Vulnerability of Farming Systems in the Upper Gangetic Plains of India

Adapting rice-wheat systems to climate change

AgMIP The Agricultural Model Intercomparison and Improvement Project

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK
CENTER FOR CLIMATE SYSTEMS RESEARCH

Key Messages Meerut, India

Use of high yield, pest resistant varieties of rice and wheat can reduce vulnerability and poverty for both current and future farms. However, future net farm returns are less under a high emissions scenario than under a moderate emissions scenario.

CLIMATE

- **Climate change impacts are increasing** with greater variability of the monsoon and more extreme heat events.
- By the 2050s, the maximum daily temperatures could **increase by 1.5 to 3°C.**
- **Temperature increases** are **greater during wheat season** than rice season.
- Annual **rainfall is projected to increase** in most models.

IMPACTS

- **Rice yield will decline by 12%** and **wheat yield by 24%** in the 2050s, even with recommended irrigation application.
- **Net farm returns decline by 14%** and **per capita income by 9%** under the hot/dry climate scenario.
- **74%** of **households could be vulnerable** to climate change in the 2050s.
- **Future agricultural systems are more resilient** to climate change than current systems.

ADAPTATIONS

- Rice and wheat **yields can increase by 13%** through the adoption of an adaptation package.
- **Net farm return** can **increase by 9-17%** and **per capita income by 6-10%** under different future scenarios.
- The **adoption rate** of the proposed adaptation package varies. **53-60%** under the sustainable development pathway, and **57-74%** under the unsustainable development pathway.

Wheat Harvest in Meerut, India

INTRODUCTION

The rice-wheat system is a critical pillar of existing farming systems in the Meerut district of Northern India, with livestock (cow and buffalo for milk purpose) an integral part of the system. Irrigated rice is grown during the wet kharif season (June-October) and irrigated wheat is cultivated during the dry rabi season (November-April). In recent years, yields have stagnated and soil health has deteriorated because of continuous crop cultivation and the imbalanced use of chemical fertilizers.

Climate change and climate variability have aggravated the problem due to an increase in maximum and minimum temperatures. 95% of the region's agricultural production is irrigated. More frequent occurrences of drought and untimely rainfall do not have a significant impact on rice-wheat system productivity.

Current farms exposed to climate changes could experience a decline in net farm returns of 4% to 14% and a decline in per capita income by 3.0% to 8.6%. As a result, population poverty rates may increase by 1.0% to 2.6%. Though the magnitude of decline in net farm returns and per capita income may seem small, these will adversely affect a large proportion of farms – nearly 49% to 74% of the population.

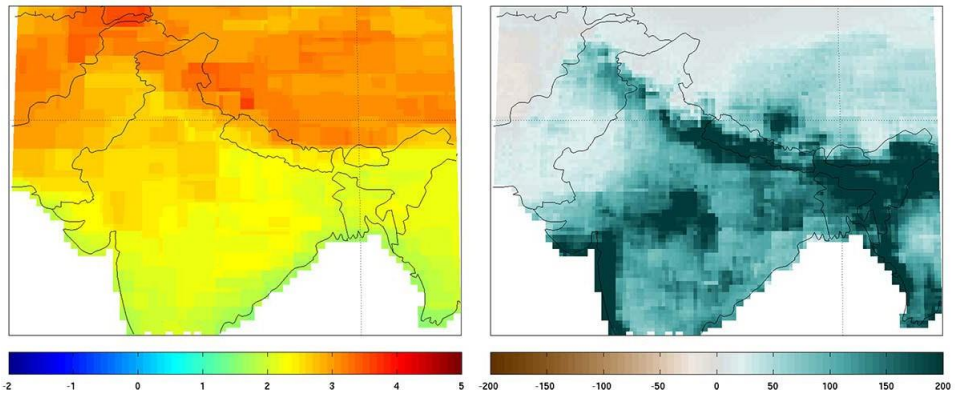
Recently, farmers have resorted to sowing wheat late – starting in December and even January. This late sowing date has exposed the crop to a higher maximum temperature during the milky/dough stages of maturation. This exposure negatively impacts the grain size of the crop and therefore reduces yield totals. The current varieties grown in Meerut are susceptible to pests and diseases.

Working with regional stakeholders, AgMIP scientists tested new adaptation measures to improve farm yield in the region. The team recognized that shifting wheat sowing back to the normal period from the 5th of November to 25th of November is of critical importance. Additionally, expanding access to new high yielding varieties that are less susceptible to pest and diseases is important. With these improvements, it is projected that rice and wheat yields will improve in this region.

The adaptation strategy of changing the sowing window and better crop varieties for the current farming system enhances rice yield by 7% to 15% and wheat yields by 12% to 19%. These changes in the production system results in 11% to 14% increase in mean net farm returns and 7% to 8% increase in per capita income. The adoption rate for the tested adaptation strategy would be 57% to 62%.

Future rice-wheat production systems in 2050s are also vulnerable to climate change. Up to 55% of rice-wheat farm households could be vulnerable to climate change impacts if unsustainable growth pathways are followed, while up to 51% are vulnerable under a sustainable pathway.

In the future production system the adaptation strategy would result in 9% to 12% increase in net farm returns, about 6% to 9% increase in per capita income and 3% to 4% decline in poverty. Under sustainable pathways, about 53% to 60% of the farm population would adopt the adaptation. The adoption rate is higher (57% to 74%) under the unsustainable pathway.



Median changes in June-April (left) temperature (°C) and (right) total precipitation (mm) from 29 climate model simulations for Meerut and surrounding region in the 2050s under a high emissions climate change scenario, compared with the 1980-2010 historical period.

Climate Change Meerut, India

Observed recent climate trends follow the global trend of warming for both maximum and minimum temperatures.

In the 2050s temperatures could increase by as much as 3.6 °C

Projections for precipitation are varied owing to the changes associated with the South Asian monsoon that dominates the region.

2050s IMPACTS OF CLIMATE CHANGE

Rice Yield	Wheat Yield	Net Farm Returns
-12%	-24%	-14%

Hot/dry Climate Model

VULNERABILITY TO CLIMATE CHANGE

Current Farming System	2050s Farming Systems	
In the 2050s	With a **Sustainable Development Pathway**	With an **Unsustainable High Growth Pathway**
74%	52%	55%

Percent of Rice-Wheat Farm Households Vulnerable to Climate Change

Why is adaptation needed?

According to stakeholders in the region, farmers are resorting to late sowing of wheat in order to maximize cotton yield, waiting until December and even as late as January to plant. This practice exposes the crop to higher maximum temperatures during milky/dough stage which affects grain size resulting in yield reduction. An adaptation strategy of planting during the normal sowing window (5th Nov-25th Nov) for wheat could increase yields. Existing varieties of rice and wheat are susceptible to pests and diseases. Several new high yielding varieties have already been developed by institutions in the region for both rice and wheat and could be adopted by farmers.

Potential Adaptation Packages

1. **Advancement of wheat sowing** to the last day of the normal sowing window (5th Nov to 25th Nov), if there is any delay in the date of sowing.
2. Use of **improved high yielding rice and wheat cultivars.**
3. **Use of balanced dose of fertilizers**

Participating Institutions: Indian Council of Agricultural Research Institutions viz., Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh; ATARI, Jodhpur, Rajasthan; National Dairy Research Institute, Karnal, Haryana; CIMMYT-India and CIMMYT-Nepal

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