Project Final Report

APEC Climate Symposium 2024

Towards a Sustainable and Resilient Society through Enhanced ENSO Response and Preparedness

APEC Policy Partnership on Science, Technology and Innovation

December 2024

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Economic Cooperation

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Executive Summary

The APEC Climate Symposium 2024 took place in Lima, Peru on 11-13 August, in cooperation with the Meteorological and Hydrological Service of Peru (SENAMHI) and APEC Peru. This event brought together approximately 120 participants from 14 APEC member economies and 2 non-APEC economies, focusing on "Enhanced ENSO response and preparedness for a sustainable and resilient society in APEC." The Symposium aimed to foster regional technical cooperation, strengthen climate resilience, and generate actionable recommendations for improving preparedness against climate risks associated with the El Niño-Southern Oscillation (ENSO).

The Symposium featured a combination of presentations and discussion sessions, designed to enhance the knowledge and understanding of attendees regarding the science and technology behind ENSO and its management in the context of the climate crisis. The keynote session addressed the impact of climate change in sustainable growth perspective, setting the stage for the discussion to follow. In the first session, scientists and researchers provided a comprehensive overview of ENSO, ensuring that government officials and stakeholders could grasp the scientific fundamentals and recognize the advancements in forecasting capabilities for this climate phenomenon. Emerging technologies such as artificial intelligence and machine learning, were highlighted for their potential in improving ENSO prediction. The second session explored the implications of climate change on ENSO, emphasizing strategies for local and regional communities to better respond to and sustainably manage its impacts. Successful case studies were shared, alongside recommendations for enhancing the coordination and application of climate services to inform decision-making in response to the climate crisis.

Experts contributed their diverse experience and insights, fostering a cohesive understanding of how to enhance climate resilience through climate services, for improved responses to ENSO and its affects on sectors such as agriculture, health and water resources management were discussed, underscoring the vital role of stakeholders in promoting collaboration and ensuring that climate services are effectively integrated into society.

Background

As climate change escalates and global land and ocean temperature rise, the APEC region faces significant challenges on its path toward a sustainable and resilient future. The impacts of ENSO – encompassing both El Niño and La Niña events – have become increasingly evident in the region. These phenomena threaten economies and local communities by causing unprecedented flood, drought, and complex weather patterns that alter the characteristics, frequency, and intensity of ENSO events.

ENSO is critical driver of annual global climate variability, influencing patterns of rainfall and temperature that can lead to extreme events such as flooding and drought. While ENSO affects many parts of the world, APEC economies located in the tropical region including Latin America and South-East Asia are particularly vulnerable to its impacts. Even though the effects of ENSO vary depending on the intensity, duration, time of year, the overarching influence of climate change exacerbates the socio-economic impacts associated with ENSO, leading to unprecedented threats to human security across the APEC region.

The consequences of ENSO extend beyond immediate weather impacts; they can severely affect food security, air and water quality, health outcomes, and ecosystems. ENSO is also associated with altered transmission patterns of vector-borne diseases as well as waterborne diseases, fish and shellfish poisoning among others. These extreme events hinder various sectors of society, impeding efforts to achieve sustainable and resilient livelihoods.

The Asia-Pacific region is known for its susceptibility to disaster, with 6.9 billion people affected between 1970 and 2020, resulting in over two million fatalities (i.e. one person lost per every 13 minutes, according to the Asia-Pacific Disaster Report 2021, ESCAP). Given this context, it is crucial for APEC community to deepen its understanding of ENSO and its impacts, while also actively engaging in response planning to pursue sustainable and resilient future.

The multifaceted challenges posed by extreme weather events driven by ENSO and climate change have intensified the complexity of existing, emerging and future risks. This underscores the urgent need for a paradigm shift in preparedness, response and recovery strategies. It is essential to identify ways to mitigate the impacts of extreme weather and climate conditions execrated by ENSO to move toward a sustainable and resilient society.

This project significantly contributes to APEC's Putrajaya Vision 2024 and the Aotearoa Plan of Action by addressing a range of environmental challenges, including climate change, extreme events, and natural disasters. Specifically, it focuses on the complexities of ENSO and its impacts, formulating response strategies that advance the shared goal of building a sustainable planet. Additionally, this project supports APEC 2024 theme of Empower/Include/Grow, promoting sustainable growth for resilient development in the region. It aligns with the APEC Disaster Risk Reduction Framework (DRRF) and the Disaster Risk Reduction Action Plan (DRRAP) by exploring how science can enhance disaster risk reduction efforts, particularly in relation to ENSO response and preparedness against emergencies.

Introduction

The primary objectives of this project are to increase awareness of local and regional climate impacts on society and to strengthen the capacity to manage the associated climate risks stemming from extreme weather and climate change. To achieve the objectives, this project focused on several key aspects: promoting knowledge-sharing about ENSO and its socio-economic impacts, highlighting the importance of established plans for preparedness and response to extreme weather and climate events, particularly those caused by ENSO, and supporting APEC member economies in developing domestic strategies and action plans to enhance resilience to climate change.

This project aimed to foster international dialogue and collaboration, facilitating the exchange of best practices, case studies, and lessons-learned regarding the science and technology behind ENSO and its impacts on climate change adaptation. The event convened experts and participants with extensive knowledge and experience in climate-related fields including ENSO prediction and its impacts on agriculture, health, and other sectors. It also engaged stakeholders interested in managing disaster risks posed by ENSO within their respective economies. Experts were invited to showcase their initiatives in predicting ENSO to better mitigate the challenges posed by climate change. These dialogues aimed to enhance mutual understanding between climate scientists and stakeholders in the disaster risk management arena, fostering a deeper comprehension of current ENSO trends, their societal impacts, and the need for domestic and regional collaboration to better respond to changing climate. Ultimately, initiative sought to bridge the gap between these two groups, promoting future cooperation in response to and preparedness for ENSO-related challenges. While advancements in this field have predominantly originated from a handful of developed economies, their successful adoption by developing economies within the APEC region holds significant potential for bolstering global resilience and sustainability efforts.

As climate variability and extreme events escalate, the severity of disasters heightens, leaving specific regions and demographics increasingly vulnerable. Considering ENSO is a regional phenomenon, both domestic and regional collaboration are crucial for effectively managing and minimizing its negative impacts. Experts shared insights on the implications of ENSO across various sectors, such as agriculture and health, emphasizing that these challenges can be addressed by leveraging science and technology alongside collaborative efforts among stakeholders. By exchanging experiences as to ENSO and its impacts, participants are expected to recognize the importance of collaboration in enhancing preparedness and response capabilities.

In terms of engagement, representatives from climate information producers, intermediaries, and user groups participated to promote mutual understanding and identify their roles and experiences from different perspectives. Experts from the World Meteorological Organization (WMO), Hombro a Hombro, a local NGO in Peru, and Credicorp., a local banking group leading climate investment in the region, were invited to share their insights. Additionally, researchers and practitioners from various economies, including the Republic of Korea; Malaysia; the Philippines; Thailand; the US; and Viet Nam among others contributed their experience in enhancing climate crisis preparedness through climate services. By including representatives from both the public and private sectors relevant to climate services, this project provided a unique platform for dialogue, fostering greater understanding of each other's concerns, needs, and current efforts, ultimately seeking opportunities for cooperation to promote human security amid environmental challenges in the region.

Symposium summary

Keynote Session. Impact of Climate Change in Sustainable Growth Perspectives

From this session, prof. Shang-Ping Xie from SCRIPPS Institution of Oceanography, University of California San Diego shared his expertise on ENSO and how climate change impacts the society in sustainable growth perspectives. He opened the session by highlighting Peru as an origin of ENSO and emphasizing the phenomenon's far-reaching effects on global weather. The talk was structured into three parts: an introduction to El Niño and its global impacts, an analysis of the recent El Niño event that ended in summer 2024, and an overview of how El Niño might shift in a warming climate.

- Global impacts of El Niño: El Niño events can dramatically alter weather patterns worldwide, as seen during the 1997-1998 event. That period saw extreme weather, such as Indonesian forest fires, Peruvian flooding, and delayed typhoon seasons in the Pacific. The phenomenon's effects on various regions, from the Tropical Pacific to East Asia and North America, underline its importance in climate science.
- Scientific progress and predictive advances: Research since the 1980s have expanded the understanding of El Niño as a coupled ocean-atmosphere event, leading to significant progress in forecasting its impacts. Advanced prediction models, which consider factors like sea surface temperature anomalies and wind patterns, have accurately predicted recent El Niño events, including the one in 2023-2024.
- Impact of climate change in El Niño patters: Increased global temperatures have intensified El Niño effects, such as storms along the U.S. West Coast and rainfall variability in East Asia. Rising sea surface temperatures may enhance El Niño's intensity initially but could decrease it by mid-century if warming trends persist. Understanding El Niño's role in climate variability is critical, as its influence extends beyond the Pacific to affect Atlantic hurricanes, Western Pacific typhoons, and global temperature records.

Session I. ENSO – Science and Technology

For this session, climate scientists from APEC member economies were invited and shared the current status of science and emerging technologies used to better understand ENSO.

Michelle L'Heureux, from Climate Prediction Center, NOAA Weather Service of USA discussed NOAA's progress in enhancing ENSO monitoring through an alternative index called the relative sea surface temperature (SST) index.

- She noted that the traditional ENSO indices like Nino 3.4, used to identify El Niño and La Niña events, has limitations because it depends on periodic climatological updates, causing inconsistencies over time due to shifting baselines. Considering these limitations, she presented the relative SST index as an alternative. Unlike traditional indices, it adjusts Nino 3.4 by subtracting an average SST across tropical zones, producing a more stable indicator of ENSO conditions. Compared to traditional Nino 3.4, **the relative SST index often showed closer alignment with predicted La Niña conditions**, hinting it may offer a stronger La Niña signal under current tropical warming conditions.
- Early ENSO impacts may manifest in forecasts with the relative SST index before traditional indices register the same conditions, which could lead to more timely, accurate ENSO-based climate forecasts. She **recommended ongoing real-time**

monitoring of both indices to assess relative SST's effectiveness in a changing climate and improve predictive resilience for ENSO events. This alternative approach may enhance the predictability and resilience of ENSO monitoring, crucial for adapting climate models to global warming trends.

Andrew Robertson from the International Research Institute for Climate and Society (IRI) at the Columbia University discussed three main topics related to ENSO forecasting: the IRI's ENSO Plume forecasts, sub-seasonal (S2S) predictions, and climate services work.

- ENSO Plume: ENSO Plume is a 20-year IRI forecasting product that aggregates global dynamical and statistical model data to produce ENSO forecasts with probability distributions. While these forecasts have a fair track record, they only predict La Niña events with around 50% accuracy, reflecting the models' limitations. He noted improvements in model accuracy for El Niño events, particularly when initialized in summer, though prediction accuracy is lower for La Niña events. Machine learning models, such as deep learning methods from Tongji University, have recently been incorporated to potentially enhance ENSO forecasting.

- S2S Prediction: He emphasized the need for climate risk management, with S2S forecasts from IRI helping stakeholders plan interventions on shorter time-scales, despite the current limitations in predicting precipitation with accuracy beyond 2-3 weeks. He showed how these forecasts can provide specific information, such as rainfall predictions over various regions like Southeast Asia and China.

- Climate services: He shared the case of **climate service that integrates ENSO and sub-seasonal to seasonal forecasts into locally relevant tools**, such as the NextGen program in Senegal. **The tailored forecasts, which as calibrated against local data, aid agricultural decision-making and address under needs through a co-developed, data-informed approach**. Through ITI's CPT software, forecasts can be find-turned to local thresholds, making predictions more actionable for sectors like agriculture.

Ken Takahashi Guevara, a principal scientific researcher from the Geophysical Institute of Peru, gave a comprehensive presentation on the diverse and complex effects of El Niño on Peru.

- Types of El Niño and its impacts on Peru: He highlighted the distinction between Eastern Pacific (coastal) and Central Pacific El Niño events. While the former brings warm waters to Peru's coast with heavy rainfall and floods, the latter impacts Peru with dry conditions, especially in the Andes and Amazon. Not all warming events bring rain, and understanding this variation is critical for Peru's forecasting needs.

- Predictive challenges and new tools: Predicting El Niño events, particularly in the Eastern Pacific, poses challenges for global models due to limited data and climate model biases. He described efforts by the Geophysical Institute of Peru to improve forecasts using regional ocean-atmosphere models and artificial intelligence (AI). They hope these tools can better predict coastal El Niño events, which are less emphasized in international forecasting efforts but crucial for Peru.

- Climate change implications: He stressed that **even if El Niño patterns remain the same, warming from climate change will intensify their impacts, raising risks for health, agriculture, and infrastructure**. **Model projections suggest that extreme**

El Niño events might become more frequent by 2030 due to global warming, increasing urgency for effective adaptation measures.

- He concluded that understanding the diverse impacts of El Niño on Peru requires differentiating between types of events. With climate change likely exacerbating impacts, AI and advanced regional models are expected to offer valuable tools for proactive decision-making and regional resilience.

Yury Wilson Escajadillo Fernandez from meteorological and hydrological service of Peru (SENAMHI) presented an overview of progress in Peru's weekly sub-seasonal climate forecasts, focusing on methodologies and results.

- He discussed data sources, calibration techniques, and model adjustments to improve weekly forecast accuracy for rainfall and temperature. The calibration uses empirical quantile mapping over meteorological stations across Peru, aiming to make forecasts more robust.

- He highlighted that the models vary by initial conditions and hindcast periods, creating challenges in consistency. Their forecasts cover weekly intervals up to four weeks, which is essential for users needing detailed, near-term climate insights. The forecast output includes deterministic rainfall maps, categorical percentile maps, and correlation maps indicating forecast reliability in specific regions.

- A significant case study involved forecasting for the "Yaku" event—a severe rainfall event on Peru's coast. Results showed varied model success, with the GFS model identifying the rainfall context up to 23 days in advance. Models were most successful in coastal regions, achieving forecast accuracy rates of up to 80%. He concluded that **sub-seasonal forecasts are critical for anticipating extreme weather events, although challenges remain, such as noisy signals and data gaps**. SENAMHI aims to publish these findings to contribute to the scientific community.

Edson from SENAMHI presented on SENAMHI’s use of Artificial Intelligence to forecast crop pest conditions, crucial for protecting crops and ensuring food security.

- Climate change and pest impact: Rising temperatures due to climate change are worsening pest problems by expanding their range, increasing survival rates, and adding pest generations, all of which heighten economic losses for farmers.

- Economic impacts of pests in Peru: Crop pests cause annual losses of USD1.2 billion in Peru, with impacts worsening during El Niño years, especially for staples like rice and potatoes.

- **Smart insect traps and AI**: SENAMHI uses AI-powered smart insect traps to monitor pests, which is more efficient than traditional methods. These traps work alongside agrometeorological stations, allowing SENAMHI to link pest patterns with climate data. He shared the case study of “Fruit fly” which is a highly destructive pest in Peru. AI helps predict the timing of its most harmful stage (larvae), enabling farmers to take timely preventive actions.

- **Predictive risk maps and agroclimatic services**: SENAMHI creates risk maps showing pest hotspots based on temperature and humidity forecasts. These maps, updated regularly, support farmers with targeted pest management, aiming to strengthen Peru’s agricultural sustainability. These points underscore SENAMHI's

use of technology to aid in pest management and safeguard crop yields amid climate change.

Session II. ENSO - Impact Assessment and Collaboration

For this session, speakers from academia and meteorological and hydrological services of APEC member economies were covered and shared their experiences on how negative impacts from ENSO are managed through collaboration in Asia-Pacific region.

Professor Sang-wook Yeh from Hanyang University shared his insights on ENSO's global significance and its impact and how to better collaborate for management.

- **ENSO is not just a local phenomenon in the Pacific but has wide-ranging impacts on global climate, hydrological cycles, and socio-economic conditions. Changes in ENSO can lead to extreme weather events like droughts, floods, and heatwaves, affecting ecosystems, agriculture, and human societies**. The recent El Niño event significantly affected weather patterns in 2023-2024, causing extreme winter precipitation in Korea. This led to damage in key agricultural areas, resulting in a rise in vegetable prices and food price emergencies.
- Despite accurate predictions by the Korean Meteorological Administration regarding winter precipitation, they failed to anticipate the extreme precipitation events. This highlighted **the need for better understanding of climate teleconnections and their impacts on local weather**. Teleconnections refer to significant relationships between weather phenomena in different locations. He explained how ENSO influences global climate through mechanisms like the atmospheric bridge and eddy-jet mechanisms, which link weather patterns across regions. The global mean surface temperature has risen significantly, which alters ENSO teleconnections and can lead to more extreme weather events. Recent trends indicated a strengthening relationship between ENSO and winter temperatures in Korea.
- Research suggested that increased ENSO variability could lead to exponential economic losses globally under climate change. As ENSO variability increases, so too may extreme weather events and their economic impacts. **Effective response to ENSO's impacts requires collaboration and information sharing among regional communities**. The Korean Meteorological Administration collaborates with various institutions to enhance seasonal forecasting, benefiting multiple sectors.
- In conclusion, he emphasized the importance of understanding ENSO and its changes in the context of climate change to improve forecasting and mitigate its impacts on society and the economy.

Maria del Pilar Cornejo, Director of the Pacific International Center for Disaster Risk Reduction, discussed the importance of redefining resilience through collaborative efforts among academia, local governments, and communities, focusing on a project in Ecuador.

- Ecuador is heavily impacted by El Niño events, particularly in the Guayas River Estuary area, which includes Duran (300,000 residents) and Guayaquil (3 million residents). Both cities face significant hydroclimatic risks, such as flooding, erosion, and landslides, exacerbated by ineffective stormwater systems.

- **Collective approach:** The initiative began in 2016 after learning from a missed opportunity in Quito, leading to discussions with the mayor of Duran. A climate resilience program was developed, aiming to address hazards and improve community livelihoods. Funding was sourced collaboratively, the research team provided in-kind resources, while the municipality matched funds. The program was aligned with the Sendai Framework for Disaster Risk Reduction, emphasizing understanding risks, strengthening governance, securing funding, and enhancing preparedness. The initiative also considered climate adaptation in light of global climate challenges. The project involved multiple mayors and aimed to create a resilient, cooperative framework across political and community sectors. Adjustments were made during the COVID-19 pandemic, incorporating community needs and establishing new policies. The early warning system for floods was developed and implemented by April 2023, improving response capabilities for extreme weather events.

- A comprehensive approach was taken to understand hazards and vulnerabilities using open-source software, enabling effective communication across municipal departments**. Community involvement was critical, with residents helping to validate risk maps and provide local data**. The system effectively utilized data during the 2024 El Niño event, allowing for timely evacuations and resource deployment, highlighting the importance of community understanding of alert levels.

- The project successfully integrated various frameworks (Sendai, Paris Agreement, SDGs) to enhance community resilience, emphasizing the need for collaborative approaches across different agendas for sustainable urban development. **She advocated for continuous community engagement and updates to ensure long-term effectiveness and adaptability in disaster risk management**.

Jing-Shan Hong, Director of the Marine Meteorology and Climate Division at the Central Weather Administration, discussed the impacts of significant La Niña events on water resource management in Chinese Taipei.

- Despite its distance from ENSO's origins in Peru, Chinese Taipei's climate is influenced by the Pacific-East Asian Teleconnection, which alters precipitation patterns. During El Niño years, warmer winters and increased rainfall are observed, while La Niña results in warmer winters with more precipitation but less in spring.

- He highlighted the unique occurrence of a "Triple Dip" La Niña from 2020 to 2022, which contributed to a severe mega drought, significantly reducing rainfall and impacting water reservoirs. The absence of typhoons during these years further exacerbated the situation, as typhoons are crucial for water resource replenishment. The analysis showed a strong subtropical high suppressing typhoon development, correlating this with global warming and La Niña.

- To address these challenges, the speaker **emphasized the importance of collaboration between meteorological and water resource management agencies**. The Central Weather Administration provided timely forecasts to manage the drought effectively. They utilized advanced forecasting techniques, including machine learning algorithms, to produce high-resolution precipitation forecasts, essential for decision-making and drought monitoring.

- In conclusion, he noted that **while scientific understanding and climate predictability have improved, effective climate service delivery, utilizing advanced technology for better decision-making, remains crucial for enhancing climate resilience in Chinese Taipei**.

Patricia del Pilar Rivera Giron from SENAMHI shared her presentation focusing on the climatic thresholds for Dengue incidence in Peru from 2001 to 2022. The study aimed to enhance climate adaptation in health systems through collaboration with the Peruvian Ministry of Health and academia.

- Dengue is a significant health concern in Peru, especially in the north coast and Amazon regions. Incidence rates have risen over the past 20 years, with notable peaks during climatic events like El Niño.

- The study identified specific climate variable thresholds and their temporal lag associated with increased dengue cases across six climate zones. They utilized data from CDC Peru, including meteorological data (temperature, humidity, precipitation) and confirmed dengue cases. The study employed cross-correlation and regression trees to analyze the relationship between climate variables and dengue incidence. Cross-correlation identified time lags between climate conditions and dengue peaks, while regression trees determined specific thresholds for increased incidence.

- According to the study, **climate variables, particularly temperature, significantly influence dengue incidence, with positive correlations identified several weeks before peaks (averaging 12 weeks)**. The north coast had the highest incidence, with precipitation being a crucial predictor, requiring at least 3.8 mm of rain per week for increased cases. In the central coast, temperature variables played a larger role, with a more complex interaction pattern. For the Amazon regions, minimum temperature was a key predictor, especially in the high rainforests. The north coast showed a 7-fold increase in incidence during favorable climatic conditions, while the central and north high rainforests exhibited increases of up to 53 times. The central low coast demonstrated minimal climatic influence on dengue incidence, suggesting other factors may play a role.

- In conclusion, **understanding climatic thresholds and their interactions is vital for effective dengue outbreak management**. In addition, **improved forecasting based on regional climatic conditions can enhance public health responses, contributing to better health outcomes** in the future.

Greys Otiniano Mego from SENAMHI discussed SENAMHI's role in providing agrometeorological services in Peru.

- She emphasized that climate change adversely affects food and water security due to global warming, altered precipitation patterns, and increased frequency of climate events. Heat stress, drought, and other climate challenges reduce soil moisture and agricultural health, leading to higher food prices and increased vulnerability for communities.
- **Peru's agricultural GDP is projected to decline by 3% in 2023, marking the largest contraction in 30 years, influenced by adverse work conditions, especially during El Niño.** The agro-export sector has seen significant growth due to public

policies and investment in infrastructure, but 2023's conditions have impacted employment in the sector. Out of 2.2 million farmers in Peru, 96% are engaged in family agriculture, making them particularly vulnerable to climate change due to their dependence on agriculture for their livelihoods.

- In this regard, SENAMHI offers the Integrated Agrometeorological Service (SAI) to mitigate climate impacts and enhance agricultural production. This includes capacity-building for farmers and the development of customized services to improve resilience against climate risks. In SAI, **a robust agrometeorological network is crucial, necessitating more observation stations across Peru**. Utilization of advanced technology like drones, phenological networks, and smart traps for monitoring crop conditions and pest populations are also necessary.
- SENAMHI provides various agroclimatic forecasts tailored to different timescales (daily, weekly, monthly) to support agricultural planning and immediate actions. Information on pests, diseases, and climate stressors is updated in real-time to aid farmers in decision-making. **The Participatory Integrated Climate Services for Agriculture (PICSA)** methodology is implemented to engage farmers in workshops, fostering collaboration between technical specialists and the agricultural community. This approach aims to reduce food losses and improve agricultural outcomes through shared knowledge and resources. She emphasized **the need for proactive agrometeorological services and collaboration to address the challenges posed by climate change, ultimately ensuring food security and economic stability in Peru**.

Panel Discussion. ENSO – Response and Preparedness

The panel discussion was chaired by Julian Baez, Director of Regional Offices for the Americas, WMO. He introduced a diverse panelist, including experts from the public, academia, private and international sectors. The main theme of the discussion is to improve preparedness and response to ENSO events, with an emphasis on early warning systems. Topics covered included risk management, adaptation strategies, and best practices for local and regional ENSO response. He mentioned that over 52% of economies have implemented multi-hazard early warning systems, through significant gaps remain. He emphasized the four pillars of an early warning system: risk awareness, hazard monitoring, communication, and preparedness actions. WMO is working with the UN, Red Cross, and others to implement early warning systems globally, focusing on protecting vulnerable communities. Collaborative efforts, such as the Global Multi-hazard Alert System (GMAS), aim to strengthen domestic meteorological services and enhance resilience. The early warning system initiatives intersect with the Sendai Framework for disaster risk reduction, UNFCCC, and the SDGs, all aiming to reduce vulnerability and increase resilience.

The panelists shared their experience and insights as to collaboration efforts to enhance response and preparedness against ENSO and climate change in Asia-Pacific region. Diverse views both from private and public sectors were shared and some recommendations were made as follows.

[Perspective – Government]

- **Strengthen Early Warning Systems Across Critical Areas**: It is important to implement comprehensive early warning systems focused on modeling, monitoring, and acting, with a strong emphasis on proactive measures to prevent disasters rather than react to them. Also, it is recommended to enhance communication channels to ensure timely warnings reach the population, especially remote communities.

- **Address Gaps in Communication and Preparedness**: It is necessary to increase efforts to bridge the communication gap between technical authorities and the public, so communities can fully understand risks and react appropriately. Also, it is recommended to focus on regional and local preparedness, ensuring local authorities are well-informed and capable of responding to potential ENSO events before they occur, not just in the aftermath.
- **Highlight Early Warning Systems as Investments**: Stakeholders are encouraged to enhance the perception of early warning systems as essential investments that reduce long-term economic costs and protect lives, rather than expenses. In this procedure, it is advised to use data on potential GDP losses due to climate change impacts to underscore the urgency of these investments.
- **Expand Infrastructure with Resilience in Mind**: It is suggested that both grey (concrete) and green infrastructure are implemented to combat flood risks, particularly in regions severely affected by ENSO events and to include technologies such as meteorological radars, new weather stations, and moisture sensors to improve real-time monitoring and enable rapid response.
- **Integrate Early Warning Systems into domestic Climate Initiatives**: It is recommended that early warning systems to be embedded within Peru's climate action plans (NDCs), targeting key areas like water, agriculture, forest conservation, and marine ecosystems. Moreover, stakeholders are encouraged to collaborate across various sectors, including agriculture, forestry, and fisheries, to safeguard vulnerable ecosystems and enhance resilience against climate-induced disasters.

[Perspective – Academia]

- **Model Development and Forecasting**: In Korea, academic experts and domestic institutes use in-house models to forecast ENSO events and their likely impacts on precipitation and temperature. This allows for informed predictions, although there are still challenges in public awareness regarding academic contributions to ENSO-related Early Warning System.
- **Collaboration with Media**: Academia are encouraged to partner with media outlets to communicate ENSO forecasts and impacts effectively to the public. Disaster-focused media teams need to work with academic experts to deliver timely ENSO-related updates, increasing public access to critical information.
- **Coordination with Government:** In Republic of Korea, academics collaborate with the Korean Meteorological Administration (KMA) by participating in seasonal forecasting meetings. KMA integrates the academic insights on ENSO impacts specifically tailored to Korea's climate, enhancing the accuracy and relevance of seasonal predictions.

[Perspective – Financial institutions]

- Standardize Climate Risk Information: Financial institutions should consolidate and translate technical climate data so risk teams can incorporate it into credit risk assessments, making long-term structural adjustments possible.

- Adapt to International Regulations: With evolving global standards on climate disclosures (e.g., TCFD), institutions should prepare to align with these frameworks, such as mandatory risk reporting seen in regions like Europe and Colombia.
- Develop Risk Mapping Tools: Utilize hotspot maps by sector and geography to identify high-risk clients and areas prone to climate events like El Niño. This can help pinpoint vulnerable clients and sectors (e.g., agriculture, fishing, and logistics).
- Create Flexible Insurance Products: For clients, especially Small and Medium Enterprises (SMEs), introduce adaptable insurance options to manage specific climate risks. This includes innovative products, such as "flexible house" insurance for climate-resilient housing solutions.
- Build Climate Expertise in Risk Teams: Enhance the skills of risk management teams in climate, environmental, and social risk assessment, enabling them to proactively handle and mitigate climate impacts.
- Improve Client Outreach and Education: Through digital and in-person outreach (e.g., WhatsApp updates and fairs), educate clients on climate risks, helping them make informed decisions about resilience strategies. By strengthening internal capacities and client awareness, the role financial institutions can play in promoting sustainability and resilience in response to climate change can be highlighted.

[Perspective – Private sector]

- Strengthen Private-Sector Coordination for Emergency Response: Hombro a Hombro, as a coalition of 72 private companies, should continue unifying efforts across sectors—such as banking, retail, and utilities—to coordinate effectively with government authorities during large-scale emergencies. This prevents redundancy and maximizes resource deployment.
- Promote a Culture of Preparedness: To foster resilience, educational programs should be scaled up. For example, Hombro a Hombro collaborates with Peru's Ministry of Education to train 10,000 teachers annually in emergency preparedness, which they, in turn, pass on to children to reinforce family-level disaster planning.
- Enhance Communication and Media Partnerships: Given limited government resources, Hombro a Hombro recommends stronger partnerships with mass media. By developing content through AI that translates technical information into public-friendly formats, essential updates can reach specific regions and communities in need.
- Invest in Workplace Disaster Preparedness Training: Encourage companies to train employees on emergency preparedness, ensuring they are familiar with family and workplace safety plans. This includes running earthquake simulators to offer real-time experience, helping employees to react effectively during actual events.
- Develop Region-Specific Disaster Information Systems: Hombro a Hombro's information center uses AI to distribute localized disaster updates through media channels, which allows Peruvians to stay informed about region-specific events, weather forecasts, and infrastructure issues. This system aims to cover real-time risks such as road safety, rainfall forecasts, and airport statuses.
- Build International Knowledge Networks: Peru's Hombro a Hombro program is learning from global leaders like Istanbul and the Philippines in business-connected

disaster response, which can enhance Peru's resilience and readiness for similar challenges.

[Perspective – International NGOs]

- Strengthen Protocols for Early Warning and Action: Develop and standardize early warning protocols that outline specific actions for volunteers, community members, and local authorities before, during, and after climate events to save lives and protect livelihoods. And focus on local-level protocols tailored to extreme conditions, such as cold weather events affecting high-altitude Peruvian communities.
- Ensure Accurate and Timely Forecast: Collaborate closely with meteorological services to refine forecasts, especially to avoid false warnings, which can drain resources. And utilize lead times to prioritize actions like cash transfers or contingency plans based on forecast accuracy and urgency, ensuring that resources are allocated efficiently.
- Promote Radio as a Vital Communication Tool: Use radios, especially in local languages (e.g., Quechua, Aymara), as an effective means of disseminating early warnings and critical updates to remote communities. Also, encourage local radio broadcasting for timely and culturally accessible communication, recognizing that radios are often a main information source in rural areas.
- Expand Financial Mechanisms for Rapid Response: Implement insurance-based financial triggers that release funds when climate thresholds are exceeded, providing rapid support to local Red Cross offices and communities. Also, use cash transfers, either via bank or direct distribution, allowing vulnerable populations to prepare or relocate ahead of disasters, thereby reducing risks and protecting livelihoods.
- Integrate Local Authorities in Preparedness: Work with local leaders to develop actionable plans so communities can independently activate early action plans or contingency measures when warnings are issued.
- Collaborate on the "Early Warning for All" Initiative: Partner with international organizations (UNDRR, IFRC) and local civil protection entities to advance early warning initiatives, focusing on "last mile" efforts to ensure warnings reach vulnerable communities. Finally, coordinate with ITU to streamline communication methods so forecasts and warnings reach affected areas as quickly as possible.

These recommendations aim to improve the effectiveness and reach of early warning systems, with a focus on practical, community-level actions, and partnerships that make climate information accessible and actionable in vulnerable regions.

Symposium Outcomes

Targeted outcomes of this project have been achieved, as evidenced by participant feedback from the post-event survey. Respondents indicated that the project set the clear objectives and successfully met its intended goals.

1. Increased international dialogue and cooperation on ENSO responses

A majority of participants expressed that this project was relevant to their economies, especially as they face extreme weather and climate events such as typhoon, flood and drought, linked to ENSO. Delegations from member economies shared their unique circumstances and experiences, fostering mutual understanding through discussions on how they have managed these impacts. Participants valued the opportunity to engage with a diverse range of stakeholders from both the public and private sectors involved in climate-related disaster risk management. This event facilitated networking and dialogue, promoting awareness of the importance of collaboration among central and local governments, as well as local communities.

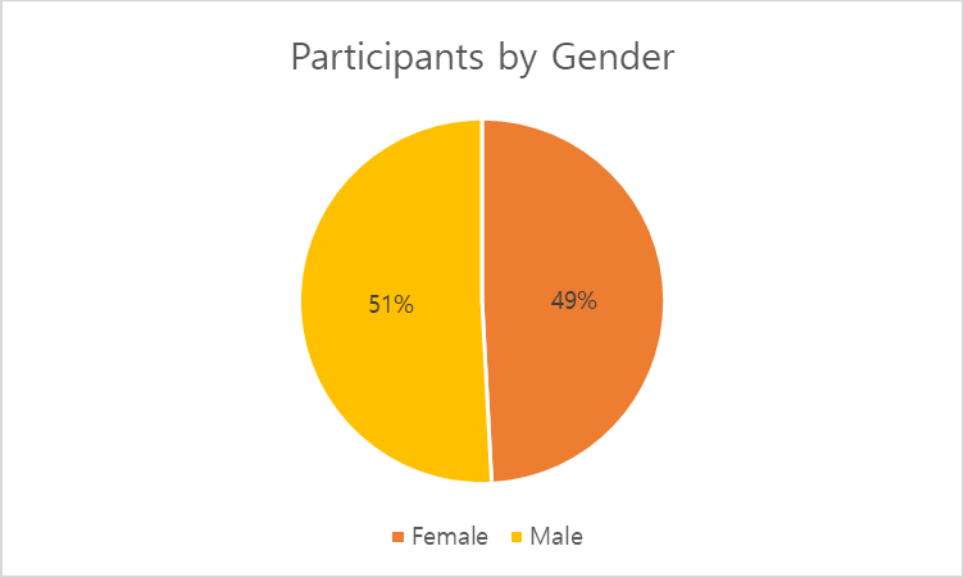
2. Increased capacity for managing ENSO-related disaster risks through collaboration

Many participants found this event meaningful for learning from leading scientists and organizations about climate change, extreme climate events, and their impacts. Feedback indicated that the symposium served as a vital tool for knowledge and capacity building. Participants reported enhanced understanding of how member economies are addressing ENSO and its impacts, as well as regional efforts to apply climate services for disaster risk management. Public sector delegates noted that their increased knowledge of ENSO science and technology would inform their domestic ENSO impact assessments. Additionally, case studies shared during the event provided useful examples for improving agro-climate services in their economies. According to the post-event survey, 88.5% of respondents reported an increase in their understanding of the topics covered. Participants plan to apply the insights gained from the event to their future work.

The primary beneficiaries of this project included policy makers, practitioners, and researchers focused on climate change adaptation in APEC region. Participants gained the latest insights into ENSO prediction science and technology, including the application of AI in forecasting. They also deepened their understanding of how ENSO affects sectors such as agriculture and health, and how member economies are collaboratively managing these challenges. With the knowledge gained from the event, participants are expected to contribute effectively to their domestic climate change adaptation planning.

The organizers solicited nominations from the APEC Emergency Preparedness Working Group (EPWG) and Policy Partnership on Science, Technology and Innovation (PPSTI) to involve high-level governmental decision-makers in climate-related emergency preparedness and climate services. As a result, 15 delegations from 8 Travel Eligible Economies (TEEs), especially those responsible for climate services and disaster risk management, attended the event.

To support APEC's effort to integrate women into economic activities, the project team prioritized gender balance among speakers and participants, actively encouraging female participation from developing economies. This effort resulted in a near-equal gender ratio, with 59 female and 61 male participants.



Participants attended from 16 economies, including 14 APEC member economies and 2 non-member economies. The workshop drew a total of 120 attendees from a range of public sector stakeholders including disaster risk management, meteorological and hydrological agencies, academia, NGOs, private sector and experts from international organizations.

Economy	Participants	Economy	Participants
Canada	1	The Philippines	8
Chile	2	Singapore	3
People's Republic of China	18	Chinese Taipei	1
Indonesia	4	Thailand	3
Japan	3	United States	22
Republic of Korea	8	Viet Nam	4
Malaysia	2	Ecuador	1
Peru	39	Paraguay	1
Total Participants	**120**		

Through expert presentations and discussions, several key recommendations and best practices were shared. These suggestions aimed to enhance the effectiveness and reach of climate services to various sectors, with a focus on practical, community-level actions, and partnerships that make climate information accessible and actionable in vulnerable regions.

- Even if El Niño patterns remain the same, warming from climate change will intensify their impacts, raising risks for health, agriculture, and infrastructure. Model projections suggest that extreme El Niño events might become more frequent by 2030 due to global warming, increasing urgency for effective adaptation measures. Thus, understanding the diverse impacts of ENSO requires differentiating between types of extreme events. With climate change likely exacerbating impacts, AI and advanced regional models are expected to offer valuable tools for proactive decision-making and regional resilience.

- Sub-seasonal forecasts are critical for forecasting extreme weather events although challenges remain such as noisy signals and data gaps. International community is encouraged to continue their research and development efforts in S2S prediction.
- Effective response to ENSO's impacts requires collaboration and information sharing among regional communities. For instance, The Korean Meteorological Administration collaborates with various institutions to enhance seasonal forecasting, benefiting multiple sectors.
- In disaster risk management, the importance of community engagement should not be undermined. Community involvement is critical, with residents helping to validate risk maps and provide local data. Continuous community engagement and system updates are key elements to ensure long-term effectiveness and adaptability in disaster risk management.
- Climate variables, particularly temperature, significantly influence dengue incidence. Thus, understanding climatic thresholds and their interactions is vital for effective dengue outbreak management. In addition, improved forecasting based on regional climatic conditions can enhance public health responses, contributing to better health outcomes in the future.
- **Strengthen Early Warning Systems Across Critical Areas**: It is important to implement comprehensive early warning systems focused on modeling, monitoring, and acting, with a strong emphasis on proactive measures to prevent disasters rather than react to them. Also, it is recommended to enhance communication channels to ensure timely warnings reach the population, especially remote communities.
- **Highlight Early Warning Systems as Investments**: Stakeholders are encouraged to enhance the perception of early warning systems as essential investments that reduce long-term economic costs and protect lives, rather than expenses. In this procedure, it is advised to use data on potential GDP losses due to climate change impacts to underscore the urgency of these investments.
- **Integrate Early Warning Systems into domestic Climate Initiatives**: It is recommended that early warning systems to be embedded within Peru's climate action plans (NDCs), targeting key areas like water, agriculture, forest conservation, and marine ecosystems. Moreover, stakeholders are encouraged to collaborate across various sectors, including agriculture, forestry, and fisheries, to safeguard vulnerable ecosystems and enhance resilience against climate-induced disasters.
- For the financial institutions to integrate climate-related risk management into their practices, they are recommended to: i) Standardize Climate Risk Information: Financial institutions should consolidate and translate technical climate data so risk teams can incorporate it into credit risk assessments, making long-term structural adjustments possible; ii) Adapt to International Regulations: With evolving global standards on climate disclosures (e.g., TCFD), institutions should prepare to align with these frameworks, such as mandatory risk reporting seen in regions like Europe and Colombia; iii) Create Flexible Insurance Products: For clients, especially Small and Medium Enterprises(SMEs), introduce adaptable insurance options to manage specific climate risks. This includes innovative products, such as "flexible house" insurance for climate-resilient housing solutions; iv) Build Climate Expertise in Risk Teams: Enhance the skills of risk management teams in climate, environmental, and social risk assessment, enabling them to proactively handle and mitigate climate impacts; and v) Improve Client Outreach and Education: Through digital and in-

person outreach (e.g., WhatsApp updates and fairs), educate clients on climate risks, helping them make informed decisions about resilience strategies. By strengthening internal capacities and client awareness, the role financial institutions can play in promoting sustainability and resilience in response to climate change can be highlighted.

- For private sector to enhance disaster preparedness and response coordination and public awareness efforts, they are recommended to: i) Promote a Culture of Preparedness: To foster resilience, educational programs should be scaled up. For example, Hombro a Hombro collaborates with Peru's Ministry of Education to train 10,000 teachers annually in emergency preparedness, which they, in turn, pass on to children to reinforce family-level disaster planning; ii) Enhance Communication and Media Partnerships: Given limited government resources, it is recommended to have stronger partnerships with mass media. By developing content through AI that translates technical information into public-friendly formats, essential updates can reach specific regions and communities in need; iii) Invest in Workplace Disaster Preparedness Training: Encourage companies to train employees on emergency preparedness, ensuring they are familiar with family and workplace safety plans. This includes running earthquake simulators to offer real-time experience, helping employees to react effectively during actual events.
- Strengthen Protocols for Early Warning and Action: Develop and standardize early warning protocols that outline specific actions for volunteers, community members, and local authorities before, during, and after climate events to save lives and protect livelihoods. And focus on local-level protocols tailored to extreme conditions, such as cold weather events affecting high-altitude Peruvian communities.
- Ensure Accurate and Timely Forecast: Collaborate closely with meteorological services to refine forecasts, especially to avoid false warnings, which can drain resources. And utilize lead times to prioritize actions like cash transfers or contingency plans based on forecast accuracy and urgency, ensuring that resources are allocated efficiently.
- Expand Financial Mechanisms for Rapid Response: Implement insurance-based financial triggers that release funds when climate thresholds are exceeded, providing rapid support to local Red Cross offices and communities. Also, use cash transfers, either via bank or direct distribution, allowing vulnerable populations to prepare or relocate ahead of disasters, thereby reducing risks and protecting livelihoods.
- Integrate Local Authorities in Preparedness: Work with local leaders to develop actionable plans so communities can independently activate early action plans or contingency measures when warnings are issued.
- Collaborate on the "Early Warning for All" Initiative: Partner with international organizations (UNDRR, IFRC) and local civil protection entities to advance early warning initiatives, focusing on "last mile" efforts to ensure warnings reach vulnerable communities. Finally, coordinate with ITU to streamline communication methods so forecasts and warnings reach affected areas as quickly as possible.

Participants Feedback

To evaluate the success of this project, participants were invited to complete a post-event survey assessing the effectiveness and outcomes of the symposium. The survey aimed to determine whether the objectives were met and whether the information shared prompted any changes following event. It included questions comparing participant's knowledge levels before and after attending the symposium, as well as assessing their satisfaction with the organization and contents of the event. Additionally, the survey explored mid-term effects of the project. Gender aspects of the symposium were also highlighted through gender-disaggregated data. Allowing for an analysis of participation rates among both invited panelists and attendees.

A total 29 participants responded to the survey. Satisfaction levels were categorized as 'strongly agree (3),' 'agree (2),' and 'disagree (1)'.

Evaluation criteria	Average Score
1. The objectives of the training were clearly defined	2.86
2. The project achieved its intended objectives	2.86
3. The agenda items and topics covered were relevant	2.79
4. The content was well organized and easy to follow	2.72
5. Gender issues were sufficiently addressed during implementation	2.55
6. The trainers/experts/facilitators were well prepared and knowledgeable about the topic	2.83
7. The materials distributed were useful	2.69
8. The time allotted for the event was sufficient	2.66

Responses indicated that participants generally held positive perceptions of the event in terms of clarity of its objectives. Notably, 100% of respondents selected 'strongly agree' or 'agree' when asked if the event achieved its intended goals. Furthermore, all participants agreed that the agenda items and topics covered were relevant to them, demonstrating that the target audience was well represented.

With regard to gender issues, all but one participant felt that these concerns were adequately addressed throughout the project, although the organizing team recognizes that there is still room for improvement in this area. Additionally, all respondents affirmed that the experts and facilitators were well prepared and knowledgeable about the topic discussed.
Participants reported a significant increase in knowledge across all discussion topics. Most importantly, 76% indicated that their understanding and skills related to ENSO and its responses had improved after attending the event. Regarding the materials provided, 97% of

respondents found them useful, and all participants felt that the time allotted for the event was sufficient.

[Annex: Program]

<table>
<tr><th colspan="3">12 August 2024</th></tr>
<tr><th>Time</th><th>Activity</th><th>Presentation</th></tr>
<tr><td>9:00-9:50</td><td colspan="2">Registration / Networking</td></tr>
<tr><td>9:50-10:00</td><td colspan="2">SENAMHI Meteorological Briefing by Piero Rivas</td></tr>
<tr><td rowspan="4">10:00-10:30</td><td colspan="2">Opening</td></tr>
<tr><td>Opening Remarks</td><td>• Raquel Hilianova Soto Torres, Vice-Minister of the Environment of Peru
• Do-Shick Shin, Executive Director, APEC Climate Center</td></tr>
<tr><td>Welcome Remarks</td><td>• Gabriela Teofila Rosas, Executive President, SENAMHI</td></tr>
<tr><td>Congratulatory Remarks</td><td>• Carlos Vasquez, APEC SOM Chair</td></tr>
<tr><td colspan="3">Keynote Session – Impact of Climate Change in Sustainable Growth Perspective
El Niño (Chair : Hyungjin Kim (Director, Climate Services and Research Division, APCC)</td></tr>
<tr><td>10:30-11:10</td><td colspan="2">El Niño and its Global Influence in a Warming Climate
Shang-Ping Xie
Professor, SCRIPPS Institution of Oceanography, University of California San Diego</td></tr>
<tr><td>11:10-11:30</td><td colspan="2">Q&A</td></tr>
<tr><td>11:30-13:00</td><td colspan="2">Lunch</td></tr>
<tr><td colspan="3">Session I – ENSO – Science and Technology
(Chair : Hyungjin Kim (Director, Climate Services and Research Division, APCC)</td></tr>
<tr><td>13:00-14:15</td><td colspan="2">▪ An Update on ENSO at NOAA CPC: Analysis, Perspectives, and Explorations Michelle L’Heureux , Physical scientist, Climate Prediction Center, NOAA Weather Service
▪ Seasonal and Sub-seasonal Prediction for Climate Risk Management Andrew Robertson, Senior research scientist, Climate group, IRI
▪ El Niño Diversity Impacts in Peru and the Effects of Climate Change Ken Takahashi Guevara, Principal scientific researcher, Atmosphere-Ocean Processes and Predictability Division, Geophysical Institute of Peru (IGP)</td></tr>
<tr><td>14:15-14:40</td><td colspan="2">Coffee break</td></tr>
</table>

14:40-15:30	▪ **Progress in Weekly Sub-seasonal Forecasts for Peru** Yury Wilson Escajadillo Fernandez, Climate prediction specialist, Climate prediction subdirection, SENAMHI ▪ **Favorable Environmental Conditions Forecast for the Incidence of Crop Pest Using AI** Edson Jair Arias Huachamber, Specialist in agrometeorological forecast, SENAMHI
15:30-16:00	Q&A / Discussion
17:00-18:30	Welcome reception
13 August 2024	
Session II – ENSO – Impact Assessment and Collaboration (Chair: Sunyong Kim (Research Fellow, Climate Analytics Department, APCC)	
9:30-9:40	SENAMHI Meteorological Briefing by Piero Rivas
9:40-10:55	▪ **Towards a better understanding of ENSO and its impacts** Sang-wook Yeh, Professor, Marine Sciences and Convergent Technology, Hanyang University ▪ **Resilience Redefined: The Synergistic Co-Creation of Academia, Local Government, and Communities** Maria del Pilar Cornejo, Director, Pacific International Center for Disaster Risk Reduction ▪ **Impact of the 2020-2022 La Niña Event on Agriculture and Water Resources in Chinese Taipei** Jing-Shan Hong, Director, Marine Meteorology and Climate Division, Central Weather Administration
10:55-11:20	Coffee Break
11:20-12:10	▪ **Climatic Thresholds for Dengue Incidence by Climate Zones in Peru from 2001 to 2022** Patricia del Pilar Rivera Giron, Climatology Analyst, Climate prediction subdirection, SENAMHI ▪ **Integrated Agrometeorological Services for Agroclimate Risk Management in Peru** Greys Otiniano Mego, Agrometeorologist, Agrometeorology Department, SENAMHI
12:10-12:40	Q&A
12:40-14:00	Lunch
Panel Discussion – ENSO – Response and Preparedness (Moderator: Julian Baez, Director of Regional Office for the Americas, WMO)	

14:00-16:00	• **Raquel Hilianova Soto Torres**, Vice-Minister of the Environment of Peru • **Sang-wook Yeh**, Professor, Marine Sciences and Convergent Technology, Hanyang University • **David Garcia Howell**, Environmental Strategic Manager, CREDICorp. • **Juan Manuel Arribas**, Executive Director, Hombro a Hombro • **Juan Bazo**, Senior Climate and Data Science Advisor, Americas and Caribbean Climate Lead, Red Cross Red Crescent Climate Centre	
16:00-16:10	Closing Remarks	▪ Do-Shick Shin, Executive Director, APEC Climate Center
14 August 2024		
9:00-11:30	▪ **Opening words** Gabriela Rosas Benancio**,** Executive President, SENAMHI	
	▪ **Opening speech** Shang-Ping Xie, Professor, SCRIPPS Institution of Oceanography, University of California San Diego	
	▪ **SENAMHI Meteorological Briefing** Kelita Quispe	
	SENAMHI Presentation ▪ **Topic 1: Atmospheric environmental monitoring in Peru for health and climate change** Jhojan Rojas ▪ **Topic 2: Climate change scenarios in Peru: effects and actions for the future** Vannia Aliaga ▪ **Topic 3: Applied Research for the Strengthening of Agrometeorological Services**, Karim Quevedo Caiña	
11:30-14:00	**Lunch**	
14:00-16:00	▪ **Topic 4: Updating the hydroelectric potential in Peru: A present and future evaluation** Christian Montesinos ▪ **Topic 5: Impact based forecasting on hydrology hazard to improve disaster risk management** Waldo Lavado ▪ **Topics 6: Advances and Challenges to International Exchange of Data with WMO in WIGOS Frame** Jorge Chira ▪ Q&A ▪ **Site visit to SENAMHI**	