

The value of short term weather forecasts in a rice-wheat cropping system in northeastern India

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1. Introduction

Aim

Research question

Study area

Introduction

- Pressure on rice-wheat cropping system:
 - Population growth
 - Weather variability
 - Climate change
 - Temperature increase, extended dry spells, intensification rainfall events

- Adaptation:
 - “Hard” measures
 - Soil and water conservation management
 - “Soft” measures
 - Provision of information > weather forecasting (rainfall) in irrigation management

Research question:

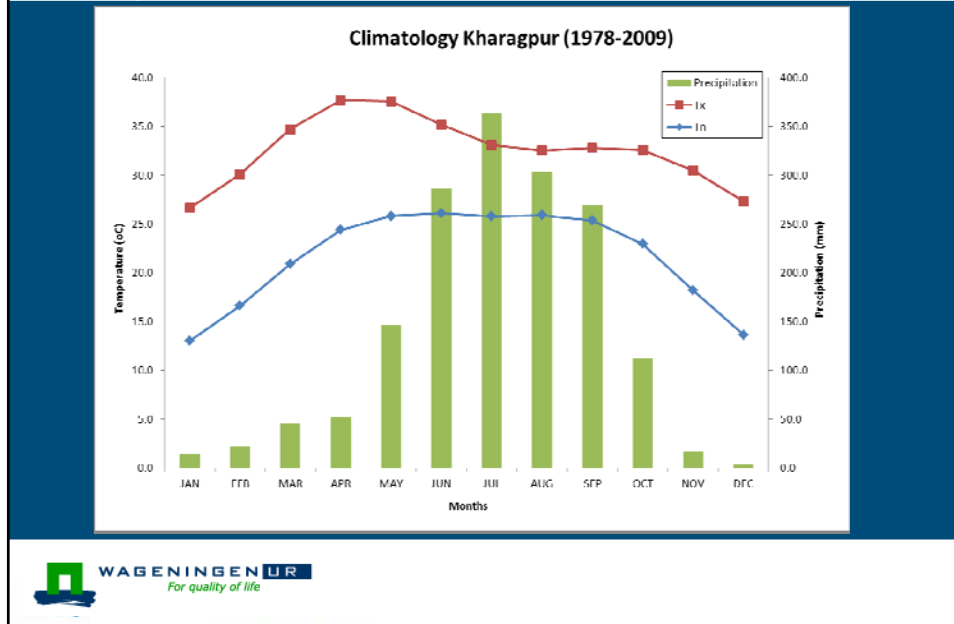
- *What is the value, in terms of sustaining yield and irrigation water efficiency, of using short-term weather forecasts in irrigation decision management for a rice-wheat cropping system in NE-India.*

- For the current (1989-2008) climate?
- For a future climate, characterized by extended dry spells and intense rainfall events

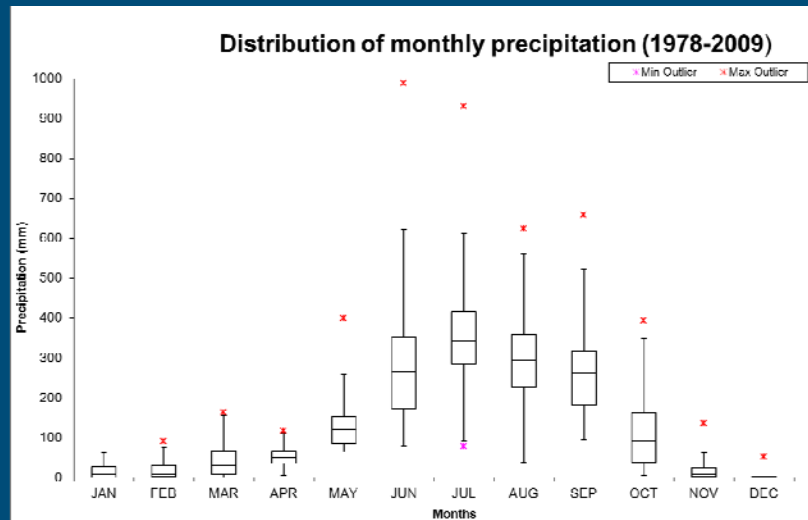
Study area



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Study area

■ Cropping calendar

- June – October: Rice cultivation
- November – March: Wheat cultivation

■ Irrigation practices

- Rice
 - Submerged
 - Rainfed, supplemental irrigation during dry spells
 - Irrigation criterium: 4.5 cm when ponding level < 0.5 cm
- Wheat
 - Irrigated
 - Irrigation criterium: unknown, probably intuitive
 - Rule-based irrigation: moisture deficit below Field Capacity (mm)

2. Method

Model
Data Input
Methodology

Data input

- SWAP model
- Data input
 - Meteorological (field data IIT Kharagpur)
 - Soil (field data IIT Kharagpur)
 - Crop
- Calibration/Validation:
 - Crop parameters (phenological dates, crop duration, grain yield)
 - Water balance (percolation, ET, ponding level)
- Data limitations:
 - ET calculated by Hargreaves (1985)
 - Soil hydraulic functions based on PTF (Wösten, 1998)
 - Lack of calibration/validation data (LAI, Biomass)

Methodology

- Two climates
 - Current climate (1989-2008)
 - Future climate (perturbed 1989-2008)

- Model runs
 - Non-irrigated
 - Irrigated (conventional)
 - Irrigated using weather forecasts
 - Issued 5-day rainfall forecasts (sep 2010 – jan 2011)
 - Issued 4-day rainfall forecasts (2007-2008)
 - Hypothetically perfect 5-day rainfall forecasts (1989-2008)
 - Forecast horizons: day1 < 5.0, day1-5 < 25.0

3. Results

Calibration/Validation

Weather forecasting – current climate

Weather forecasting – future climate

Calibration / Validation

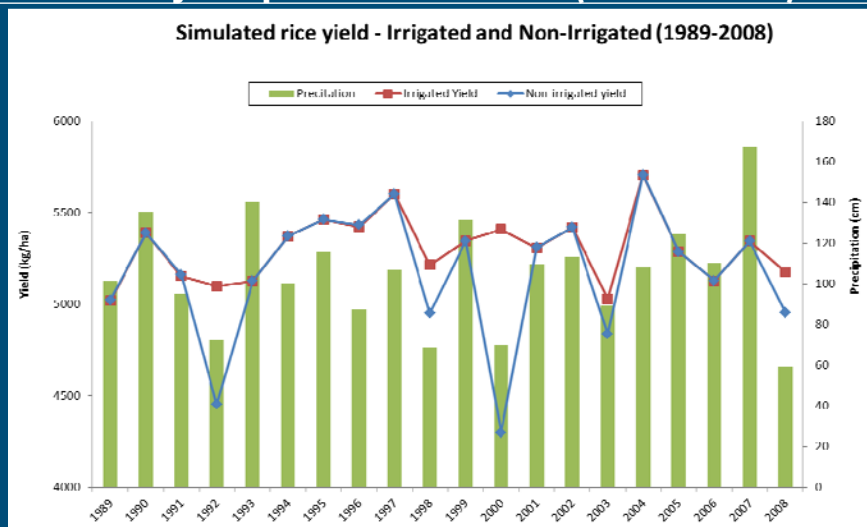
■ Rice

- Crop phenology OK, yield underestimation for one year
- Underestimation ET

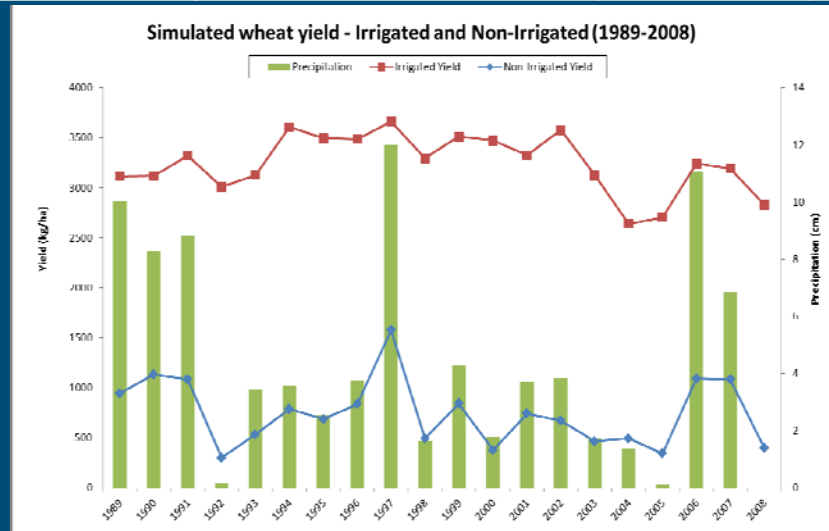
■ Wheat

- Crop phenology OK
- Underestimation ET

Rice: 20 year period simulation (1989-2008)



Wheat: 20 year period simulation (1989-2008)



Weather forecasts – current weather (Rice)

■ Rice (average 1989-2008)

Year	Forecast	Forecast Horizon	Irrigation Depth (cm)	No. of Applications	Yield (kg/ha)
1989-2008 average	Without Forecast	Non-irrigated	n.a.	n.a.	5180
		Irrigated	13.50	3.0	5300
	5-day perfect	Day+1 < 5	12.38	2.8	5301
		Day1-5 < 25.0	9.90	2.2	5302

- Irrigation water saving: 3.6 cm (27%)
- Grain yield is sustained
- Long forecast horizon saves more water

Weather forecasts – current weather (Rice)

- Dry years (< 1000 mm)
 - Potential Irrigation water saving 5.1 cm (19.6%)
 - 1991: irrigation water saving 13.5 cm (60.0%)
 - Grain yield is sustained

- Drought sensitive years (1992, 1998, 2000, 2003, 2008)
 - Potential Irrigation water saving 5.4 cm (17.0%)
 - Grain yield is sustained
 - Ponding level is sustained

- 2007 (Real 4-day issued weather forecast)
 - Irrigation water saving 4.5 cm (50.0%)
 - Grain yield is sustained
 - Short forecast horizon saves more water

Weather forecasts – Future weather (Rice)

- Perturbed 1989-2008 mean
 - Potential irrigation water saving 5.2 cm (33%)
 - Grain yield sustained

- Dry years (< 1000 mm)
 - Potential irrigation water saving 6.2 cm (22%)
 - Grain yield sustained

- Drought sensitive years
 - Potential irrigation water saving 7.2 cm (20%)
 - Grain yield sustained
 - Ponding level sustained

Weather forecasts – Summary (Rice)

- Potential irrigation savings 3.6 – 13.5 cm (17 - 60%)
 - Grain yield sustained
 - Ponding level sustained
- Current vs. Future climate
 - Potential additional irrigation water savings 1.6 cm (+31%)
 - Grain yield sustained

Weather forecasts (Wheat)

- Wheat – Current climate
 - Insignificant irrigation water savings
 - Rainfall distribution during winter extremely dry

Average (1989-2008)	Pr = 0	Pr < 5 mm	Pr < 10 mm	Pr < 20 mm
Accumulated frequency (%)	92.5	97.3	98.3	99.1

- Wheat – Future climate
 - No irrigation water savings

4. Discussion

Discussion/Limitations (1)

- Sensitivity of the model (lack of input data)
 - Transpiration very sensitive to changes in crop factor
 - Rice: percolation very sensitive to changes in puddling layer depth and thickness
 - Total crop water requirement?

- Field irrigation schedule and irrigation decision criteria for wheat unknown

Discussion/Limitations (2)

- Lack of record of real, issued weather forecasts
 - 4-day forecasts
 - 5-day forecasts
 - Accuracy of short term weather forecasts
- Applicability: field constraints
 - Irrigation decisions dependent on factors such as water costs, pumping costs, labor, crop price
 - Farmers do not always control their own irrigation supply
 - Farmer's attitude to weather forecasting

5. Conclusion

Conclusions

- Short term weather forecasts: potential to save irrigation water for rice
 - Potential higher for a future climate
- For wheat, short term weather forecasts not useful to save irrigation water
 - Extremely dry climate
 - Lack of field irrigation schedule
 - Potential to improve yield when field irrigation schedule is known

6. Recommendations

Recommendations (1)

- Extend methodology from farm-level decision making to irrigation decision making on a higher level
- Mapping field variables
 - irrigation decision criteria
 - Field irrigation schedules
 - availability of irrigation water throughout cropping seasons
 - Farmer's attitude to weather forecasts
 - Information provision to farmers
- Field experiment simulating effects of delaying irrigation decision on soil moisture and yield

Recommendations (2)

- Collection of longer record of weather forecasts
- Optimization of irrigation schedules for both crops considering field constraints (Wang and Cai, 2009)
- Exploring possibility to use other weather forecast variables and IMD's agro-advisory bulletins

Thank you for your attention

- Questions?

Weather forecasts – current weather

- Rice (dry years):

<i>Year</i>	<i>Method</i>	<i>Forecast Horizon</i>	<i>Irrigation Depth (cm)</i>	<i>No. of Applications</i>	<i>Mean interval without irrigation (days)</i>	<i>Yield (kg/ha)</i>
Dry years (P < 1000 mm)	Without Forecast	Non-irrigated	n.a.	n.a.	n.a.	5180
		Irrigated	25.88	5.8	19	5234
	5-day perfect	Day+1 < 5	23.63	5.3	20	5236
		Day1-5 < 25.0	20.81	4.6	23	5236

1991	Without forecast	Irrigated	22.5	5.8	18	5234
	5-day perfect	Day+1 < 5	13.50	5.3	22	5236
		Day1-5 < 25.0	9.00	4.6	36	5236

Weather forecasts – current weather

■ Rice (yield reduction years):

<i>Year</i>	<i>Method</i>	<i>Forecast Horizon</i>	<i>Irrigation Depth (cm)</i>	<i>No. of Applications</i>	<i>Mean interval without irrigation (days)</i>	<i>Yield (kg/ha)</i>
1992, 1998, 2000, 2003, 2008	Without Forecast	Non-irrigated	n.a.	n.a.	n.a.	4699
		Irrigated	32.4	7.2	14	5185
	5-day perfect	Day+1 < 5	29.7	6.6	15	5186
		Day1-5 < 25.0	27.0	6.0	17	5186

Weather forecasts – current weather

■ Rice (2007 – 4-day):

<i>Year</i>	<i>Method</i>	<i>Forecast Horizon</i>	<i>Irrigation Depth (cm)</i>	<i>No. of Applications</i>	<i>Mean interval without irrigation (days)</i>	<i>Yield (kg/ha)</i>
2007	Without Forecast	Non-irrigated	n.a.	n.a.	n.a.	5345
		Irrigated	9.00	2	36	5345
	5-day perfect	Day+1 < 5	9.00	2	36	5345
		Day1-5 < 25.0	4.50	1	55	5345
	4-day issued	Day+1 < 5	4.50	1	55	5345
		Day1-4 < 20.0	9.00	2	36	5345