</b>	Papua New Guinea	Stephen Mesa	Department of Agriculture & Livestock	M
<b>90</b>	Papua New Guinea	Albert Milala	Climate Change & Development Authority	M
<b>91</b>	Papua New Guinea	Mathew Moihoi	Department of Mineral Policy and Geo Hazards	M
<b>92</b>	Papua New Guinea	Stephen Mombi	Department of Agriculture & Livestock	M
<b>93</b>	Papua New Guinea	Tom Morris	Department of Agriculture & Livestock	M
<b>94</b>	Papua New Guinea	Martin Mose	National Disaster Office	M
<b>95</b>	Papua New Guinea	Leka Mou	Department of Agriculture & Livestock	M
<b>96</b>	Papua New Guinea	Ethel Namuri	Climate Change & Development Authority	F
<b>97</b>	Papua New Guinea	Lussinda Nawayap	Png Red Cross National Society	F
<b>98</b>	Papua New Guinea	Latin N'drihin	Climate Change & Development Authority	M
<b>99</b>	Papua New Guinea	Pila Ninigi	PNG Science and Technology Secretariat	M
<b>100</b>	Papua New Guinea	Regina Nukundj	Department of Agriculture & Livestock	F
<b>101</b>	Papua New Guinea	Ashan Numa	Australian High Commission	M
<b>102</b>	Papua New Guinea	Andrew Oaego	National Disaster Office	M
<b>103</b>	Papua New Guinea	Daphne Onaga	Department of Agriculture & Livestock	F

<b>104</b>	Papua New Guinea	Melanie Paiiva	PNG APEC Secretariat	F
<b>105</b>	Papua New Guinea	Isidore Sitapai Pasanai	PNG APEC Secretariat	M
<b>106</b>	Papua New Guinea	Priscilla Pep	Climate Change & Development Authority	F
<b>107</b>	Papua New Guinea	Daniel Peter	PNG APEC Secretariat	M
<b>108</b>	Papua New Guinea	Samuel Peter	University of Papua New Guinea	M
<b>109</b>	Papua New Guinea	Mark Pilon	PNGFA	M
<b>110</b>	Papua New Guinea	Emily Pomoh	Climate Change & Development Authority	F
<b>111</b>	Papua New Guinea	Kisolel Lina Posanau	National Weather Service	F
<b>112</b>	Papua New Guinea	Brendan Pulai	PNG APEC Secretariat	F
<b>113</b>	Papua New Guinea	John Pundari	Ministry Of Environment Conservation And Climate Change	M
<b>114</b>	Papua New Guinea	Manau Patricia Renagi	Climate Change & Development Authority	F
<b>115</b>	Papua New Guinea	Reuben Robin	Climate Change & Development Authority	M
<b>116</b>	Papua New Guinea	Konilias Roka	Australian High Commission	M
<b>117</b>	Papua New Guinea	Alfred Rungol	Climate Change & Development Authority	M
<b>118</b>	Papua New Guinea	Nathan Sapala	Climate Change & Development Authority	M
<b>119</b>	Papua New Guinea	Erick Sarut	Climate Change & Development Authority	M
<b>120</b>	Papua New Guinea	Gwen Sissiou	Climate Change & Development Authority	F
<b>121</b>	Papua New Guinea	Robin Suang	PNG APEC Secretariat	M
<b>122</b>	Papua New Guinea	Debra Sungi	Climate Change & Development Authority	F
<b>123</b>	Papua New Guinea	Elias Taia	Department of Agriculture & Livestock	M
<b>124</b>	Papua New Guinea	Ricks Tanda	Global Green Growth Institute (GGGI)	M
<b>125</b>	Papua New Guinea	Donald Tokunai	East New Britain Provincial Administration	M
<b>126</b>	Papua New Guinea	Gabriel Tuno	PNG National Weather Service	M
<b>127</b>	Papua New Guinea	Merie Unagi	Department of Agriculture & Livestock	F
<b>128</b>	Papua New Guinea	Terence Vincent	PNG Tourism Promotion Authority	M

129	Papua New Guinea	Charlie Vulum	PNG National Weather Service	M
130	Papua New Guinea	Nanao B Vulum	National Weather Service	F
131	Papua New Guinea	Brian Wapi	Department of Agriculture & Livestock	M
132	Papua New Guinea	Julie Wapo	PNG APEC Secretariat	F
133	Papua New Guinea	Charlie Wayar	PNG APEC Secretariat	M
134	Papua New Guinea	Cephas Wenge	Climate Change & Development Authority	M
135	Papua New Guinea	Anna Yamanea	Department of Agriculture & Livestock	F
136	Papua New Guinea	Ruel Yamuna	Climate Change & Development Authority	M
137	Papua New Guinea	Dan Yansom	NISIT	M
138	Papua New Guinea	Simon Yaukah	PNG APEC Secretariat	M
139	Papua New Guinea	Steven Collin	SOM Chairs' Office	M
140	Papua New Guinea	Ingrid Kuman	SOM Chairs' Office	F
141	Papua New Guinea	Nerida Kwarara	SOM Chair's Office	F
142	Papua New Guinea	Apeame More	SOM Chairs' Office	F
143	Papua New Guinea	Morea Onno	SOM Chairs' Office	M
144	Papua New Guinea	Rensie Panda	SOM Chairs' Office	F
145	Papua New Guinea	Ivan Pomaleu	Office Of the APEC 2018 SOM Chair	M
146	Papua New Guinea	Frederick Tamarua	SOM Chairs' Office	M
147	The Philippines	Edna Juanillo	Philippine Atmospheric, Geophysical and Astronomical Services Administration	F
148	The Philippines	Rosemarie Ann Marasigan	Philippine Atmospheric, Geophysical and Astronomical Services Administration	F
149	The Philippines	Phoebe Pua	Department of Agriculture - Bureau of Soils and Water Management	F
150	The Philippines	Teresita Sandoval	Department of Agriculture – Bureau of Soils and Water Management	F
151	Sweden	Elisabeth Simelton	World Agroforestry Centre	F
152	Chinese Taipei	Ching-Teng Lee	Central Weather Bureau	M
153	Chinese Taipei	Ming-Ying Lee	Central Weather Bureau	M
154	Chinese Taipei	Hen-i Lin	Chung-hua Institution For Economic	M

Research				
155	Chinese Taipei	Shih-Yu Wang	Utah State University	M
156	Chinese Taipei	Tien-Chiang Yeh	Central Weather Bureau	M
157	Thailand	Songkran Agsorn	Thailand Meteorological Department	M
158	Thailand	Boonlert Archevarahuprok	Thai Meteorological Department	M
159	Thailand	Somchai Boonpradub	Ministry of Agriculture and Cooperatives	M
160	Thailand	Pronmongkol Chidchob	Ministry of Agriculture and Cooperatives	M
161	Turkey	Nüket Sivri	Istanbul University - Cerrahpaşa	F
162	United States of America	Rebecca Anne Bolinger	Colorado State University	F
163	United States of America	Jagath Janapriya Kaluarachchi	Utah State University	M
164	United States of America	David Letson	University Of Miami, Rosenstiel School Of Marine And Atmospheric Science	M
165	United States of America	Dennis James Timlin	United States Department of Agriculture	M
166	Vanuatu	Philip Malsale	Secretariat of Pacific Regional Environment Programme	M
167	Viet Nam	Le Thanh Hai	National Center For Hydro-meteorological Forecasting	M
168	Viet Nam	Vo Thi Quynh Nga	Ministry of Agriculture and Rural Development	F
169	Viet Nam	Tran Dai Nghia	Institute of Policy and Strategy for Agriculture and Rural Development, MARD	M
170	-	Bernard Li	APEC Secretariat	M