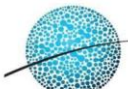




Asia-Pacific  
Economic Cooperation



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Building Resilient Agro-Food Systems From Production To Consumption

2017 APEC CLIMATE SYMPOSIUM | CAN THO, VIET NAM

# A Model Project for the Establishment of Climate Information Services in Tonga To Enhance Food Security in a Sustainable Manner

Kwang-Hyung Kim, STRATEGIC PLANNING TEAM, CLIMATE APPLICATION DAPARTMENT @APCC



APCC APEC CLIMATE CENTER





# A holistic approach is needed to solve the **PROBLEM~!**

**Tonga AgroMet Project** - A Model Project for the Establishment of Climate Information Services in Tonga to Enhance Food Security in a Sustainable Manner

## Climate Information Services

- Tonga Meteorological Service: historical weather data, nowcast, warnings, weather/climate forecasts
- Installation of agro-met station
- Delivery: radio, TV, email, apps
- National Climate Outlook Forum

## Climate Smart Technologies

- Agromet index-based crop phenology and yield prediction
- ICT technologies for data collection & analysis, and information delivery
- Crop model-based decision support tool
- Crop pest spray tools

**Tonga  
Agricultural  
Community**

## Agricultural Development Plan

- Tonga Agriculture Sector Plan (2016-20)
- Cooperation with local NGOs for community level adaptation strategy
- National Agriculture Data Management Plan by the MAFFF

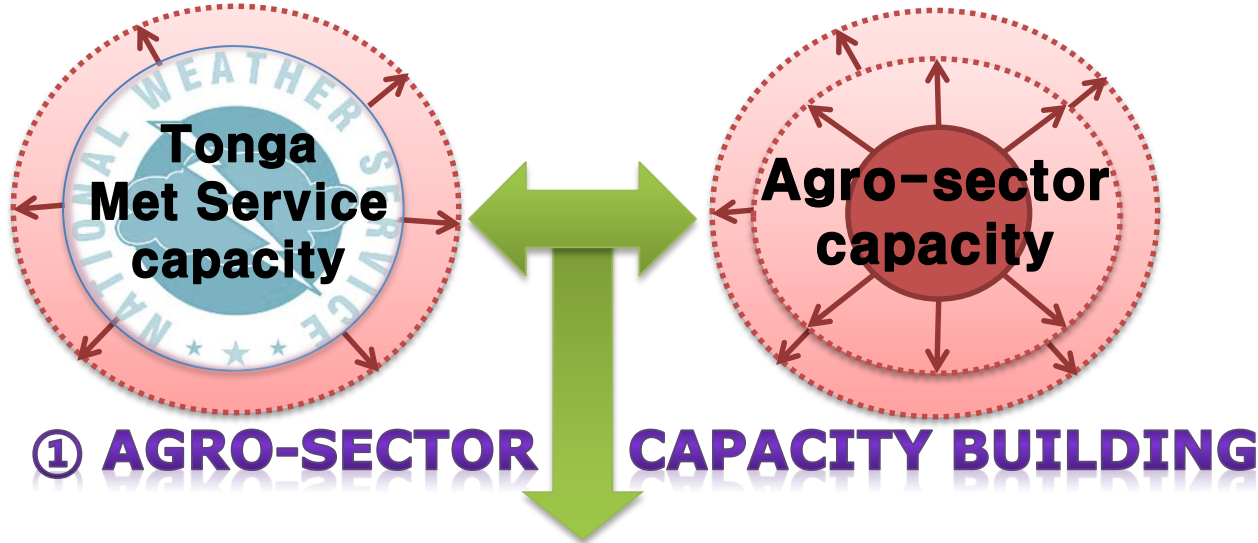
## Local Knowledge and Institutions

- Establish AgroMet Working Group
- Capacity building for extension, NGOs, commercial farmers
- Farmer field school or national forum
- Traditional knowledge and know-how sharing



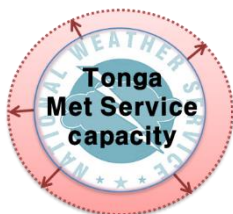
# Tonga AgroMet Project

- Enhancing Climate Service through Ensuring Data Availability



# Tonga AgroMet Project

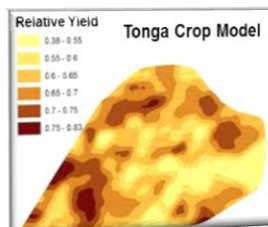
- Enhancing Climate Service through Ensuring Data Availability



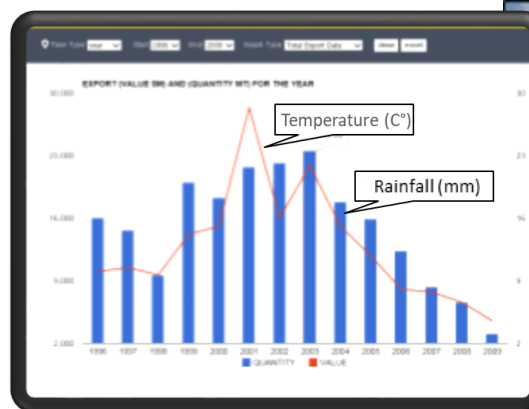
① AGRO-SECTOR CAPACITY BUILDING



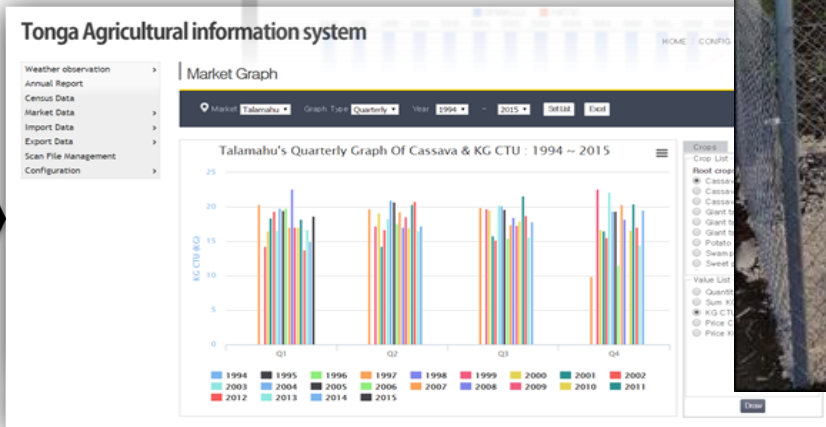
② CLIMATE SERVICES FOR AGRICULTURE



1. Development of an agriculture database
2. Generation of agro-met information



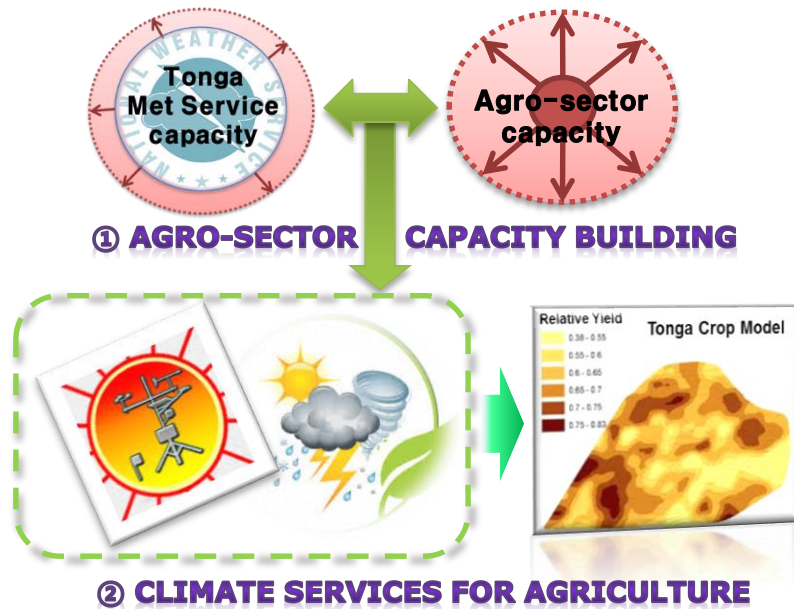
AgroMet Station



DB management system (TAIS)

# Tonga AgroMet Project

- Enhancing Climate Service through Ensuring Data Availability



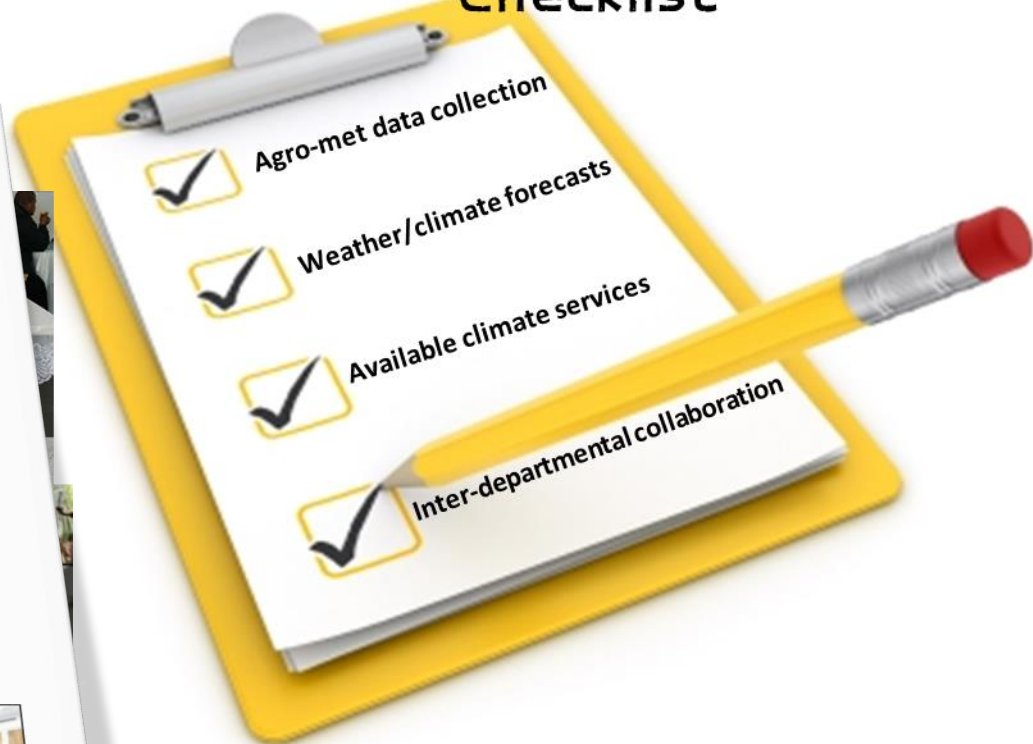
1. Development of an agriculture database
2. Generation of agro-met information
3. Development and delivery of agro-climate services
4. Assessment of users' needs and capacities
5. Research on the core relationships between climate and agriculture through modeling and field trials



# Challenge 1. Climate service should be based on stakeholder-driven portfolios

1. Initial assessment of the current level of climate service for agriculture in the target country

## Climate Service for Agriculture Checklist





# Stakeholder-driven portfolios of options for farmers, extension and local partners

1. Initial assessment of the current level of climate service for agriculture in the target country

2. Identification of the long list of climate service needs based on the initial assessment and multiple stakeholder workshops

## **Recommendations and Way Forward**

- Farmers well prepared for next El Nino events
- Improved capacity for data management
- Easy access to weather/climate information, be clear about limitations of forecast, education, increased forecast accuracy
- Effective control on unexpected crop disease and pest outbreak due to climate variabilities
- Improved partnerships and communications of climate information
- Increasing incomes : improved quality and quantity of crop products for export and local market and improved risk management capacity to variable climates
- Increased understanding on climate and biological interactions
- Sustaining project outcomes and building capacity

# Stakeholder-driven portfolios of options for farmers, extension and local partners

1. Initial assessment of the current level of climate service for agriculture in the target country
2. Identification of the long list of climate service needs based on the initial assessment and multiple stakeholder workshops
3. Narrowing down the options by cost/benefit analyses and urgency-based selection
4. Development of **final climate service portfolios** with best outcomes from focus group meetings

## • Focus Group Meetings



# Selection of realistic, practical service options through further intensive discussions

- Discussion with partners for operational capacity

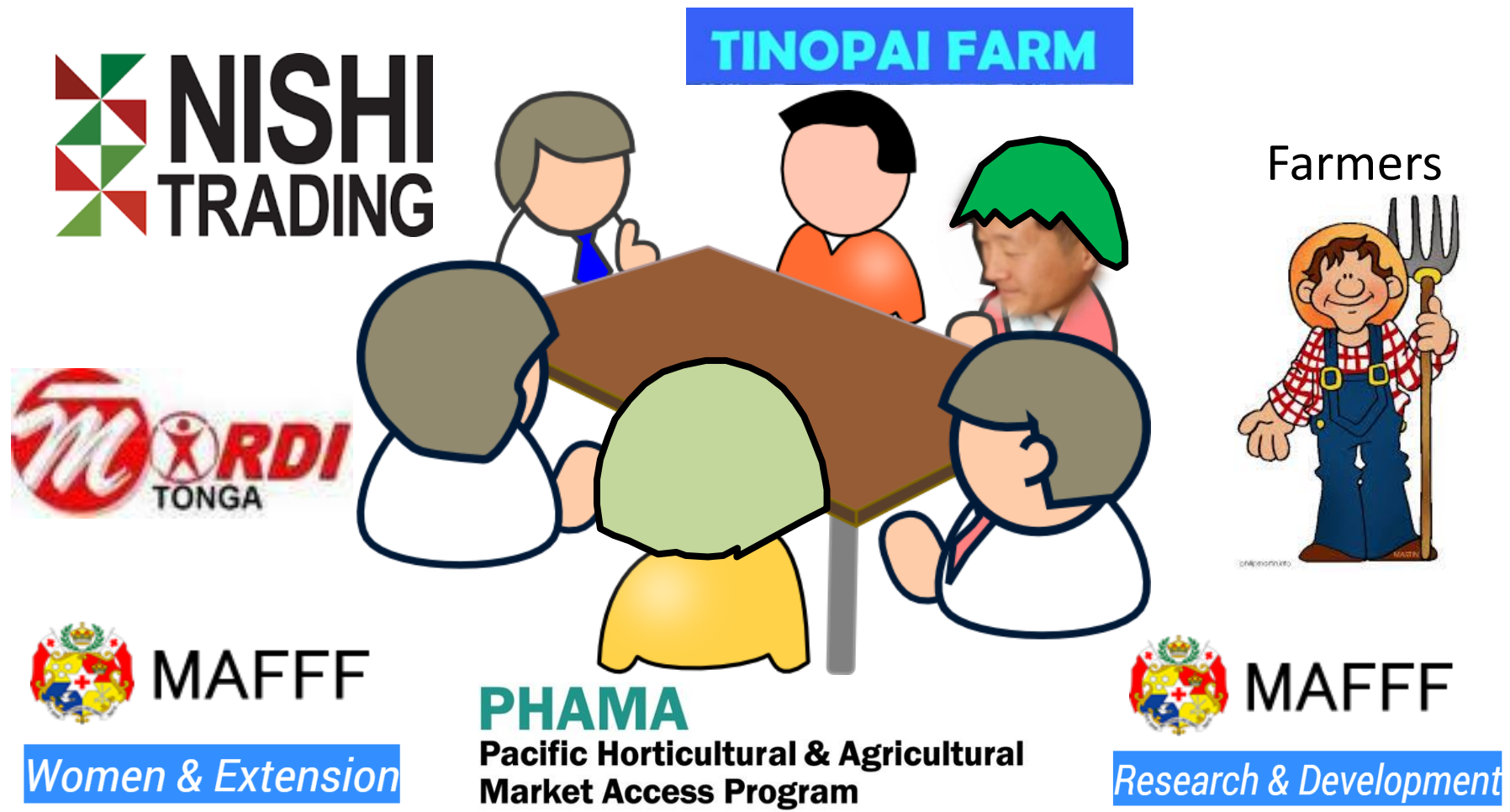


- AgroMet Working Group Meetings



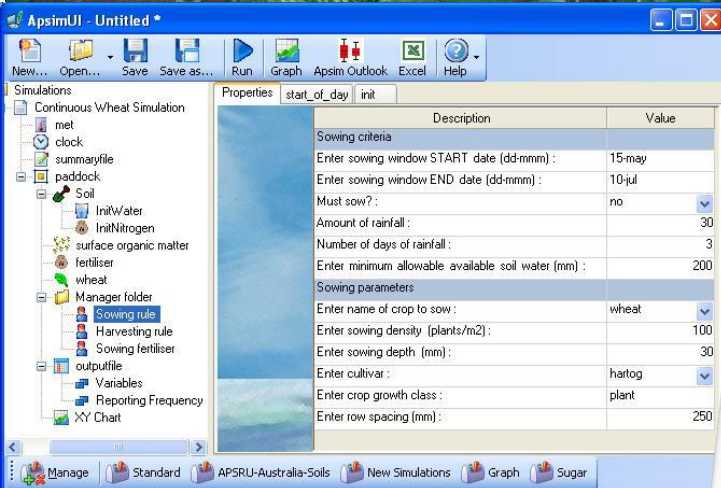
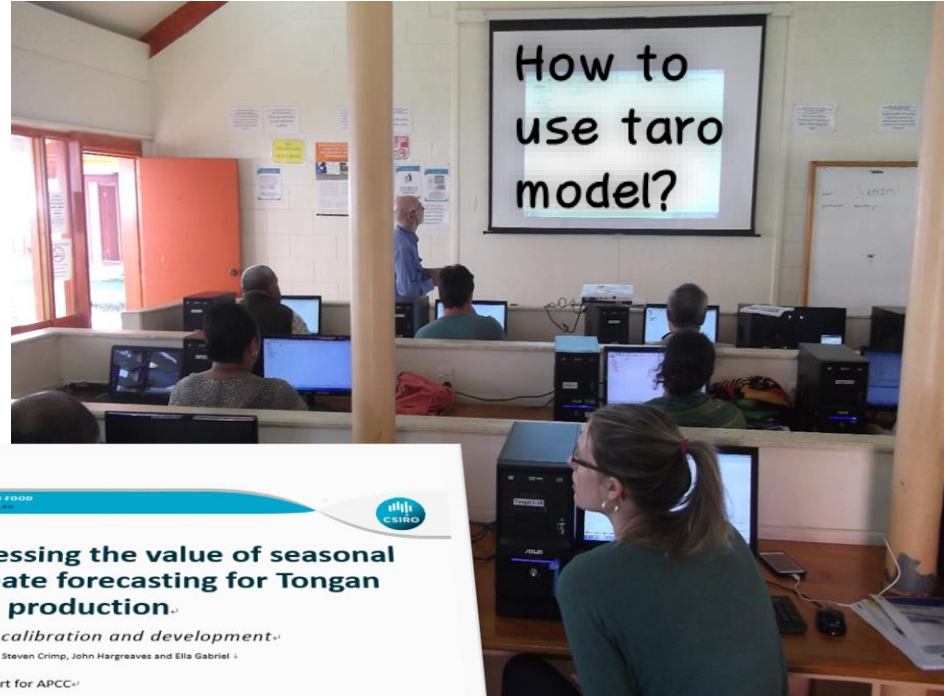
# Selection of realistic, practical service options through further intensive discussions

- Communications with Stakeholders (public and private)



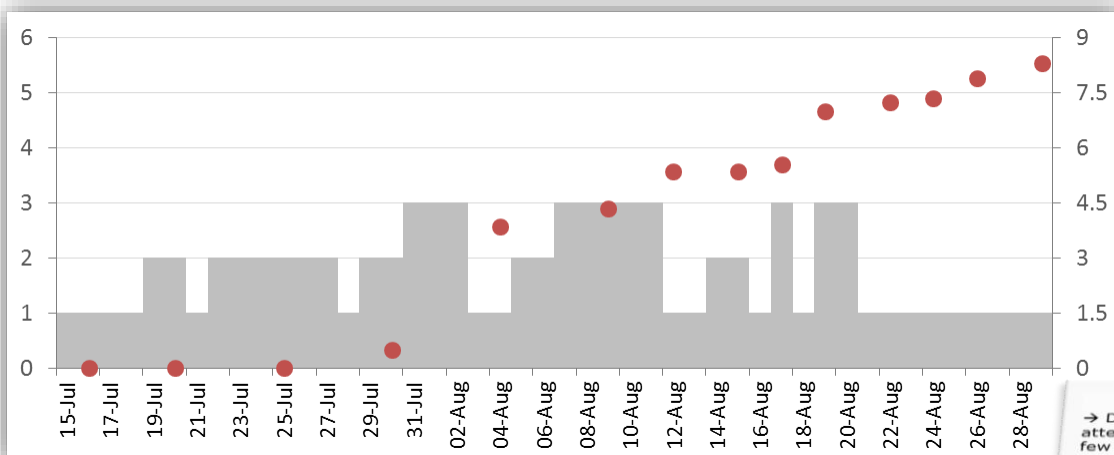
# Challenge 2. Decision making using the climate service should be supported by sound, state-of-the-art science and technology

## Taro simulation model development for farm decision making support



# Research on the core relationship between climate and agriculture

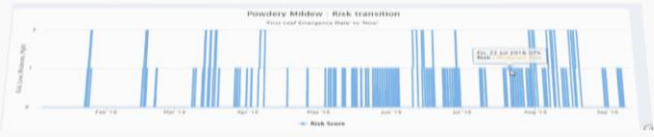
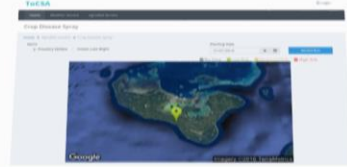
## ● Disease spray model development and field validation for disease control



Treatment	Farmer's	ToCSA-based	Control
Number of spray	<b>5</b>	<b>4</b>	<b>0</b>
Final Yield (mt/ha)	<b>5.9</b>	<b>6.2</b>	<b>4.8</b>
Max Disease Severity (%)	<b>7.5</b>	<b>8.4</b>	<b>28</b>

**Spray protocol with ToCSA**

- During two weeks from planting, you don't need to pay attention to the risk score, because there have been very few powdery mildew incidence reported during the period
- After two weeks from planting, you may want to check the risk score every five days
- If you find high risk peak over the last days, you will need to take a close look at the field to find any symptoms of powdery mildew. If you find symptom, spray systemic fungicide right away
- Or, you may just spray a systemic fungicide at least within 3 days after the high risk score. However, if another high peak appears within 7 days after the systemic fungicide application, don't need to spray another
- During moderate risk period, watch over the field for any powdery mildew epidemic

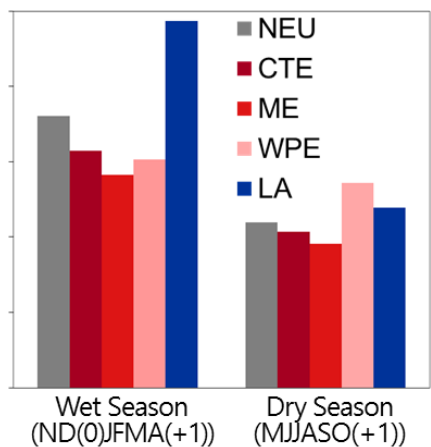


# Research on the core relationship between climate and agriculture

## Statistical model development for yield prediction with ENSO forecasts



Climate

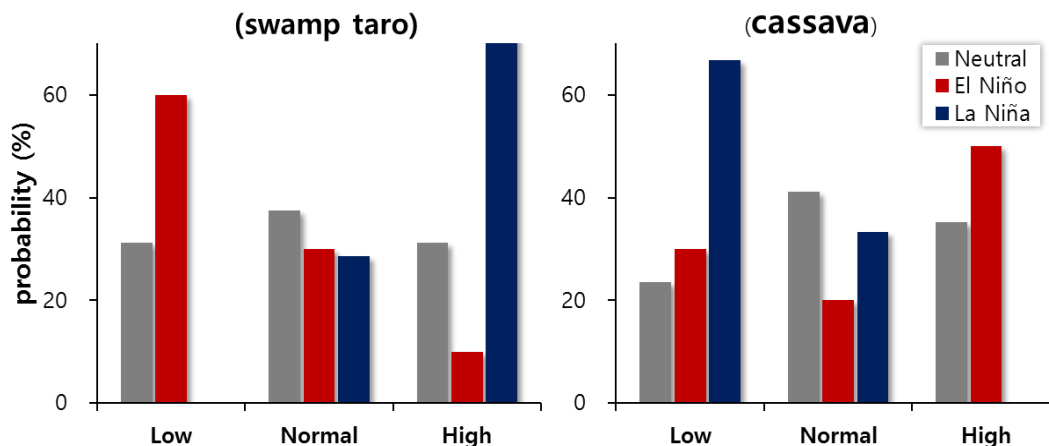


+

Agriculture

crop	CTE		WPE		ME		All El Nino		NEU		LA		P-value	
	mean	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.	mean	st.dev.	five ENSO phases	three ENSO phases
Tomato	118.92	18.70	74.96	72.65	124.70	70.48	108.62	62.97	135.99	86.40	101.77	141.93	0.943	0.646
Beans	14.73	7.92	7.20	5.27	9.17	2.99	9.69	5.00	12.61	6.76	4.13	1.14	<b>0.032</b>	<b>0.013</b>
Capsicum	20.43	3.13	13.38	7.31	17.15	5.07	16.67	5.59	18.25	9.10	12.97	5.14	0.549	0.356
Carrot	29.17	5.03	23.43	15.72	24.19	7.10	24.96	9.23	21.97	10.26	16.71	8.64	0.562	0.273
Onion A	5.53	1.05	2.29	0.82	4.62	3.13	4.10	2.51	6.85	5.44	6.31	10.01	0.778	0.500
Onion B	2.12	0.81	0.83	0.35	5.22	8.72	3.28	6.19	2.13	1.47	1.42	1.99	0.397	0.581
Lettuce	17.81	1.98	10.32	4.93	10.34	6.11	11.73	5.72	13.03	6.97	6.48	4.91	0.156	0.107
Head cabbage	33.70	17.88	52.74	41.49	34.71	12.10	39.91	23.70	48.23	20.81	24.30	15.13	0.148	0.068
Chinese cabbage	29.59	5.23	19.97	17.90	25.39	7.42	24.60	10.57	37.09	20.97	13.76	5.68	0.170	0.314
Cucumber	17.93	13.46	24.70	13.95	20.94	11.37	21.47	11.28	20.35	11.99	19.83	11.68	0.974	0.957
pumpkin	7.54	0.02	0.97	1.67	6.52	5.89	5.06	4.92	5.16	5.19	1.95	3.68	0.283	0.369
Zucchini	4.70	0.76	0.58	0.95	2.86	2.91	2.54	2.53	3.95	3.54	0.81	0.77	0.126	0.087
Lu	60.64	12.61	25.73	24.83	36.51	16.05	38.10	20.85	40.87	23.06	19.21	12.70	<b>0.099</b>	<b>0.077</b>
Pele	26.17	15.02	14.34	15.05	19.98	6.16	19.53	10.54	18.91	10.46	13.69	9.45	0.576	0.507
Swamp taro	44.45	27.21	56.16	13.66	73.19	57.15	62.33	41.53	54.10	27.29	118.67	60.77	<b>0.028</b>	<b>0.006</b>
Taro tarua	290.58	3.97	159.92	96.28	238.70	166.75	225.44	129.96	272.59	173.14	370.89	414.45	0.746	0.457
Giant taro	51.19	21.28	47.31	42.99	88.82	100.02	68.84	73.16	122.34	172.83	51.93	73.20	0.778	0.446
Sweet potato	981.88	474.41	198.55	186.23	416.85	286.63	464.37	391.85	404.45	304.79	403.31	716.29	0.343	0.333
Cassava	927.02	240.25	336.17	336.86	523.04	223.33	547.78	317.84	551.36	239.83	269.88	119.58	<b>0.013</b>	<b>0.063</b>
Yam	240.28	77.68	168.11	144.02	174.83	92.28	185.91	99.47	207.00	121.61	130.24	93.30	0.631	0.358
Potato	11.17	15.79	7.98	5.90	8.31	6.34	8.78	7.41	12.11	10.39	5.14	2.16	0.553	0.230
Banana	193.23	241.65	43.98	51.40	213.56	261.67	158.62	209.36	188.31	223.78	87.76	164.08	0.694	0.608
Plantain	61.73	44.39	96.76	136.91	89.20	78.15	85.97	85.29	95.80	73.75	64.78	115.62	0.942	0.748
Pata	19.45	4.04	27.06	36.47	15.26	13.10	19.64	20.07	133.39	457.51	9.99	5.84	0.914	0.606

== Statistical models on crop supply and climate





# Research on the core relationship between climate and agriculture

- **Seasonal market price estimation based on seasonal climate forecast**

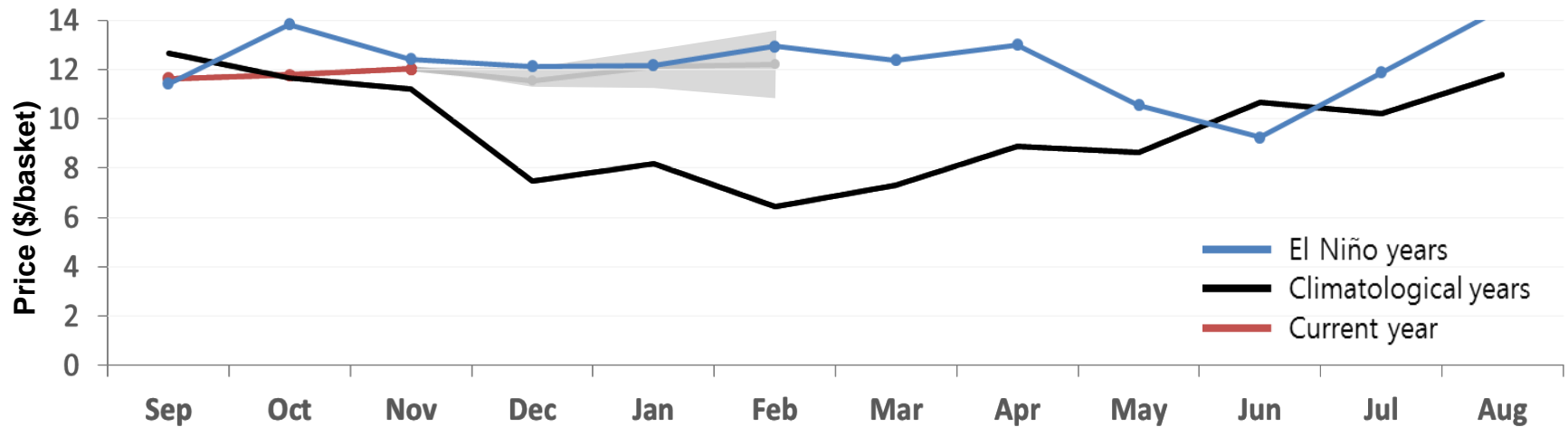
Home   Weather Service   AgroMet Service   Farm Diary   Communications   Config Menu

## Seasonal Market Price Estimation

Station

Crop

Swamp Taro Market Price (\$/basket)



# Putting all the results from the R&D activities into Agro-Climate Service Box

Traditional Knowledge

Disease spray models

Taro simulation model

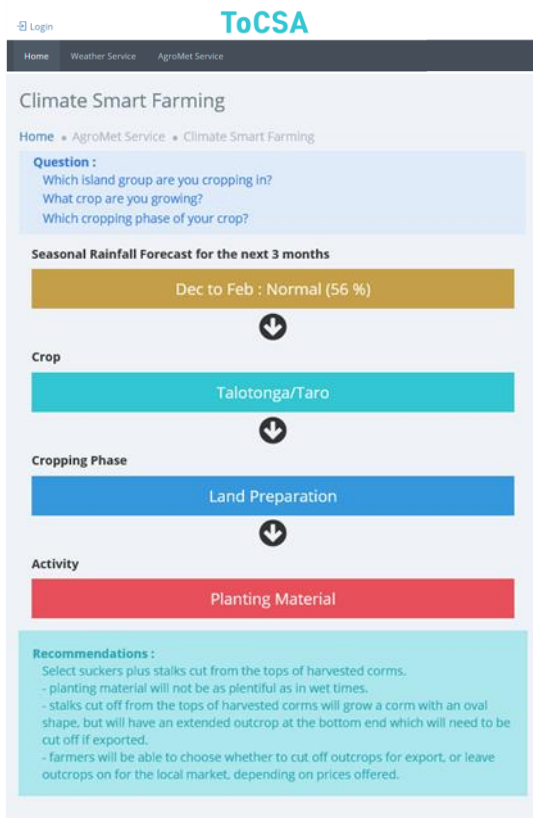
Statistical model  
for yield prediction  
with ENSO forecasts

Weather and Climate Information



# Development and delivery of the ICT-based agro-climate services in Tonga

## Tonga Climate Service for Agriculture (ToCSA)

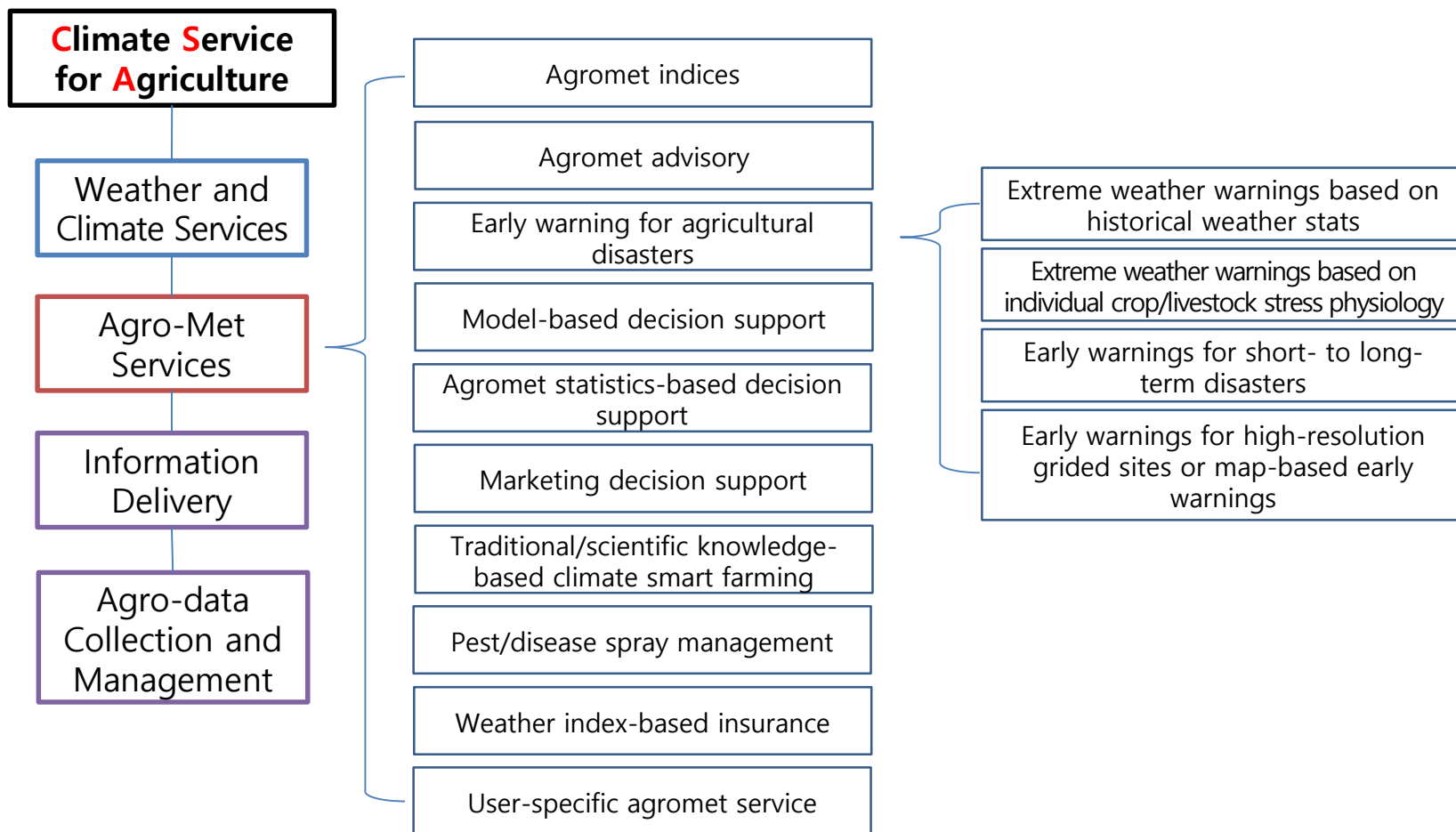


- Crop Yield Prediction (SCF-based)
- Weather/Climate Information
  - Historical and Forecast (WF&SCF) Data
- AgroMet Indices (SCF-based)
- Crop Disease Spray Planner
- Crop Management Simulator (SCF-based)
- Climate Smart Farming (SCF-based) = traditional knowledge inventory
- Farm Diary (data collection/analysis)

Web-based, mobile-compatible  
Decision Support System



# Climate Services for Agriculture are in a modular format → Customizable





# Challenge 1 & 2. Sound, state-of-the-art science and technology-supported decision-making using climate services derived from stakeholder-driven portfolios

## Conclusion

- Comprehensive assessment of the current level (capacity & capability), and multiple, intensive selection process for the climate service options resulted in stakeholder-driven portfolios for the climate services
- Sufficient communications with stakeholders through multiple participatory meetings assured their ownership for the final outputs
- Process-based, statistical agriculture model development accompanied with participatory field and desk validation gave enough confidence to users in utilizing the resulting information for their decision making
- Champion farmers are doing trials such as intercropping and different planting dates using the crop simulation model
- Market supply and price estimation using climate information and weather index-based insurance are now the priority of MAFFF strategic plan for climate resilience, seeking internal and external funds

# Challenge 3. Improving agro-data management capacity and establishing data-oriented guideline for sustainable data management in MAFFF

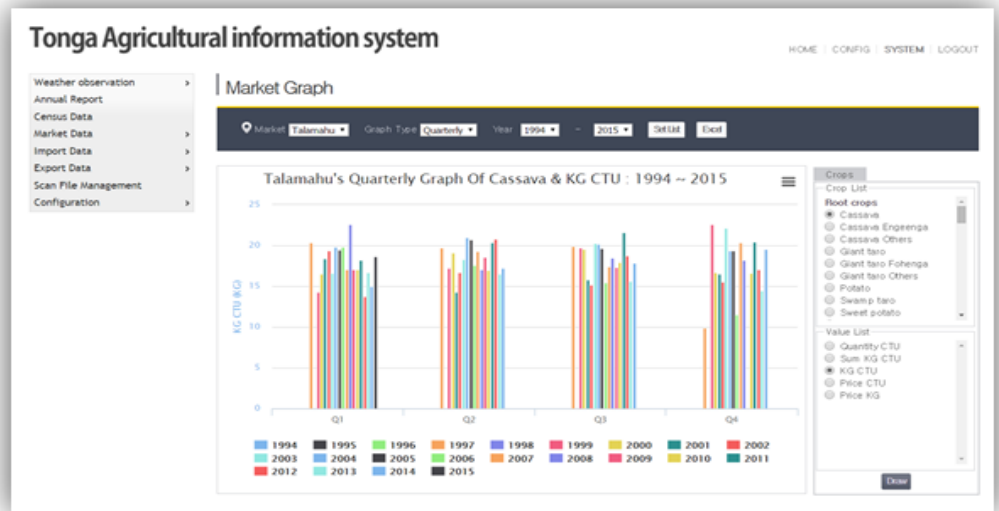
- Past agro-data in a form of hardcopy
- Recent data mostly electronic files, but missing as staffs rotate their dept.
- No guideline for data management



# Development of an agriculture database

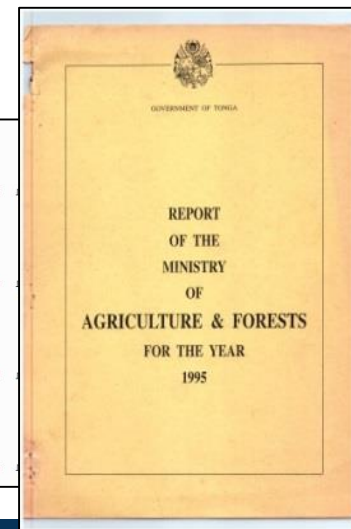
## Tonga Agricultural Information System

User Manual



DB management system (TAIS)

Data No	Category	Subject
7	Annual Report	Annual Report 19
6	Annual Report	Annual Report 19
4	Annual Report	Annual Report 19
3	Annual Report	Annual Report 19
2	Annual Report	Annual Report 19
1	Annual Report	Annual Report 19

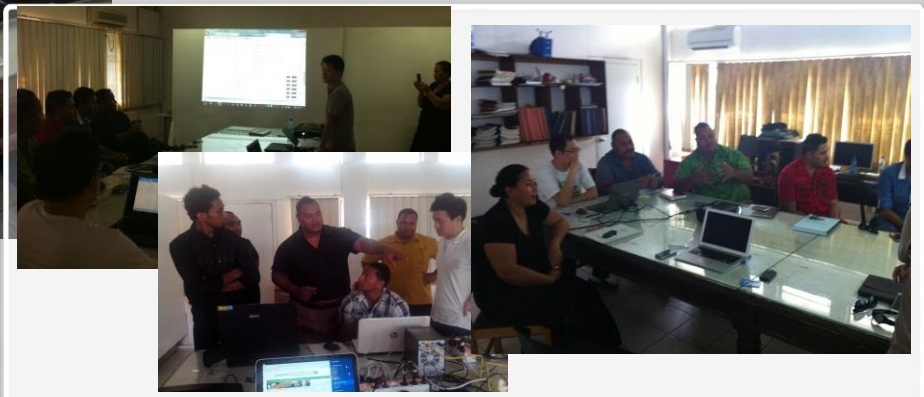
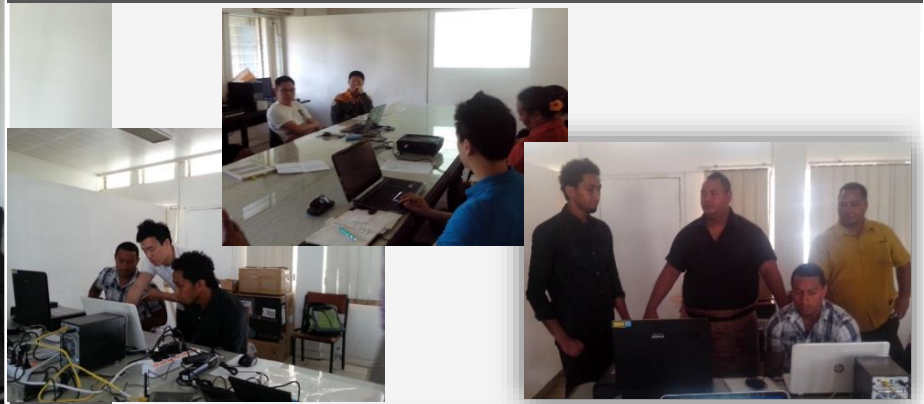




# Sustainable use of the agriculture database management system, TAIS




**1** Training on digitization and DB management system



Meetings to explain the importance of DB management **2**

**3** Meetings with high level officials (Ministers)



# Sustainable use of the agriculture database management system, TAIS

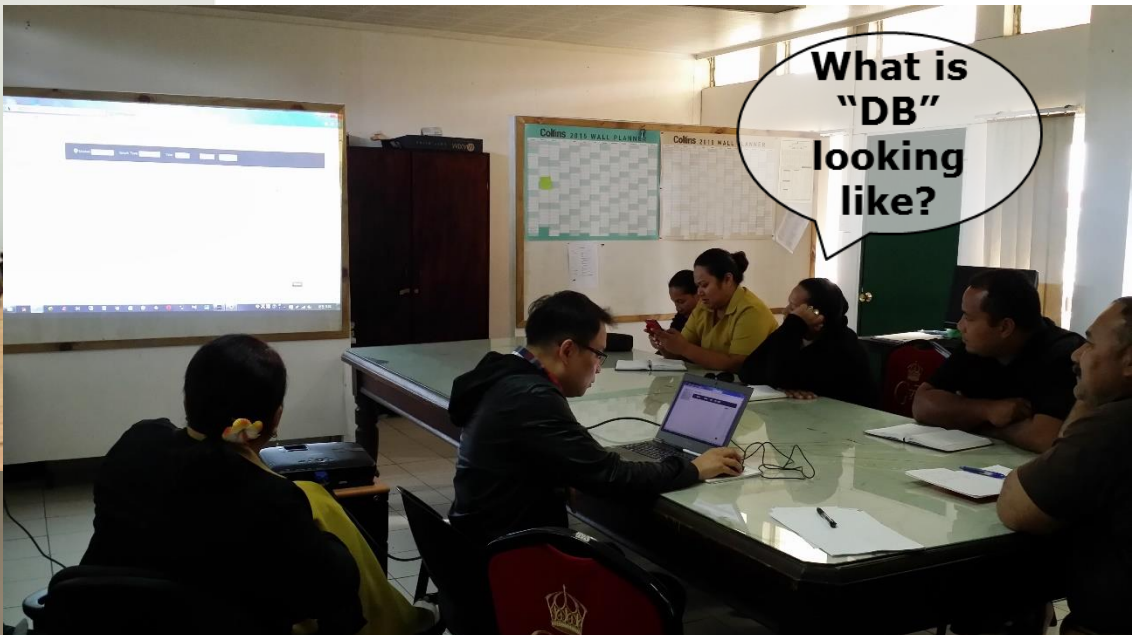
- **Why we need the standardized, mainstreamed collection and use of long-term, quality-controlled agriculture data ?**
  - \* **Big data analysis : Statistics**
  - \* **Agricultural model development, planning, extension material**
  - \* **Basis for the national agriculture policy development**
  - \* **Essential for climate change adaptation**
  - \* **Reflect the current knowledge level of Ministry**
  - \* **Limitless potential for future works**

# Ministry guideline for data management established in MAFFF

Serious...  
We shouldn't  
give up DB



What is  
"DB"  
looking  
like?



**Multiple trainings  
for TAIS!**

"we will never forget  
this is the must task  
of us, and need to  
continue!"

# Guideline extended to a new task on agro-data collection and management in MAFFF

## Extension Diary



- Extension Diary is an ICT Extension Tool for
  - 1) **Collecting** agriculture data with geospatial information
  - 2) **Analyzing** the collected data in various temporal/spatial scales to get essential statistics
  - 3) **Visualizing** the agriculture data on the map for a management purpose

→ Extension Diary is utilized not only for the Annual Crop Survey once a year but also for regular (weekly or monthly or seasonally) crop surveys by extension workers or farmers

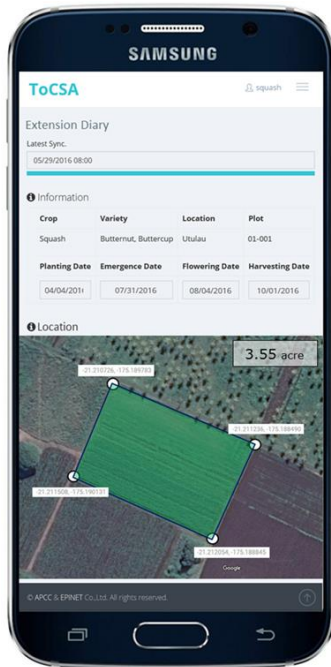
### → Collecting Information

- (1) Crop, Variety, Grower, Cropping type
- (2) Planting, Emergence, Flowering, and Harvesting Dates
- (3) GIS info with a map (Coordinate)
- (4) Number of Seeds applied and/or Final Yield



# Extension Diary consists of **two** components

**A mobile device application for offline data collection**



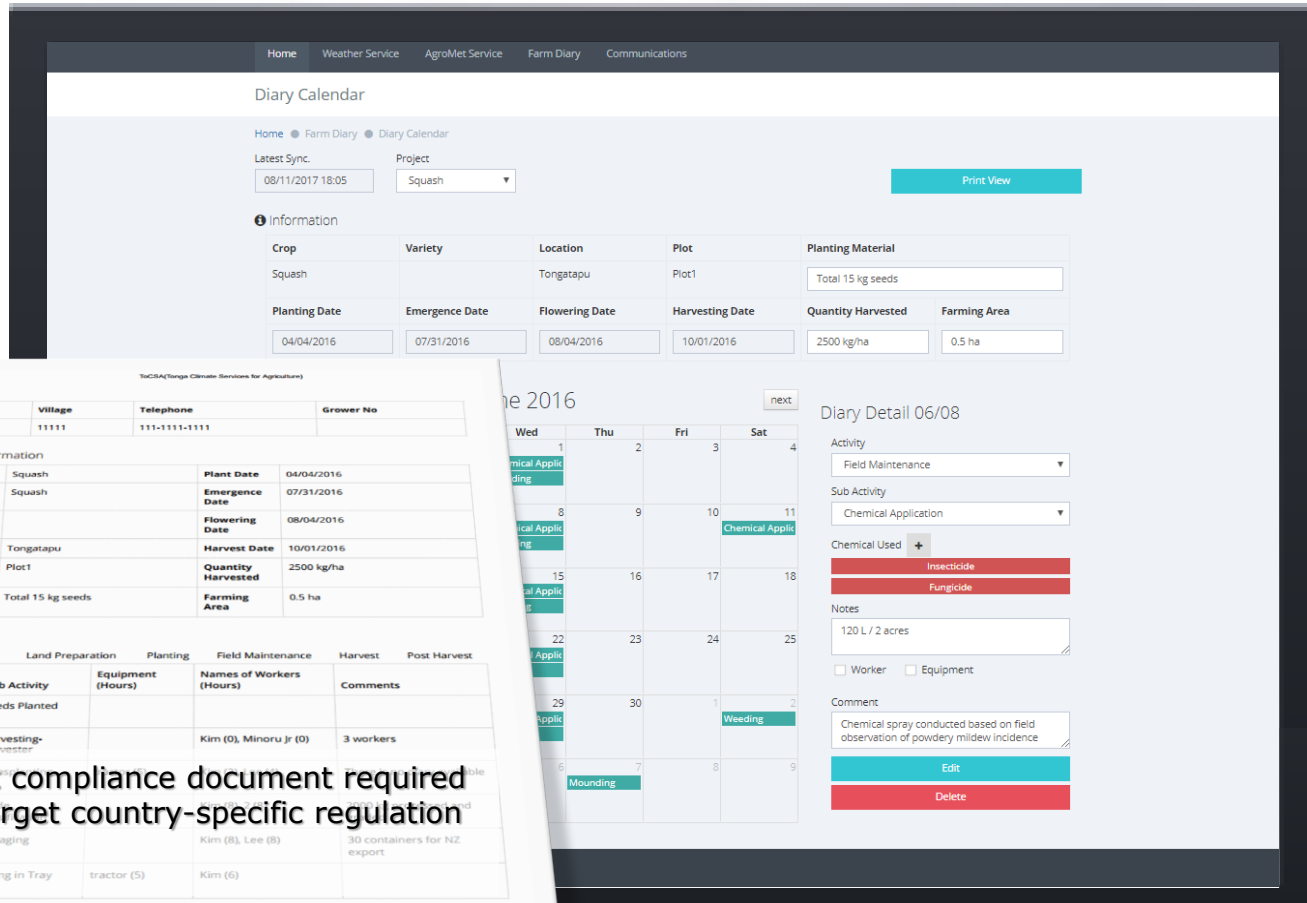
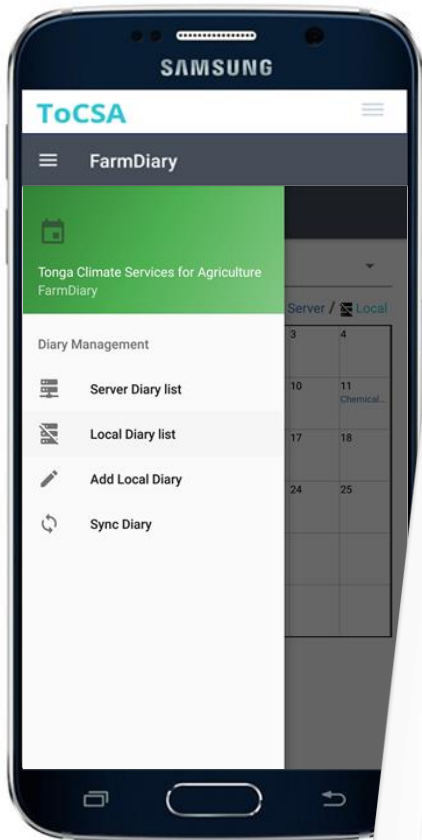
**A desktop analysis and GIS-based visualization using a web-based Extension Data Management System on ToCSA**



# Commercial Farmers join agro-data collection in their farm management

**A mobile device application for offline data collection**

**A desktop analysis and management tool on ToCSA**



2017. 8. 16. ToCSA(Tonga Climate Services for Agriculture)

User

Name	Village	Telephone	Grower No
squash	11111	111-1111-1111	

Crop Information

Project	Squash	Plant Date	04/04/2016
Crop	Squash	Emergence Date	07/31/2016
Variety		Flowering Date	08/04/2016
Location	Tongatapu	Harvest Date	10/01/2016
Plot	Plot1	Quantity Harvested	2500 kg/ha
Planting Material	Total 15 kg seeds	Farming Area	0.5 ha

Job Sheet

Date	Sub Activity	Equipment (Hours)	Names of Workers (Hours)	Comments
04 / 04 / 2016	Seeds Planted			
10 / 01 / 2016	Harvesting- Harvester		Kim (0), Minoru Jr (0)	3 workers
03 / 17 / 2017	Packaging		Kim (8), Lee (8)	30 containers for NZ export
08 / 02 / 2017	Sowing in Tray	tractor (5)	Kim (6)	

Application Details

Date Applied	Chemical Used	Brandname	Active Ingredient	Applicaiton Rate	Note
04 / 06 / 2016		Abamectin	Abamectin 1.8g/L	1g / 1ml	

http://met.gov.to:2016/user\_farm\_diary\_open\_window.do?memberId=&projectId=1&plantDate=04/04/2016&harvestDate=10/01/2016 1/3

**Export compliance document required for target country-specific regulation**



## Challenge 3. Improving agro-data management capacity and establishing data-oriented guideline for sustainable data management in MAFFF

### Conclusion

- Tonga Agriculture Information System is now an official DB management system in MAFFF
- It is now mandate to upload market survey, export and import, and regular reports (Annual Crop Survey, FAO Census, etc) into TAIS
- MAFFF is going to collect monthly agro-data focusing on major cash and staple crops using the Extension Diary based on their internal data management guideline
- Champion commercial farmers are using Farm Diary to collect their own agro-data and for their compliance document for export
- Local NGOs are planning to develop their own Extension Diary to use in a community level data collection for baseline and future disaster impact assessment

## Challenge 4. Reaching out as many end users as possible up to community level

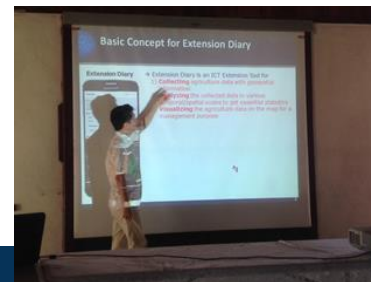
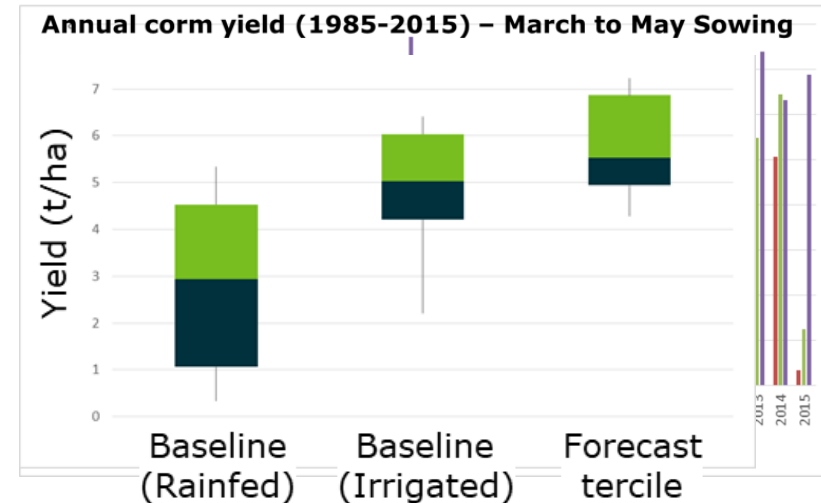
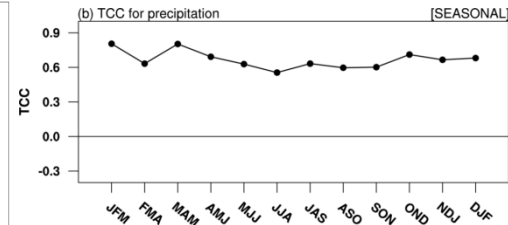
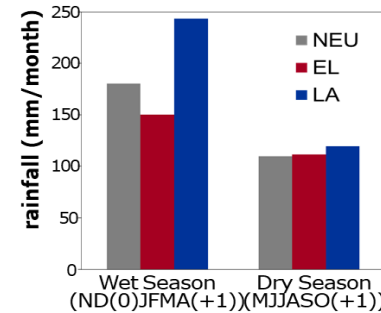
- Collaboration with local NGOs and champion farmers



- Reaching out up to 122 villages with ToCSA to provide an essential weather/climate information and as one of the community level adaptation strategies to CC

# Applied climate education to convince farmers

- Understanding the probabilistic nature, and reliability and limitation of climate forecasts
- Understanding the potential benefits of using climate forecasts in crop management
- Identify decision points in farm activities using climate information
- Learn why we need quality agro-data and how to utilize available agriculture and climate information
- Country-specific, local context-based climate change impact results (present and future)



# Various ways of information dissemination

- Web-based/mobile-compatible system
- Regular agro-met advisory email
- TV and radio advertisement
- Agro-met advisory handout
- Push alarm via mobile-device application
- Face-to-face trainings and fora
- Education material for Farmer Field School



# Communication materials

## Building agricultural resilience with climate services

## APEC Climate Center

As a hub of climate science and application activities in the Asia-Pacific, APCC provides optimized climate information and technology for the region and beyond. APCC strives to contribute to safer and more resilient communities through innovative research, operational products and services, and capacity building in the field of climate science and its applications.

## Tonga AgroMet Project

### Project Overview

The project, which is one of many collaborations between the APEC Climate Center (APCC) and the Government of the Kingdom of Tonga, runs from August 2014 to December 2016 and focuses on building capacity and linking the agriculture and meteorological sectors to develop critical climate service for agriculture.

### Components

1. Stakeholder and user needs assessment
2. Development of the **Tonga Agricultural Information System (TAIS)**
3. Research on the core relationships between climate and agriculture through modelling and field trials
4. Development of the **Tonga Climate Service for Agriculture (ToCSA)**



1. AGRO-MET CAPACITY BUILDING



2. CLIMATE SERVICES FOR AGRICULTURE

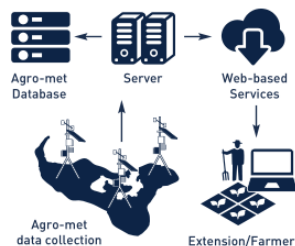
## Tonga Agricultural Information System (TAIS)

A comprehensive database was developed to bring together climate, agriculture, market and crop yield statistics. The **Tonga Agricultural Information System (TAIS)** is a customized portal and forms a core component of the Tonga AgroMet Project. This information can now be used for climate services, enabling farmers and extension workers to understand the relationship between climate and crop production. **TAIS** is maintained and updated by MAFFF for agricultural database management.



Database management system (TAIS)

## Agromet Network



## Tonga Climate Service for Agriculture (ToCSA)

**ToCSA** is a web-based, mobile-compatible decision support system, designed to support Tongan farmers in managing and planning for the impacts of climate variability on their crops and livelihoods. **ToCSA** hosts multiple agro-climate services to provide:

- Weather and climate information: historical data, warnings, weather and seasonal forecasts
- Seasonal crop phenology and yield prediction
- Crop pest risk management
- Planting date and irrigation decision support
- Climate smart farming knowledge integrated with seasonal forecast
- Farm Diary to track farm choices, including planting and the use of pesticides, and generate export certificates



ToCSA: <http://met.gov.to/2016/> // mobile-compatible system

## FACTSHEET

## CLIMATE SERVICES FOR AGRICULTURE

AGRICULTURAL PRODUCTIVITY IN TONGA  
BRINGING DATA AVAILABILITY AND ENHANCING SERVICES



### FEATURES

Tonga Agricultural Information System (TAIS)  
 → A customized agricultural database to bring together climate, agriculture, market, and crop yield statistics  
 → Used for agricultural database management by Tonga MAFFF

Weather & Climate Forecasts  
 → Weather forecasts with severe weather warnings  
 → Seasonal forecasts for long-term agricultural decision making  
 → Includes the probability of major seasonal climate phenomena such as El Niño and La Niña

Weather Analysis  
 → Real-time weather information  
 → Historic climate data analysis  
 → Agromet index calculation

Pest Spray  
 → Crop disease risk forecast for timely spray based on weather forecasts

Crop Supply Statistics  
 → Market supply estimation for major crops based on ENSO forecasts

Crop Management  
 → Crop management options with yield probability information using seasonal climate forecasts  
 → Recommendations to aid complex agricultural decision making

Farm Diary  
 → Personalized diary available to track farm choices including planting and use of pesticides or fertilizer  
 → Links to smartphone application with offline use and online updating  
 → Used for the export certificate

For Agriculture (ToCSA) is being developed in partnership between APCC, the Tonga Meteorological Service, Food, Forests and Fisheries Extension Services (TMS). It is designed to support agricultural risk management and decision-making systems in Tonga.

In the same way climate and agricultural data are being shared. By developing an agro-climate service, Tongan exporters will be better equipped to manage climate variability.

In activities in the Asia-Pacific, APCC provides climate science and technology for the region and beyond. APCC strives to contribute to safer and more resilient communities through innovative research, operational products and services, and capacity building in the field of climate science and its applications.



## Challenge 4. Reaching out as many end users as possible up to community level

### Conclusion

- Now more farmers and extension workers know about ToCSA, and getting weather and climate information through ToCSA
- This is an ongoing process with huge potential as more collaborations and follow-up projects are realized
- Additional information and features identified in the climate service portfolios should be added through continuous updates (funding) of the system
- As more users understand the climate services for agriculture through educational opportunities, more end users in the communities can be reached out

# Challenge 5. Mainstreaming the climate services for agriculture to increase long-term sustainability

- Handover and operation agreement for TAIS and ToCSA
- Joint-agreement for agro-met station maintenance



# Contribution to the 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



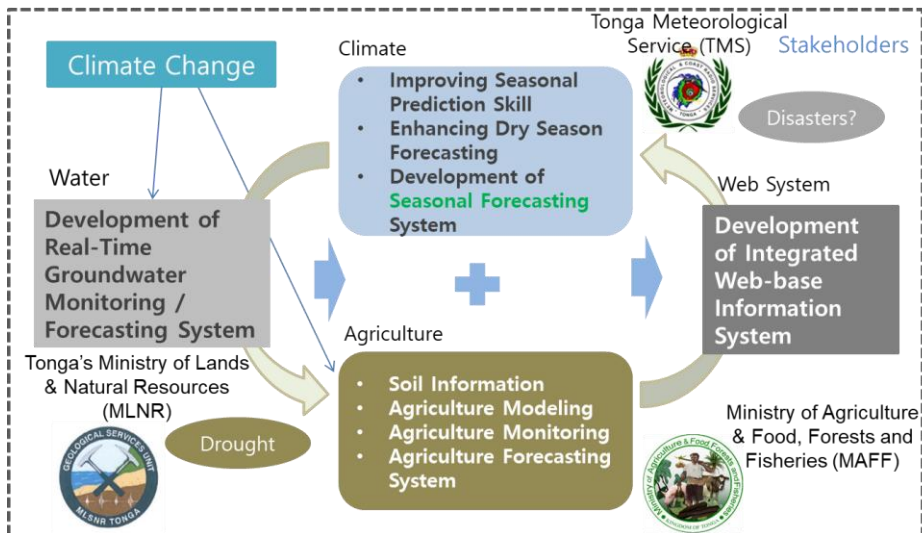
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THE KINGDOM OF TONGA  
**Tonga Agriculture  
Sector Plan  
2016-2020**

THE WORLD BANK  
IBRD • IFC • IDA • WORLD BANK GROUP  
IFAD  
Investing in rural people

# Projects implementing major components in TASP through ToCSA are under way

## ● Tonga Agri-Water Project



## ● FAO Agricultural and Rural Statistics

- ✓ Statistics strategy will define essential agriculture data, and ToCSA will be used for data collection, analysis, and visualization

## ● ADB Climate Resilience Sector Project

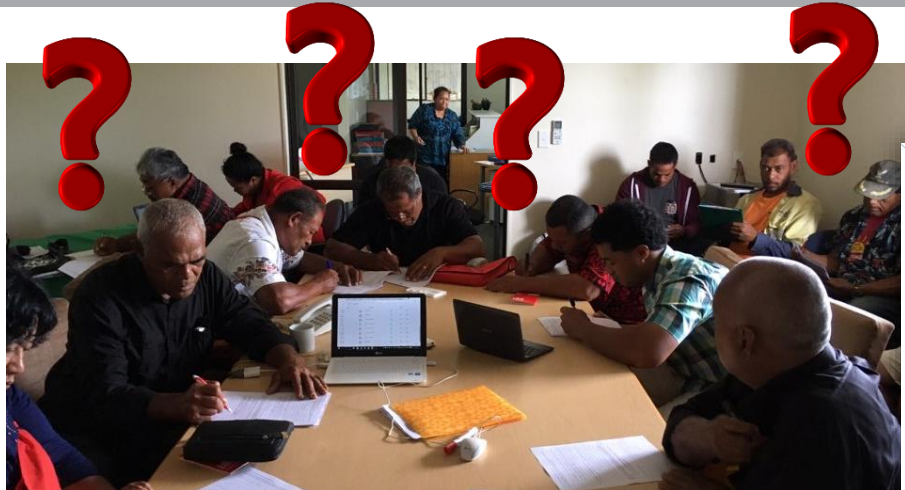
- ✓ Dense AWS network installed over Tonga and connected with ToCSA to provide location-specific climate services for community
- ✓ Reference stations for the preparation of weather index-based insurance as a future risk management option

## ● IFAD Tonga Rural Innovation Project

- ✓ Farmer Field School uses ToCSA as a means for climate information delivery and educational material for Tonga rural communities
- ✓ Baseline community data collected and managed using the Extension Diary on ToCSA



# Intensive trainings for ToCSA users and system operators



*"Do you think this is helpful to you?"*



ToCSA Workbook  
Service for Agriculture (ToCSA) Training and Workshop  
2017

Tonga Climate Service for Agriculture  
Admin Manual



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(Futa lolo)





## Challenge 5. Mainstreaming the climate services for agriculture to increase long-term sustainability

### Conclusion

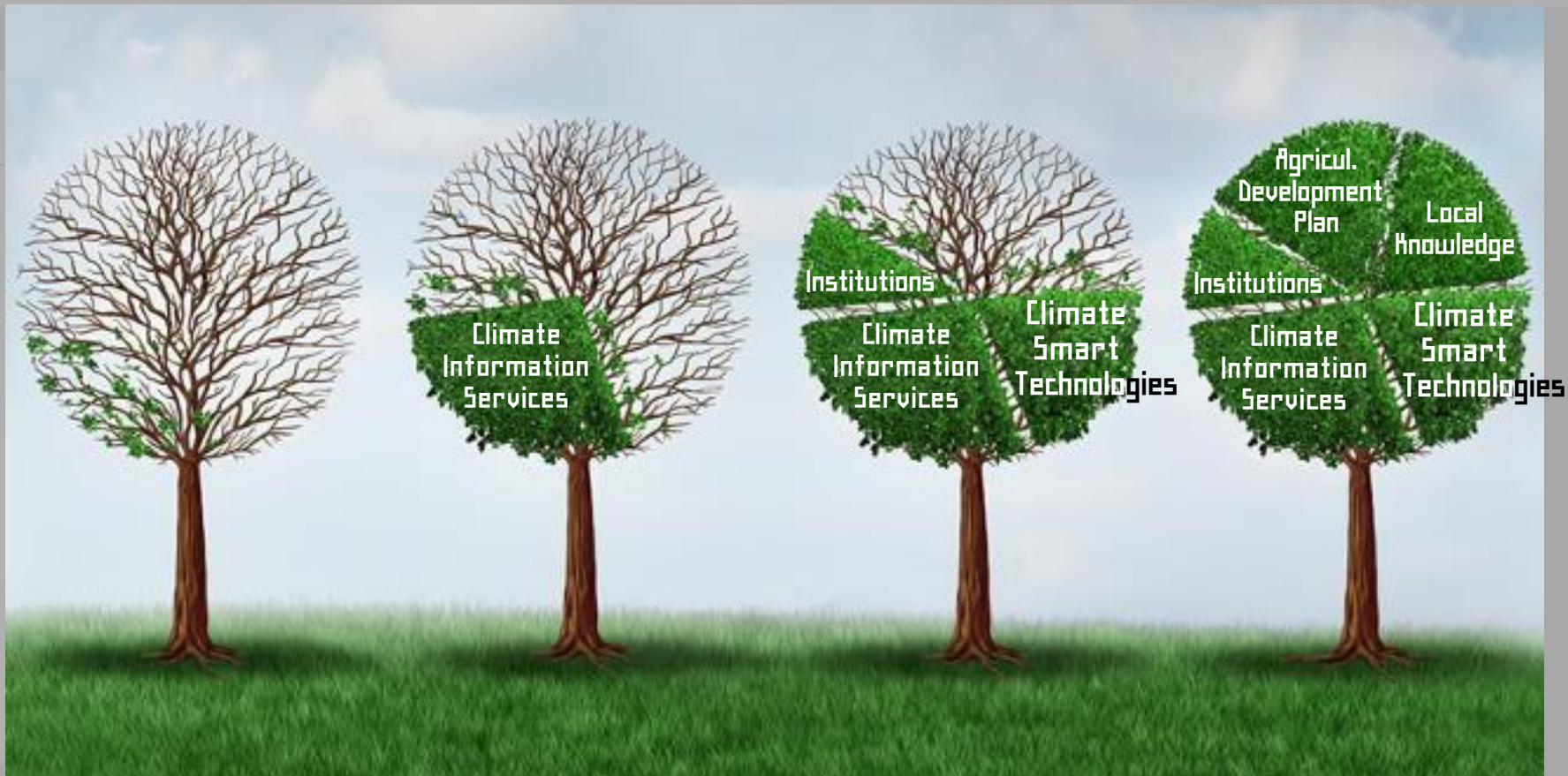
- Official agreements with Tonga government state the mainstream use of ToCSA as a means for climate service for agriculture
- ToCSA is a realization of the major climate change adaptation plan in the Tonga Agriculture Sector Plan (TASP)
- TASP states active use of climate information for coping with climate variability and extremes severely affecting agriculture in Tonga
- Connecting ToCSA with follow-up and existing projects ensures continuous use of ToCSA and thus periodic updates of the system leading to sustainable, viable services for Tongan stakeholders
- Continuous training and exposure of ToCSA to users and operators resulted in positive influence to users and committed operation by operators



# Lessons Learned

1. Climate service should be based on stakeholder-driven portfolios
2. Decision makings using the climate service should be supported by sound, state-of-the-art science and technology
3. Improving agro-data management capacity can be realized with the establishment of necessary guidelines for sustainable data management
4. Find the best way to reach out as many end users as possible up to community level
5. Mainstreaming the climate services for agriculture increases long-term sustainability

## Tonga Climate Service for Agriculture







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

Time Series

7 Day

Seasonal

Date	Weather		Wind		
6PM 03		Cloudy		E	Light
9PM 03		Cloudy		E	Light



# People



Farmers



○ **APCC Participants :**  
**Dr. Kwang-Hyung Kim**  
**Ms. Christianne Aikins**  
**Ms. Mara Baviera**

**Dr. Uran Chung**  
**Dr. Moosup Kim**  
**Ms. Yeo Min Jeong**  
**Ms. Eunjeong Lee**