

TRAVEL REPORT FORM

출장보고서

결 재	선임연구 원	과장	부서장	원장
	11/08	11/08	11/08	11/08
협 조	김대하	이우섭	유진호	권원태
	과장			
협 조	11/08			
	김형진			

I. Travel Overview 출장개요

1. Traveler(s) 출장자

Department 소속	Position 직위(직급)	Name 성명	Note 비고
기후분석과	선임연구원	김대하	
예측기술과	선임연구원	김광형	

2. Travel Period 출장기간

- 김대하: 2019.10.27.-30.
- 김광형: 2019.10.27.-31.

3. Occasion and destination 행사 및 출장지

- 2019 Asia Pacific Climate Service Workshop (APCSW)
- Central Weather Bureau, Taipei, Taiwan

II. Major Activities 주요업무 수행내용

1. Main Contents and Activities 주요내용 및 활동

- APCSW 참석 및 발표 (김대하 Session II 발표, 김광형 Session II 좌장 및 Session III 발표)
- 주요내용
 - Keynote Session
 - a. Evolving U.S. National Weather Service Climate Services by Dr. Fiona Horsfall at NOAA NWS, USA: S2S 시간규모 기후예측의 재해예방 가능성에 대한

논의, Impact-based decision support services를 통한 지역, 주, 연방정부 의사 결정기능 강화에 관한 강조.

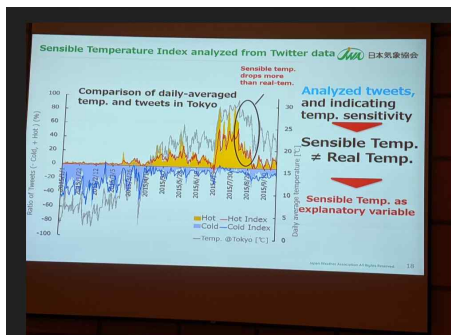
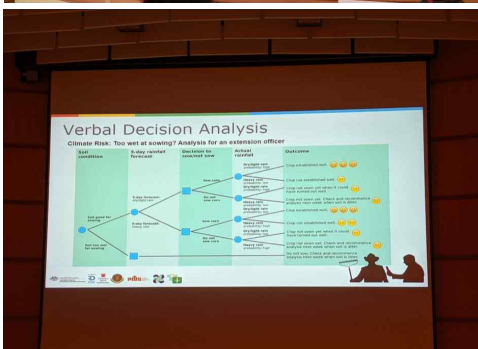
- b. New Challenges in Climate Science and Application by Dr. Pao-Kuan Wang at Research Center for Environmental Changes, Taiwan: 날씨와 기후예측의 구분 에 대한 강조. 혼돈시스템의 예측가능성에 대한 기본 내용에 대한 발표.
- c. The Quality and Future of Climate Services by Dr. Daniela Jacob at Climate Service Center Germany: 증가하는 전지구 기후변화 위험을 소프트웨어적으로 대비하는 서비스 개발의 중요성을 강조. 정책결정에 도움이 되도록 기후정보를 변환할 필요성을 강조함. 불확실성을 피하기보다는 정량화해서 의사결정을 지원하는 방향으로 서비스를 바꿔나가야 함을 강조.
- Session I: Tell Your Story – Climate Service Development chaired by Dr. Mark C. P. Cheng: 국가 날씨 기후 서비스 개발에 대한 기본정보 및 전망, 서비스 발전방향, 성공과 실패사례에 관한 6개 발표가 이루어졌음
 - a. Climate Services: Products and Applications by Mark C. P. Cheng
 - b. Climate Information and Climate Service in Thailand by Kornrawee Sitthichivapak
 - c. KMA Extreme Climate Services by Bak Seonyeong
 - d. Challenge of Regional Climate Modelling by Claas Teichmann
 - e. The Role of Private Sector to Revitalize Weather Business by Motohiro Honma
 - f. Climate Services in Vietnam by Mau Nguyen Dang
- Session II: Climate Products and Assessment chaired by Drs. Hen-I Lin and Kwanghyung Kim: 실제 사용되고 있는 Application 섹터 기후 정보서비스 체계, 기후변화 영향평가 프레임 및 정보전달 체계, 서비스 발전 전략에 관한 6개 발표
 - a. Dealing with Climate Needs of a Dry State by Robert Gillies
 - b. A Risk-based Decision-Centric Assessment of Water Supply Capacity in a Complex River Basin under Climate Change by Daeha Kim
 - c. Climate Information Service for the Prevention of Agriculture Disasters by Ming-Hwi Yao
 - d. Climate Smart Service by Ching-Pin Tung
 - e. Applying Climate Information for Public Health Warning by Yu-Chun Wang
 - f. How to Use Economic Assessment to Tailor Climate Service Products by Hen-I Lin
- Session III: Climate Communication and Management chaired by Dr. Kung-Yueh Camyale Chao: 여러 섹터를 위한 의사소통, 자료배포 기법, 날씨 기후 서비스 도구와 관리방법, 의사전달 활동 및 기술개발 사례, 서비스 성공을 위한 주요 요소에 관한 6개 발표
 - a. Challenges and Opportunities in the Delivery of Climate Services for Small

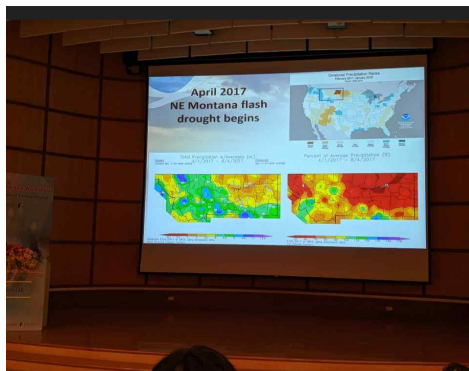
Holders Farmers in the Philippines by Thelma Cinco

- b. Community Based Adaptation to Climate Change in Taiwan by Kung-Yueh Camyale Chao
- c. Climate Change Impact and Adaptation Knowledge Service by Hsin-Chi Li
- d. Needs and Wants from 44 Markets for Climate Service and Challenge of the Private Sector by Daisuke Abe
- e. Lessons Learned for the Establishment of Climate Services for Agriculture by Kwanghyung Kim
- f. Climate Field School as a Way to Improve the Provision and Use of Tailored Climate Services in Indonesia by Nelly Florida Riama

2. Relevance to APEC Climate Center's Activities 결론 및 소감

- Utah Climate Center의 Drought monitoring system with weather datasets, Multi-hazard interdisciplinary visualization system이 상당히 인상적이었음
- 대만에서 현재 이루어지고 있는 Climate Service는 상당히 좋은 Visualization 기술과 타분야(의료, 농업, 재난)와의 긴밀한 연계성을 가지고 있는 것으로 보임
- 일본 연구자 발표에서는 트위터 자료로 기온을 사람이 느끼는 체감온도로 변환해 폭염 모니터링을 시도하고 있는 것을 확인하였으나 변환기법에 대한 논란이 많을 것으로 보임
- 동남아 지역에서도 상당히 기후서비스가 진전되고 있음을 확인하였고 점차 서비스 기능도 다양화될 것으로 보임
- 현장사진





3. Suggestions and Remarks 건의사항

- 없음

III. References (Presented and Collected Materials) 주요 수집자료

(with attachment of any information or report in case of attendance of conferences, workshops and meetings) 학술대회, 워크숍, 회의 등 참석 시 관련 정보 및 문서 첨부

- 워크숍 요약집 (오프라인 보관)

Agenda

Monday, October 28, 2019

09:00-09:30	Registration	
09:30-10:00	Opening Ceremony	
09:30-10:00	Welcome and Opening Remarks	Mr. Wen-Jong Chi (Administrative Deputy Minister, Ministry of Transportation and Communications, Taiwan) Dr. Junne-Jih Chen (Deputy Minister, Council of Agriculture, Taiwan) Mdm. Man-Li Chen (Legislator, Legislative Yuan, Taiwan) Mr. Chia-Ping Cheng (Deputy Director-General, Central Weather Bureau, Taiwan)
10:00-10:20	Group Photo & Coffee Break	
10:20-12:00	Keynote Session	Chair: Mr. Chia-Ping Cheng (CWB)
10:20-11:00	Evolving U.S. National Weather Service Climate Services	Dr. Fiona Horsfall (Branch Chief, Analyze, Forecast, and Support, Climate Services Branch, National Oceanic and Atmospheric Administration National Weather Service, USA)
11:00-11:40	New Challenges in Climate Science and Applications	Dr. Pao-Kuan Wang (Director & Distinguished Research Fellow, Research Center for Environmental Change, Academia Sinica, Taiwan)
11:40-12:00	Q&A	
12:00-13:30	Lunch	
13:30-14:10	Keynote Session	Chair: Mr. Chia-Ping Cheng (CWB) Dr. María Máñez Costa (GERICS)
13:30-14:10	The Quality and Future of Climate Services*	Dr. Daniela Jacob (Director, Climate Service Center Germany, Germany)
14:10-17:30	Session I: Tell Your Story – Climate Service Development	Chair: Mr. Chia-Ping Cheng (CWB) Dr. María Máñez Costa (GERICS)
14:10-14:30	Climate Services: Products and Applications	Mr. Chia-Ping Cheng (Deputy Director-General, Central Weather Bureau, Taiwan)
14:30-14:50	Climate Information and Climate Service in Thailand	Ms. Kornrawee Sitthichivapak (Deputy Director-General, Meteorological Department, Thailand)
14:50-15:10	KMA Extreme Climate Services	Ms. Seonyeong Bak (Assistant Director, Climate Extremes Analysis and Assessment Team, Korea Meteorological Administration, Korea)
15:10-15:30	Coffee Break	
15:30-15:50	Challenges of Regional Climate Modelling	Dr. Claas Teichmann (Scientist, Climate Service Center Germany, Germany)
15:50-16:10	The Role of Private Sector to Revitalize Weather Business	Dr. Motohiro Honma (Executive Engineer, Disaster Mitigation Solutions Department, Japan Weather Association, Japan)
16:10-16:30	Climate Services in Vietnam	Dr. Mau Nguyen Dang (Deputy Director, Center for Meteorology and Climatology, Institute of Meteorology, Hydrology and Climate Change, Viet Nam)
16:30-17:30	Wrap-up and Discussion	
18:30-20:30	Welcome Party (By Invitation)	

* this keynote speech will be delivered remotely from Germany

Tuesday, October 29, 2019

08:30-09:00	Registration	
09:00-12:20	Session II: Climate Products and Assessment	Chair: Dr. Kwanghyung Kim (APCC) Dr. Hen-I Lin (CIER)
09:00-09:20	Dealing with Climate Needs of a Dry State	Prof. Robert Gillies (Director, Utah Climate Center, Utah State University, USA)
09:20-09:40	A Risk-based Decision-centric Assessment of Water Supply Capacity in a Complex River Basin under Climate Change	Dr. Daeha Kim (Research Fellow, Climate Analytics Department, APEC Climate Center, Korea)
09:40-10:00	Climate Information Service for the Prevention of Agriculture Disasters	Dr. Ming-Hwi Yao (Researcher Fellow, Taiwan Agricultural Research Institute, Taiwan)
10:00-10:20	Coffee Break	
10:20-10:40	Climate Smart Service	Prof. Ching-Pin Tung (Department of Bioenvironmental Systems Engineering, National Taiwan University, Taiwan)
10:40-11:00	Applying Climate Information for Public Health Warning	Prof. Yu-Chun Wang (Chair of Dept. of Environmental Engineering, Chung Yuan Christian University, Taiwan)
11:00-11:20	How to Use Economic Assessment to Tailor Climate Service Products? An Example of Climate Service for Fishery in Taiwan	Dr. Hen-I Lin (Director, Center for Science and Technology Policy Evaluation, Chung-Hua Institution for Economic Research, Taiwan)
11:20-12:20	Wrap-up and Discussion	
12:20-13:30	Lunch	
13:30-16:50	Session III: Climate Communications and Management	Chair: Dr. Fiona Horsfall (NOAA) Mr. Kung-Yueh Camyale Chao (ICDI)
13:30-13:50	Challenges and Opportunities in the Delivery of Climate Services for Small Holders Farmers in the Philippines	Mrs. Thelma Cinco (Chief, Impact Assessment and Applications Section, Climatology and Agrometeorology Division, Philippine Atmospheric, Geophysical and Astronomical Services Administration, the Philippines)
13:50-14:10	Community Based Adaptation to Climate Change in Taiwan	Mr. Kung-Yueh Camyale Chao (Executive Director, International Climate Development Institute, Taiwan)
14:10-14:30	Climate Change Impact and Adaptation Knowledge Service	Dr. Hsin-Chi Li (Research Fellow, National Science and Technology Center for Disaster Reduction, Taiwan)
14:30-14:50	Coffee Break	
14:50-15:10	Needs and Wants from 44 Markets for Climate Service and Challenge of the Private Sector	Mr. Daisuke Abe (Executive Officer, Service Operation and Development, Weathernews Inc., Japan)
15:10-15:30	Lessons Learned for the Establishment of Climate Services for Agriculture	Dr. Kwanghyung Kim (Research Fellow, Department of Climate Prediction, APEC Climate Center, Korea)
15:30-15:50	Climate Field School as a Way to Improve the Provision and Use of Tailored Climate Services in Indonesia	Mrs. Nelly Florida Riama (Director, Research and Development Center, Agency for Meteorology, Climatology, and Geophysics of Indonesia, Indonesia)
15:50-16:50	Wrap-up and Discussion	
16:50-17:20	Conclusion (Each Session Chairs)	Chair: Prof. Robert Gillies
17:20-17:35	Closing Remarks	Dr. Tze-Luen Alan Lin (Deputy Executive Director, Office of Energy and Carbon Reduction, Executive Yuan, Taiwan)
18:00-20:00	Dinner Party (By Invitation)	

2019

Asia Pacific Climate Service Workshop

Current Trends and Future Challenges of Climate Services



October 28-30, 2019

International Conference Hall

Central Weather Bureau

64 Gongyuan Road, Taipei

Taiwan

"The well-known adage "climate is what you expect and weather is what you get" clarifies the difference between the climate and weather. Climate information services prepare users for the weather they will actually experience. Climate services provide climate information in a way that assists decision making by individuals and organizations. Such services require appropriate engagement along with an effective access mechanism and must respond to user needs." – GFCS/WMO



GERICS
Climate Service Center
Germany



Organizers

Central Weather Bureau (Host)



Central Weather Bureau (CWB) is the central government meteorological research and forecasting institution of Taiwan, distinctively taking the responsibility for meteorological, seismological, and related marine and astronomical operations of the nation by making astronomical observations, reporting on sea conditions, and conducting research into seismology and providing earthquake reports. CWB fulfills various requirements on meteorological information from other government agencies and the public. CWB is headquartered in Taipei City and is administered under the Ministry of Transportation and Communications.

Climate Service Center Germany (Co-host)



The Climate Service Center Germany (GERICS) was initiated by the German Federal Government in 2009 as a fundamental part of the German hightech-strategy for climate protection. Functioning as a think tank, GERICS develops prototype products in the area of climate services, works in close cooperation with science and practice partners from politics, economy and administration, and actively promotes networking among these actors. GERICS offers, in a scientifically sound manner, products, advisory services and decision-relevant information in order to support government, administration and business in their efforts to adapt to climate change. The focus of current activities is in the water, energy and ecosystems sectors, and cities.

Chung-Hua Institution for Economic Research (Co-host)



The Chung-Hua Institution for Economic Research (CIER) is an autonomous economic research organization which conducts both public research and fee-supported research. As a Taiwan-based international policy think tank, CIER focuses on economic and industry-related research, providing genuine and constructive recommendations to the government on key policies, and assisting in industrial advancement.

International Climate Development Institute (Co-host)



International Climate Development Institute (ICDI) is a non-profit organization which concerns the right of development under climate change impacts. By providing its professional knowledge and skills on climate governance, this think tank engages in planning and implementing of national climate policy with the PPP approach; supporting local communities and vulnerable groups on capacity building to achieve climate-resilient and sustainable lives.

Organizing Committee *(in alphabetical order)*

Academia Sinica	Dr. Ching-Cheng Chang
Central Weather Bureau (CWB)	Mr. Mark C. P. Cheng (Chair) Dr. Shi-Min Lin Dr. Guo-Chen Lu Mr. Lee-Yin Shen Dr. Tzay-Ming Leou Ms. Meng-Shih Chen
Chung-Hua Institution for Economic Research (CIER)	Dr. Hen-I Lin Dr. Dean Liu
Chung Yuan Christian University	Prof. Yu-Chun Wang
Climate Service Center Germany (GERICS)	Dr. Mar ía Máñez Costa
International Climate Development Institute (ICDI)	Mr. Kung-Yueh Camyale Chao
National Science and Technology Center for Disaster Reduction (NCDR)	Dr. Lee-Yaw Lin
National Taiwan University	Prof. Ching-Pin Tung
Utah State University	Prof. Simon Wang

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15:50-16:10	Public-Private Partnerships in Japan - A Case of Weather Technologies	Dr. Motohiro Homma (Executive Engineer, Disaster Mitigation Solutions Department, Japan Weather Association, Japan)
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10:40-11:00	Applying Climate Information for Public Health Warning	Prof. Yu-Chun Wang (Chair of Dept. of Environmental Engineering, Chung Yuan Christian University, Taiwan)
11:00-11:20	Climate Services in India	Dr. A.K. Srivastava (Scientist 'F' & Head Climate Monitoring and Analysis Group, Climate Research & Services, India Meteorological Department, India)
11:20-12:20	Wrap-up and Discussion	
12:20-13:30	Lunch	
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15:50-16:50	Wrap-up and Discussion	
16:50-17:20	Conclusion	Each Session Chairs
18:00-20:00	Dinner Party (By Invitation)	

Wednesday, October 30, 2019

08:30-17:00	Field trip (By invitation)
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Overview

2019 Asia Pacific Climate Service Workshop:

Current Trends and Future Challenges of Climate Services

Background

Abnormal weather conditions and extreme events are occurring more frequently all over the globe. Extreme climate anomalies are becoming the new normal in the future. In the past five years, Taiwan has suffered tremendously from disasters caused by extreme weather conditions, including the indirect impact on amplified economic fluctuations. These drastic changes in climate have departed past life experiences and subsequently influenced routine operations of social and economic activities that were built upon those past experiences. WMO as well as weather and climate service providers dedicate in providing seamless approach to provide users the services across all timescales. Therefore, it is important for weather service and climate service providers to work together. Meteorological agencies all over the world have begun to invest in this development. Many Western nations including the U.S. had listed climate anomalies as a top issue in national security. Therefore, timely and coordinated development in climate services is inevitable and crucial.

Central Weather Bureau has organized this first Asia Pacific Climate Service Workshop in order to provide an opportunity to coordinate and learn from leading developments of climate service worldwide. This work shop is cohosted by the Climate Service Center Germany (GERICS), Chung-Hua Institution for Economic Research (CIER), and International Climate Development Institute (ICDI). The purpose of this workshop is to bring together experts, forecasters, and policy-makers to discuss past and future developments of climate services and to share their applications and best practices while enhancing interaction and strengthening partnerships among international climate service and cross-sectoral researchers.

Objectives

The key objectives of this workshop are:

- To review the current status, challenges and opportunities in national and international weather and climate services
- To highlight recent progress and accomplishments in climate applications, and identify the challenges ahead in different areas of weather and climate service
- To exchange the knowledge and experiences in building weather and climate services and share stories from the various sectors

Keynote Session

In this session the speakers will provide an overview of regional and global issues of innovative weather and climate services and climate risk management and promoting the utilization of climate knowledge and information service in various application sectors, from his/her works of experiences.

Session I: Tell Your Story – Climate Service Development

This session will cover the topics about the overview of the governments or organizations regarding recent development of weather and climate services and future perspectives, to enhance climate knowledge and information service and help tackle climate change.

- National development of weather and climate services: overview and outlook
- Weather and climate service implementation strategies and action plans
- Stories of success and failure

Session II: Climate Products and Assessment

This session will discuss the topics about the utilization of climate products and services in various application sectors, help understand how climate change and climate prediction affect various application sectors and try to grasp the needs of climate information for specific sectors.

- Application of weather and climate services in various sectors
- Assessment of evaluating benefits for weather and climate services
- Assessment of strategies and action plans for weather and climate service

Session III: Climate Communications and Management

This session will explore the strengths and limitations of current climate service with respect to application, scientific knowledge diffusion, communications and management.

- Communication and dissemination of cross-sectoral scientific research knowledge
- Weather and climate service tools and management
- Communication activities or technologies promoted by weather and climate services
- Key factors to achieve the success in applying weather and climate services

How to get there

The Central Weather Bureau (CWB) is a 7-minute walk from the Metro Rail Transit (MRT) National Taiwan University Hospital (on red line). More details and logistics will be published on <http://www.cwb.gov.tw/eng/>

Taipei City

Taipei City is the capital of Taiwan. The cultural kaleidoscope of Taipei pulses wherever you go. Incense-veiled temples dating back to dynastic times blend seamlessly with a neon street life of a decidedly more modern era. Taipei has dozens of world-class restaurants where gourmets can sample the best regional Chinese cuisines; and for the gourmand, there are plenty of night markets serving up scrumptious evening snacks in an environment of chaotic excitement and fun.



Financial Support

Central Weather Bureau (CWB), Ministry of Transportation and Communications, Taiwan

Registration

No Registration fee is required. Details on the registration procedures will become available by mid-August on the website: <http://www.cwb.gov.tw/eng/>

Special Events

A workshop welcome banquet and a farewell party will be held on the evenings of Oct. 28th and Oct. 29th.

A field trip for invited participants and guests will take place on Oct. 30th. For more details, please contact us.

Contact us

Dr. Tzay-Ming Leou

Senior Technical Specialist

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Dr. Dean Liu

Assistant Research Fellow

Chung-Hua Institution for Economic Research (CIER), Taiwan

Phone: +886-2-2735-6006 ext 411

E-mail: deanliu@cier.edu.tw

A risk-based decision-centric assessment of water supply capacity in a complex river basin under climate change

Daeha Kim
Climate Analytics Department
APEC CLIMATE CENTER



Paradigms for Unknown Future

'Predict-then-act' paradigm:

✓ *High risk, high return!*

Prob. of homerun = 5.6%
Prob. of strikeout = 18.3%
(626 homeruns in entire career)



Paradigms for Unknown Future

'Robust adaptation' paradigm:

✓ *low risk, low return*

For his entire career

Prob. of homerun = 0.44%

Prob. of strikeout = 10.3%

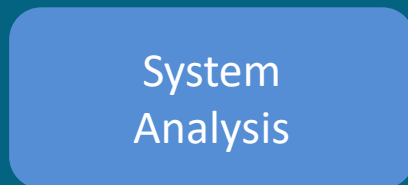
*He has made 1 or 2 homeruns a year ,
but has spoiled a number of pitches!*



Two Frameworks for CCIA

Scenario-driven vs. vulnerability based frameworks

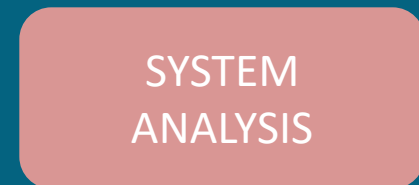
Top-Down



For 'Predict-then-act'



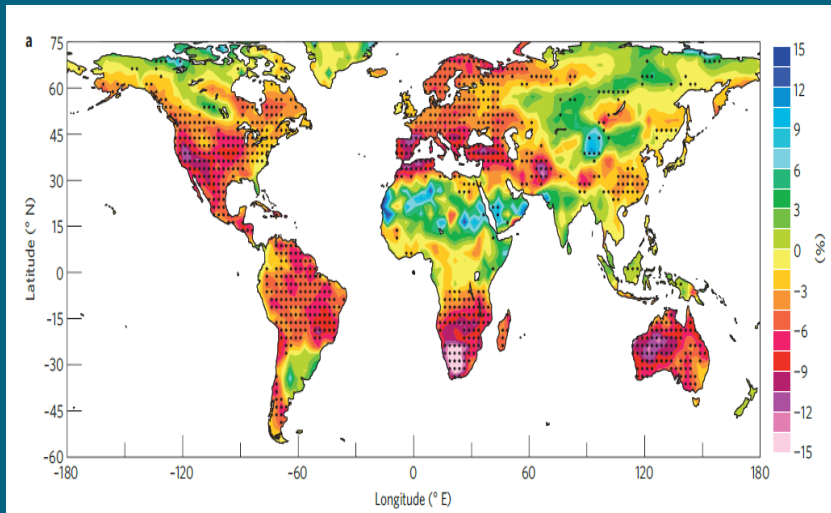
Bottom-Up



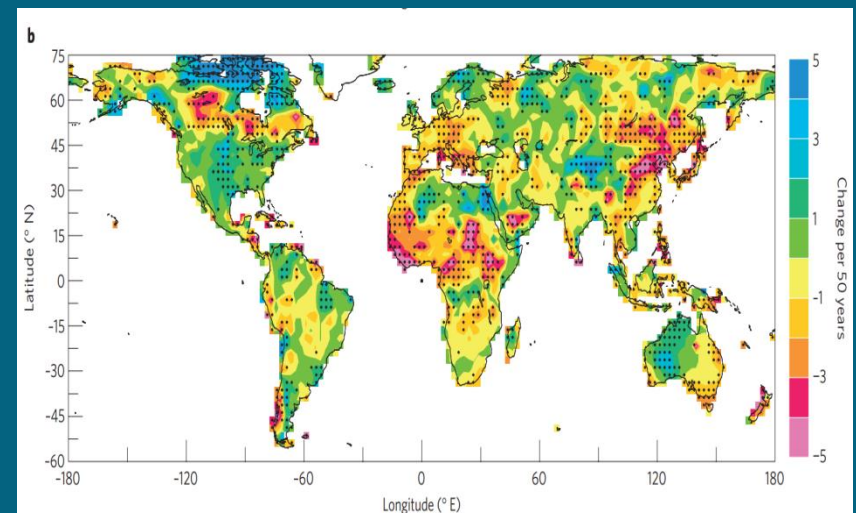
For 'Robust adaptation'

Top-Down Framework for CCIA

Can we rely on top-down assessments for policymaking?
Does this type of information support decision-makers?



< Projected drought trends under RCP 4.5 >

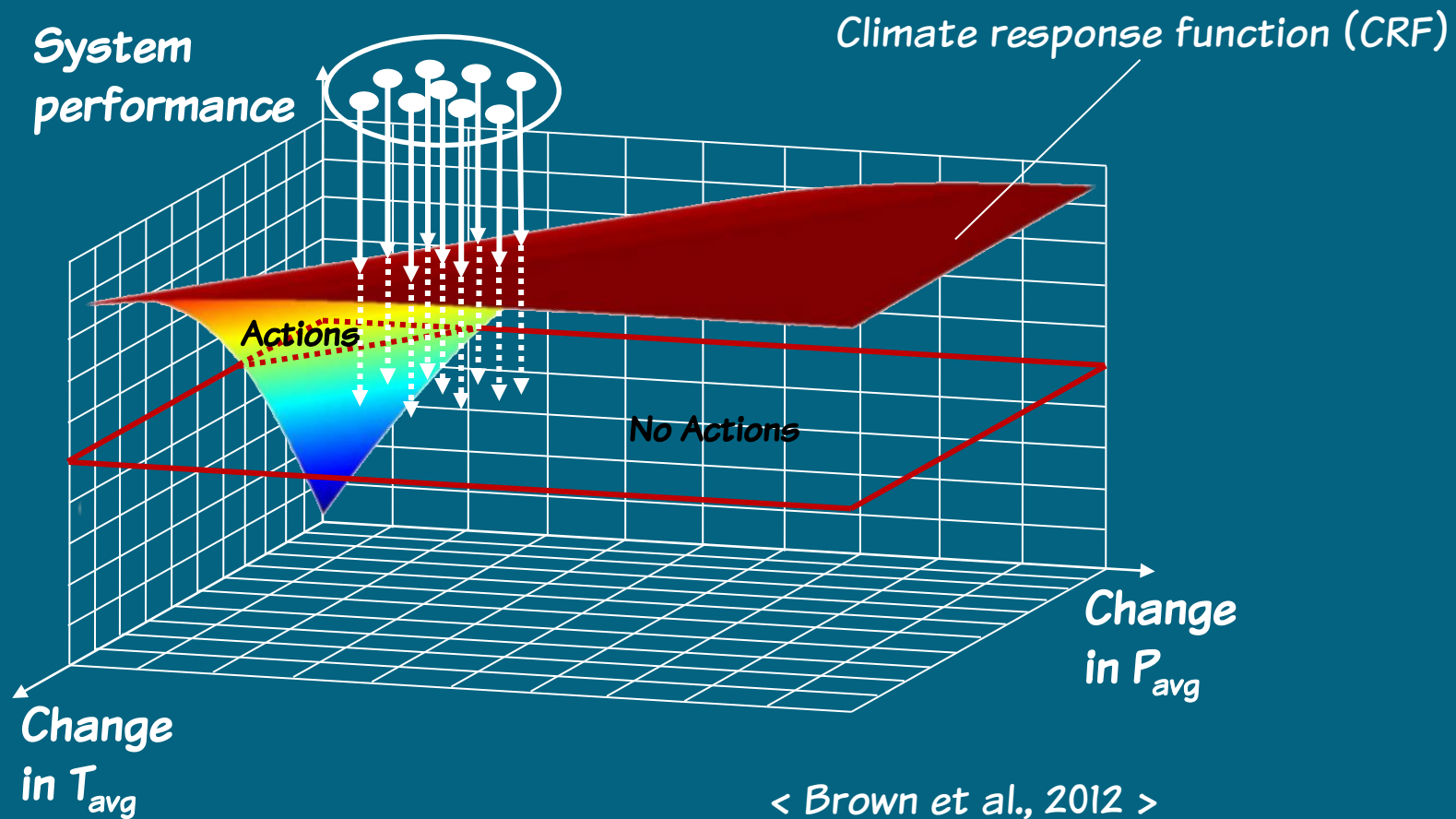


< Trends of observed droughts >

Source: Dai (2013)

How about a bottom-up framework?

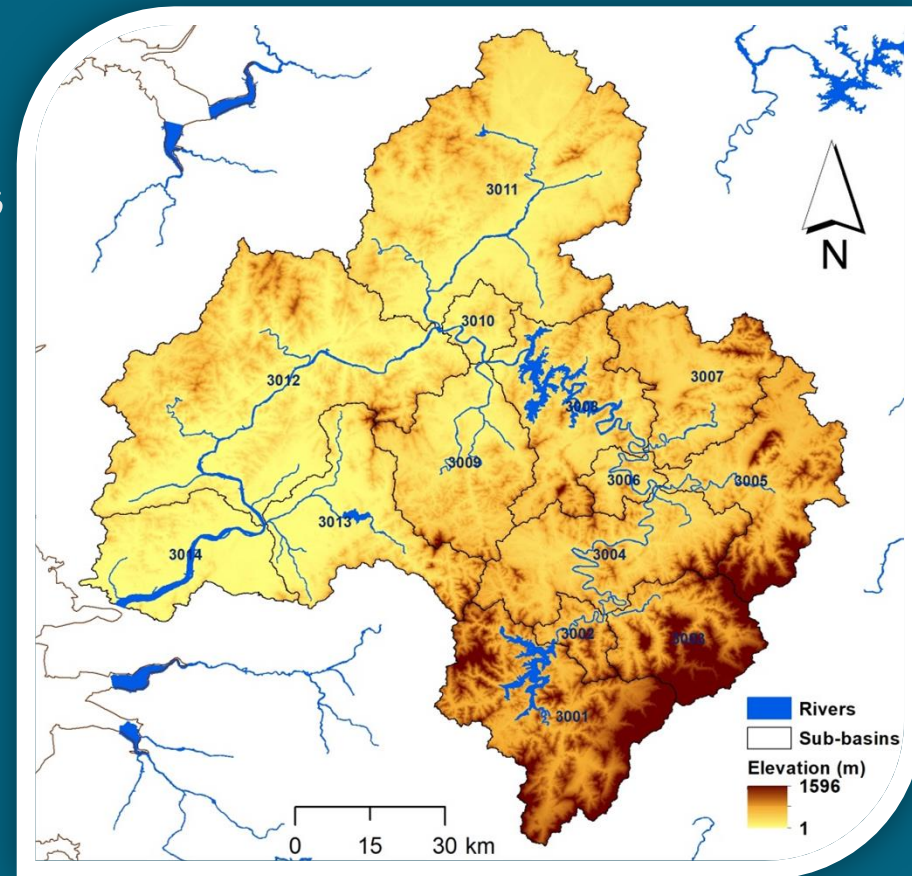
Decision scaling (Brown et al., 2012):



A Case Study for Supply Reliability

Geum River Basin:

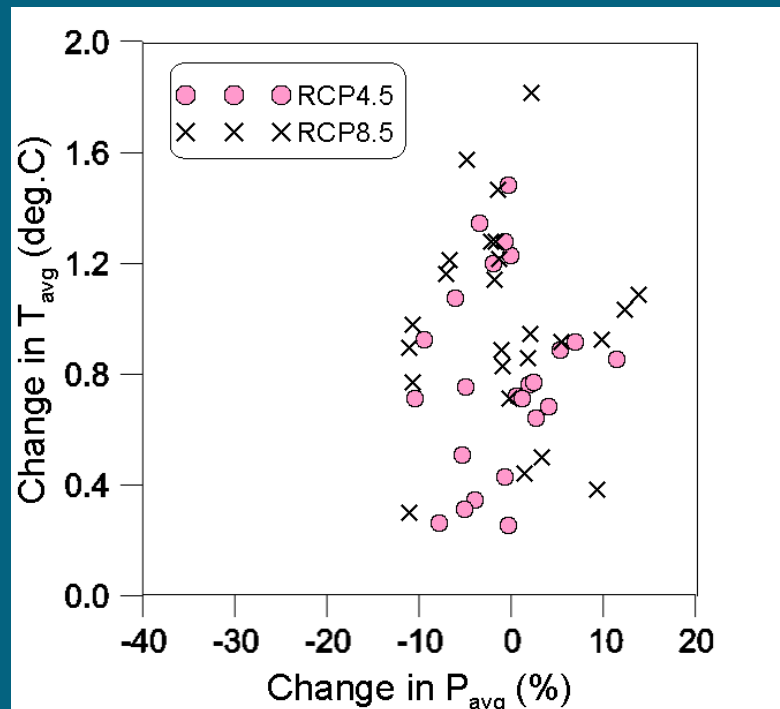
- ✓ Area of 9,915 km²
- ✓ Operated by two dams and many small reservoirs
- ✓ Mean annual prcp.:
1,245 mm/a (1976-1995)
1,325 mm/a¹ (1995-2015)
→ +80 mm/a/20y
- ✓ Mean annual temp.:
11.7 deg. C (1976-1995)
12.2 deg. C (1996-2015)
→ +0.5 deg.C/20y



Climate Change Scenarios

CMIP5 RCP4.5 & RCP8.5 scenarios:

- ✓ 25 GCMs for 2020-2039 (corrected by DQM)
- ✓ Substantial incongruity! Which one would you select?



< Climatic shifts relative to 1996-2015 >

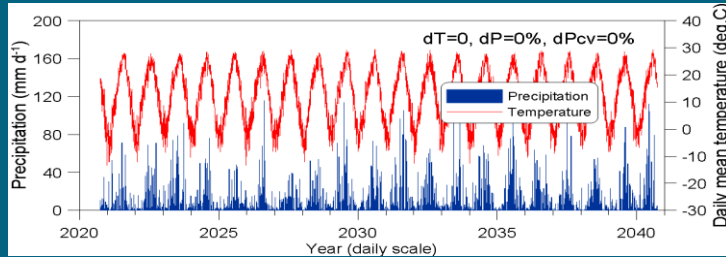
Assessment Procedure

1. Prepare pre-validated models
2. Generate plausible weather series perturbed by climatic stresses
3. Force the validated models with the synthetic weathers
4. Evaluate supply reliability for each stress
5. Develop one or multiple relationships between climate stresses and corresponding reliabilities

Stochastic Weather Generations

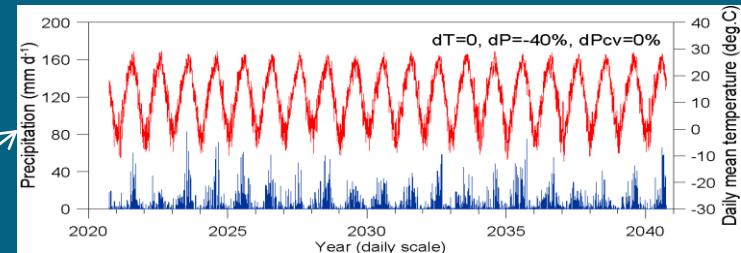
For stress-imposed 20-year-long daily P and T:

✓ $dP_{avg} = -60-40\%$, $dP_{cv} = -40-80\%$, $dT_{avg} = 0-6 \text{ deg.C}$
(539 combinations)

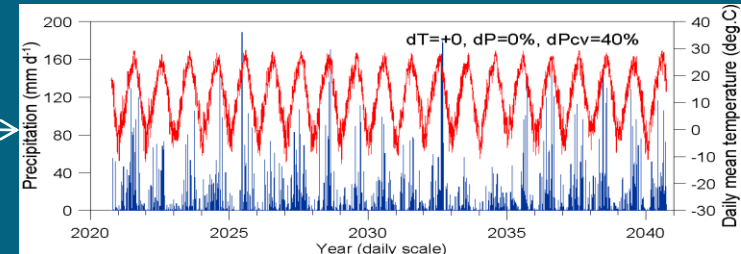


$dP_{avg} = 0\%$, $dP_{cv} = 0\%$, $dT_{avg} = +0 \text{ C}$

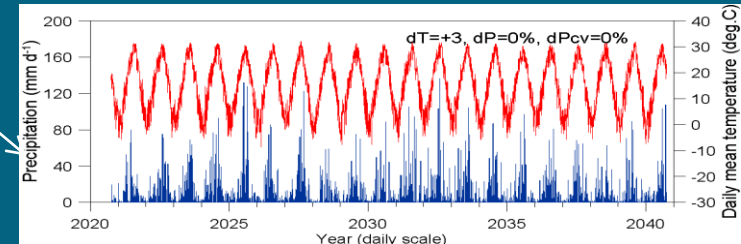
$dP_{avg} = -40\%$



$dP_{cv} = +40\%$



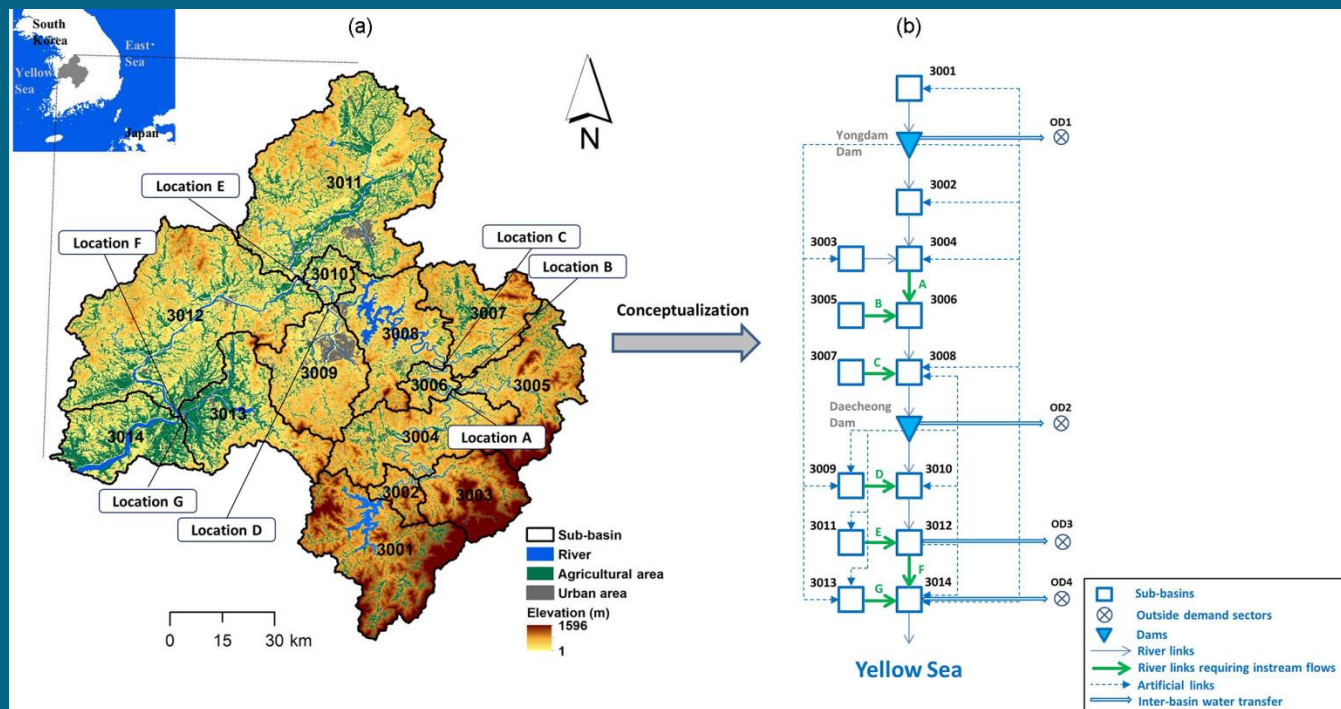
$dT_{avg} = +3 \text{ C}$



Water Allocation Modeling

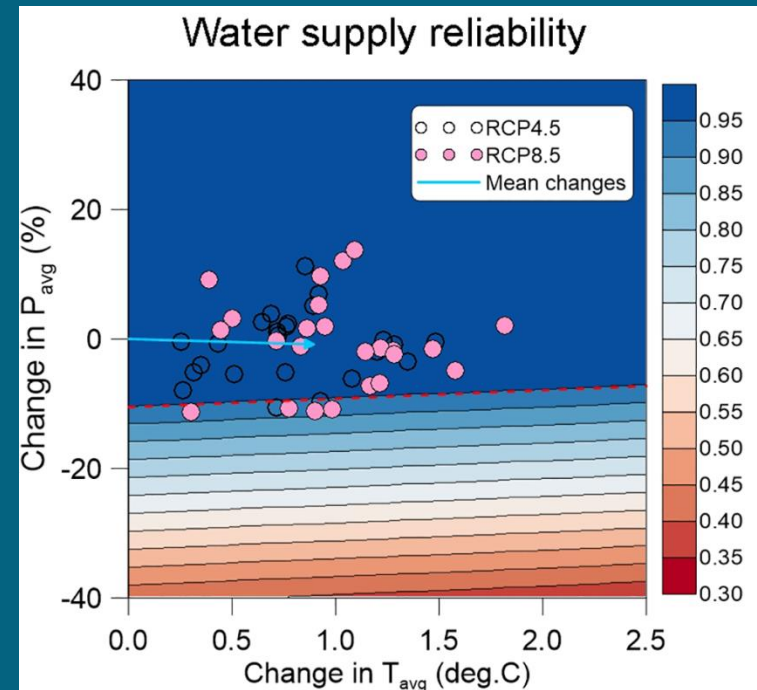
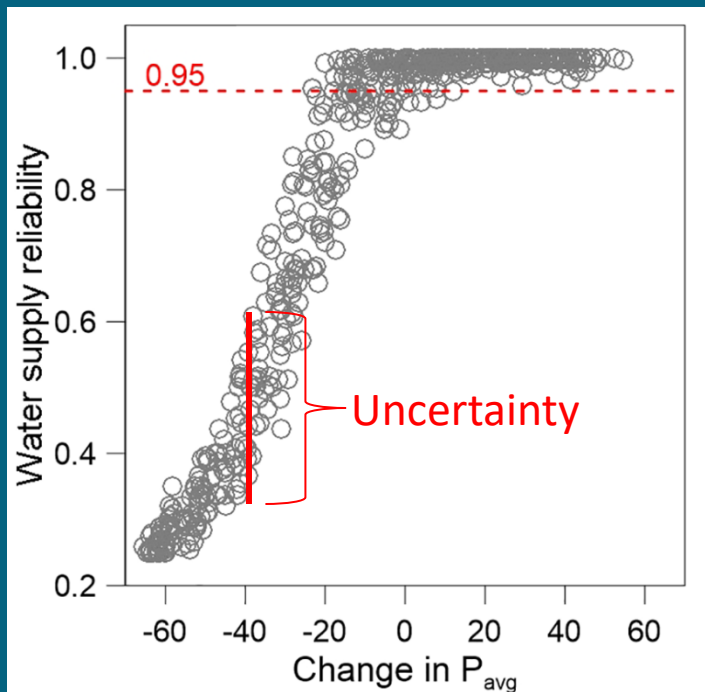
Incremental Dynamic Programming:

- ✓ Optimization towards minimizing scarcity and maximizing water storage



Assessing Water Supply Reliability

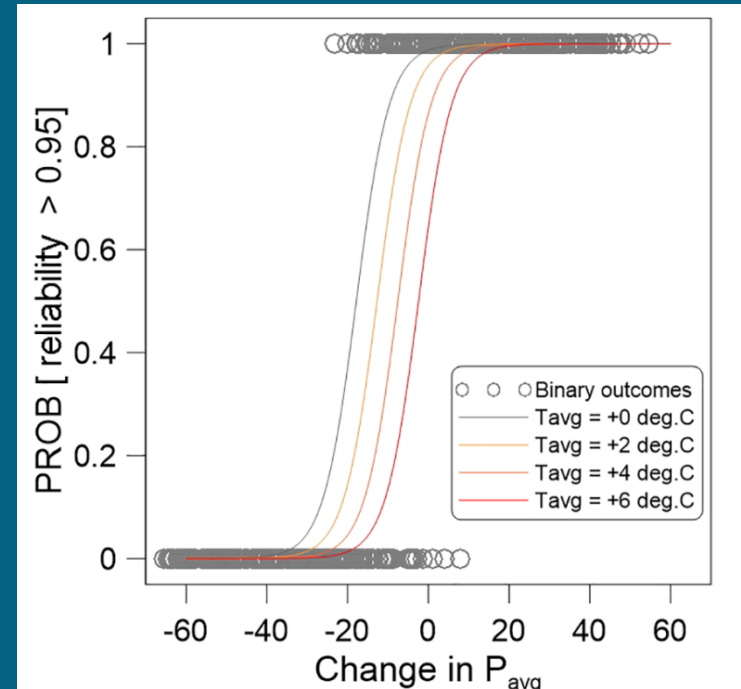
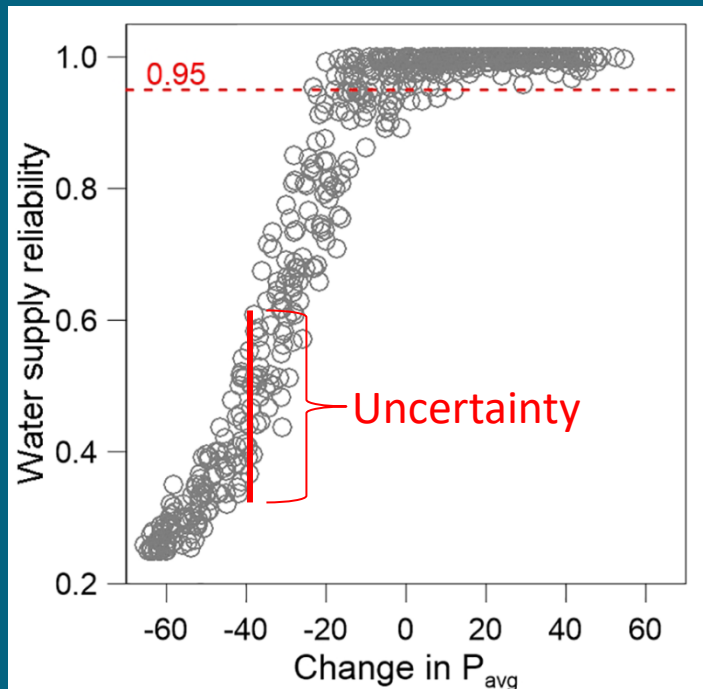
Mean System Performance vs. climate stresses :



Assessing Water Supply Reliability

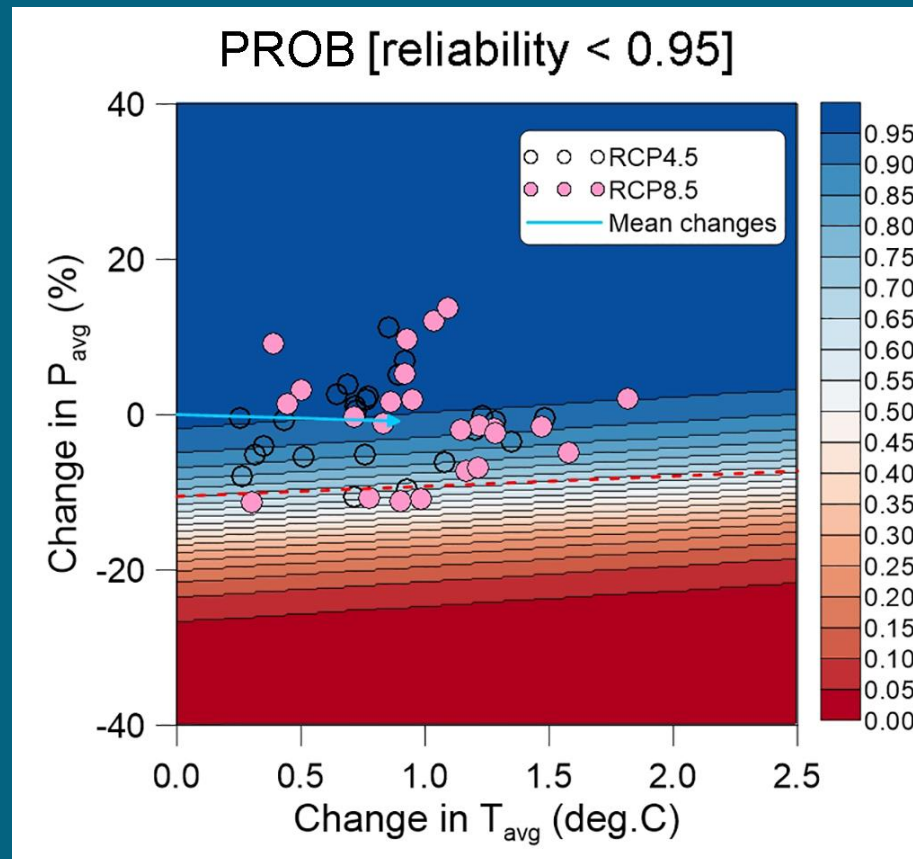
Probability of Satisfactory Performance against 0.95:

✓ *To consider uncertainty from climatic variability*



Water Supply Reliability

Probability of Satisfactory Performance against 0.95:



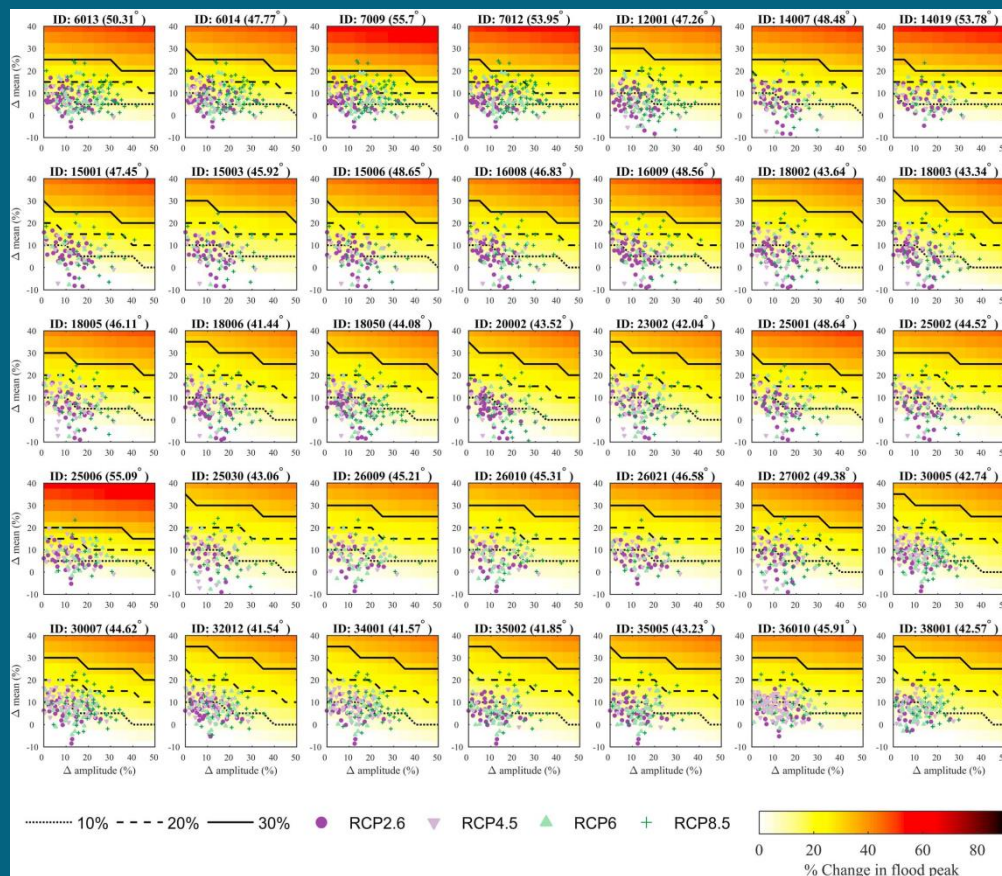
Lessens from Case Study

The decision-centric framework:

- ✓ *Could visualize system sensitivity to climatic stresses at a glance*
- ✓ *Together, many climate projections could be overlaid*
- ✓ *Uncertainty could be considered together in the surface*
- ✓ *Could produce a condensed but comprehensive information to policymakers!*

Kindred Applications

A flood risk assessment for multiple Irish catchments

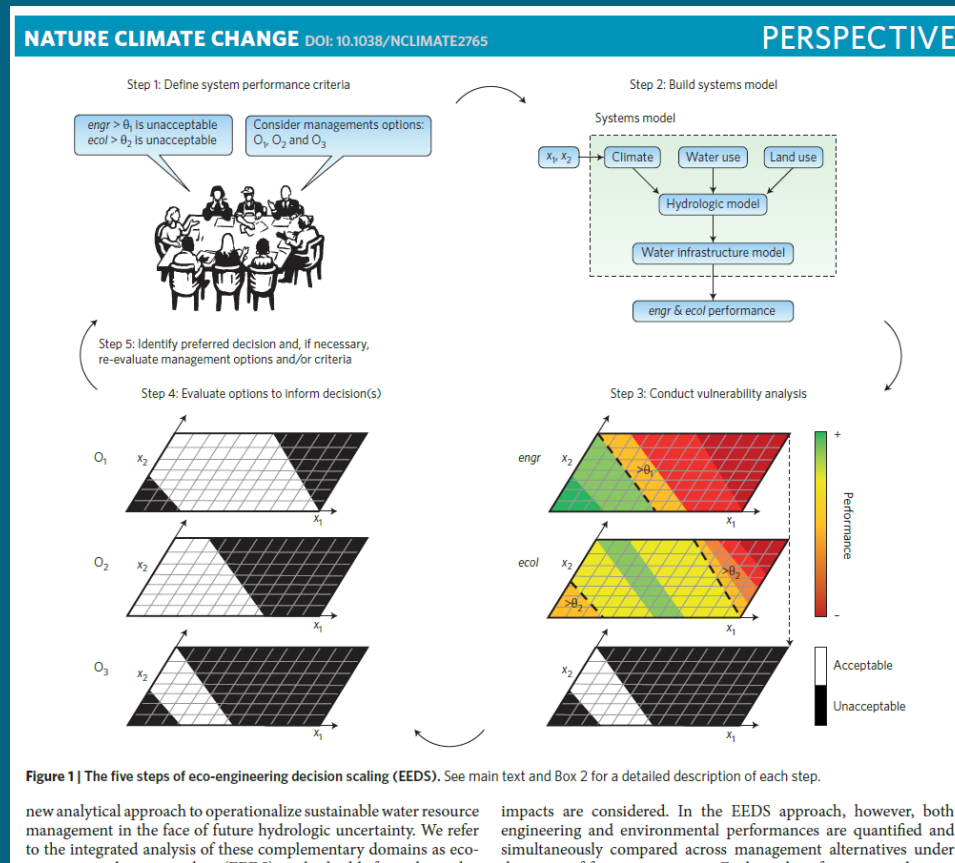


< Broderick et al., 2019 >

A DIRECTION FOR FUTURE

Multi-purpose assessments are needed!

✓ e.g. Environmental sustainability + Water supply capacity

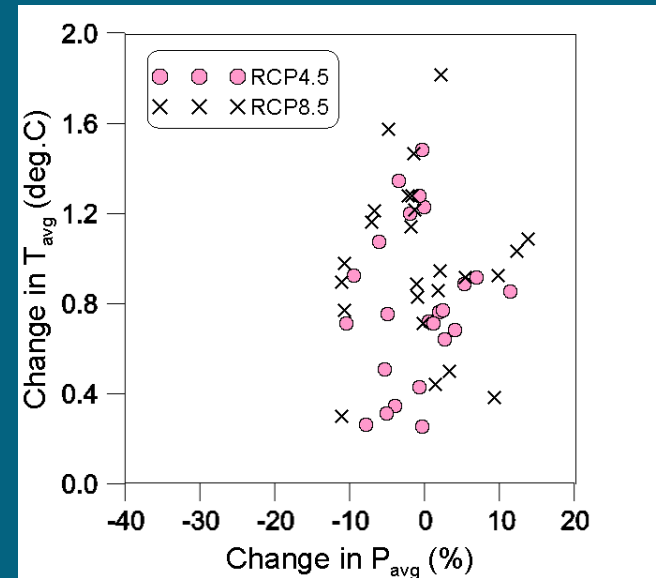
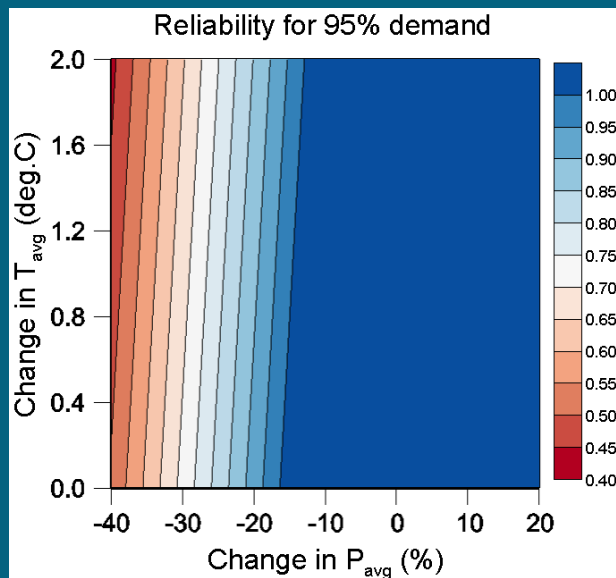


< Poff et al., 2015 >

Some Practical Points

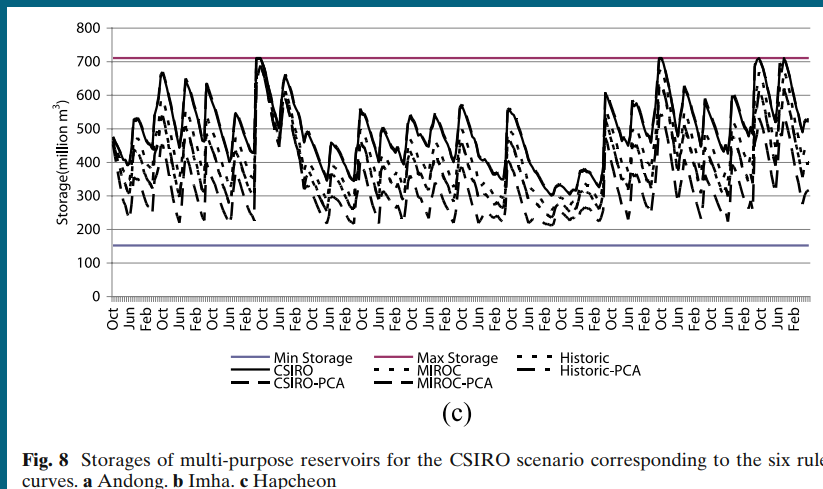
Is this useful framework often used?

- ✓ *Perhaps... but it requires multiple tools from different fields...*
- ✓ *For more uses, convenience should be given for analyzers (e.g., some objective-oriented packages)*

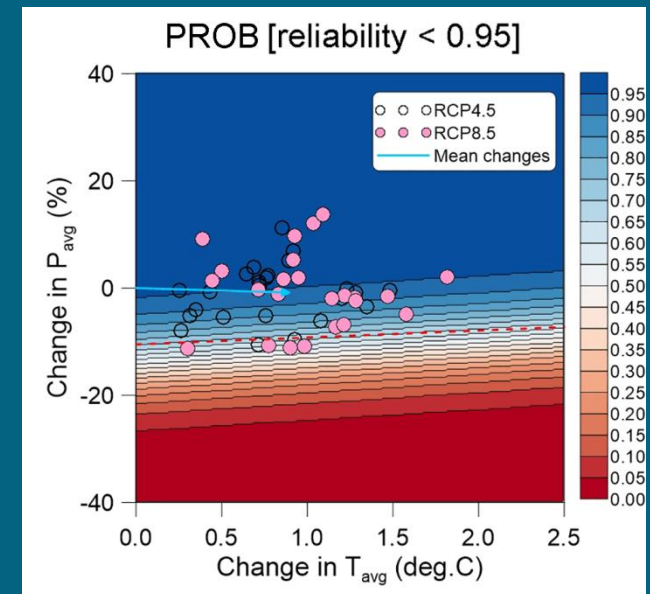


Top-down assessment have often been used, but did they help decision makers? Which one do you want to use?

“Long-term planning requires a **telescope** rather than a microscope!”



VS.



< Eum and Simonovic, 2010 >

Questions? d.kim@apcc21.org



For more information: Kim et al. (2019), HESS, 23, 1145-1162

Lessons Learned in Establishing Climate Services for Agriculture

Kwang-Hyung Kim, CLIMATE SERVICES AND RESEARCH DAPARTMENT @APEC CLIMATE CENTER



“Climate-Smart Agriculture through *Climate Services for Agriculture*”

Climate-Smart Agriculture



Farmer Smart



Weather Smart	Water Smart	Carbon Smart	Nutrient & Pest Smart	Energy Smart	Knowledge Smart
- Seasonal weather forecast - ICT based agro-advisories - Climate analogues	- Aquifer recharge - Rainwater harvesting - Community management of water - On-farm water management	- Agroforestry - Conservation tillage - Land use systems - Livestock management - Alternate wetting and drying	- Site specific nutrient management - Precision fertilizers - Catch cropping/ legumes - Ecological engineering	- Biofuels - Fuel efficient engines - Residue management/ biochar - Minimum tillage	- Farmer to farmer learning - Farmer networks on adaptation technologies - Seed and fodder banks - Market info - Off-farm risk management- kitchen garden

Climate-Smart Agriculture

Climate Services for Agriculture

Farmer Smart



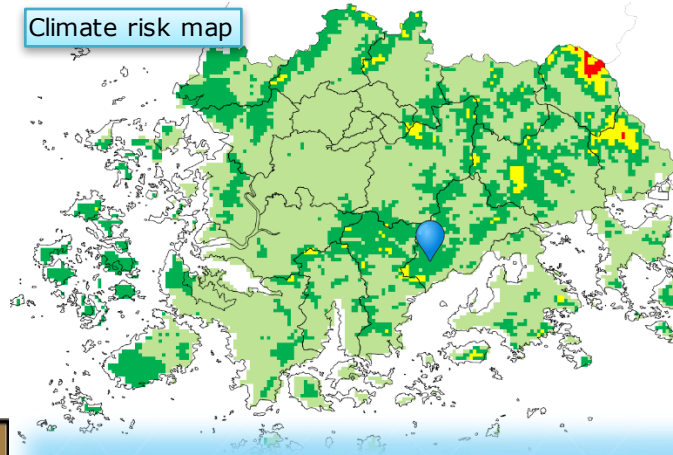
Crop Selection

- Advice from experts
- Market demand, access, outlook
- CSA-supporting policies available
- Training and knowledge sharing platform
- Climate services available

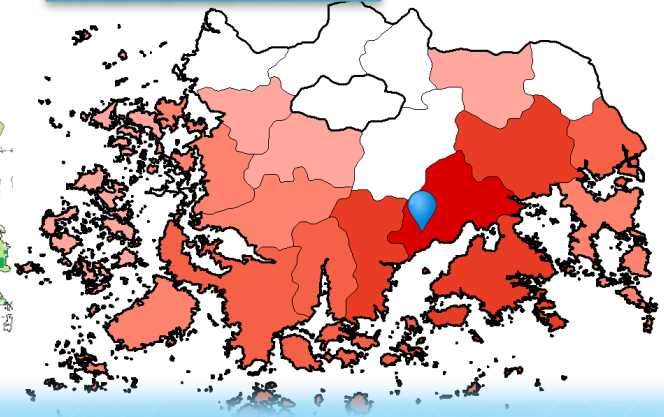
Site Selection

- Climate risk vulnerability
- Crop suitability based on soil and climate (historical and future)

Climate risk map



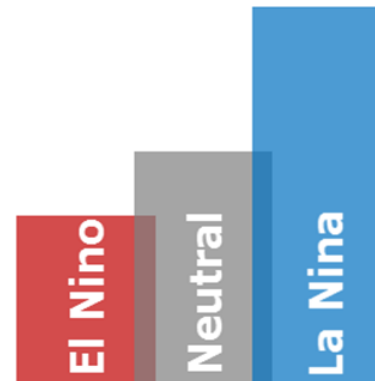
Suitability map for wheat



Wheat

- Nat

Annual Rainfall Amount



The province of Camarines Sur may experience weakening of La Niña



There's a probability of 4 to 10 tropical cyclones or weather



The "above normal" forecasted rainfall, particularly on the rainfed areas, may be affected specially at the first quarter of the year with the delay of planting due

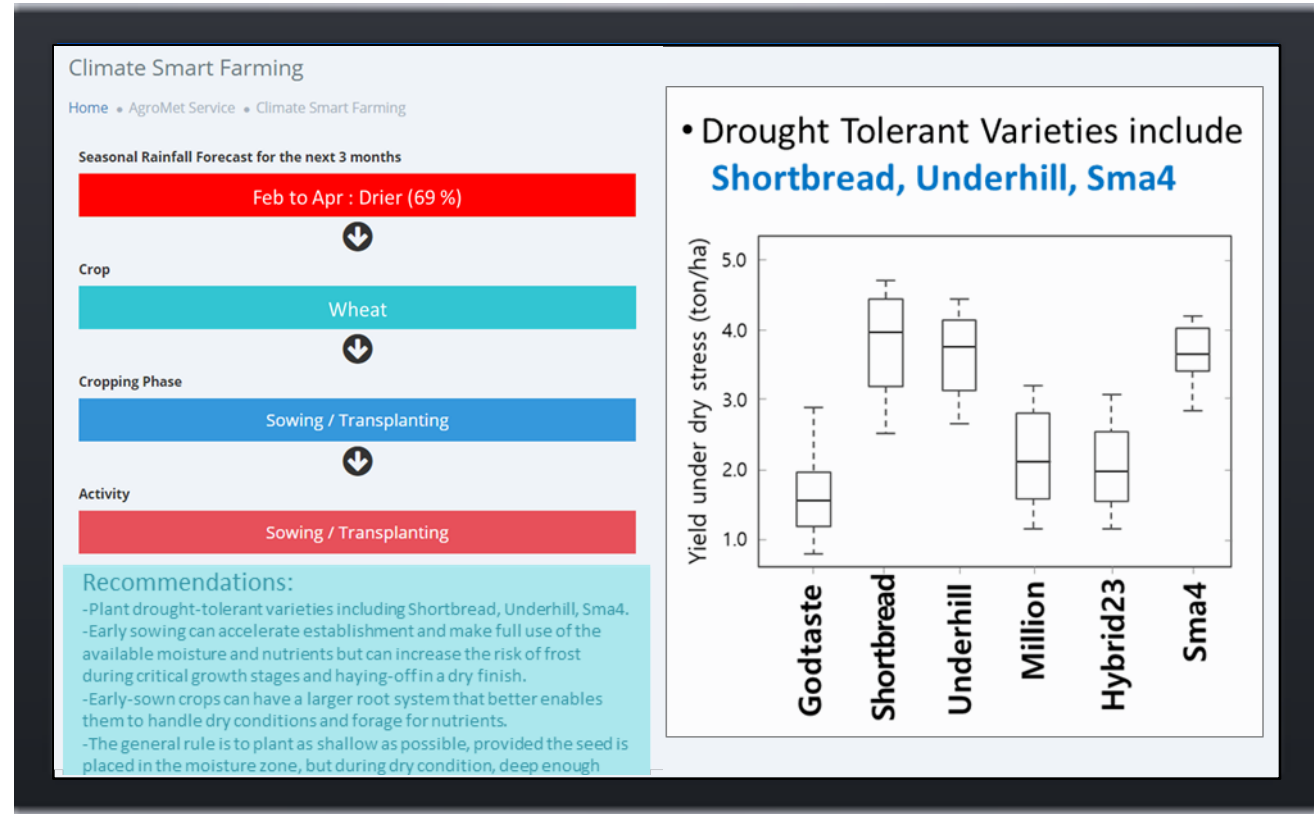
□ **Selecting variety**



Farmer Smart =



- El Niño advisory
- Drier than normal
- Decision-support tool : Selection of high-yield variety and planting date





Farmer Smart =



- El Nino advisory
- Drier than normal
- Decision-support tool : Selection of high-yield variety and planting date





Farmer Smart =

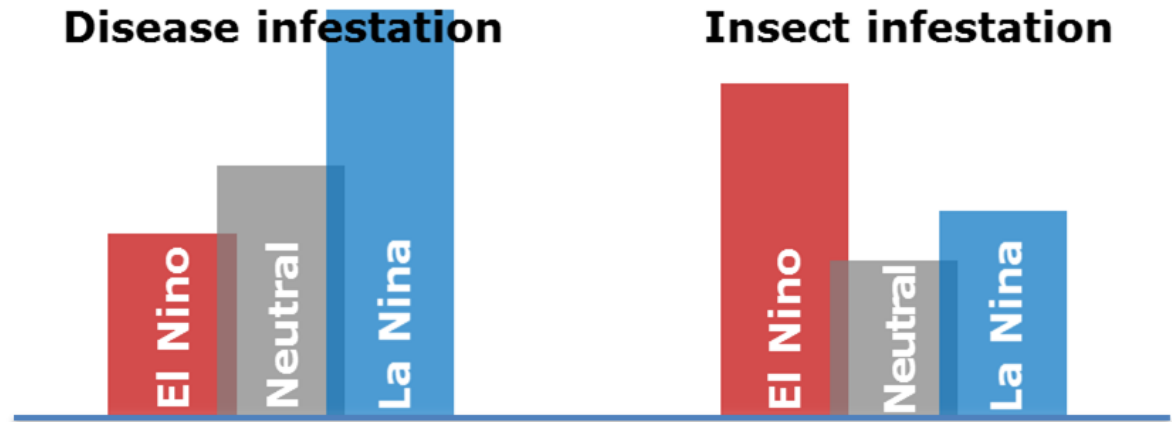


- El Niño advisory
- Drier than normal
- Decision-support tool : Selection of high-yield variety and planting date
- Insect infestation increases, thus cultivated *Underhill* for insect control

Pest infestation rate based on ENSO phases

Disease infestation

Insect infestation



□ Managing tillage



Farmer Smart =



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- Minimum tillage to protect soil moisture

No-till Drill





Farmer Smart =



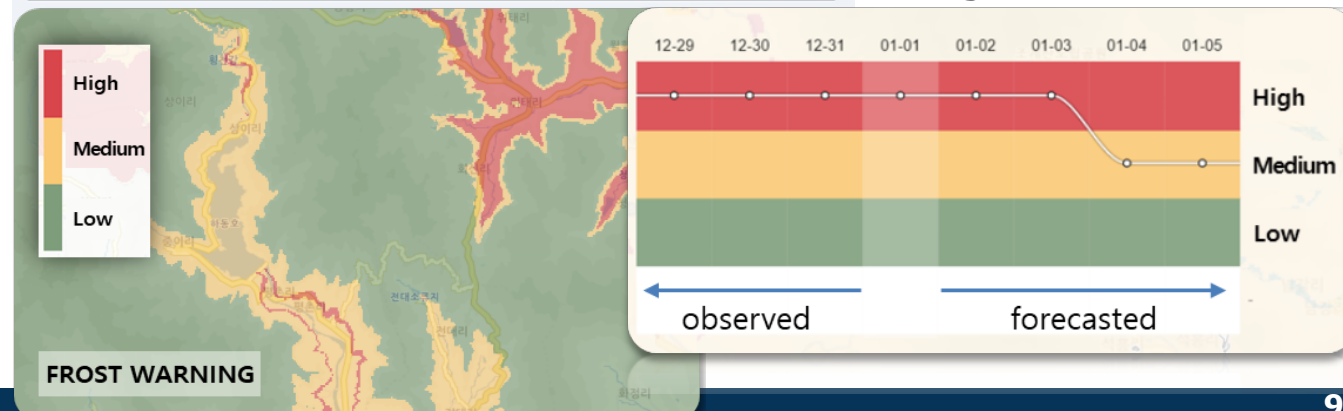
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- Minimum tillage to protect soil moisture
- Informed farm management based on weather and climate information

Informed decisions based on weather/climate information

☞ Weather and Climate Forecasts

1 day	7 Day	Seasonal
	Rainfall	Temp
Jan to Mar [Observed]		
May to Jul [Forecast]	77%	83%
Aug to Oct [Forecast]	63%	52%
	■ DRIER ■ NORMAL ■ WETTER	■ WARMER ■ NORMAL ■ COOLER

☞ Early Warning for Agricultural Disasters



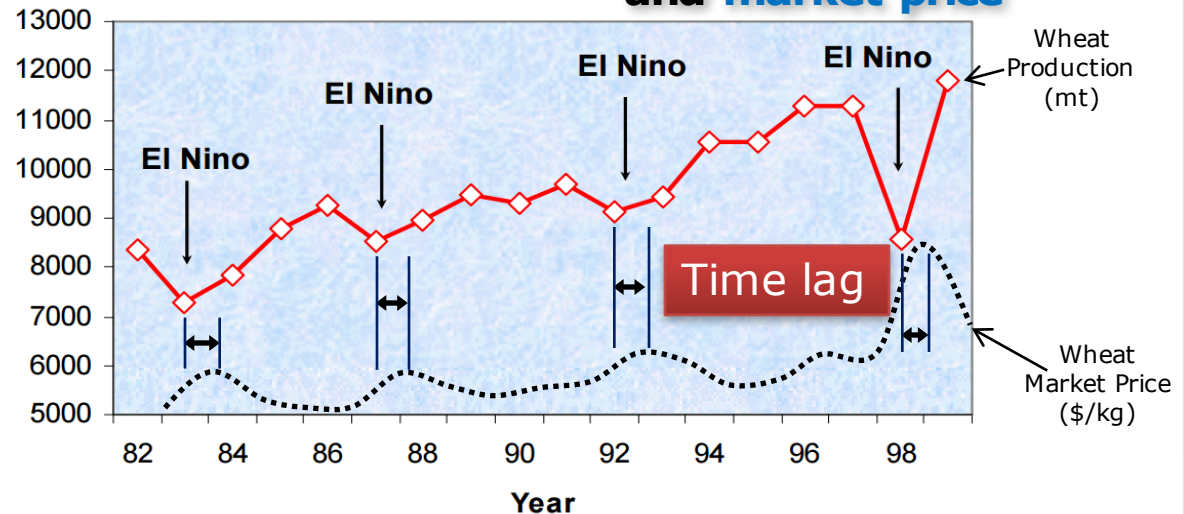


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- Did NOT forward sell hay, decided to harvest wheat grain later

Relation between climate and wheat production and market price



Hay 3t = \$3000
VS
 Grain 0.5t = \$3000
VS
 Grain 1t = \$6000



Market



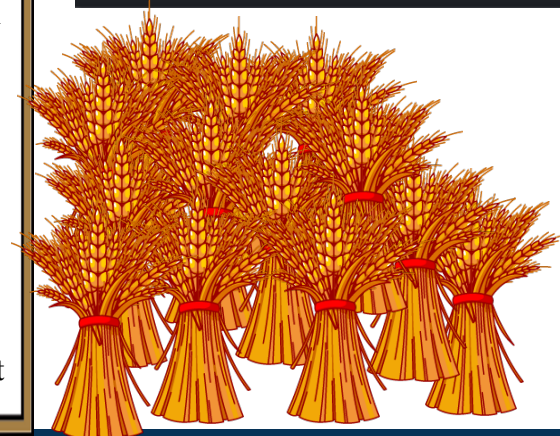
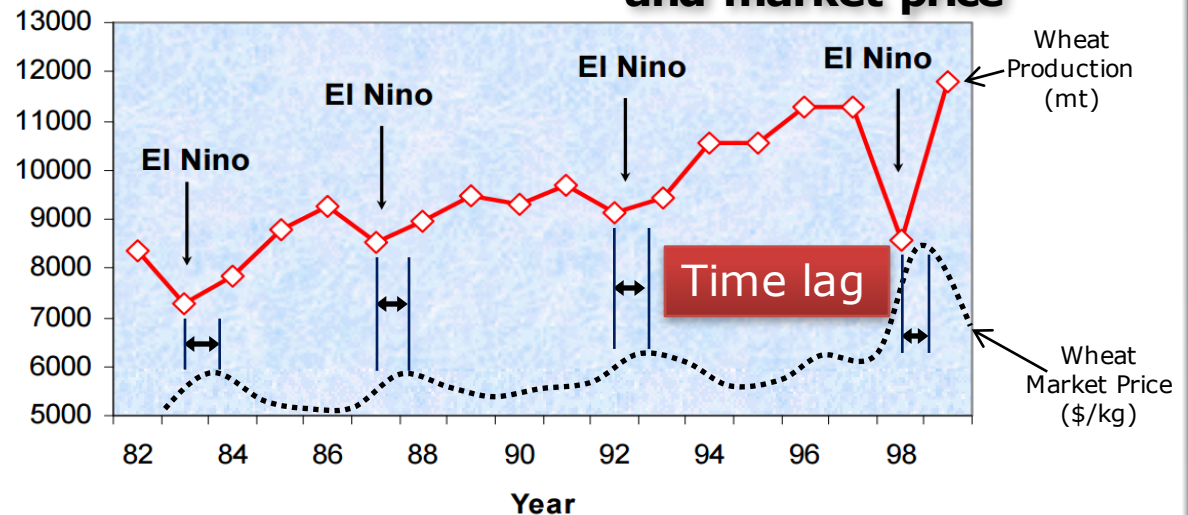
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Relation between climate and wheat production and market price



Market

□ Carbon credit



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Carbon sequestering activities through CSA practices

Carbon credits generated through Carbon Market

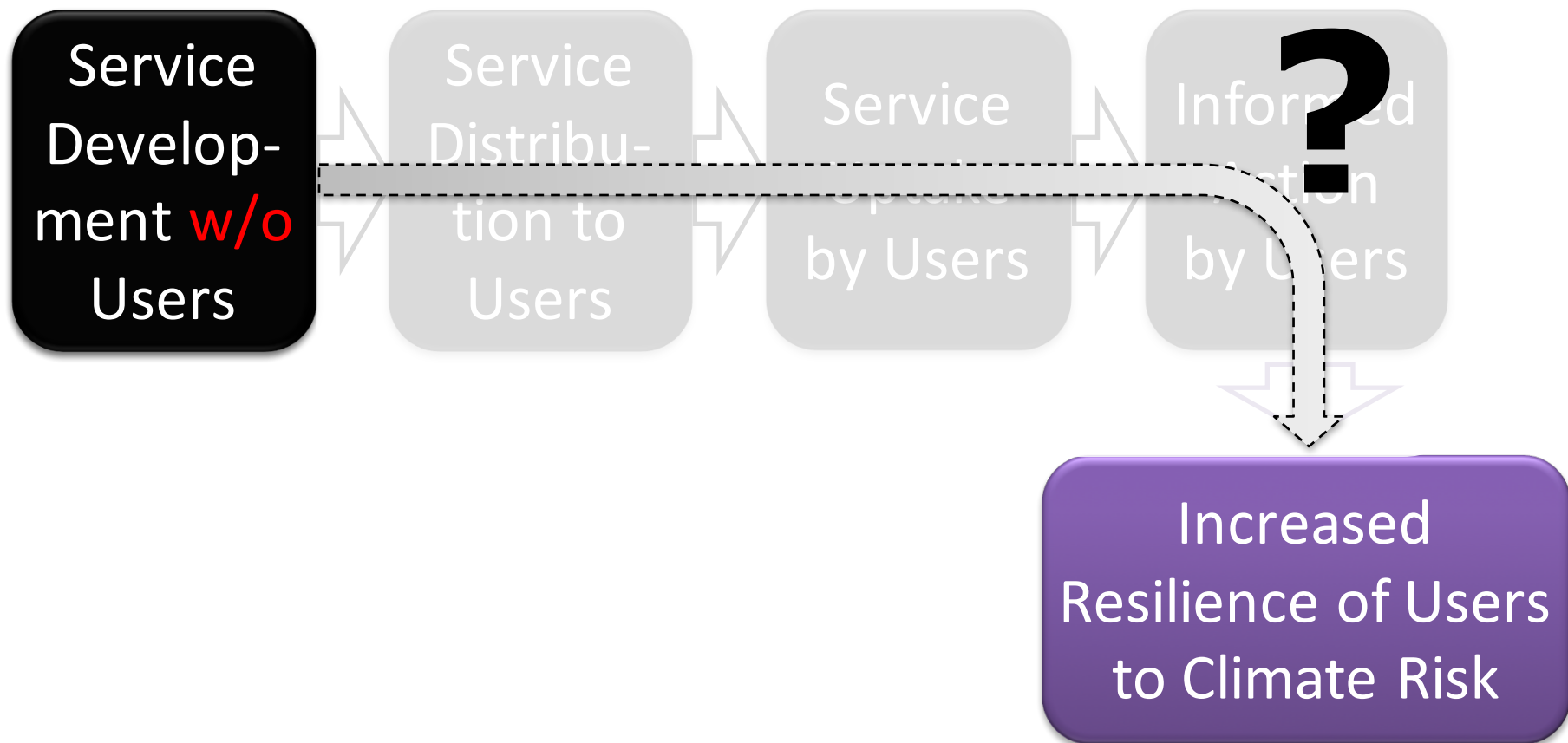


Feedback

Farmers Climate School

-Sharing knowhow and knowledge with fellow farmers

Climate Service Value Chain





Strategies for effective climate services for agriculture

- Coordinating regular provider and user working group platforms to co-develop, disseminate, and apply climate services, and update based upon feedback mechanism from users in place
- Improvement and strengthening of agrometeorological networks and ensure data sharing policy for free data to the public, simultaneously enhancing the availability of parallel agricultural data
- Assuring salience, credibility, legitimacy to be built for the climate services
- Effective monitoring and early warnings for extreme weather and climate events for timely informed decision-making by agricultural stakeholders
- Promotion and use of weather and climate forecasts for operational, tactical, and strategic decisions by the agricultural stakeholders
- Promotion of problem-solving scientific research and development for credible, science-based climate services, together with users
- Improving the dissemination of climate services to the next-/end-users
- Development of climate service-based adaptation strategies to climate change and variability
- Contextualizing climate services to existing climate-smart agriculture platform



Holistic Approach for the Establishment of Climate Services for Agriculture in Tonga

Climate Information Products

- Tonga Meteorological Service: historical weather data, nowcast, warnings, weather/climate forecasts
- Process-based & statistical model-based agronomic decision support tools
- Agromet index-based early warning
- Agromet bulletin production/delivery

Climate Smart Technologies

- Local varieties and cropping systems with abiotic and biotic stress tolerance
- Indigenous climate smart practices to climate risks (drought, cyclone, etc)
- ICT technologies for data collection & analysis, and information delivery
- Integrated pest management practices

Tonga Agricultural Community

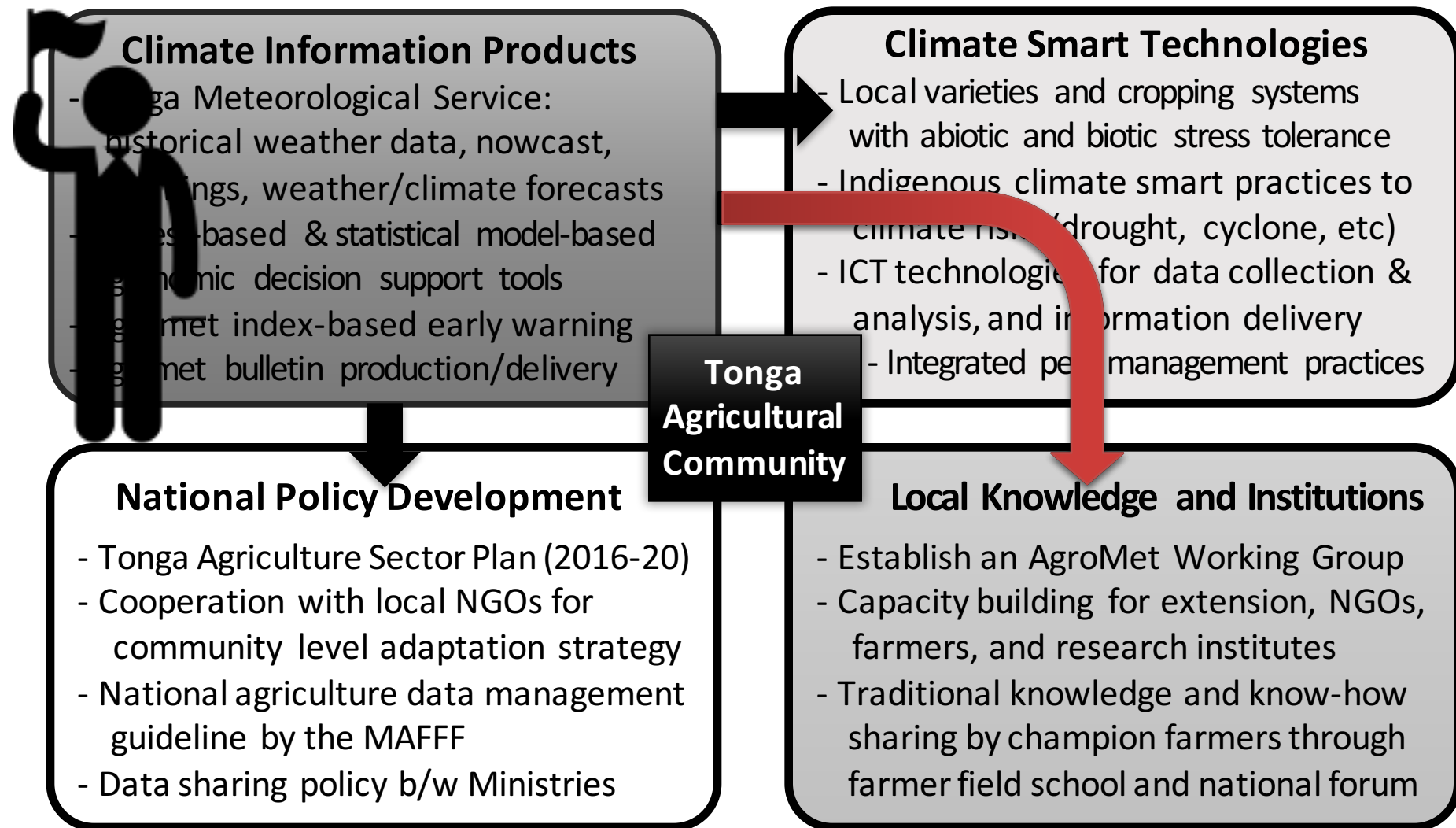
National Policy Development

- Tonga Agriculture Sector Plan (2016-20)
- Cooperation with local NGOs for community level adaptation strategy
- National agriculture data management guideline by the MAFFF
- Data sharing policy b/w Ministries

Local Knowledge and Institutions

- Establish an AgroMet Working Group
- Capacity building for extension, NGOs, farmers, and research institutes
- Traditional knowledge and know-how sharing by champion farmers through farmer field school and national forum

Climate Approach for the Establishment of Climate Services as a **butler** for Agriculture in Tonga





Holistic Approach for the Establishment of Climate Services for Agriculture in Tonga

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Establish an AgroMet Working Group

- Agromet Working Group



TINOPAI FARM



Farmers



TMS

PHAMA

Pacific Horticultural & Agricultural
Market Access Program



MAFF

AgroMet Working Groups are always the starting point for the Climate Services for Agriculture

• Tonga AgroMet Working Group



• Vanuatu AgroMet Working Group



• Nepal AgroMet Working Group



• Laos AgroMet Working Group





Roles of the AgroMet Working Group

- To advise on the development of climate information service products and the policy implementation
- To develop agro-met work plans to be incorporated into national agricultural sector plan
- To assess the needs and gaps of users to ensure that climate information services address the actual problems on the fields
- To serve as an expert body to provide agromet advice to public and private entities and associations
- **To link the climate information providers and users, so that both understand each other's languages and approaches, capacities, inherent biases, etc, and thus enhance the salience, credibility, and legitimacy of the end information products, which will then make sure the sustainability of the climate information services' value chain**

Capacity Building Opportunity

○ Farmer Field School, Extension Meetings, NCOF



Tonga Farmer Field School

- Face-to-face comm.
 - knowledge exchange
 - training of trainers
- Working with local NGOs and champion farmers
- Inter-departmental collaboration





Holistic Approach for the Establishment of Climate Services for Agriculture in Tonga

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**Tonga
Agricultural
Community**

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Climate-smart practices and technologies are to be guided by climate information products

✓ Drought ✓ Flood ✓ Tropical Cyclone ✓ Tsunami ✓ Pest and Disease

● Climate Information Products Required

- Drought early warning system
- Location-specific drought risk map
- Decision support tools for climate smart irrigation
- Dynamic cropping calendar
- Climate information (historic and forecasts)



● Climate-Smart Practices and Technologies

- Drought-tolerant crops and varieties
- Adjusting planting date
- Improving or building village irrigation systems
- Drought-tolerant traditional farming practices and systems



Seasonal forecast-informed decision making tables

Before making decisions on
what and where to plant

Pre-Season Decision Table

Activity	Climate Condition	Climate-Smart(CS) Recommendations	Local-Specific CS Recommendations
Climate and Cropping	Normal	- Optimal temperature for growth is 25-30°C, At 28.5-30°C, sprouting is faster and optimum - Optimal annual rainfall is 1,000-1,500mm - As most manioc varieties in Vanuatu are relatively taller, they are not tolerant to cyclone and above 40km/h wind can cause lodging - Periods of water logging will reduce tuber quality (become bitter) and cause root rot if soil is constantly wet; This will promote vegetative growth with loss of leaves and growing high	
	Wetter Rainfall		
	Drier Rainfall	Climate and Cropping	
	Hotter Temp	- Although there is evidence that providing adequate water moisture prior to harvest can reduce these levels - More than 40°C temperature will affect manioc, resulting in possible yield loss; At 30-40°C, higher rate of photosynthesis occurs in the field	
Crop (variety) Selection	Cooler Temp	Less than 12°C temperature will inhibit plant growth, thus possible yield loss; At 28°C, faster shading of leaves occurs with reduction in the number of branches	
	Normal	Depending on target market and demand, and available planting material (Smas 1, smas 2, smas 3, smas 4, smas 5, smas 6, smas 7, smas 8, smas 9, Taroabe 1, red hand, manioc bicolor)	
	Wetter Rainfall		
	Drier Rainfall	Crop(Variety) Selection	
Land Preparation	Hotter Temp	- pest and diseases - Apply agroforestry systems to act as buffering strips for cooling air temperature for crops	
	Cooler Temp		
	Normal	- Determine cropping area according to available planting material, crop-care capability (including weeding and pest control) - Prepare land by tractor, rotary hoe, or by hand; Land preparation may depend on soil type and drainage, the field may be prepared as mounds, ridge, or flat- or no-tilled - When traditional system are practiced, where the plot is cleared from existing vegetation thus exposing high organic matter in the soil, slash and mulch is advised for land preparation - Land preparation may be delayed if rain is heavy and frequent because tractor ploughing is not	
	Wetter Rainfall		
Other Pre-Season Preparation	Drier Rainfall	- Increase cropping area or more drought tolerant crops like manioc relative to other drought-susceptible crops - Rotary hoes can be used for soil/land preparation and mounding (same way as in extreme wet conditions) - Increase small size plot in different location to avoid production lost during dry conditions	
	Hotter Temp	Apply agroforestry systems to act as buffering strips for cooling air temperature for crops	
	Cooler Temp		
	Normal	- Irrigation preparation can be prepared depending on water availability during normal years - Prepare mulching materials such as vetiver grass and other organic materials such as compost to apply to the crop	
Other Pre-Season Preparation	Wetter Rainfall		
	Drier Rainfall		
	Hotter Temp		
	Cooler Temp		

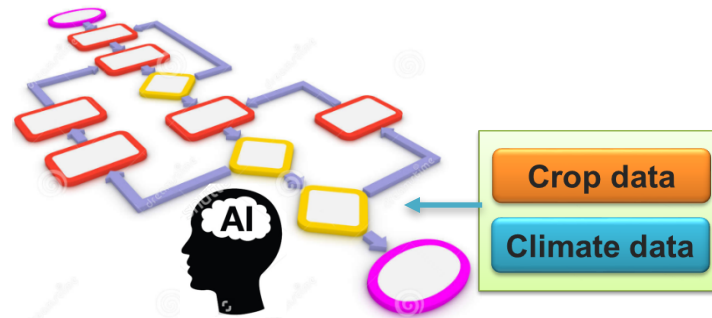
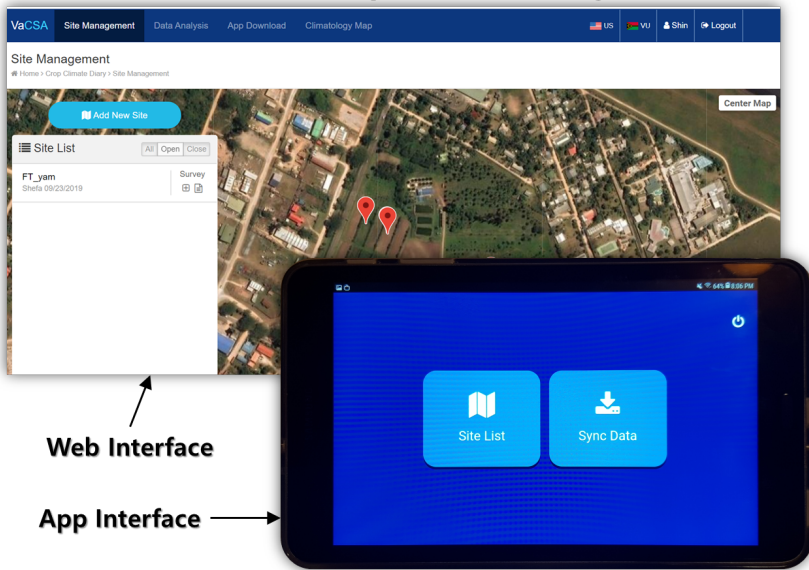
After decisions made on
what and where to plant

On-Season Decision Table

Activity	Climate Condition	Climate-Smart(CS) Recommendations	Local-Specific CS Recommendations
Planting	Normal	- Manioc is normally planted in the months of July to October, but as some farmers do, it can be planted throughout the year - Planting materials: Select stalks that have just harvested and not sprouted, because sprouting before planting will weaken the ability of stalks to grow after the stalk is cut and planted - Plant stalks 10-20 cm deep on the mounds with planting space of 3m x 1m - Check that manioc stalks have not started to rot and are still viable by cutting some stalks to see if the - Manioc is normally planted in the months of July to October, but as some farmers do, it can be planted throughout the year - Planting materials: Select stalks that have just harvested and not sprouted, because sprouting before planting will weaken the ability of stalks to grow after the stalk is cut and planted - Plant stalks 10-20 cm deep on the mounds with planting space of 3m x 1m - Check that manioc stalks have not started to rot and are still viable by cutting some stalks to see if the	
	Wetter Rainfall	Manioc stalks that are planted sprout faster under wet conditions	
	Drier Rainfall	Plant stalks deeper (15-20 cm) on the mounds at dry conditions	
	Hotter Temp	Cooler temperature <15°C will inhibit plant growth, and lead to impaired sprouting and reduction in leaf production	
Nutrient Management	Cooler Temp	Fertiliser is not normally used for manioc farming in Vanuatu because they are too expensive and not practical to apply, and also very heavy to transport to remote cultivating plots/gardens	
	Normal	Nutrient Management	
	Wetter Rainfall	- Manioc grows best during crop rotation cycle - Apply compost and other organic materials differently during wetter rainfall – How?	
	Drier Rainfall	Apply compost and other organic materials differently during drier rainfall – How?	
Pests Weed Management	Hotter Temp		
	Cooler Temp	- Monitor disease symptoms, although it is difficult as the manioc canopies are too high to observe - Monitor weed growth and weed as needed; First weeding will be needed after 3-4 weeks; Second weeding will be needed at 12-13 weeks, which will be the final weeding needed, because the manioc will grow enough leaves to shade the ground below and stop more weeds growing - The most vigorous and early branching cultivars are advised to grow because they tend to develop a canopy rapidly and higher densities will also contribute to early formation of shade cover to inhibit weed growth	
	Normal		
	Wetter Rainfall	- Weed growth is faster in wet conditions, thus the first weeding will be needed after 2-3 weeks and the second weeding at 10-12 weeks - Monitor especially for insect pests during dry periods - Weed growth is slower in dry conditions, thus the first weeding may not be needed until 5-6 weeks and the second weeding at 14-15 weeks - Since insect pests reproduce faster during hot season, monitor the presence of insect pests	
Harvest	Drier Rainfall	- In Vanuatu manioc is harvested by hand; Manioc roots are generally ready for harvest 7 – 12 months after planting depending on cultivar - It is best to harvest when the starch content is at its maximum; For most cultivars this occurs at around 60-65 weeks; For early maturing varieties, it can be as early as 7 months 36-48 hours, thus it is best to harvest only what is true growing until they are warned - Materials that were affected by pest and diseases - of rainfall since they can rot easily	
	Wetter Rainfall		
	Drier Rainfall		
	Hotter Temp		
Harvest	Cooler Temp		
	Normal		
	Wetter Rainfall		
	Drier Rainfall		
Harvest	Hotter Temp		
	Cooler Temp		
	Normal		
	Wetter Rainfall		

Crop Climate Diary or Extension Diary

VaCSA Crop Climate Diary



→ ICT Extension Tool for

- 1) **Collecting** agriculture data with geospatial information using the state-of-the-art technology
- 2) **Analyzing** the collected data by linking with climate data
- 3) **Visualizing** the agriculture and climate data and statistics on the map for effective data management

ToCSA Extension Diary





Holistic Approach for the Establishment of Climate Services for Agriculture in Tonga

Climate Information Products

- Tonga Meteorological Service: historical weather data, nowcast, warnings, weather/climate forecasts
- Process-based & statistical model-based agronomic decision support tools
- Agromet index-based early warning
- Agromet bulletin production/delivery

Climate Smart Technologies

- Local varieties and cropping systems with abiotic and biotic stress tolerance
- Indigenous climate smart practices to climate risks (drought, cyclone, etc)
- ICT technologies for data collection & analysis, and information delivery
- Integrated pest management practices

**Tonga
Agricultural
Community**

National Policy Development

- Tonga Agriculture Sector Plan (2016-20)
- Cooperation with local NGOs for community level adaptation strategy
- National agriculture data management guideline by the MAFFF
- Data sharing policy b/w Ministries

Local Knowledge and Institutions

- Establish an AgroMet Working Group
- Capacity building for extension, NGOs, farmers, and research institutes
- Traditional knowledge and know-how sharing by champion farmers through farmer field school and national forum

Mainstreaming the climate services for agriculture by supporting national policy and guideline development

- MOUs, Agreement, Guideline Development, ...



Tonga Agriculture Sector Plan (TASP)

- Through the AgroMet Working Group, climate services for agriculture suggested as a major adaptation plan to climate change and variability



CONTACT

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Forests and Fisheries
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and Food, Forests and Fisheries
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Tonga
Phone : 676 23038
Fax : 676 23093
Email: mof-fg@mof.gov.to

THE KINGDOM OF TONGA

Tonga Agriculture Sector Plan 2016-2020



THE WORLD BANK
Borrower - GOV. OF TONGA



IFAD
Investing in rural people


Office of
The Hon. Minister of Agriculture, Food, Forests and Fisheries
Hon. Simiti Taeseing Fakau
Minister of Agriculture, Food, Forests and Fisheries
Tel: (676) 231010
Fax No: (676) 231481
Email: mtaeseing@mof.gov.to
Ref No.: MIN/40/16
DATE: 13 June, 2016

Mr. Hong-Sang Jung
Director
APEC Climate Center
Republic of Korea.

Dear Mr. Hong-Sang Jung,

RE: Appreciation of Partnership:
Ministry of Agriculture, Food, Forests and Fisheries (MAFFE)
AND APEC Climate Center (APCC)

I am pleased to write this letter in appreciation of the work that your organization has provided for Tonga in this project and to be under the responsibility of MAFFE. It was unfortunate with sudden changes that I was not in Tonga for the handing over of the equipment and facilities to the ministry. However I am happy to note that the Hon. Prime Minister of Tonga, attended the programme to show your team that we are grateful for this work.

The training of the staff is also important to the ministry on linking of meteorological data to agriculture activities in working towards resilience to climate change. I would also like to see however in future the possibility of installation of some facilities as in the Vaini Research Station in the outer islands. It is critical as well to have access to meteorological data in the outer outer islands (5) as there are extreme cases in these respective islands that need to be addressed before it becomes a disaster. I hope that through building capacities of staff as well to monitor and understand the situations using of data can reduce such incidence in future.

In view of the above, thank you for your support of the ministry in this project and I look forward for possible extension of such equipment to the outer islands in the near future.

Yours sincerely,


Hon. Simiti T. Fakau
Minister of Agriculture, Food, Forests and Fisheries



METEOROLOGY & COAST RADIO SERVICES
MINISTRY OF METEOROLOGY, ENERGY, INFORMATION, DISASTER MANAGEMENT,
ENVIRONMENT, CLIMATE CHANGE AND COMMUNICATIONS
KINGDOM OF TONGA
P. O. Box 945, Domestic Terminal, Palapenue Airport, Tonga
Phone : (676) 35358 Fax: (676) 35123 www.met.gov.to



Ref: ME/12/2016

15 December 2016

Director General of APCC
Busan,
Korea

Dear Sir,

Tonga Climate Services for Agriculture Website

This is to confirm and inform you that the Tonga Climate Services for Agriculture website is now operational and hosted by the Tonga Meteorological Service and is the official source of climate information for Tongan Farmers.

May I take this opportunity to personally thank APCC for the capacity building offered to the Tonga Meteorological Service during the improving of agriculture production through enhanced meteorological services project.

Look forward to a continued fruitful working relationship.

Sincerely,



Mr. Ofa Fa'anunu
Director of the Tonga Meteorological Service.



Partnership Report (2012)
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← Letters acknowledging ToCSA as a means for climate service for agriculture in both Ministries

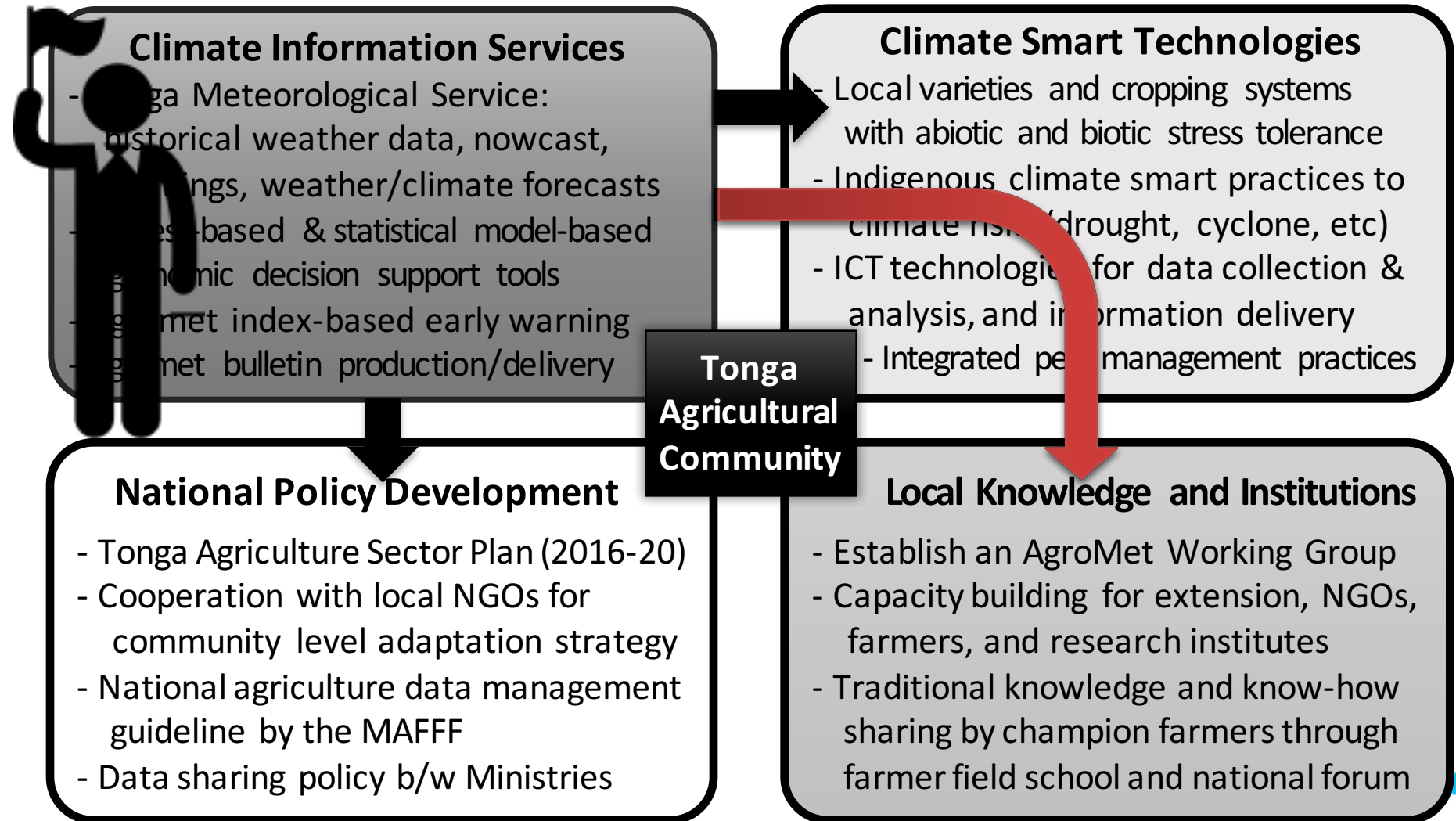


Collaboration with local NGOs and farmers for community level adaptation strategy



- Reaching out local communities with climate services for agriculture to provide essential weather and climate information
- Climate services for agriculture as one of the community adaptation strategies to climate change

Climate information services as a **butler** for Climate Service



Christianne Michiko Aikins External Affairs Department

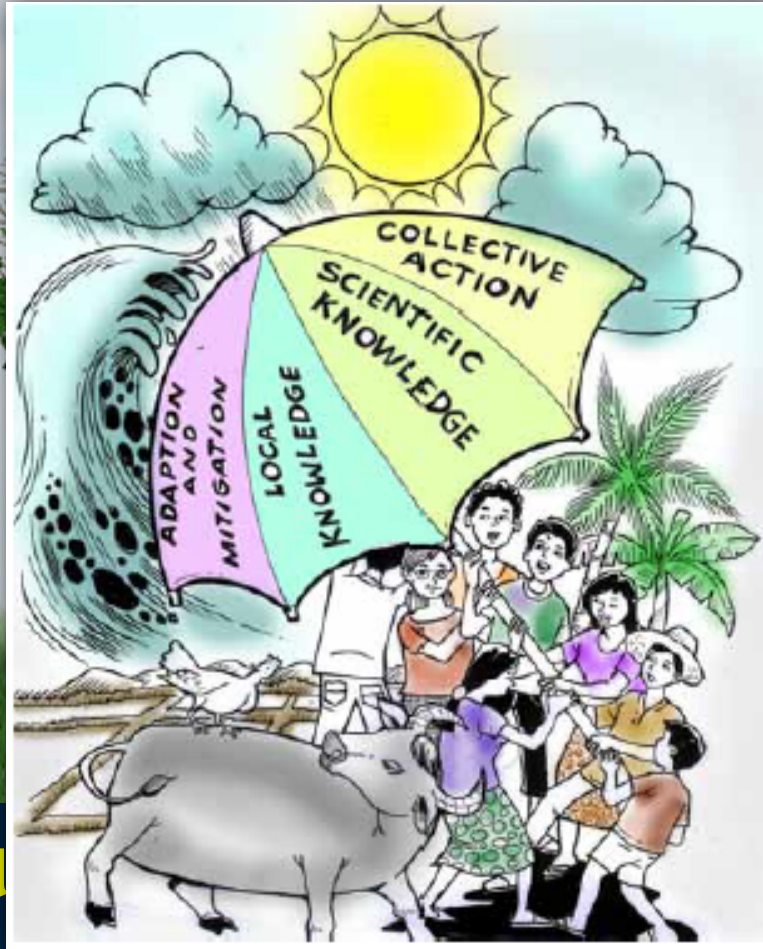
Kim, K.-H. et al., 2019. *Use of seasonal climate forecasts in agricultural decision-making for crop disease management*. In: Iizumi, T., Hirata, R., and Matsuda, R. (Eds.), *Adaptation to Climate Change in Agriculture: Research and Practices*, Springer Singapore.

Research and Practices

Use of Seasonal Climate Forecasts in Agricultural Decision-Making for Crop Disease Management

Abstract Recently, seasonal climate forecasts (SCFs) and their advances have gained increasing attention in agricultural communities, specifically because of

Kim, K.-H., 2019. *Establishment of Climate Services for Agriculture in the Pacific Island Countries: The Tonga AgroMet Project as a Case Study*. Climate Services. DOI:10.1016/j.cliser.2019.100124.



(Photo from <http://rhlgroup.com.au/>)

Thank you