Sep. 17. 2014 ICID – WG-CLIMATE

An Approach to Assessing Damage on Rice Yield associated with Paddy Inundation by Climate Change

National Institute for Rural Engineering, NARO

Presented by Takao Masumoto

Background

- Adaptation to climate change is important subject

Focus on Flood disaster …

- ✓ Heavy rainfall will occur more frequently in the future.
- ✓ Inundation risks in low-lying paddies are estimated to rise.

- Paddy fields are often damaged by flooding because they are located principally in low elevation areas of river basins.

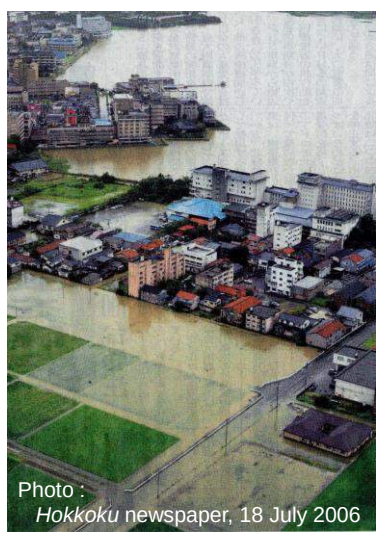


Photo : *Hokkoku* newspaper, 18 July 2006

Flooding Damage on Rice

- Flooding is one of the main causes of decrease in rice yield, therefore, to assessing the damage is particularly important.
- However, the damage will change with flood conditions (e.g. developing stage of rice, water depth, duration of submergence etc.)
- A reduction scale in rice yield is effective to estimate these damage quantities.

Normal Rice | Flooded Rice

Objective and today's contents

I. Formulate a reduction scale in rice yield

» The scale shows relationships between flooding conditions and reduction ratio of yield.

» Carry out a experiment to collect data for the scale

» The scale is used for standard of damage estimation

II. Approach to damage estimation on rice yield

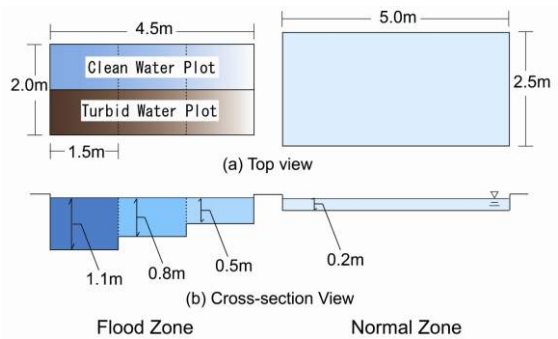
» Calculate the damage by applying the reduction scale to simulated data

» Results show reduction amounts of rice yield and its economic loss

» The results will be expected to use as index of risk assessment of climate change on drainage systems

Pseudo-Flooding Experiment

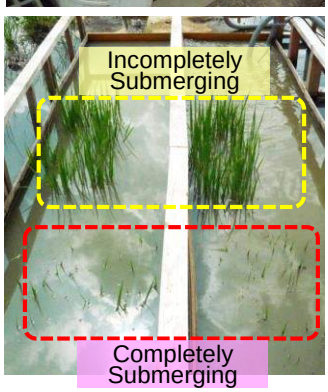
- A Pseudo-Flooding Experiment (P.F.E.) was planned, and conducted in 2012.
- We constructed an experimental arena in a real paddy field.
- The arena consists of the Normal and Flood zone.
  - • Normal Zone = to use normal cultivation
  - • Flood Zone = to use flood test



Methodology of the P.F.E

- Cultivar:「Koshihikari」
- The rice was grown by using wager pots so that we could move them, easily.

- If the rice became to specified developing stage, they would be moved to the flood zone
- After the fixed duration was passed, they were moved to the normal zone, again.

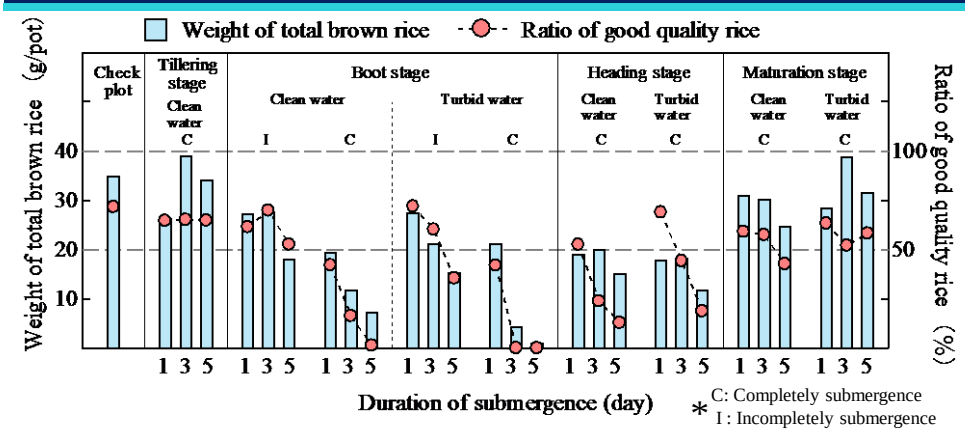


Setting of Flooding Conditions

Ⅰ	Developing stage of rice	:	1) Tilling stage or 2) Booting stage or 3) Heading stage or 4) Maturation stage
Ⅱ	Submergence situation	:	1) Completely submergence or 2) Incompletely submergence
Ⅲ	Turbidity of water	:	1) Clean Water or 2) Turbid water
Ⅳ	Duration of submergence	:	1) 1 day or 2) 3 days or 3) 5 days

- Flooding condition was classified by combination of them.
- But,…You can be free to set these conditions and cultivar.
- Finally, the scale will be created based on the result of Yield Survey in each condition.

Results of Yield Survey in 2012



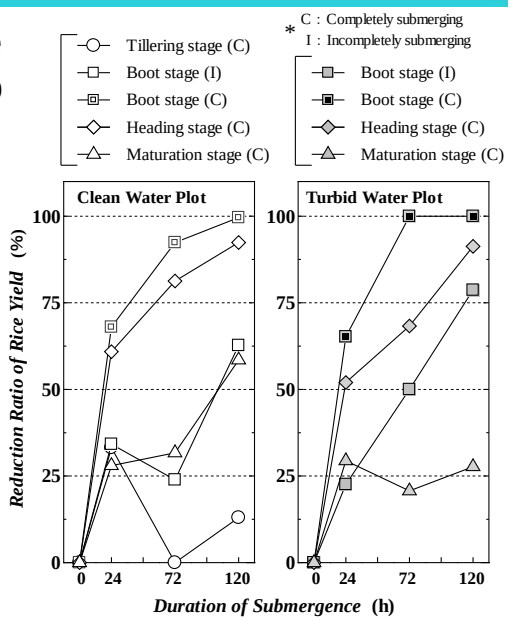
- After Harvesting, ①weight of total brown rice, and ②ratio of good quality rice were investigated, particularly.
- Reduction ratio was calculated by using weight of good-quality brown rice (calculated as ①×②)

Reduction Scale in Rice Yield

- The results were arranged according to developing stage of rice.

Horizontal axis:
Duration of submergence
Vertical axis:
Reduction ratio of rice yield

- We can know the reduction ratio under any flooding conditions.

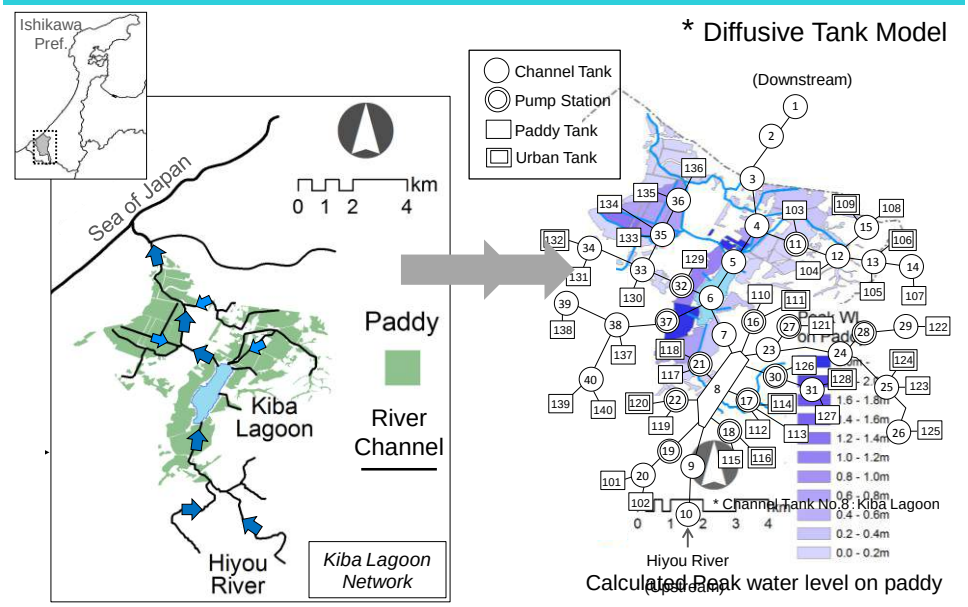


Application of the Scale

- The flooding damage on rice was estimated by applying the scale to outputs from simulation model.
  - » A heavy rainfall event, observed on July 16th to 19th (about 290 mm/3days) in 2006, was input to the model.
  - » Hourly water depth on each paddy (72 hours) was checked for the damage estimation.

Target paddy: The paddies, which was inundated over 24 hours, with a depth of more than 0.3 m. (Criteria of drainage planning in japan)

Target Area and Model Diagram



Assumptions for Damage Estimation

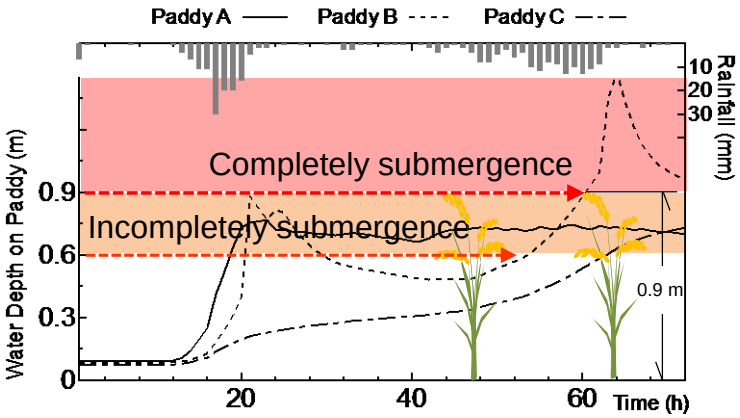
We have to know…

1. **Developing Stage** ＝ To use for selection of the reference scale
2. **Duration of Submergence**＝ To use for estimation of reduction ratio

- Developing stage =「**Booting Stage**」
  - » Decided from occurrence date of the event. (July 16th ～19th)

- Duration of Submergence was clarified from relation between plant length and water depth on paddy.
  - » Plant length in booting stage is about 0.9 m. (from investigation)

Calculation of Submergence Duration



- The durations were calculated separately divided into completely and incompletely submergence.

  0.6 m <H< 0.9 m ⇒ Incompletely Submergence
  0.9 m <H ⇒ Completely Submergence

13

Damage estimation in Each Paddy

Paddy Block No.	Area of Paddy block A (10a)	Incompletely Submerging		Completely Submerging		Total Reduction Ratio R (%)	Damage Amount of rice D (kg)
		Period of Duration (hour)	Reduction ratio ri (%)	Period of Duration (hour)	Reduction ratio rc (%)		
117	812	54	39.7	0	0.0	39.7	170,797
129	193	35	28.9	13	35.3	54.0	55,321
131	320	22	20.7	19	51.6	61.6	104,647
135	535	18	17.0	11	29.9	41.8	118,606
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

$$R = r_i + (100 - r_i) \times r_c \quad (1)$$

$$D = A \times R \times Yn \quad (2)$$

r_i, r_c : Reduction ratio from the scale

Yn : Normal Yield per unit area (here, **5300 kg/ha**)

Total of Damage and Economic Loss

- The total damage amount of rice yield was estimated as about **900,000 kg** at this event.
  - » Equal to 15,000 bags (1 bag = 60 kg)

- We can also convert the amount into money to estimate economic loss (E_{loss}).
  - » $\boldsymbol{E_{loss}}$ **(Yen)** $= \boldsymbol{B \times P}$ (3)

    B: Number of bags （= 15,000 bags）

    P: The purchase price of a bag（= 16,000 Yen）

- The loss was calculated as **240 million Yen.**

  (Equal to 2.3 million dollars or 2.4 billion KRW)

Conclusion

- We formulated the reduction scale in rice yield based on the result of the practical experiment.
- The result showed that the damage in rice yield would change significantly with the conditions.

- Simultaneously, we tried to assess damage on rice by using the scale and outputs from the drainage model.
- This result is one of examples, but this methodology is available to calculate the damage on paddies cultivated throughout a basin.


END
Thank you for your Attention !!