Development of a cross-scale and cross-sector adaptation assessment model integrating agriculture and water resources fields: A case study of regional to local scale

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Abstract

The gap between governmental policy and actions taken by local officials often exists and this gap could be even more severe when it is climate adaptation policy. On the other hand, most of existing studies tend to pay more attention to the structure and the performance of the model rather than the practical operation procedure. To minimize the gap and to evaluate the effectiveness of the adaptation policy, a cross-scale and cross-sector adaptation assessment model, Agriculture and Hydrology assessment model (AgriHydro), is proposed in this study. AgriHydro is established physically to embed top down policies and bottom up local actions and combine with the standard assessment framework, Climate Adaptation 6-Steps and Climate Risk Template, to support decision-making. For sub-models of the AgriHydro, the Aquacrop crop model and the system dynamic water distribution model were calibrated and integrated to form the feedback mechanism. The weather generator (WthGen) modular including climate change scenarios is also established and coupled into the AgriHydro to form a fully functional adaptation assessment tool. An actual application for analyzing the adaptation policy for water supply and crop yield in Taoyuan City of Taiwan is implemented due to the diversity and the complexity of Taoyuan City in land use and water system. The results reflect the possible trade-off of future risks between water resource and agriculture fields under different climate and social scenarios. Moreover, this study shows that the proposed model can provide the linkage to the standard assessment framework, which allows a consist understanding among users on risk and model output. This enables AgriHydro to become a practical and operational tool for decision making and ready for further application.

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Purpose

The purpose of this study is to develop an integrated model, **AgriHydro**, and to operate with **Climate Adaptation Algorithm (CAA)** in order to form the pathway and to support decision-making. Therefore, the targets of this study are:

1. **Develop AgriHydro with feedback mechanism (interdisciplinary).**
2. **Demonstrate how AgriHydro operate as a tool with CAA.**
3. **Show the potential future development of AgriHydro.**

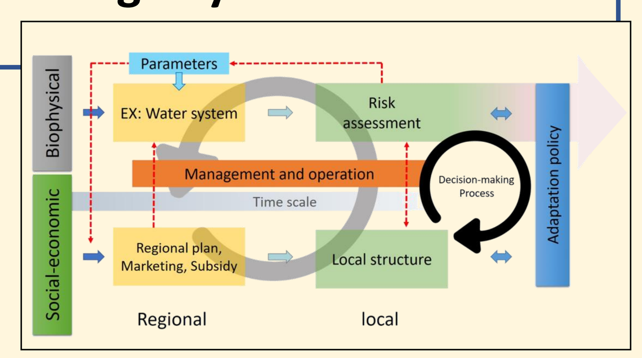

Fig.1 Two main Feedback Cycles.

Method & Sub-model

GWLF

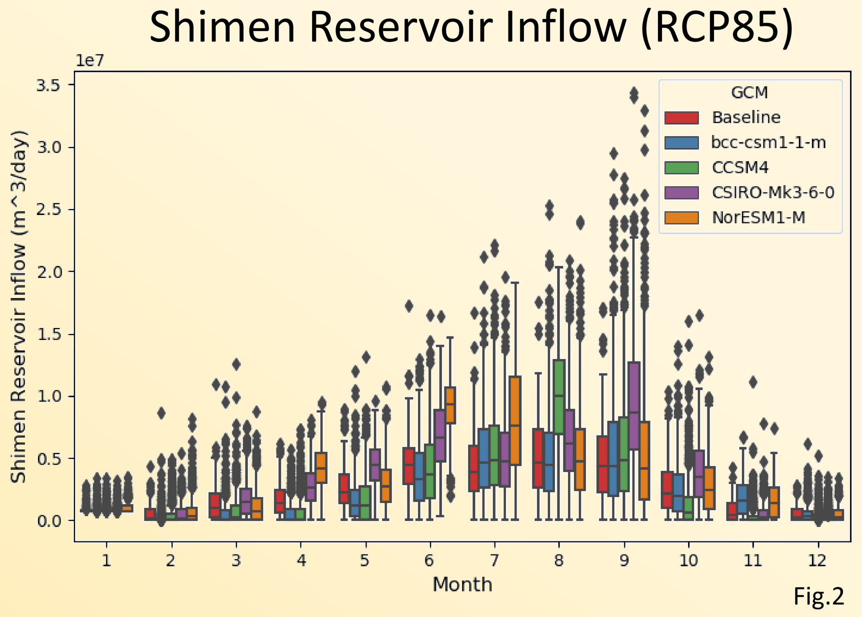

Fig.2

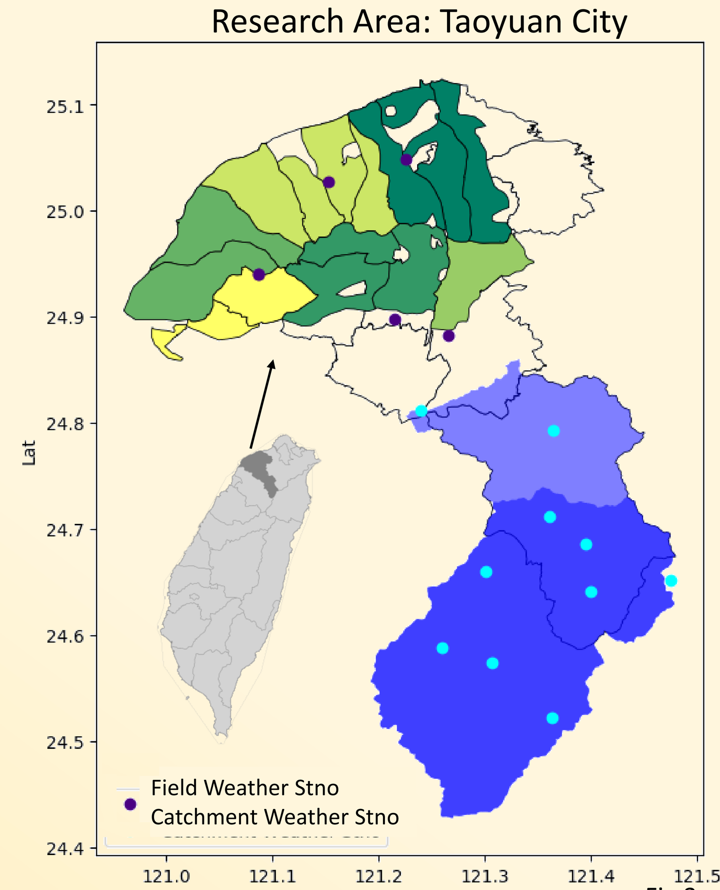

Fig.3

GWLF model shows good performance at tenday scale (RMSE: 21.12 CMS, CE: 0.92, year: 2008-2017). Fig.2 is the monthly trend of RCP85 over 2021-2040, which the inflow increase during summer and decrease in winter.

Multi-site Weather Generator

$$V = \gamma \times W \times RN + RN$$

This study used multi-site weather generator (WG) to downscale the GCM data. We applied Richardson type multi-site WG (Khalili et al. 2009) and added climate scenarios modular into WG. The performance of the 7 weather stations simulation result is shown in fig.4 and fig.5. Overall, it performs well while underestimates the interstation correlation.

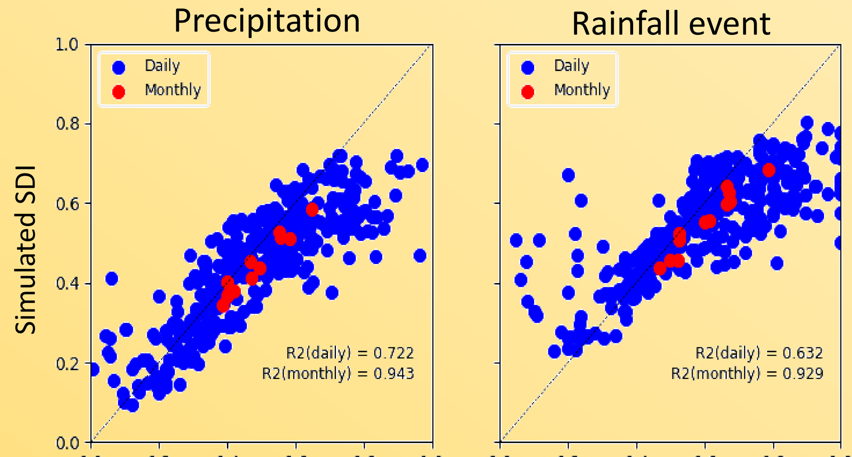

Fig.4

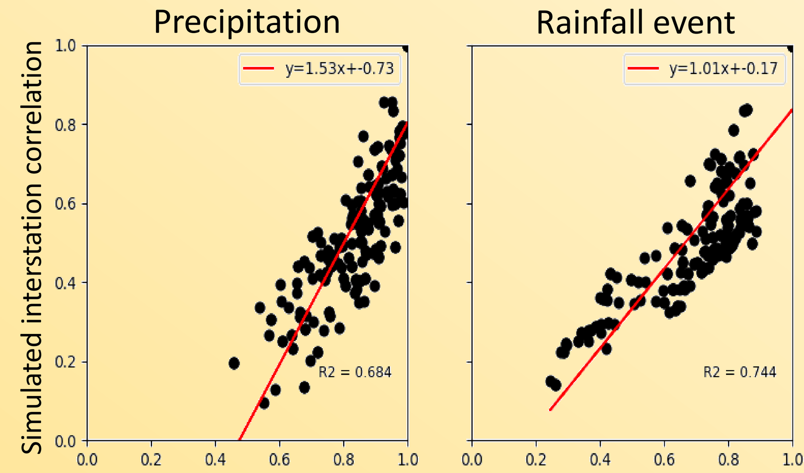

Fig.5

AgriHydro

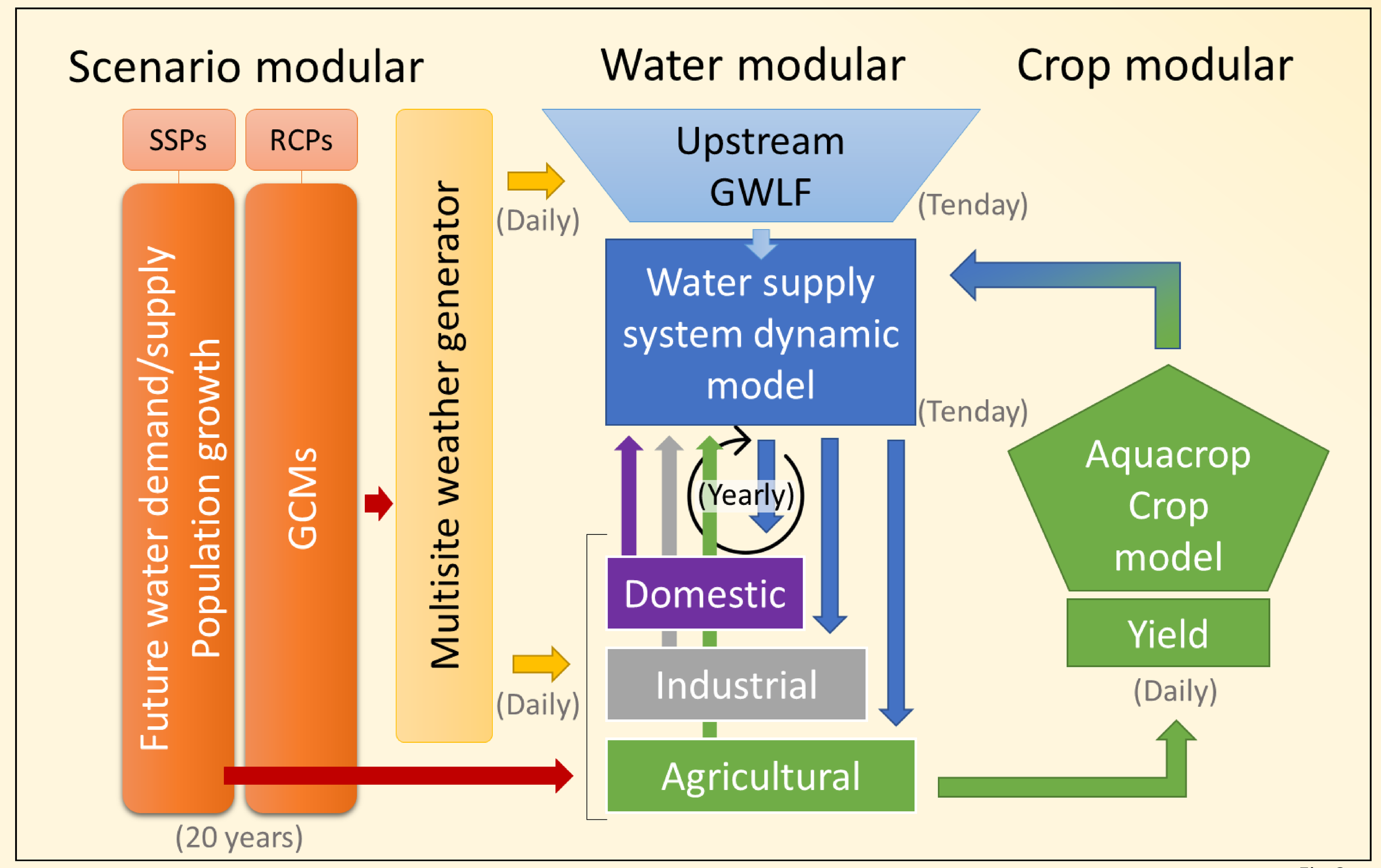

Fig.6

Climate Adaptation Algorithm

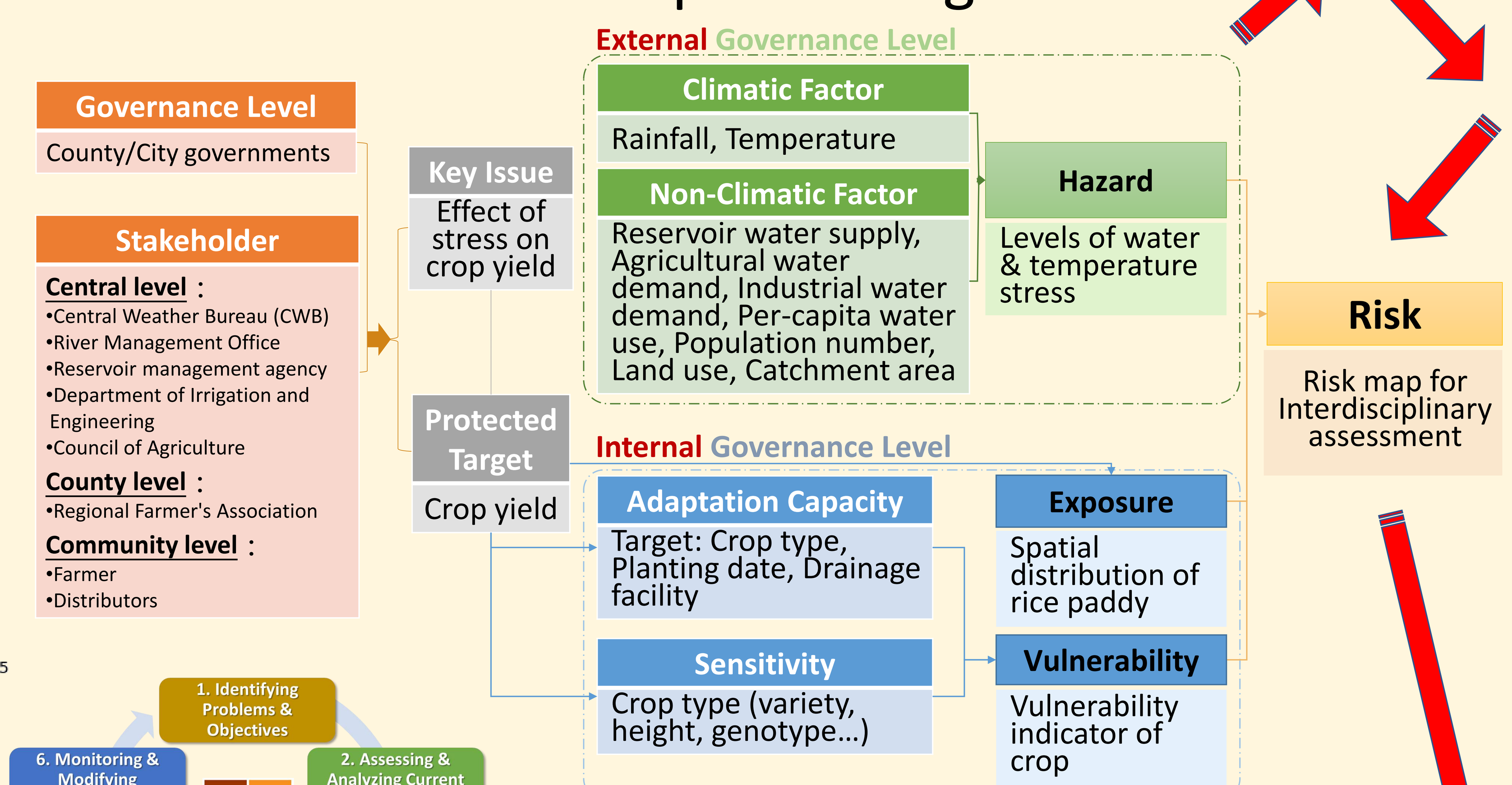

Fig.7 Risk template

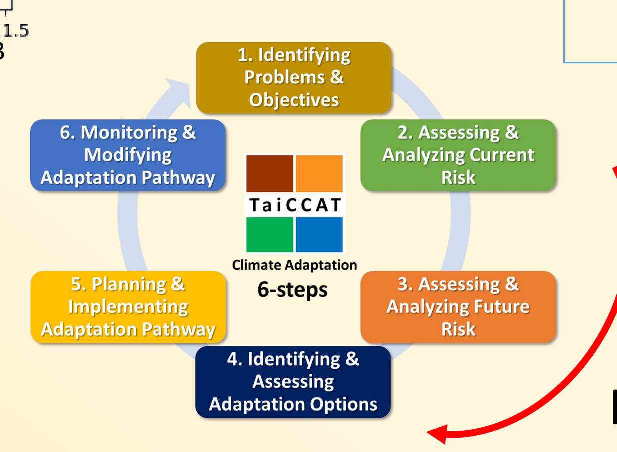

Fig.8 6-steps

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Conclusion & Future work

This study developed integrated model, AgriHydro, and demonstrated how it conducted scenario-based climate adaptation assessment along with CAA. The future vision of this study is to :

1. Include economic model (trade, market).
2. Embed decision-making process (second feedback cycle) which will affect such as land use change and effectiveness of adaptation strategies.
3. Form Dynamic Adaptive Policy Pathways (Haasnoot et al., 2013; Kwakkel et al., 2016).
4. Combine with short-term forecasting model.

AquaCrop

Fig. 9 & 10 show the water demand of 2nd growing period relies more on irrigation, while 1st growing period faces more water shortage in later analysis.

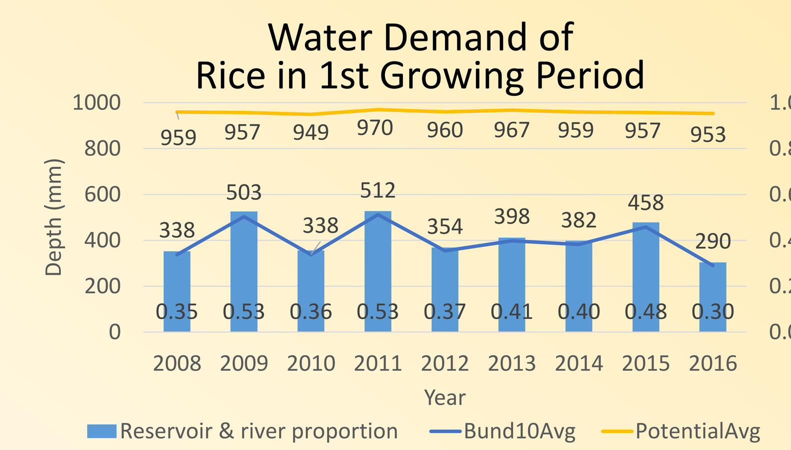

Fig.9

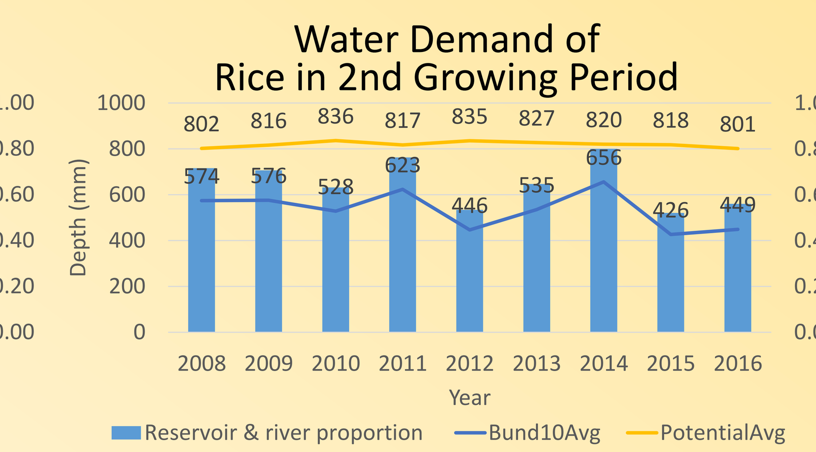

Fig.10

Key Result

Indicators

1. Shortage Index (SI) $= \frac{100}{N_{year}} \sum_{i=1}^{N_{year}} \left(\frac{Deficiency_i}{Demand_i}\right)$

2. Yield Reduction Ratio (YRR) $= \sum_{field,\, crop\ type,\, planting\ date} \left(\frac{Potential - Actual}{Potential}\right)$

1. Future Trends

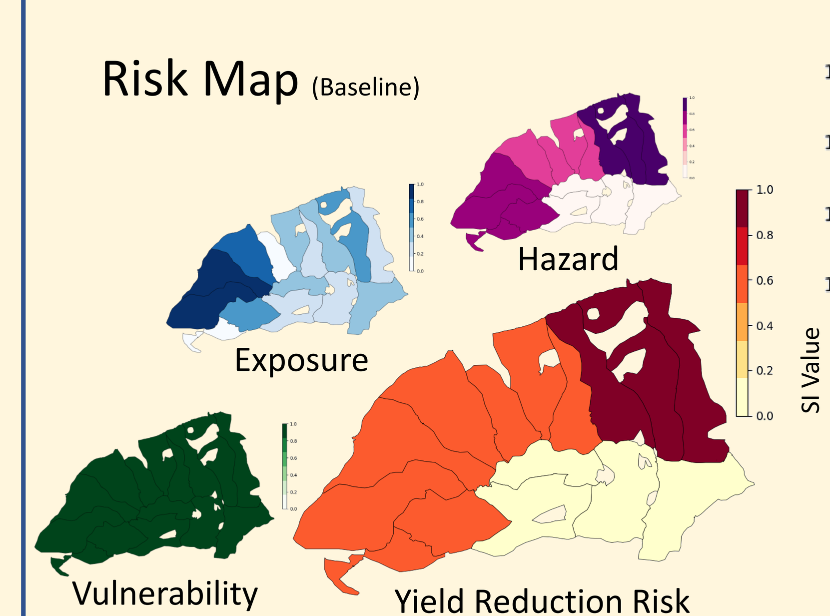

Fig.11

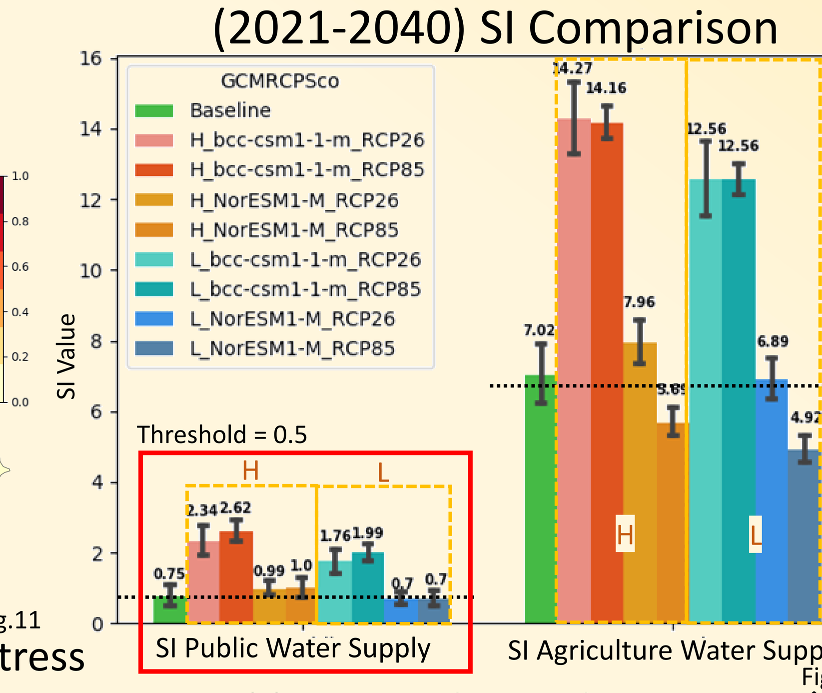

Fig.12

Hazard: Temperature & water stress
Exposure: Planting area
Vulnerability: Crop type (Rice=1, soybean=0.5)

H: Public water demand => 22.74%↑
L : Public water demand => 12.11%↑

2. Effectiveness of Adaptation Options

AgriHydro interdisciplinary model indicates the effectiveness of different adaptation options, either trade-offs or synergies, among different disciplines. The trade-off example of public water SI and agriculture YRR under NorESM1-M_RCP85 (2021-2040) is shown in fig. 13.

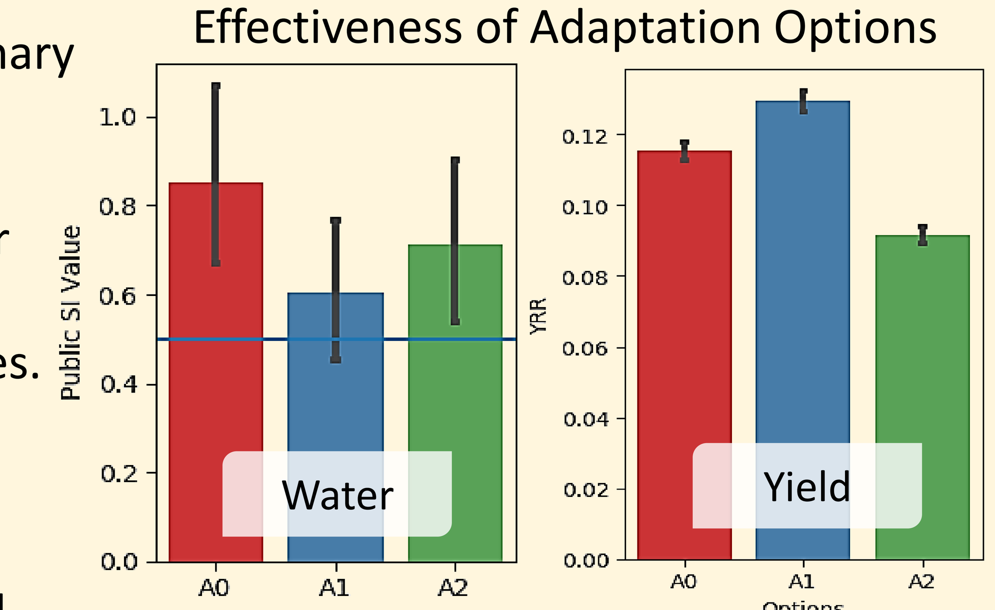

Fig.13

A0: All rice (original status),
A1: 50% soybean in 2nd growing period,
A2: 20% soybean in 1st & 2nd growing period.