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

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Despite ample evidence that human societies and ecosystems have become increasingly vulnerable to climate-driven disasters, formulating actionable policies is still a prodigious challenge due to weak connections between researchers, stakeholders, and authorities. To close the large gap between climate sciences and policymaking and to understand each other's values regarding climate information, the Asia–Pacific Economic Cooperation (APEC) Climate Symposium 2018 was held with the theme of overcoming the challenges of an uncertain future through enhanced climate information and services (www.apcc21.org/ic/aspinfo.do?lang=en&menuID=symposium).

In the opening ceremony, honorable John Pundari, the Minister for Environment Conservation and Climate Change of Papua New Guinea, emphasized the importance of timely, high-quality, and accessible information to support decision-making processes for reducing the ever-increasing risk of global warming in Papua New Guinea. Tien-Chiang Yeh, the director general of the Central Weather Bureau of the Chinese Taipei, also addressed the necessity for strong connectivity between climate sciences and policymaking, especially with the Asia–Pacific region becoming increasingly vulnerable to natural disasters.

The main sessions began with two keynote speeches about climate change and policy development. In the first speech, Mark Howden, the director of the Climate Change Institute at Australian National University, stressed that public perception of climate change seems insufficient even though the scientific community has produced immeasurable evidence of human influences on the atmosphere. Compared to other urgent issues

APEC CLIMATE SYMPOSIUM 2018

What: More than 170 participants from 19 countries, who work for national hydrological and meteorological services, governments and the private sector, the media, nongovernmental agencies, and in academia, convened to discuss how to enhance climate information and services in order to link between sciences and actions for reducing climatic risks.
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threatening human livelihood, climate change appears to be a distant and abstract risk. Indeed, potential solutions to climate change may require unacceptable socioeconomic costs, restricting necessary actions for risk reduction. He noted that the paradigm of climate research and services should be shifted from climate-centered knowledge production to value-centered platforms that can encourage active participation of stakeholders. Subsequently, Edward Vrkic, the senior advisor for climate change of the United Nations Development Programme, promoted collaboration between private and public sectors to find long-term and sustainable solutions to upcoming challenges. He claimed that the concept of climate change should evolve to boost our perception of the associated risks. He emphasized that translating scientific research to simple and clear messages would help individuals have a better understanding of climatic risks and implement necessary actions.

LOW PUBLIC PERCEPTION OF CLIMATE CHANGE. It is urgent to promote the public perception of climate change. Through the main sessions, the speakers repeatedly pointed out that the public insufficiently perceives the risk of climate change. While climate change can result in ecological collapse that undermines even human health (McMichael et al. 2006), this unprecedented risk does not seem to be a high priority for the public and policymakers. In part, the low perception can be attributed to the time scale mismatch between climate change and the general interest of the public. By its definition, climate takes at least a multidecadal period to change. In contrast, individuals are likely to focus their immediate attention on clear and urgent issues rather than a vague and distant problem at such a long time scale.

Hence, it is salient to clearly show the urgency of climatic risks and the value of risk reduction to the public. For example, in his presentation, Chalapan Kaluwin, a professor at the University of Papua New Guinea, illustrated declining land availability and increasing environmental damages across the Pacific Islands caused by sea level rise and climate extremes. He clearly visualized that societal vulnerability has been increasing in the regions far from the developed world. In addition, Hojeong Park, a professor at Korea University, presented a case study showing that earlier investments for CO_2 abatement are economically better, since societal costs substantially increase with uncertainty and irreversibility. The conclusions drawn by the two speakers seemed to enhance the participants' perception of increasing climatic risks.

Nonetheless, the effects of this perception are likely temporary and are thus insufficient to result in the necessary actions for mitigation and adaptation. More effort is needed to close the vast gap between the science and actionable policies. Several speakers at the event encouraged the formation of participatory programs in which stakeholders can be directly involved in the information and policy development processes.

IMPORTANCE OF PARTICIPATORY PROGRAMS FOR REDUCING CLIMATIC RISKS. Strengthening connectivity between local stakeholders, authorities, and scientific communities is a key to reducing climatic risks in practice. Simon Wang, an associate professor at Utah State University, argued that bottom-up information development is of great importance. He encouraged stakeholders' participation in developing climate information and educational programs, because inadequate end-users' understanding can significantly limit usability of climate information and policies. Philip Malsale, a climatology officer at the Secretariat of the Pacific Regional Environmental Programme, showed a climate service that incorporated local traditional knowledge via participatory activities, indicating that stakeholders' feedback is a valuable asset for service providers and policymakers.

Through the main sessions, several speakers introduced mobile- and web-based systems that operationally disseminate climate monitoring and forecasts, such as the Pacific Island Countries Advanced Seasonal Outlook of the APEC Climate Center, U.S. Drought Monitoring System, and AgroClimate of the University of Miami. The speakers noted that their state-of-the-art systems should keep evolving in accordance with end-users' needs, implying that supply-driven and one-way frameworks can be easily discarded. Elisabeth Simelton, project manager at the World Agroforestry Center, stressed that enhanced value chains can be built by engaging both service providers and local practitioners in all steps of production, translation, transfer, and the use of climate services.

Simply, the key is to promote communication between developers and recipients of scientific information, services, and policies. If it is difficult to distinguish between developers and recipients of a climate service, it would be a success indicator. Climate forecasts can be embedded in successful services and programs, since they allow users to manage climatic risks in a proactive manner. How to properly utilize

climate forecasts was another important subject discussed in the symposium.

TRANSLATING CLIMATE FORECASTS INTO USEFUL INFORMATION. Climate forecasts should be translated into information tailored to end-users' needs. While physics-based climate models have been noticeably improved over the past two decades, there remains a gap between providers and users of climate forecasts. If they are improperly transferred to application sectors, climate forecasts could instead result in inappropriate, untimely, and misleading policies. Still, uncertainties associated with climate predictions are not fully understood, and thus it is very risky to accept them as absolute future conditions for resources and disaster management. In theory, deterministic forecasts can even be viewed as probabilistic information (Weijs et al. 2010).

In the discussion sessions, however, it was echoed that the usability of climate forecasts may not be dependent on predictive skills or uncertainties but rather on their value in application sectors. Wang and Simelton emphasized the bottom-up information development to add value to climate forecasts. An agricultural sector, for instance, may need forecasts of the first fall freezes rather than the monthly mean temperature. Flood forecasts would be better for a water manager than precipitation itself. These examples led to the notion that a good translator can better contribute to value creation than a skillful climate modeler. Refining climate forecasts as per end-users' needs would become a prerequisite to promote their usability.

In other words, the participatory model should be applied in the production of climate forecasts, too, since it is a part of climate information and services. The value-centric utilization of climate forecasts would help practical risk reduction in application sectors. The participatory model also helps users to understand the limitations of climate forecasts. However, climatic risks can often be intertwined with other socioeconomic and environmental conditions, requiring cross-disciplinary analyses of multiple datasets. Climate data and forecasts cannot be the only information for climate services and policy development.

INTERDISCIPLINARY DATA ANALYSES FOR SUPPORTING CLIMATE SERVICES AND POLICIES. Useful insights for climate services and policies may be hidden in datasets beyond the discipline of climate sciences. Jagath J. Kaluarachchi, the dean of the college of engineering at Utah State University, provided a case study for the Siwa Oasis in Egypt. The analyses of water withdrawal data by his research team showed that overexploitation of the Egyptian oasis caused water insecurity, while it had been seemingly attributed to drying climate. This implies that conventional climate-centered frameworks for policymaking may not contribute to reducing climatic risks entangled with diverse socioeconomic and environmental factors.

Since climatic risks are often multifaceted, cross-disciplinary data analyses would be required for the development of better services and actionable policies. Data sciences may help to solve multifaceted problems. Joonha Kim, the director of the International Environmental Research Institute at Gwangju Institute of Science and Technology, emphasized that big data may play a crucial role in adapting to climate change and illustrated an integrated disaster management system supported by big data from social networks and high-quality weather stations. He noted that, due to rapid socioeconomic and environmental changes, cross-disciplinary analyses of bigger data would become essential for disaster and resources management. Since data-driven approaches, such as artificial neural networks and machine learning, have already emerged in climate sciences, they may be soon embedded in climate forecast systems and relevant services.

During the 3-day symposium, the experts in various fields shared their experiences to build more cohesive knowledge that can link science and technology to necessary actions for reducing climatic risks. The key lesson from this event was that promoting collaboration between researchers, practitioners, and authorities is of equal importance to producing scientific knowledge and accurate climate forecasts. A successful platform for climate services can be built from understanding sociological, psychological, institutional, and environmental aspects all together. In summary, the following lessons are worth reemphasizing:

- An effective knowledge transfer can be achieved by active communication between scientists, authorities, and stakeholders, and it improves the public perception of climatic risks.
- Participatory programs can add value to climate services and policies and significantly enhance their usability and usefulness.
- Cross-disciplinary, bottom-up, and value-centric platforms should be built for future climate services to consider the multifaceted nature of upcoming climate risks.

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