Evaluation of Climate Change on Crop Production and Food Security in Taiwan(1/3)

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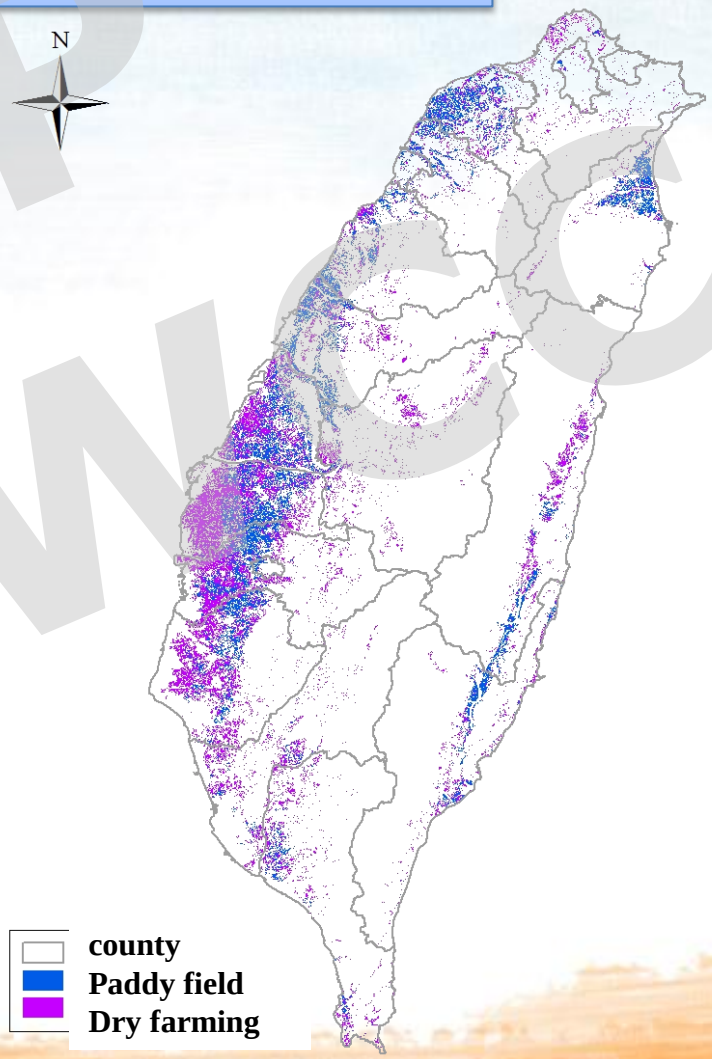
Outline

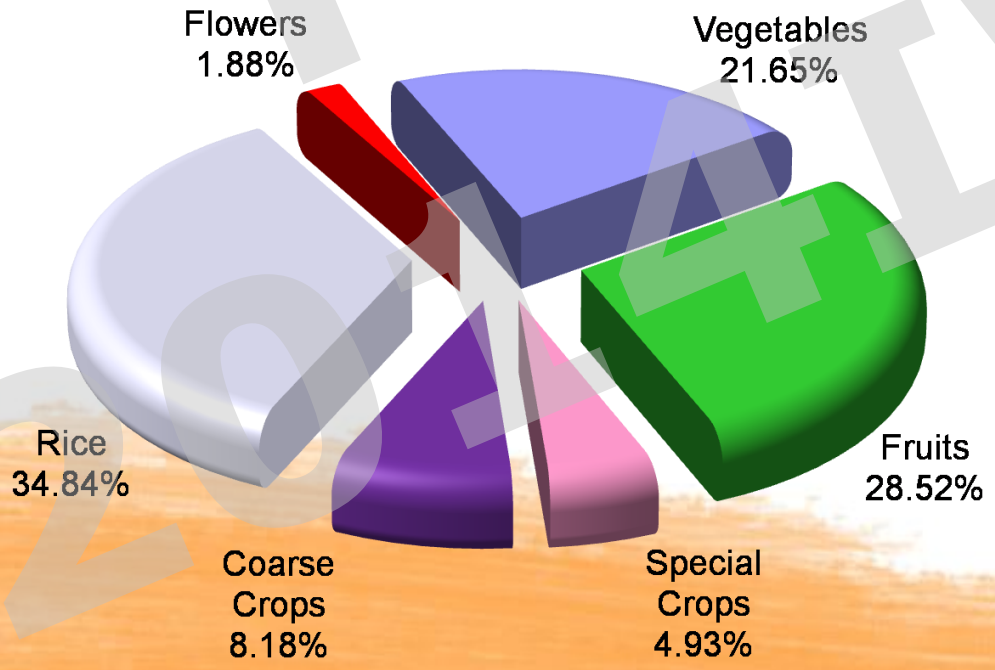
- Introduction
  - Current status of agricultural production in Taiwan
  - Damage of agricultural disasters
- To estimate crop yields under different climate scenarios
- To strengthen R&D on agricultural disasters
- conclusions

1.Introduction- current status of agriculture production in Taiwan

- Taiwan land area is about thirty six thousands square kilometer.
- Arable farmland is about twenty two percent of Taiwan island.
- Major cultivation area, concentrated on the southwestern part of Taiwan, produces the eighty percent of total agriculture value.

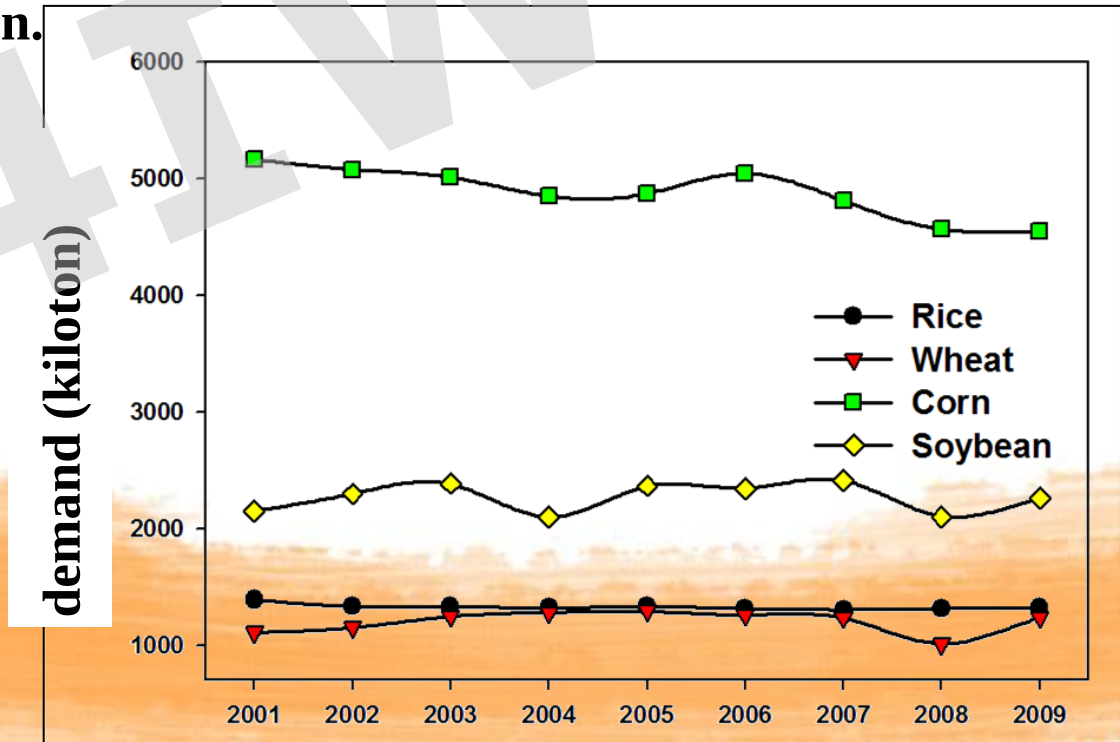


- Taiwan, located in the subtropical zone, is usually hot and with heavy rainfall in summer, but warm and dry in winter .
- The agricultural and food products are valued at 179.1 billion NT dollars per year, including rice, fruits, vegetables and etc.
- Flowers industry occupied less than 2%, but it is the main export agricultural products, especially, the orchid.



1.Introduction – annual demand of cereals crop in Taiwan

- In 2010, Taiwan's food sufficient rate was 31.7% (counted by calories).
- Wheat, corn and soybean rely heavily on import.
- However, whole world food supply has been heavily affected by the climate change.
- How to decrease the supply pressure and maintain the food security are important issues in Taiwan.



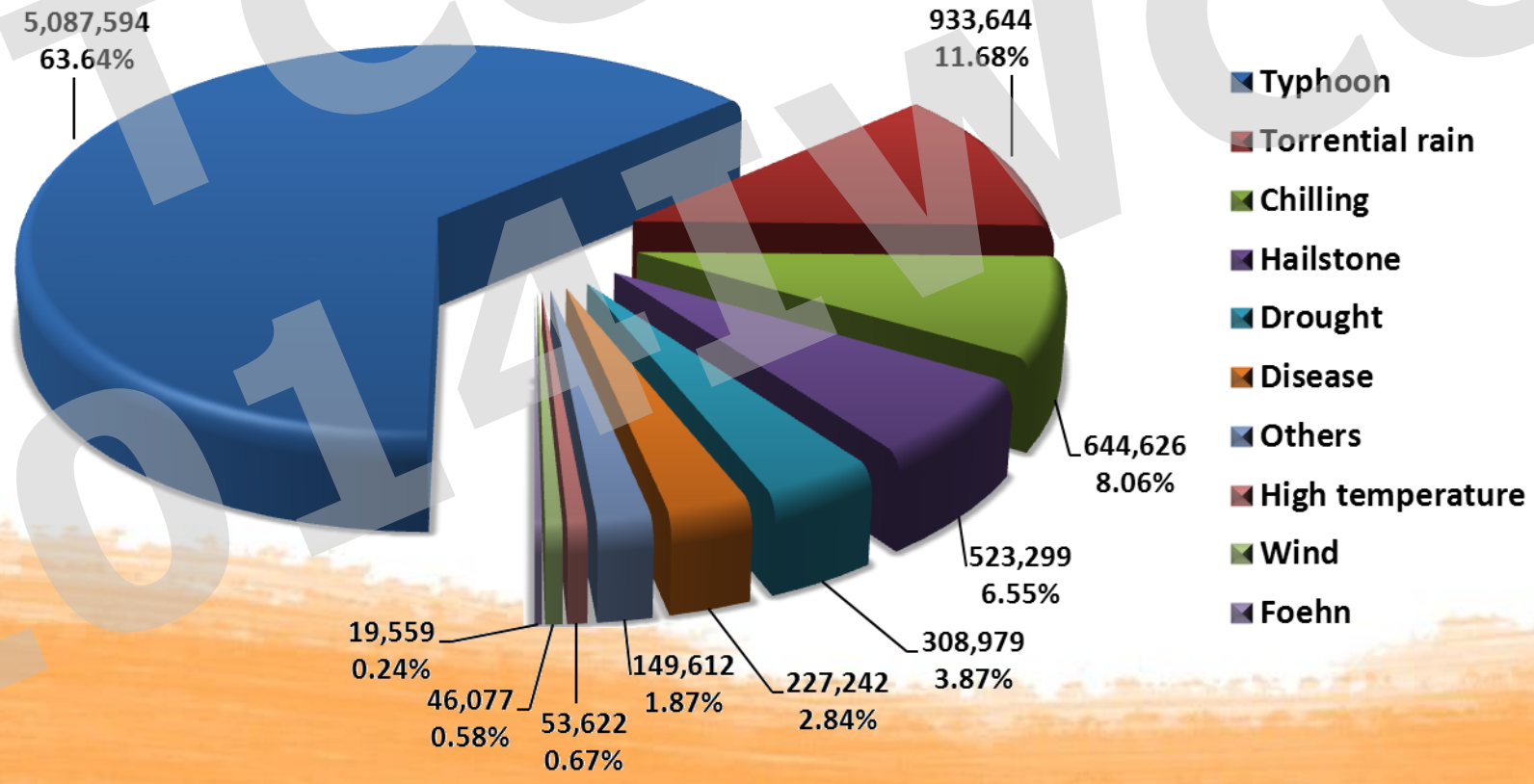
- According to CWB reports, during 1897 to 2008, Taiwan's plain area temperature has increased 1.2 ℃, which means the isotherm of years move northward about 100 km.
- These dramatic climate changes will affect the agricultural production and increase the damage of agricultural disasters. For this reason, Our government had paid more attention to this issue, including food security and the disasters happen.

COA held on 15 June 2010, "in response to climate change adaptation policy meeting of agriculture".

Damage of agricultural disasters – disaster classification

- According to the disaster records in last 30 years, typhoon is the first agricultural disaster, and the loss is up to 63% of all disasters losses.

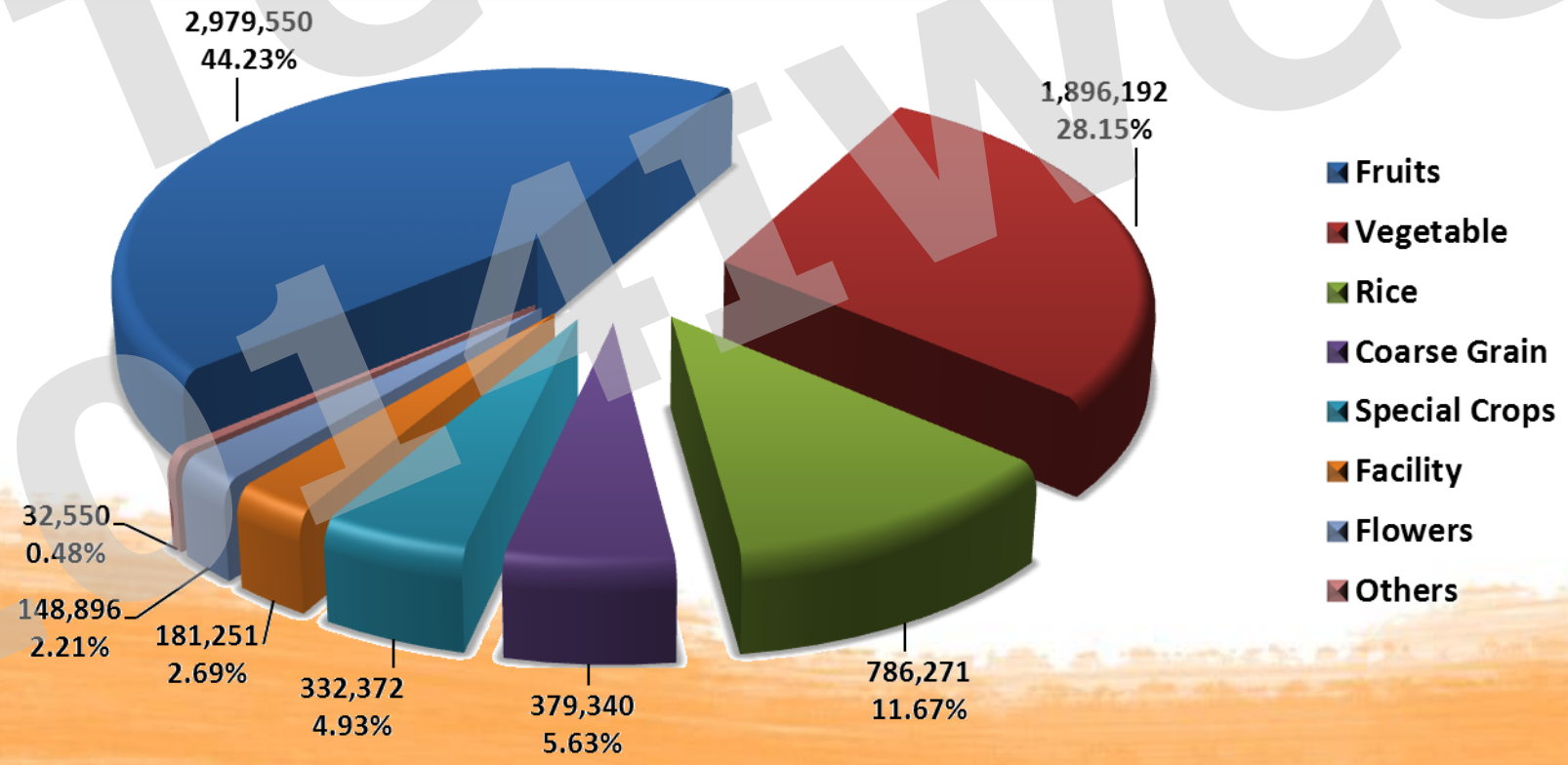
(Unit：Thousand dollars/year)



Damage of agricultural disasters - crop classification

- According to the crop classification, fruit is the worst agricultural disaster losses, followed by vegetables and rice. Sum of those three crop losses is up to 84% of all losses.

(Unit：Thousand dollars/year)



Disasters happen during the first season of rice

Season	Month	1	2	3	4	5	6
disasters			Chilling	Pest Water damage Chilling	Pest Water damage	Pest Water damage Heat wave	Pest Typhoon strong wind
Stage		seedling	Maxi. tilling		Booting and flowering	Grain filling	Mature
							

Disasters happen during the second season of rice

season	month	7	8	9	10	11	12
Disasters		Typhoon drought Water damage		Typhoon Pest	Pest Typhoon Foehn	Pest Low solar radiation	Water damage
Stages		seedling	Maxi. tilling		Booting and flowering	Grain filling	Mature
							

Research Emphasis:

- **To estimate the crop yield under different climate scenarios**
  - Crop model was used to simulate future crop yield under different climate scenarios.
  - To understand the food gaps between the demand and supply in the future by estimation of food sufficient rate
- **To strengthen R&D on agricultural disasters**

DSSAT crop model Ver 4.5

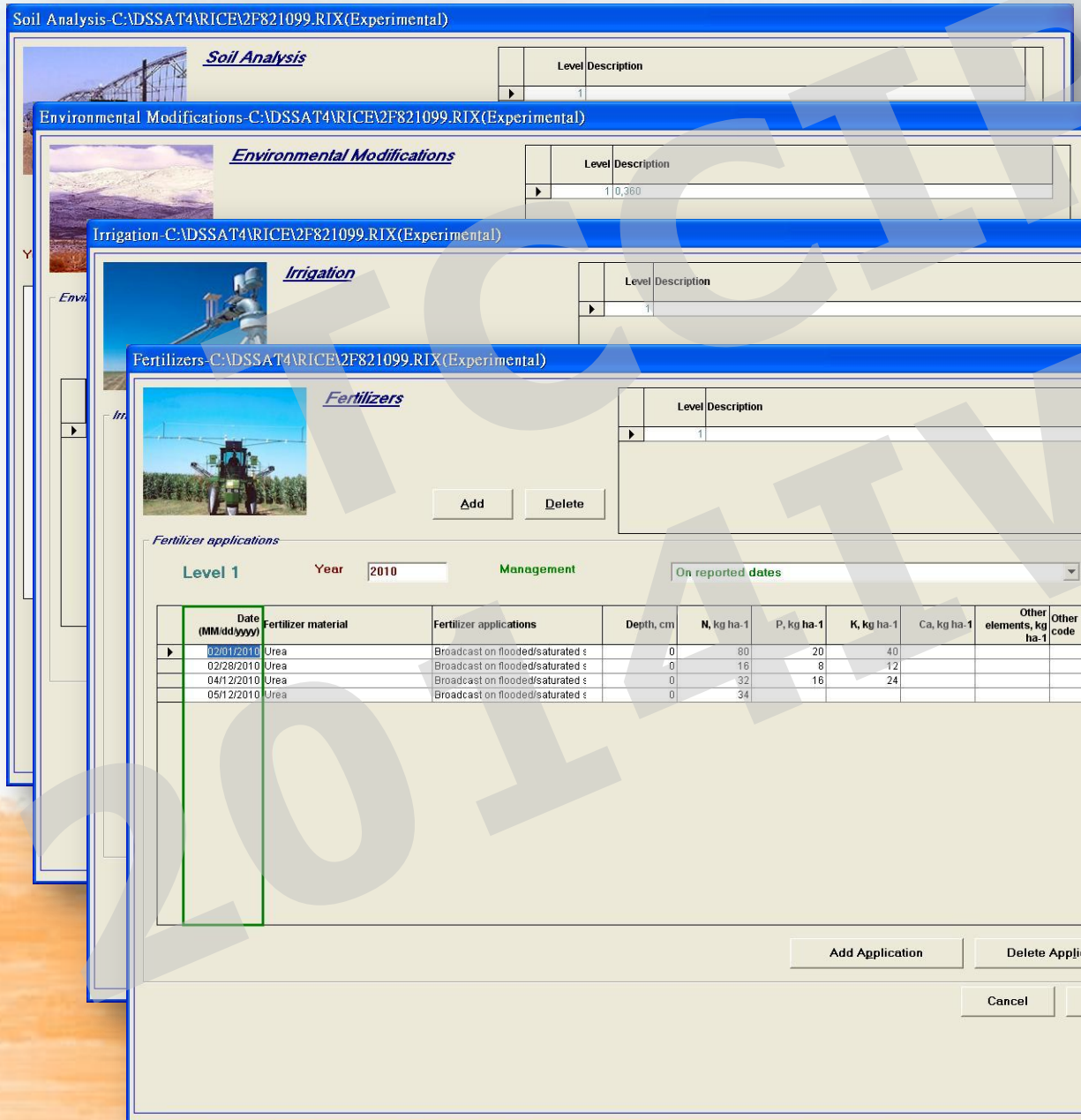
(Decision Support System for Agrotechnology Transfer)

- To simulate growth, development and yield as a function of soil-plant-atmosphere dynamics
- DSSAT has been used for many application ranging from on-farm and precision management to regional assessments of the impact of climate variability and climate change

Cereals	Legumes	Root Crops	Oil Crops	Fiber	Fruit Crops
Barley	Chickpea	Cassava	Sunflower	Cotton	Pineapple
Maize	Cowpea	Potato			
Millet	Drybean	Tanier			
Rice	Faba bean	Taro			
Sorghum	Peanut				
Wheat	Soybean				
	Velvet bean				

Vegetables	Forages	Various
Bell Pepper	Bahia grass	Sugarcane
Cabbage	Brachiaria	Fallow
Tomato		

DSSAT model parameters



soil analysis

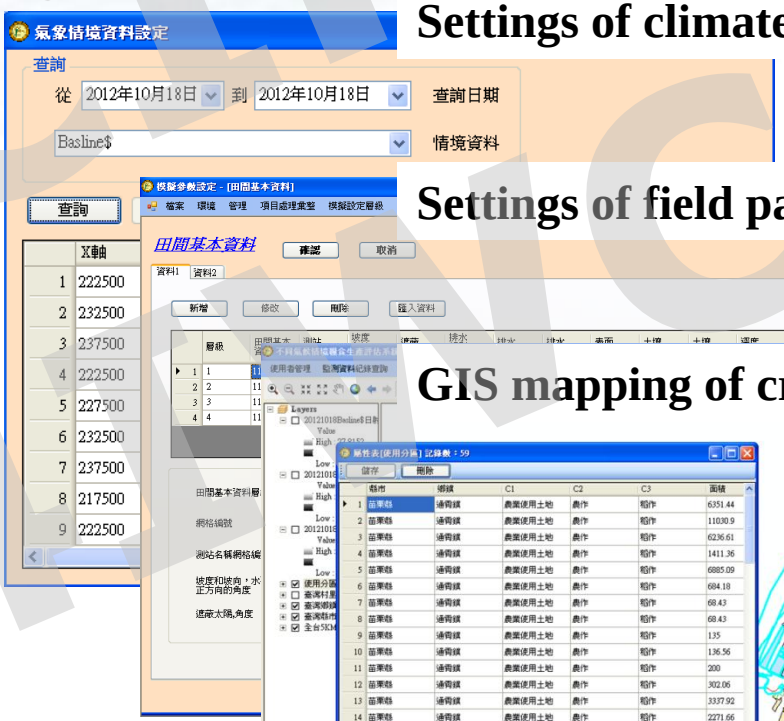
Environment control

Irrigation management

Fertilization management

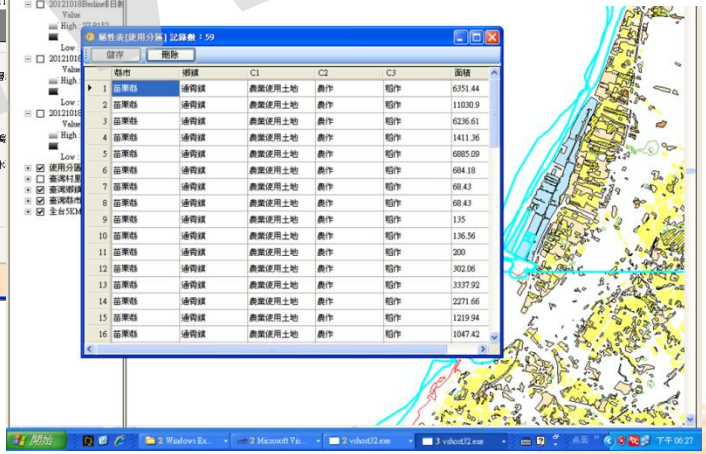
The evaluation system of food production under different climate scenarios (constructed by this study)

Settings of climate scenarios

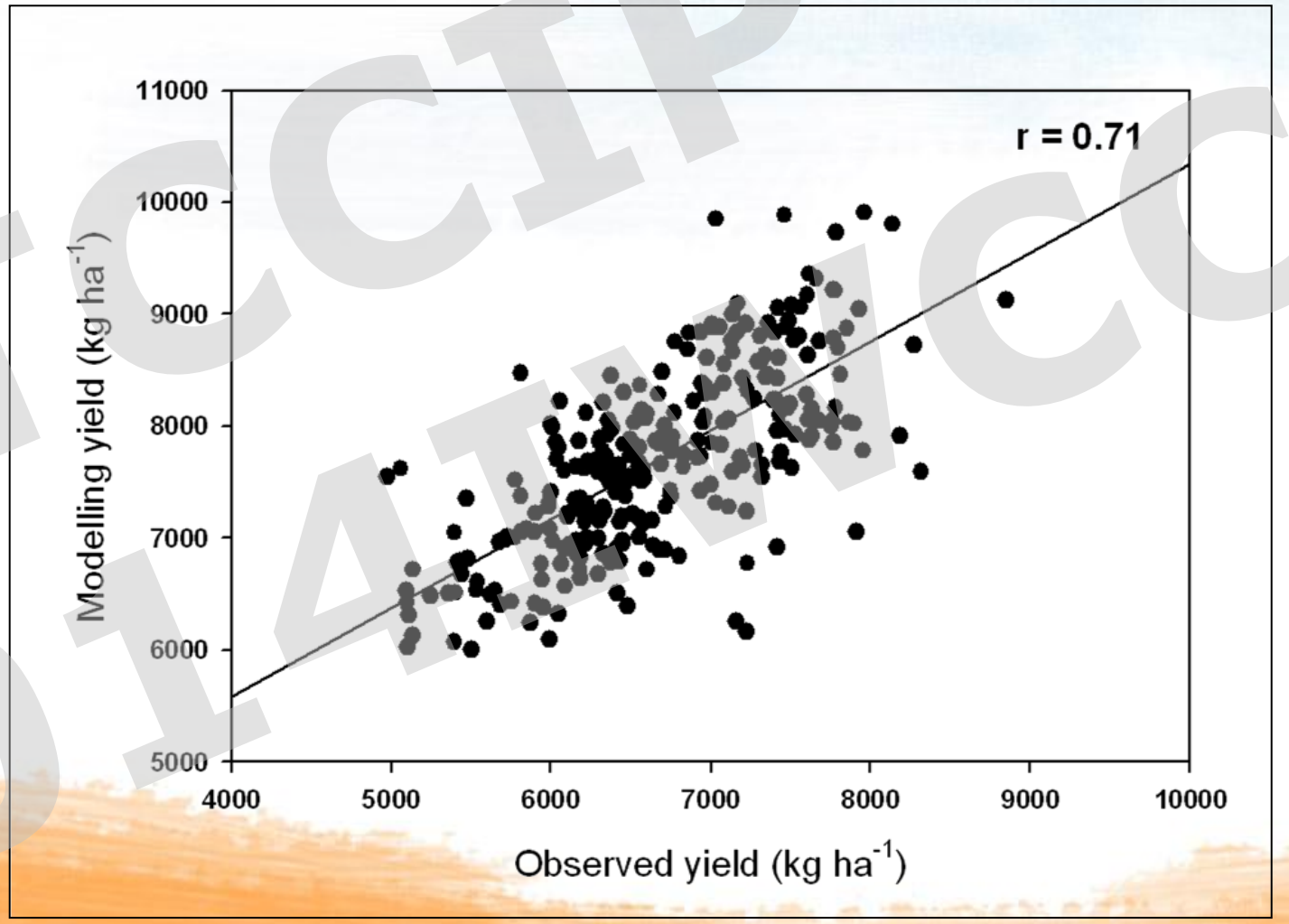


Settings of field parameters

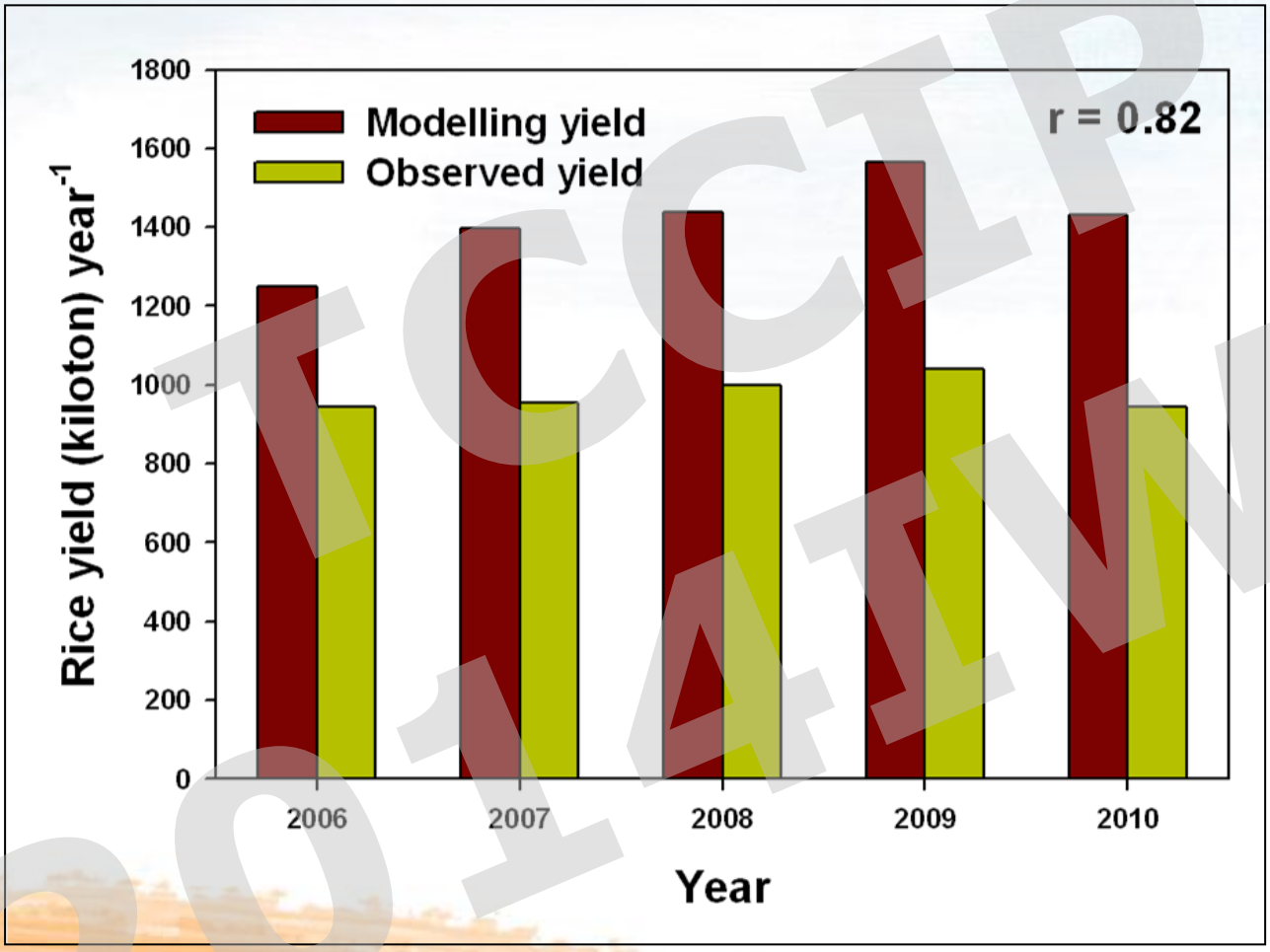
GIS mapping of crop yield



Validation of DSSAT's simulation(1/2) using field data



Validation of DSSAT's simulation(2/2) using national rice yield



we set the no stress (including irrigation and fertilization) condition during the different crop stages in simulated process.

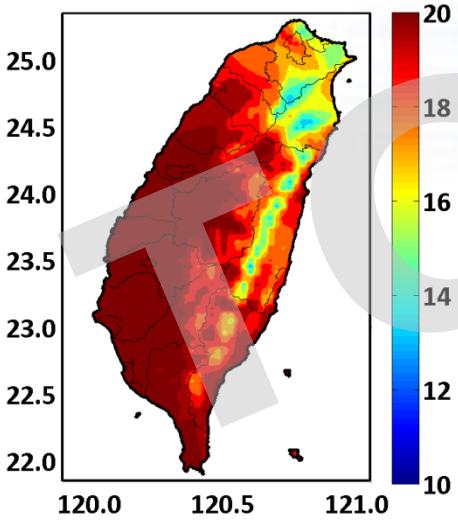
The correlation coefficient between the modeling and observed yield of national rice production

- **To estimate the crop yield under different climate scenarios**

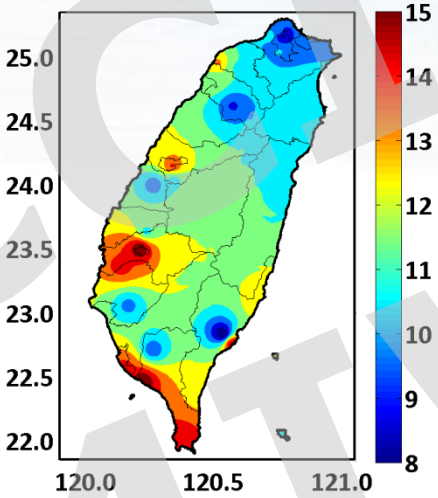
- **MRI- WRF -5km data (daily rainfall, max and min temperatures, and solar radiation)**

1. Japan Meteorological Agency (JMA) Meteorological Research Institute(MRI)
2. Weather Research and Forecasting model system (WRF)
3. dynamic downscaling data

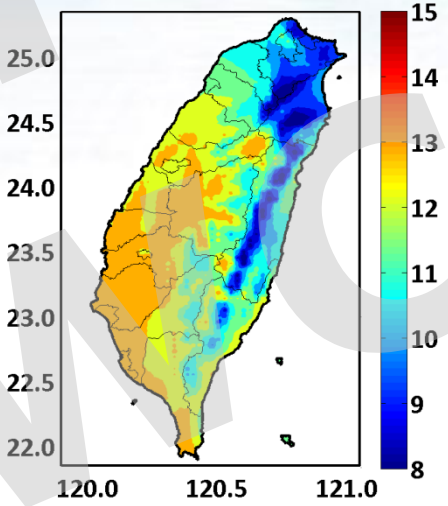
Bias correction of MRI_wrf_5km solar radiation(baseline)



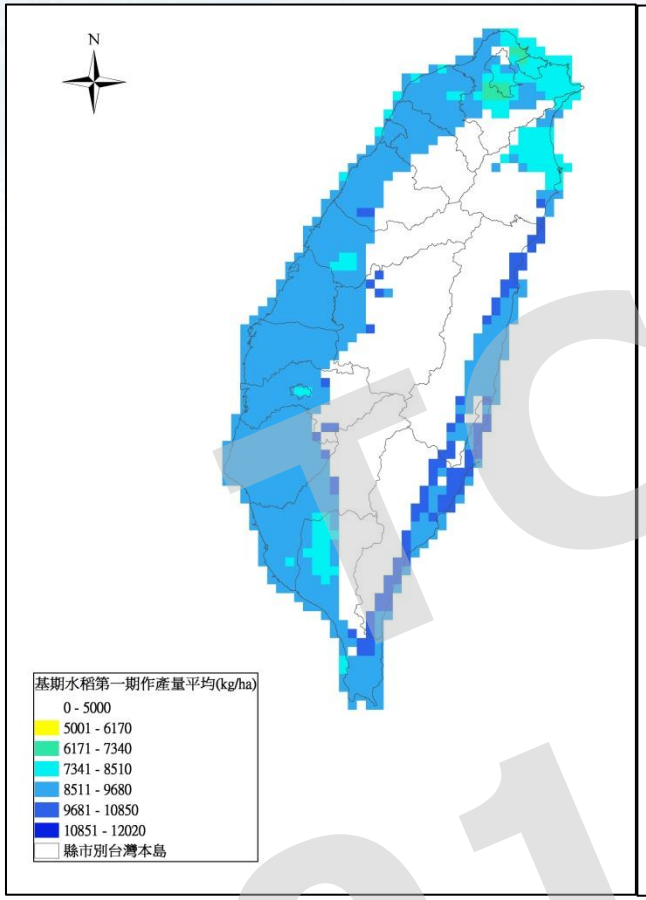
before BC

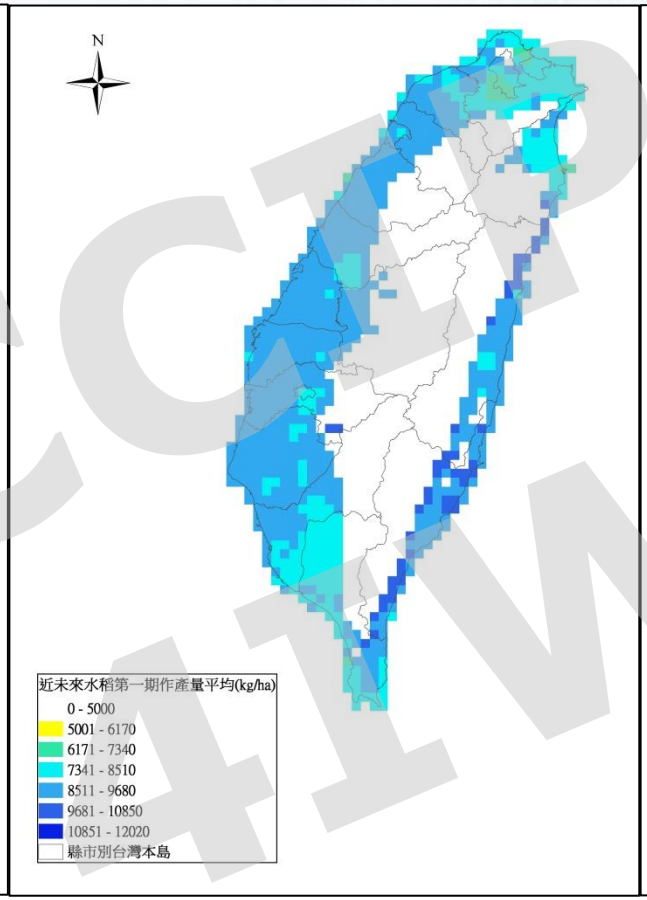


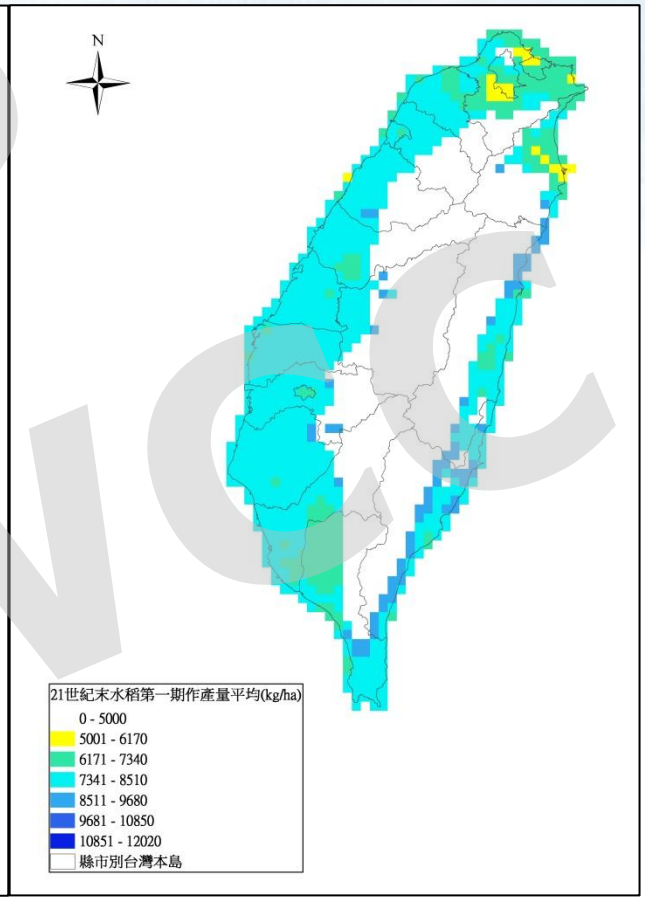
Stations



after BC







Baseline :

1979 ~ 2003

Average yield :

9066 kg ha^{-1}

Near future :

2015 ~2039

Average yield :

8739 kg ha^{-1}

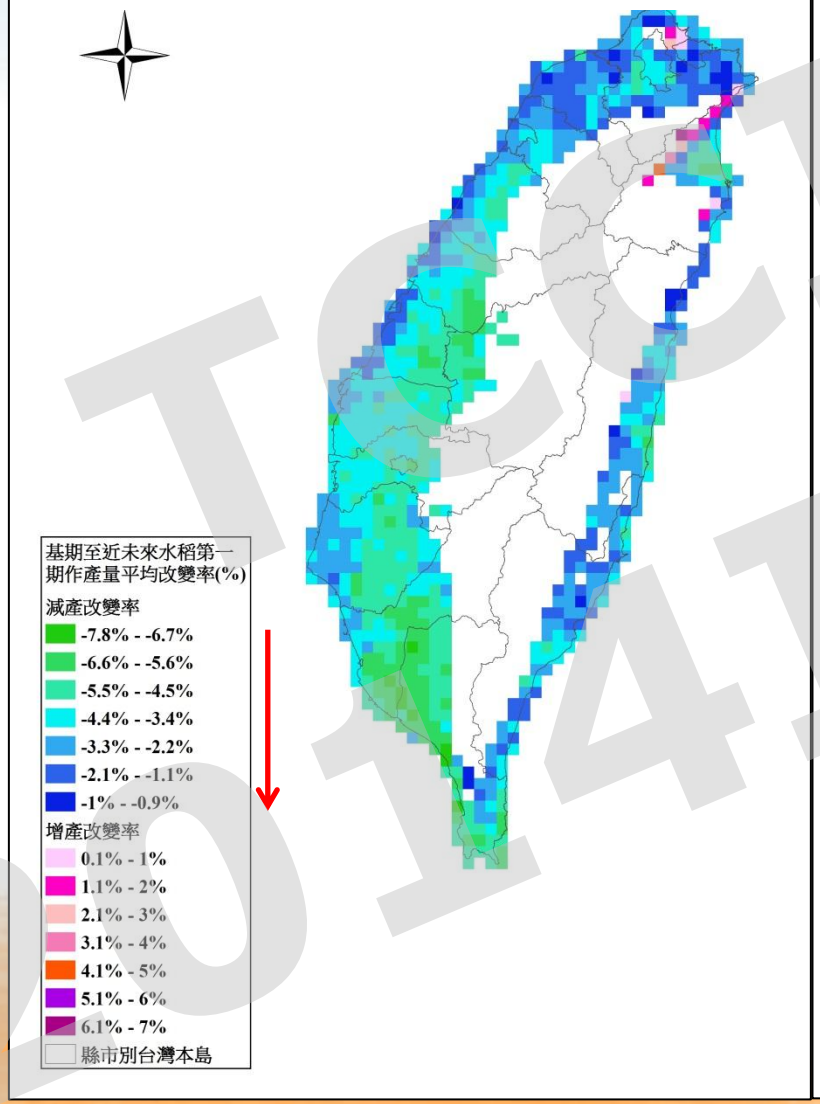
End of century:

2079 ~ 2099

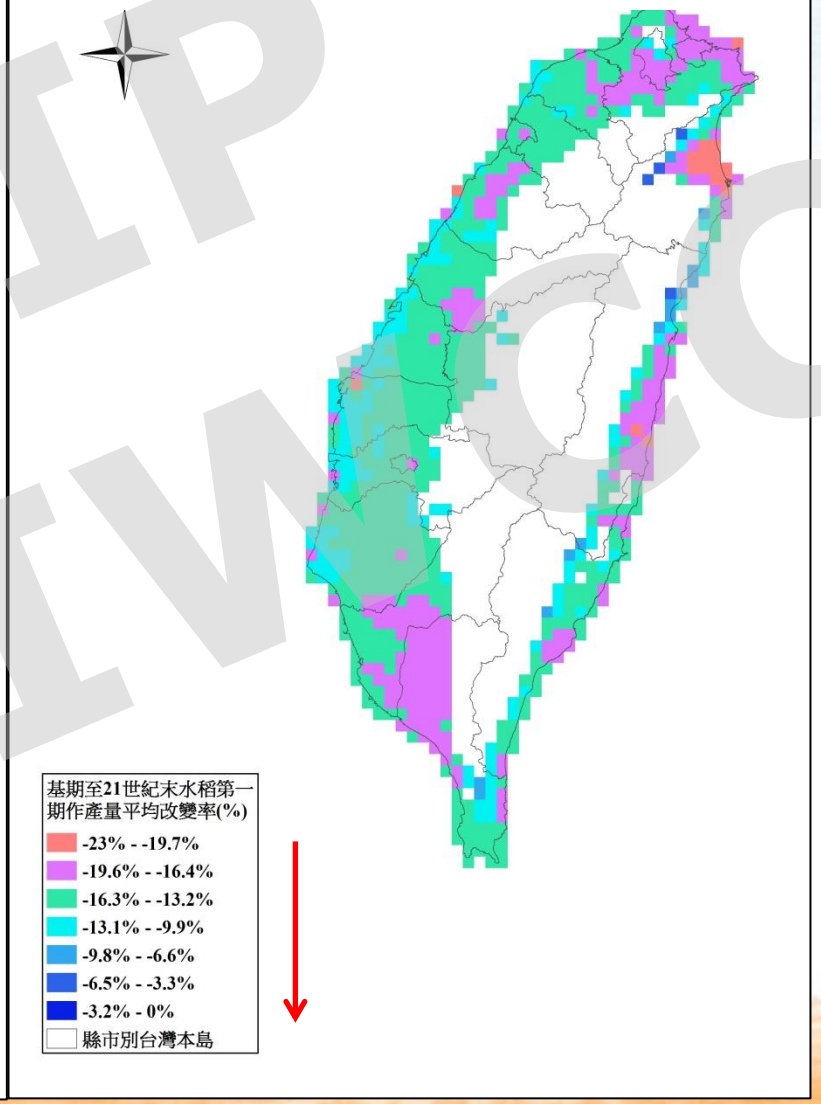
Average yield :

7713 kg ha^{-1}

Change rate of 1st crop yield in Near-Future



Change rate of 1st crop yield in End-of-Century



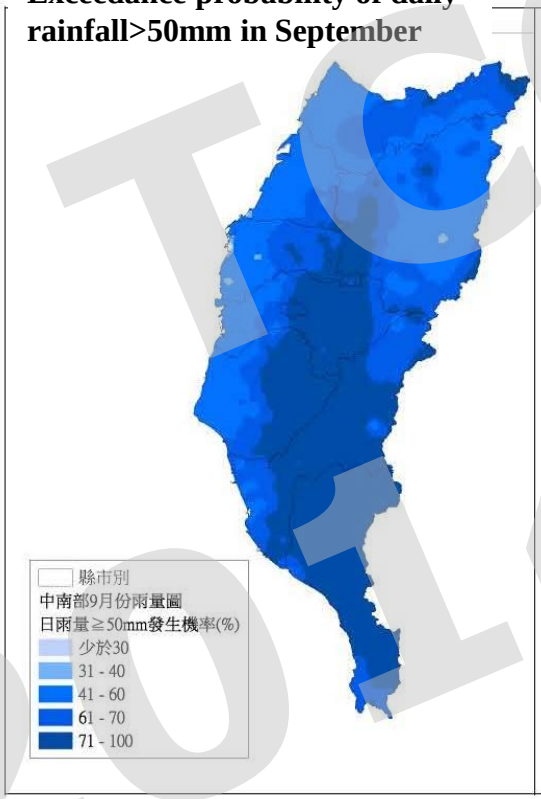
$$\text{Change rate}(\%) = \frac{\text{near future rice yield} - \text{baseline rice yield}}{\text{baseline rice yield}}$$

Future Research Emphasis:

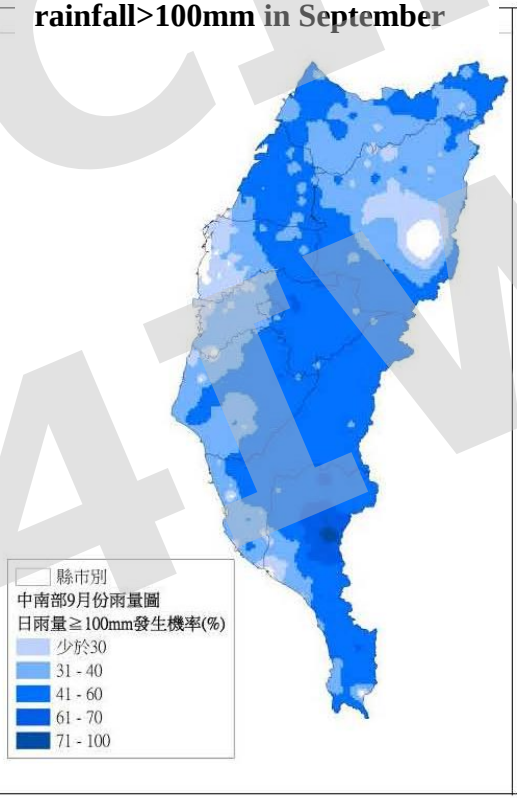
- To estimate the crop production under different climate scenarios
- To strengthen R&D on Agricultural disasters

The probability of occurrence of meteorological disasters

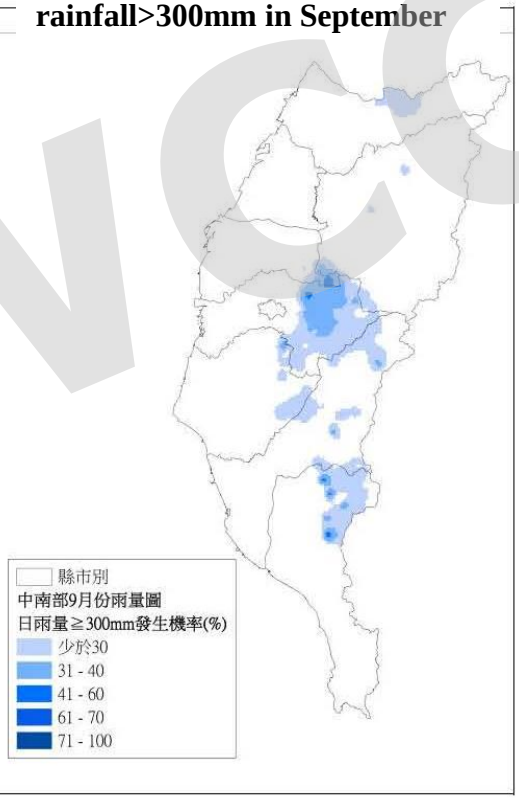
Exceedance probability of daily rainfall>50mm in September



Exceedance probability of daily rainfall>100mm in September



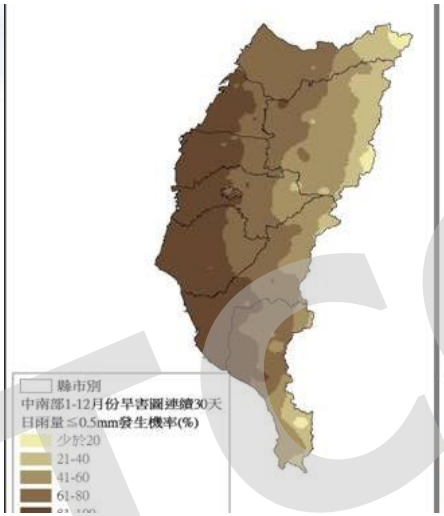
Exceedance probability of daily rainfall>300mm in September



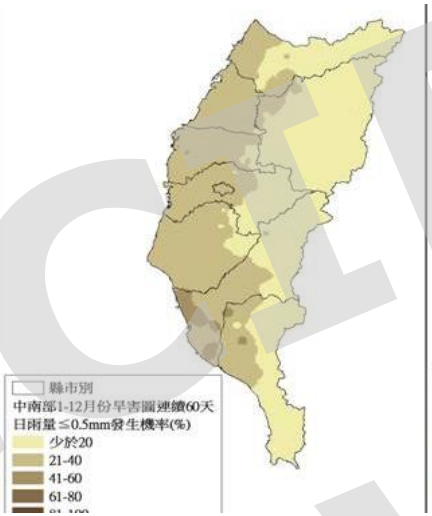
The probability of heavy rain occurred in southwestern area of Taiwan

Drought damage

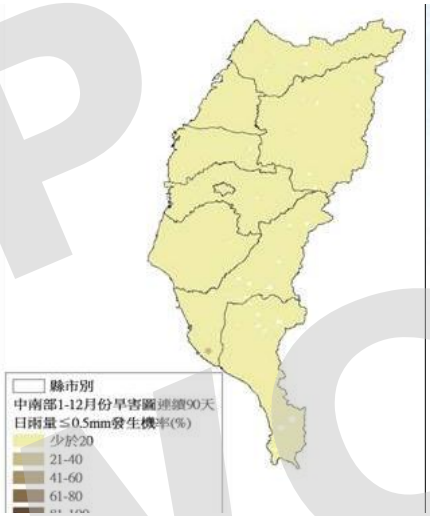
Exceedance probability of Dry spell >30 days



Exceedance probability of Dry spell >60 days

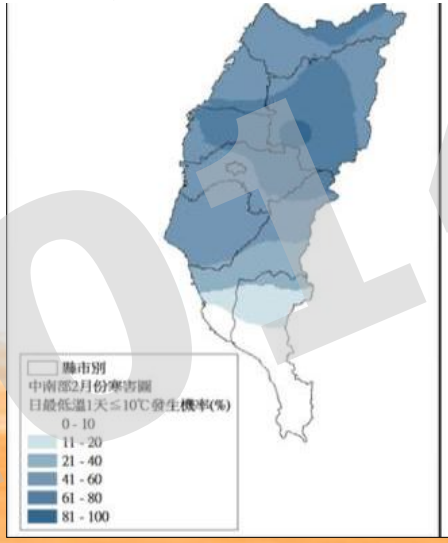


Exceedance probability of Dry spell >90 days

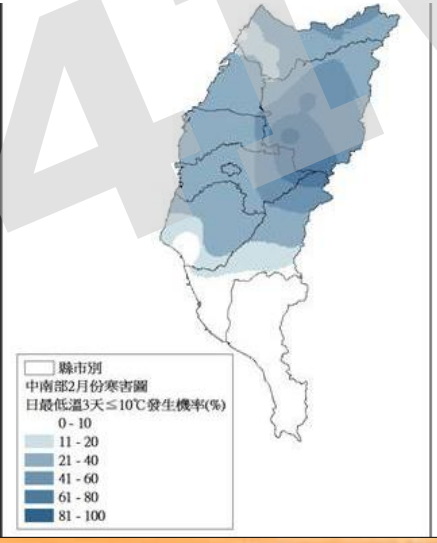


Chilling damage

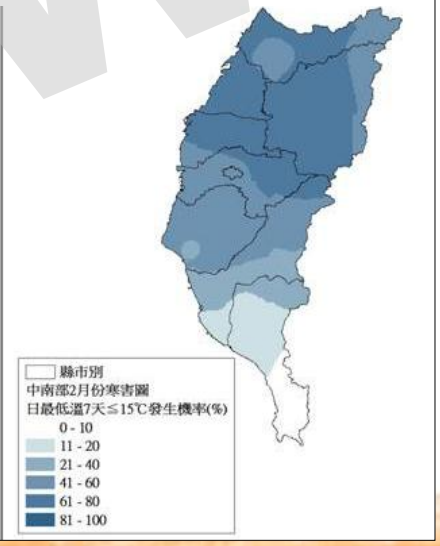
lowest daily temperature(1 day) <10 ℃ in Feb.



lowest daily temperature(3 day) <10 ℃



lowest daily temperature(1 week) <15 ℃

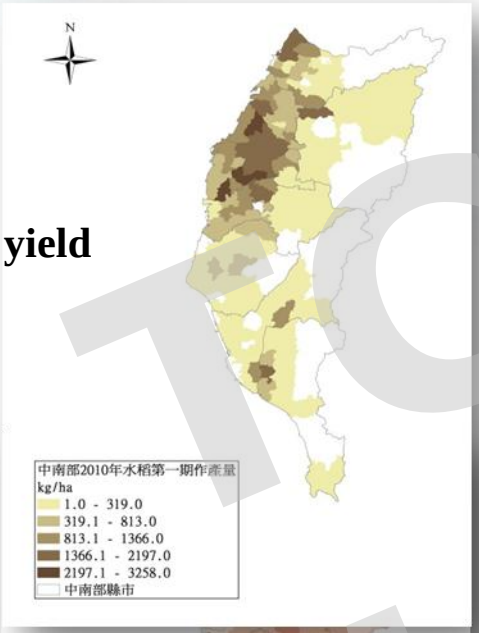


The probability of drought and low temperature occurred in southwestern area of Taiwan

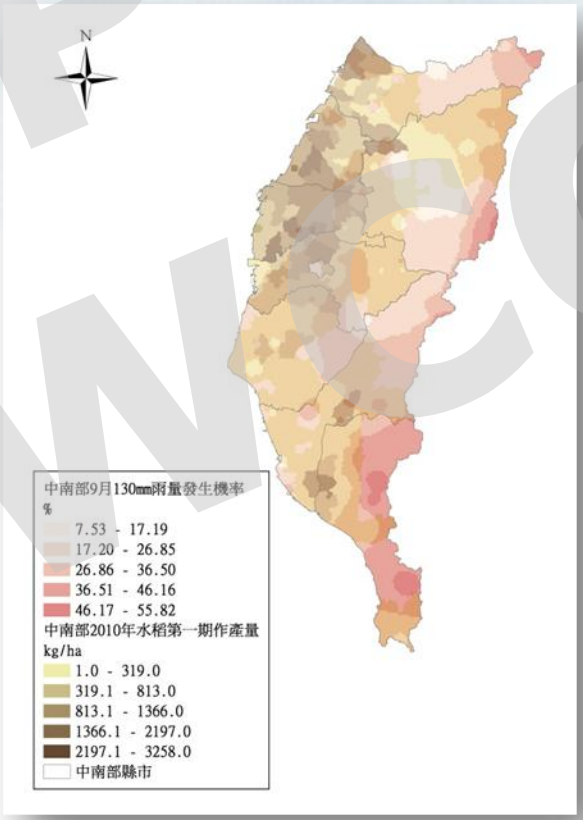
Probability map of crop disasters on climate change

crop disasters probability in the future

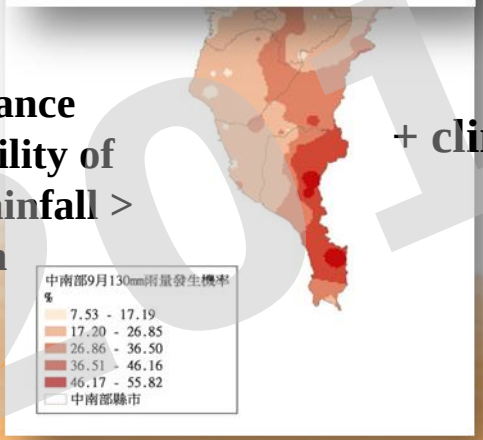
1st crop yield



overlap



Exceedance Probability of daily rainfall > 130 mm



+ climate scenarios

To combine the meteorological disasters, crop lose data and climate scenarios which can mapping the crop disasters probability in the future

4.Conclusion

- To comply with the climate dramatically change, how to design a food security scheme to ensure the food security and stability is our challenge.
- To enhance the innovation of disaster forecast and prevention technology is a key point to ensure the development of the sustainable agriculture of Taiwan.

Thanks