Linking farmer's participation with modeling approach to study the impact of climate change and to identify suitable adaptation strategies for rice-wheat production in Indo-Gangetic Basin

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AgMIP The Agricultural Model Intercomparison and Improvement Project

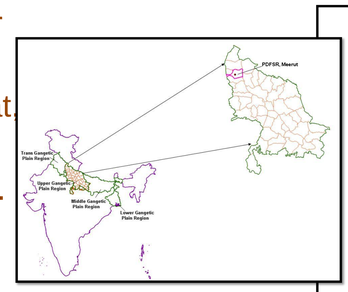
USDA UKaid from the British people

1. Introduction

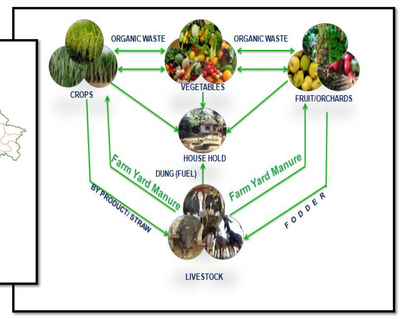
- Increase in the occurrence of extreme weather events - heat waves and intense precipitation affect agricultural production and thereby the food security and livelihoods of small and marginal farmers in Indo-Gangetic Plains (IGP) of South Asia, which is the food basket of the region.
- It is projected that under RCP4.5, the temperature increase will be 1.1°C and 3.0°C during *Rabi* (December to February) in 2035 and 2100, respectively, and the corresponding precipitation will also increase on the order of 4% and 14%. During *Kharif* (June to August), the increase of temperature will be 0.9°C and 2.4°C in 2035 and 2100, respectively, and the corresponding precipitation will also increase on the order of 6% and 13% - IPCC(2013) AR5
- Integrated assessment of climate-change impacts on future agricultural systems through modeling provides meaningful estimates to help policymakers to develop constructive and concrete national and regional plans

2. Farming systems

- **Study area :** Meerut district of Uttar Pradesh state of India in western IGB
- **Farming system:** Sugarcane-wheat, Rice –Wheat and other minor crops (maize, sorghum) and livestock.
- **Farm survey data:** 76 farms
- **Assumptions:**
  - Rice: PR106 & Wheat: PBW343
  - Irrigation depth – 5 cm
  - Plant density, Plant spacing – as per recommendations
  - Soil parameters for 7 farms analyzed and incorporated to the nearby farms



IGP-India and study site

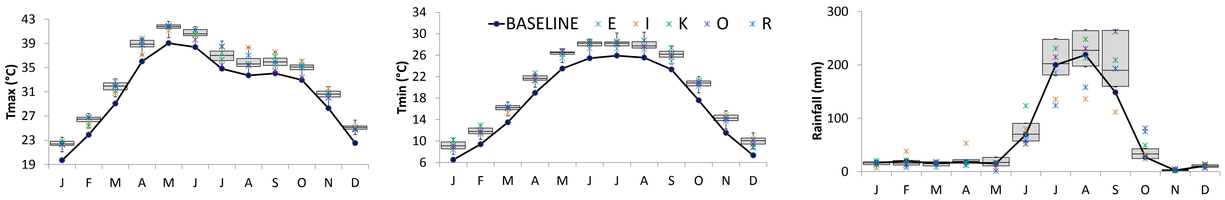


Farming system in Meerut

RAPs parameters used in analysis

RAPS Parameters	Direction of Change	Magnitude (%)
Variable cost of production	Increase	20
Farm size	Decrease	10
Herd size	Decrease	10
Milk yield	Decrease	10
Non-farm income	Increase	50

3. Climate analysis

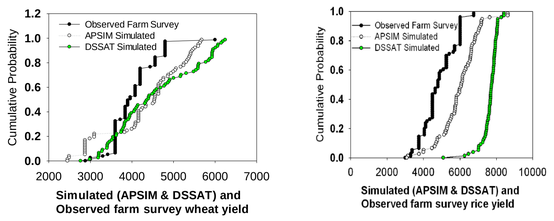


Climate Change Summary : Climate changes for 2050s compared to historical period for five targeted GCMs (RCP8.5)

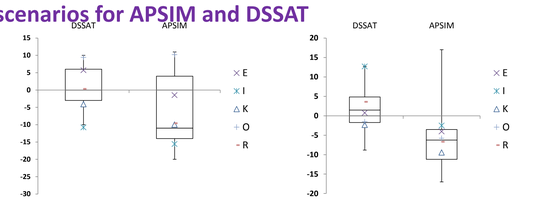
Growing Season	CCSM4	GFDL-ESM2M	HadGEM 2-ES	MIROC5	UKMO HadGEM2-ES
	E	I	K	O	R
Temperature change for Rice (°C)	2.4	2.9	2.2	1.7	2.7
Precipitation change for Rice (%)	3.1	-25.6	29.6	26.6	-8.4
Temperature change for Wheat (°C)	1.9	2.8	2.9	2.4	2.9
Precipitation change for Wheat (%)	-23.0	26.2	6.1	-13.9	-18.4

4. Crop modeling

Cumulative distribution functions for observed farm-survey and APSIM and DSSAT simulated rice and wheat yields



Distribution of mean yield changes (%) from 20 GCM-based scenarios for APSIM and DSSAT



- Decline in mean rice yield ranges from 8% to 23% with APSIM. However, DSSAT simulations shows both decline (4% to 19% under GFDL-ESM2M, HadGEM2-ES and MPI-ESM-MR) as well as increase (2% to 5% under CCSM4 and MIROC5).
- In the case of wheat, APSIM estimates show decline in mean yield (17% to 29%), while DSSAT shows an increase (6% to 15%).
- Differences between the DSSAT and APSIM projections are due to differences in sensitivity of the crop models to increases in CO_2 (571 ppm) and temperature.

Adaptation packages:

- Advancement of date of sowing—10 days from the present.
- Use of short-duration rice and wheat varieties.
- Balanced fertilizer application in both rice and wheat.
- Modification of first date of irrigation in wheat.

5. Impacts and adaptation

Impact of Climate Change in Future without Adaptation

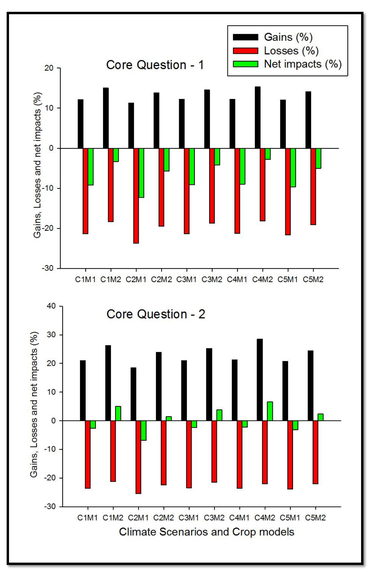
	CCSM4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	APSIM	DSSAT	APSIM	DSSAT	APSIM	DSSAT	APSIM	DSSAT	APSIM	DSSAT
Losers (%)	55	41	64	47	55	43	55	39	56	45
Gains (% mean NR)	21	26	19	24	21	25	21	29	21	24
Losses (% mean NR)	-24	-21	-25	-22	-23	-22	-24	-22	-24	-22
Projected NR without CC (INR/ farm)	58977	59161	58931	59062	58973	59115	58983	59356	58968	59084
Projected NR with CC (INR/ farm)	56985	63010	53618	60164	57086	62014	57226	64244	56565	60968
Projected PCI without CC (INR)	23614	23660	23603	23636	23613	23649	23616	23709	23612	23641
Projected PCI with CC(INR)	23114	24628	22268	23912	23139	24377	23174	24938	23008	24114
Projected poverty rate without CC(%)	48	48	48	48	48	48	48	48	48	48
Projected poverty rate with CC (%)	49	46	51	48	49	47	49	45	50	47

INR- Indian Rupees; NR-Net Return; CC-Climate Change; PCI-Per Capita Income; 1 USD= 61 INR

Adoption of Adaptation Package

	CCSM4		GFDL		HadGEM_2ES		MIROC-5		MPI-ESM	
	APSIM	DSSAT	APSIM	DSSAT	APSIM	DSSAT	APSIM	DSSAT	APSIM	DSSAT
% adoption rate	59	49	65	46	62	49	60	49	62	49
Projected NR without adaptation (INR/ farm)	57175	63061	53986	60172	57351	62058	57439	64277	56843	61004
Projected NR with adaptation (INR/ farm)	66062	69805	64054	66077	66883	68629	66513	71154	66406	67510
Projected PCI without adaptation (INR)	23161	24640	22360	23915	23206	24388	23228	24946	23078	24124
Projected PCI with adaptation (INR)	25394	26335	24890	25398	25601	26040	25508	26674	25481	25758
Projected poverty rate without adaptation (%)	49	46	51	48	49	47	49	45	50	47
Projected poverty rate with adaptation (%)	45	43	46	44	44	43	44	42	45	44

- The adaptation strategy is likely to result in an increase of 15.5 to 18.6% in mean net farm returns for APSIM but the magnitude of increase would be lower (10 to 11%) for DSSAT
- The per capita income would increase by 10 to11% and 6 to 7% for APSIM and DSSAT, respectively.
- The poverty rate would decline by 3 to 5% for the population as a whole



6. Conclusion

- All the 5 GCMs projected increase in Max. and Min. temperature with greater uncertainty in rainfall.
- The adoption rates for the adaptation strategy ranges from 59 to 64% for APSIM but less than 50% (46 to 49%) for DSSAT under five climate scenarios.
- Overall, the adaptation strategy result in an increase in mean net farm returns for the population as a whole. However, 36 to 41% population still remains vulnerable to climate change.
- It may be noted that the adaptation is tested for one crop (wheat) only and the yield increases are not substantially higher because a substantial proportion of farm population do not adopt the adaptation strategy.
- Different adaptation packages and a set of elaborate RAPS visualizing more realistic features of the future agricultural production systems need to be tested to formulate an effective strategy under climate change and for ensuring economic viability and livelihood security of smallholders in the region.

1 ICAR — हर कदम, हर डगर किसानों का हमसफर भारतीय कृषि अनुसंधान परिषद — Agrisearch with a human touch

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