Climate Services for Agriculture and Food Security

Dr. N. Subash

Head, Division of Agricultural Physics
School of Natural Resource Management
ICAR-Indian Agricultural Research Institute
New Delhi-110 012

Stakeholder Consultation Workshop on
National Framework for Climate Services for India (NFCS-India)
5-6th October, 2023

Organized & Coordinated by
O/o Director General of Meteorology, New Delhi & O/o Climate Research & Services, Pune
India Meteorological Department, Ministry of Earth Sciences, GOI
Co-hosted by CHRIST University, Lavasa Campus, Pune

Why Climate Services are important in agriculture sector?

- The **management of weather and climate risks in agriculture** has become an important issue due to climate change.
- **The Intergovernmental Panel on Climate Change (IPCC) has highlighted multiple climate risks for agriculture and food security**
- Wise use of **weather and climate information** can help to make better-informed policy, institutional and community decisions that

-reduce related risks and enhance opportunities,

-improve the efficient use of limited resources and

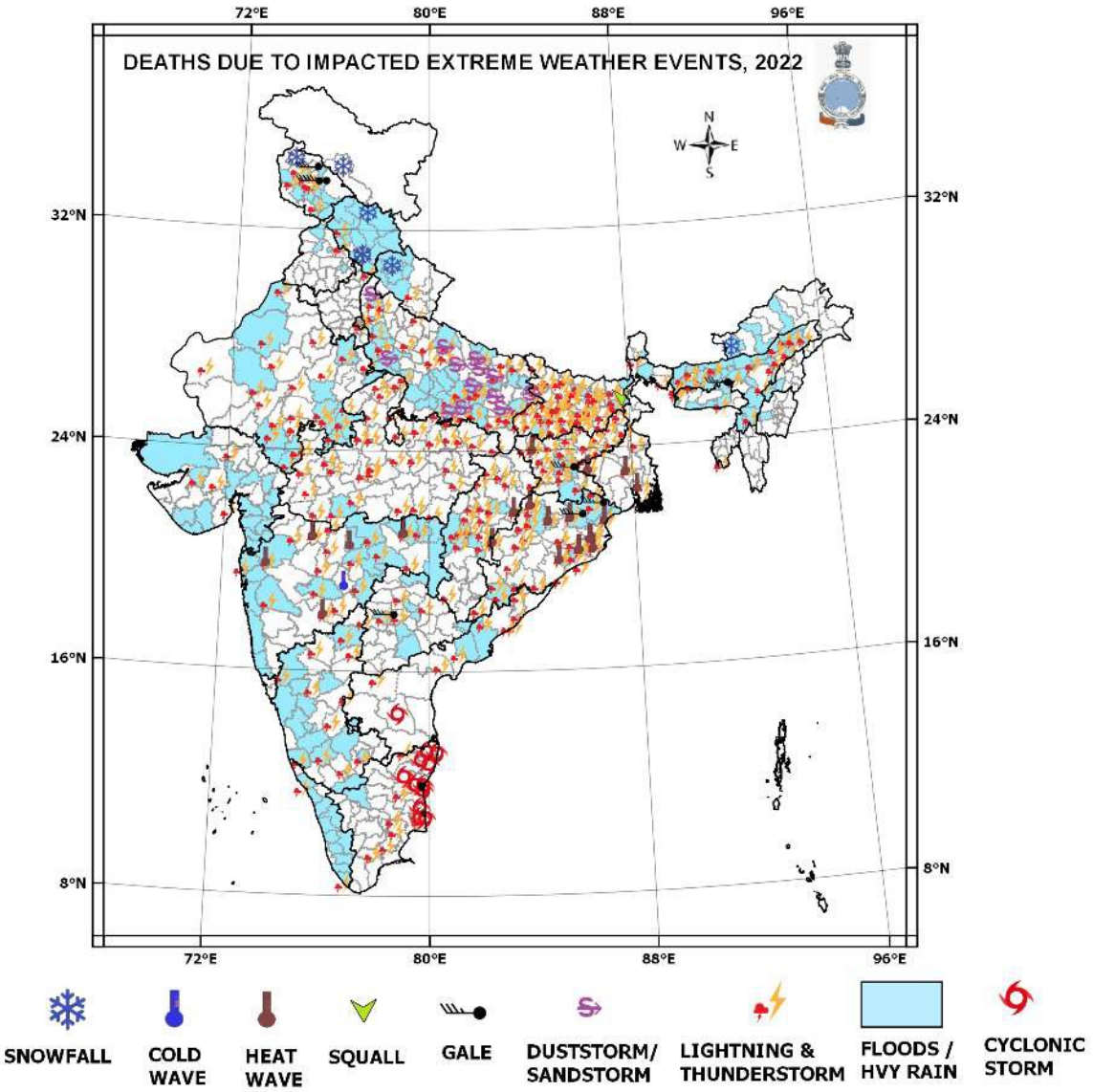
-increase crop, livestock and fisheries production.

How farmers are making decisions based on weather and climate information?

	Types of information	Vehicles of delivery	Farmer decisions affected
Weather (days to weeks)	Observed rainfall and temperature	Mobile	Timing of planting and harvest
	Daily forecasts upto one week	Radio	Timing of fertilizer, pesticides and irrigation application
	Alert on pest and diseases	News papers	Protecting lives and property
	Early warning of extreme weather events		

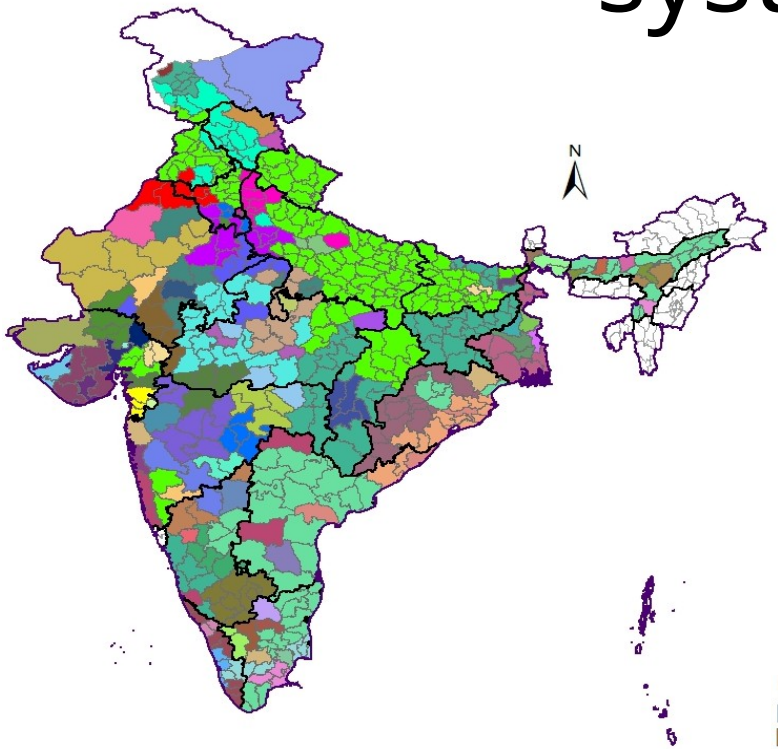
	Types of information	Vehicles of delivery	Farmer decisions affected
Climate variability (months to years)	Probabilities for seasonal rainfall and temperature	Workshop with experts, interaction with agri. Extension experts	Selecting crops and variety Livestock stocking rates and feeding Intensity of input use Labour and marketing strategies Intensification and diversification Diversification of sources of income
	Particular agricultural risks – dry spells, rainy season start date etc		
	Historical variability of climate action		

	Types of information	Vehicles of delivery	Farmer decisions affected
Climate Change (decades or longer)	Projection of future rainfall and temperature	Workshop with researchers and interaction with agri. Extension experts	Major capital investments Changing farming systems Breeding aspects.
	Historical trends in rainfall and temperature		
	Historical changes in extreme weather events		



The Significant Extreme Weather Events Occurred over India during 2022

First Predominant cropping system



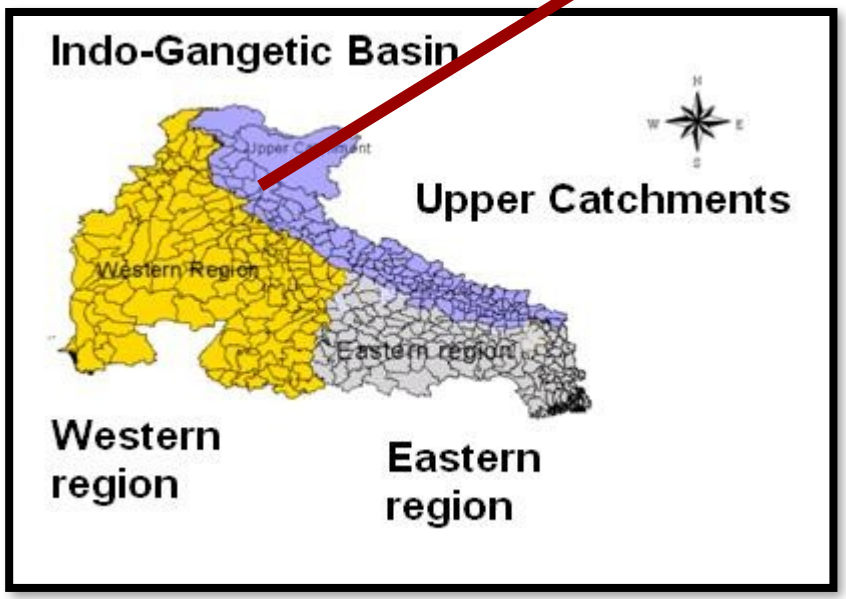
80 cropping systems found over India

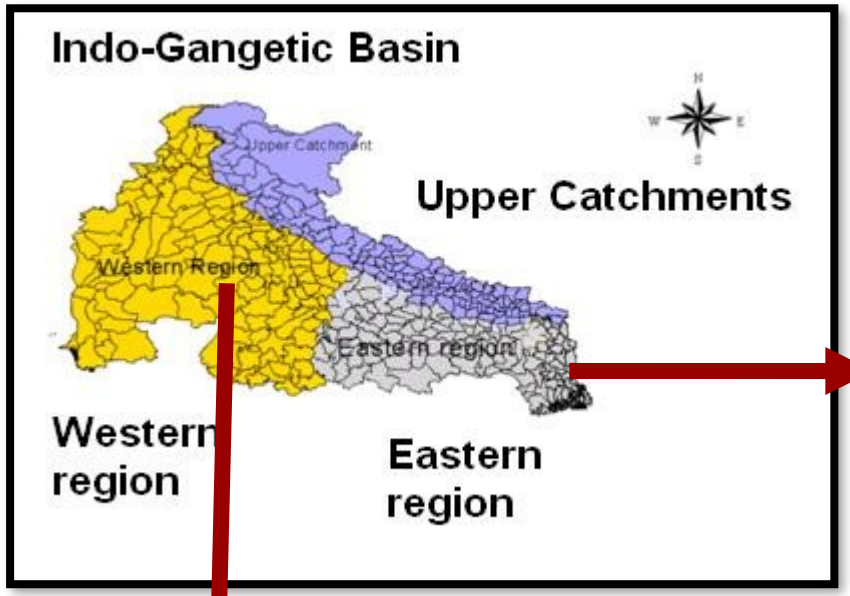
Cropping systems

- Arhar-fallow
- Barley-fallow
- Buck wheat-fallow
- Cator-castor
- Chilli-cotton
- Cotton-cotton
- Cotton-fallow
- Cotton-pigeonpea
- Cotton-wheat
- Fallow-gram
- Fallow-mustard
- Fallow-rice-fallow
- Fallow-sorghum
- Fallow-wheat
- Groundnut-cumin
- Groundnut-fallow
- Groundnut-mustard
- Groundnut-pearlmillet
- Groundnut-wheat
- Hillmillet-pigeonpea
- Jute-rabi pulses
- Jute-rice
- Kharifpulses-fallow
- Kodokutki-fallow
- Maize+pulses-fallow
- Maize-cotton
- Maize-fallow
- Maize-gram
- Maize-maize
- Maize-mustard
- Maize-potato-wheat
- Maize-wheat
- Millet-fallow
- Pearlmillet-fallow
- Pearlmillet-mustard
- Pearlmillet-sorghum
- Pearlmillet-wheat
- Ragi-cotton
- Ragi-fallow
- Rice
- Rice-blackgram
- Rice-fallow
- Rice-greengram
- Rice-groundnut
- Rice-horsegram
- Rice-jute
- Rice-jute-rice
- Rice-lablab
- Rice-lathyrus
- Rice-mustard-jute
- Rice-mustard-summer rice
- Rice-potato-summer rice
- Rice-potato-vegetables
- Rice-pulses
- Rice-rice
- Rice-rice-fallow
- Rice-rice-groundnut
- Rice-rice-pulses
- Rice-rice-rice
- Rice-rice-sorghum
- Rice-rice-toria
- Rice-sugarcane
- Rice-sunflower
- Rice-vegetables
- Rice-vegetables-jute
- Rice-vegetables-summer rice
- Rice-wheat
- Rice-winter jhuming
- Sorghum-fallow
- Sorghum-groundnut
- Sorghum-wheat
- Soyabean-fallow
- Soyabean-gram
- Soyabean-wheat
- Soybean-wheat
- Sugarcane-ratoon
- Sugarcane-wheat
- Urd-sorghum
- India boundary
- State boundary
- District Boundary
- Data not available

Indo-Gangetic Basin – Food Basket of South Asia

- Low productivity (Rice-Wheat 4-5 t/ha)
- Poor investment in infrastructure
- Medium-high precipitation (1000-2000 to > 2000 mm)
- High potential for cold water fisheries and livestock
- Degradation of Land and water resources
- Low human capital - high out-migration
- Downstream environmental constraints





- **Low Productivity** (R-W:4-8 t/ha) - Food deficit region
- **Low investment in infrastructure**
- Medium - High rainfall (1000-2000 to > 2000 mm)
- **Underutilization of ground water (< 20 %)**
- **Very few developed irrigation network**
- High risk of flooding, poor drainage and moderate drought
- Out-migration of laborers

- **High Productivity** (R-W: 8-12 t/ha) - Food surplus region
- **High investment in infrastructure**
- Higher inputs of agro-chemicals
- Low - Medium rainfall (500-1000 to 1000-2000 mm)
- **Over exploitation of ground water (>80 %)**
- **Well developed irrigated network**
- Severe to moderate drought prone areas
- In-migration of labour

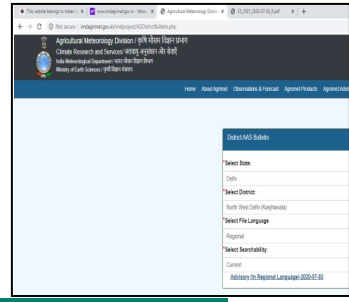
Preparation and dissemination of weather based agro-met advisory

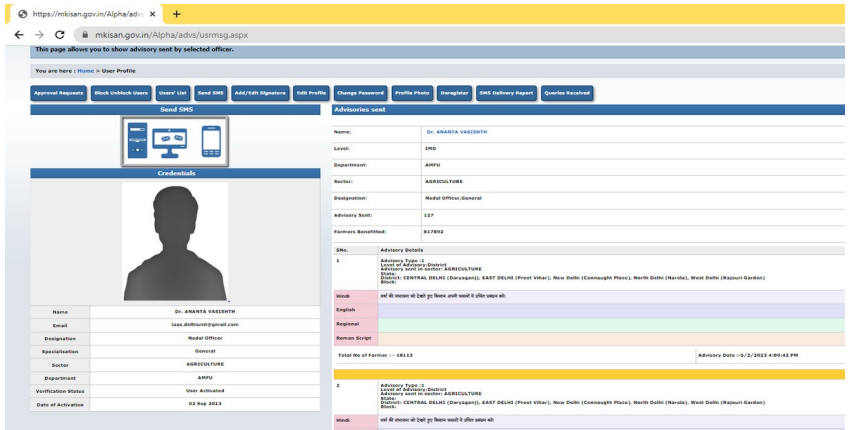
- Weather based agromet advisory bulletin were prepared on every Tuesday and Friday in both Hindi as well as in English on the basis of past, real time and weather forecast for next five days.
- These bulletins were sent through electronic media among farmers and stake holder.
- **104 agromet advisory bulletins** were prepared in Hindi as well as in English and **2,25,934 SMS** regarding agromet advisory were sent through the **m-Kisan portal** and **1603 SMS** through different **WhatsApp** group during 2022-23.
- These agro-met advisories are uploaded on IMD and IARI website.
- Daily weather data and medium range weather forecast were uploaded on the Institute website.

Benefit loss to the farmer by weather based agromet advisories in 2022-23

- During 2022-23 information on rainfall forecast helps to minimize the cost of cultivation in the crops by saving three irrigation and pesticides spray in the crops.

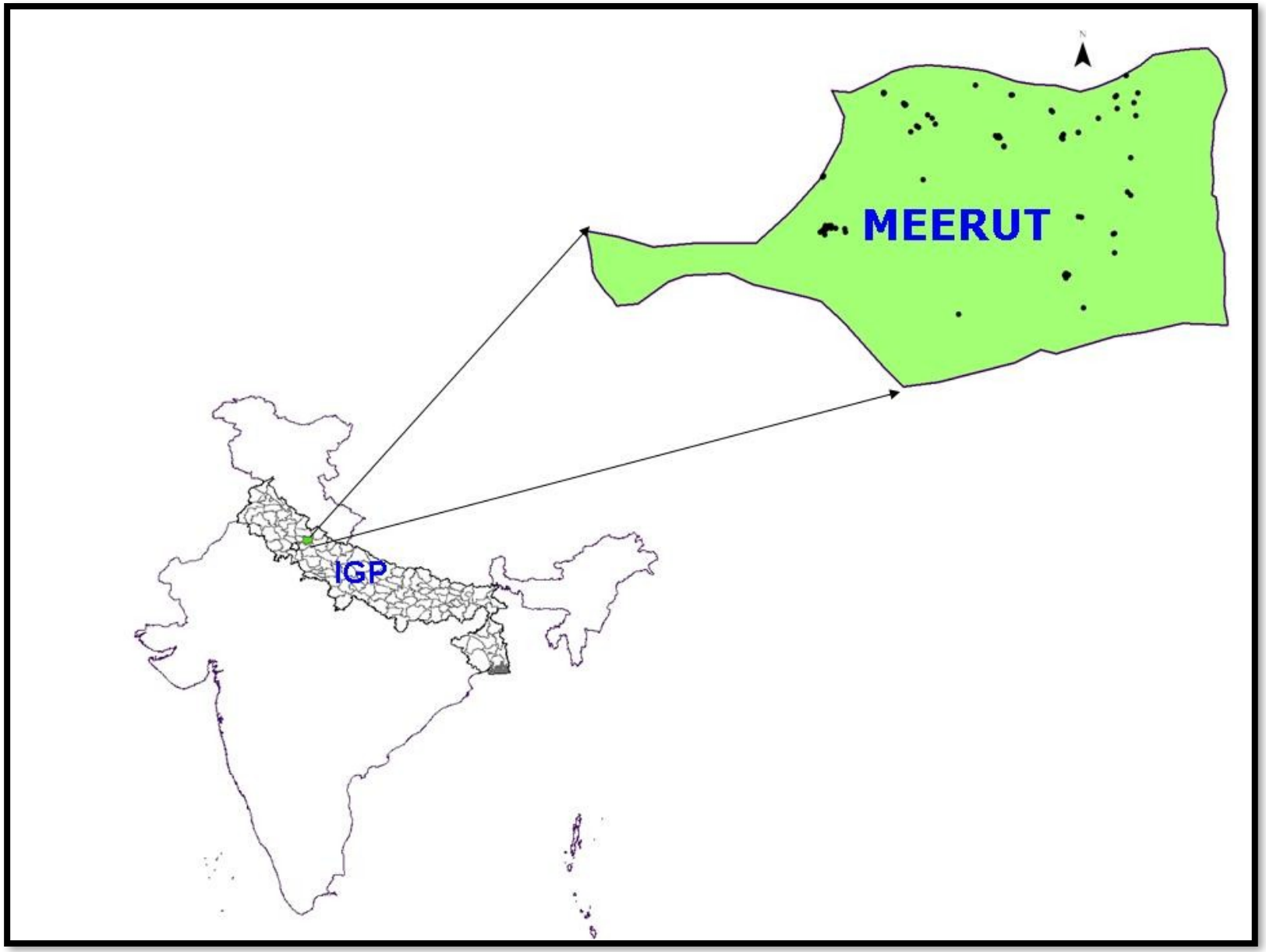
Weather information and Agromet advisory	Profit
Based on rainfall forecast, farmers were advised for not to do irrigation and all type of sprays in all vegetables and other standing crops on 7th October 2022, 17th and 29th March 2023.	Farmers saved **three irrigation** as well as **three sprays** during *Rabi* 2022-23. Total =Rs. 9,600/ acre for each crop (*Rs. 3200/acre each for one irrigation as well as one spray)



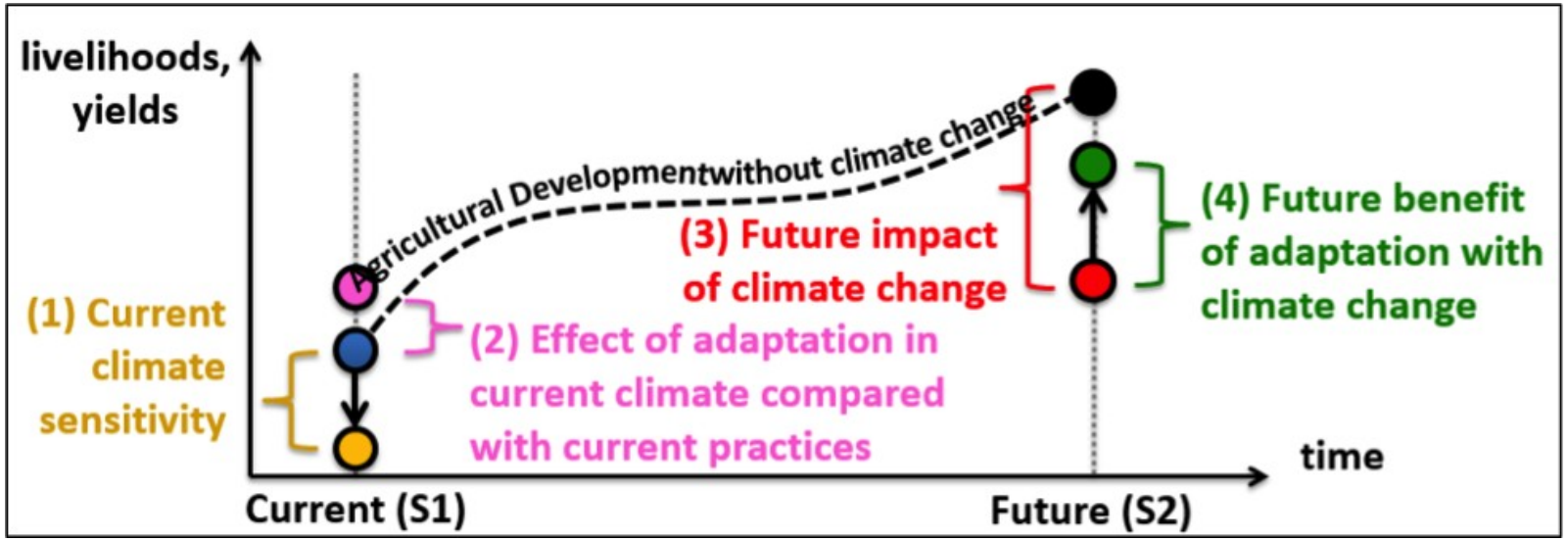


Integrated assessment of impact of climate change at farm level

Study site and spatial spread of the rice-wheat farms



Rationale for RAPS –Answer Core Research Questions for RIA



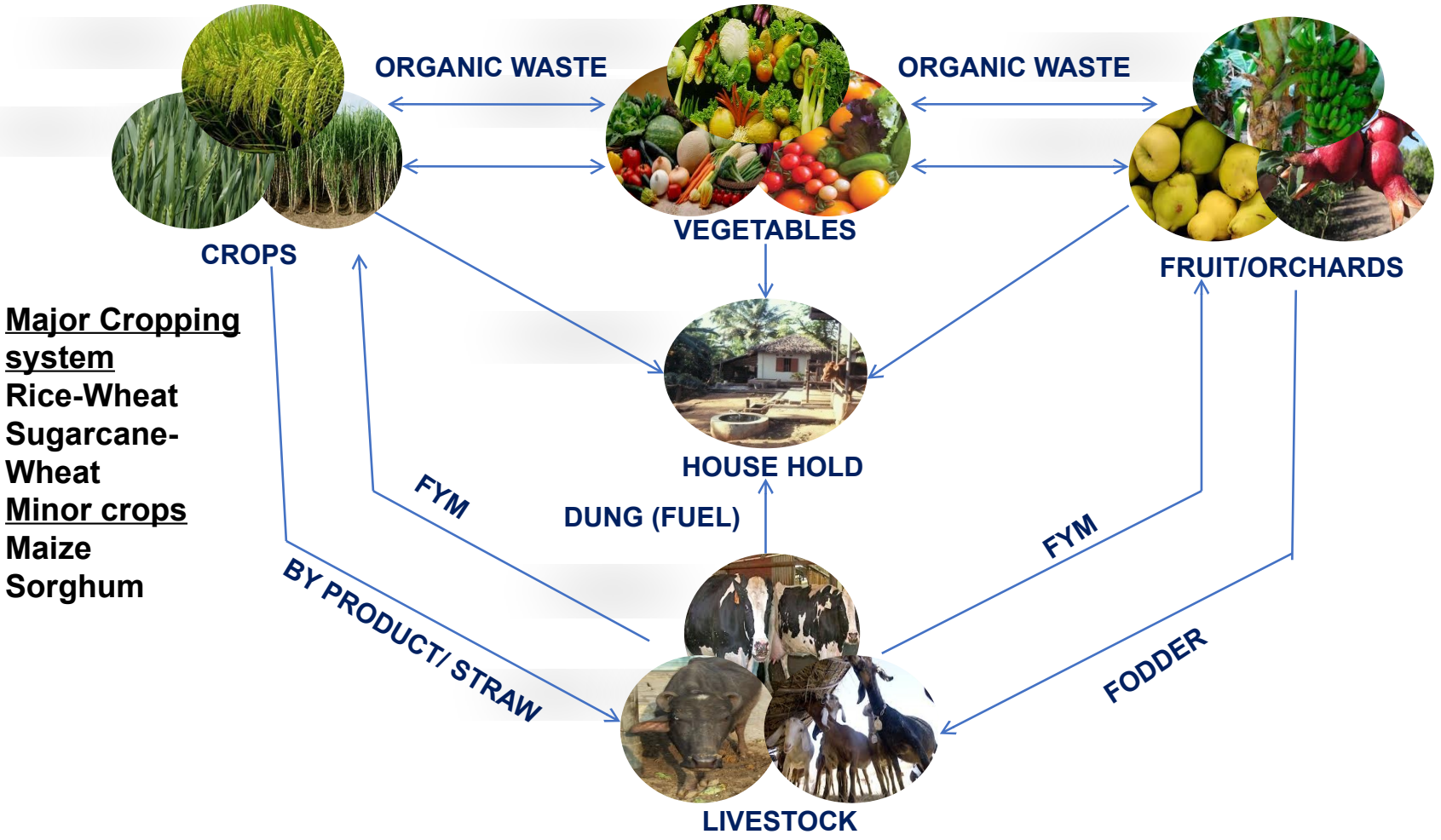
Q1: What is the sensitivity of current agricultural systems to climate change?

Q2: What are the benefits of adaptation in current agricultural systems?

Q3: What is the impact of climate change on future agricultural production systems?

Q4: What are the benefits of climate change adaptations?

Farming Systems of Study area



Major Cropping system

Rice-Wheat

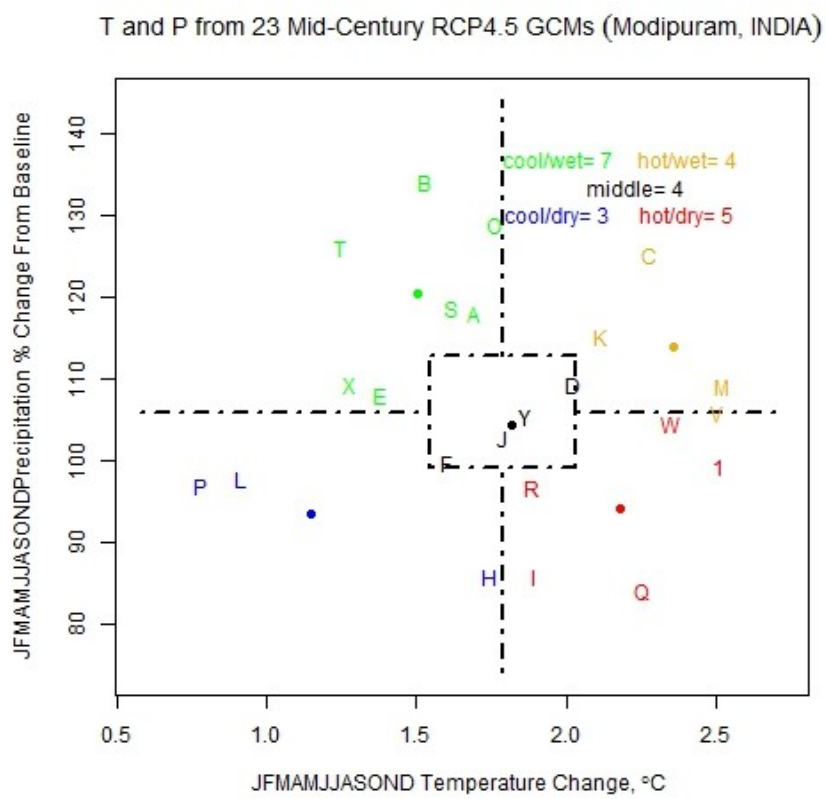
Sugarcane-Wheat

Minor crops

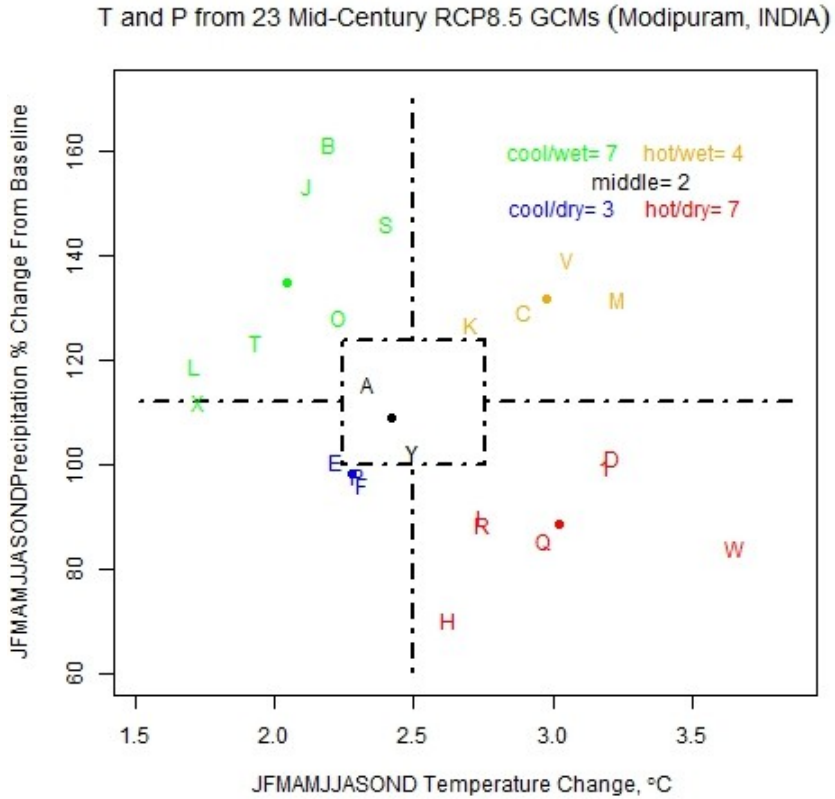
Maize

Sorghum

GCM selection – RCP4.5 & RCP8.5
Mid-term century (2040-2069)



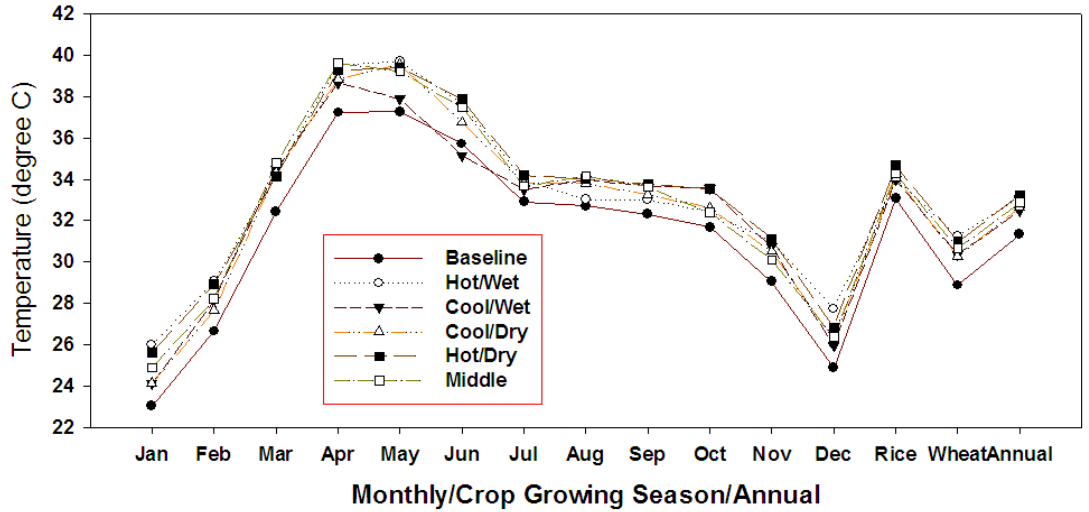
M,S,L,Q,Y
(IPSL-CM5A-LR, MRI-CGCM3, inmcm4, MPI-ESM-LR, HadGEM2-AO



C,T,P,Q,A
(BNU-ESM, MIROC5, MIROC-ESM, MPI-ESM-LR, ACCESS1-0)

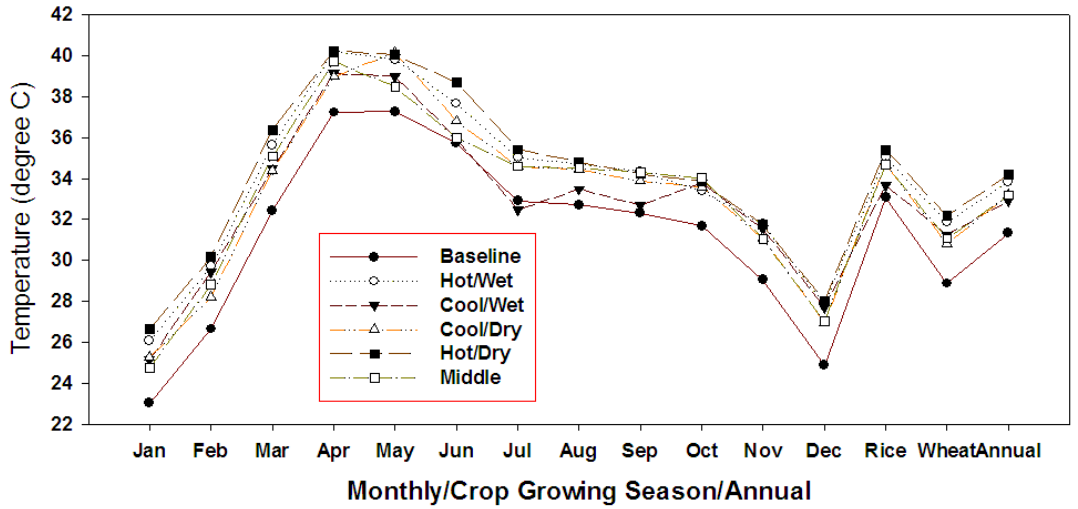
Mean monthly/growing seasonal mean maximum temperature (RCP4.5 & 8.5 – 2040-2069) of selected GCMs compared to baseline (1980-2010)

RCP4.5



	Rice	Wheat	Annual	
Baseline	33.1	28.9	31.3	
G-4.5	34.0	31.3	33.1	hot/wet
A-4.5	34.0	30.3	32.5	cool/wet
I-4.5	34.1	30.3	32.6	cool/dry
K-4.5	34.7	31.0	33.2	hot/dry
O-4.5	34.3	30.7	32.9	Middle
M-8.5	35.0	31.9	33.8	hot/wet
U-8.5	33.7	31.2	32.9	cool/wet
I-8.5	34.7	30.8	33.2	cool/dry
E-8.5	35.4	32.2	34.2	hot/dry
A-8.5	34.7	31.1	33.2	Middle

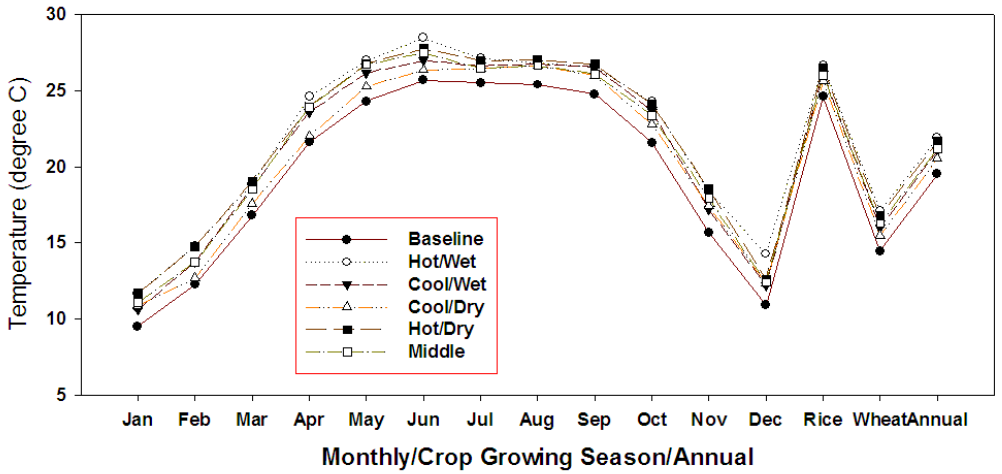
RCP8.5



	Rice	Wheat	Annual	
Baseline				
G-4.5	0.9	2.4	1.8	hot/wet
A-4.5	0.9	1.4	1.2	cool/wet
I-4.5	1.0	1.4	1.3	cool/dry
K-4.5	1.6	2.1	1.9	hot/dry
O-4.5	1.2	1.8	1.6	Middle
M-8.5	1.9	3.0	2.5	hot/wet
U-8.5	0.6	2.3	1.6	cool/wet
I-8.5	1.6	1.9	1.9	cool/dry
E-8.5	2.3	3.3	2.9	hot/dry
A-8.5	1.6	2.2	1.9	Middle

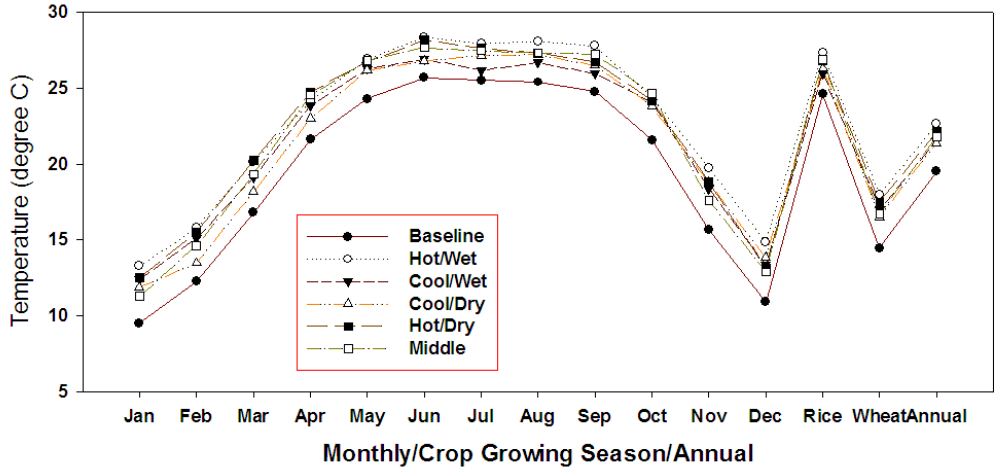
Mean monthly/growing seasonal mean minimum temperature (RCP8.5 – 2040-2069) of selected GCMs compared to baseline (1980-2010)

RCP4.5



	Rice	wheat	Annual	
Baseline	24.6	14.5	19.5	
G-4.5	26.6	17.1	21.9	hot/wet
A-4.5	26.1	16.0	21.1	cool/wet
I-4.5	25.6	15.5	20.5	cool/dry
K-4.5	26.5	16.8	21.7	hot/dry
O-4.5	26.0	16.3	21.2	Middle
M-8.5	27.3	18.0	22.6	hot/wet
U-8.5	26.0	17.0	21.5	cool/wet
I-8.5	26.3	16.5	21.4	cool/dry
E-8.5	26.8	17.5	22.1	hot/dry
A-8.5	26.9	16.7	21.8	Middle

RCP8.5



	Rice	wheat	Annual	
Baseline				
G-4.5	2.0	2.6	2.4	hot/wet
A-4.5	1.5	1.5	1.6	cool/wet
I-4.5	1.0	1.0	1.0	cool/dry
K-4.5	1.9	2.3	2.2	hot/dry
O-4.5	1.4	1.8	1.7	Middle
M-8.5	2.7	3.5	3.1	hot/wet
U-8.5	1.4	2.5	2.0	cool/wet
I-8.5	1.7	2.0	1.9	cool/dry
E-8.5	2.2	3.0	2.6	hot/dry
A-8.5	2.3	2.2	2.3	Middle

Change in mean monthly/growing seasonal mean Rainfall (RCP8.5 – 2040-2069) of selected GCMs compared to baseline (1980-2010)

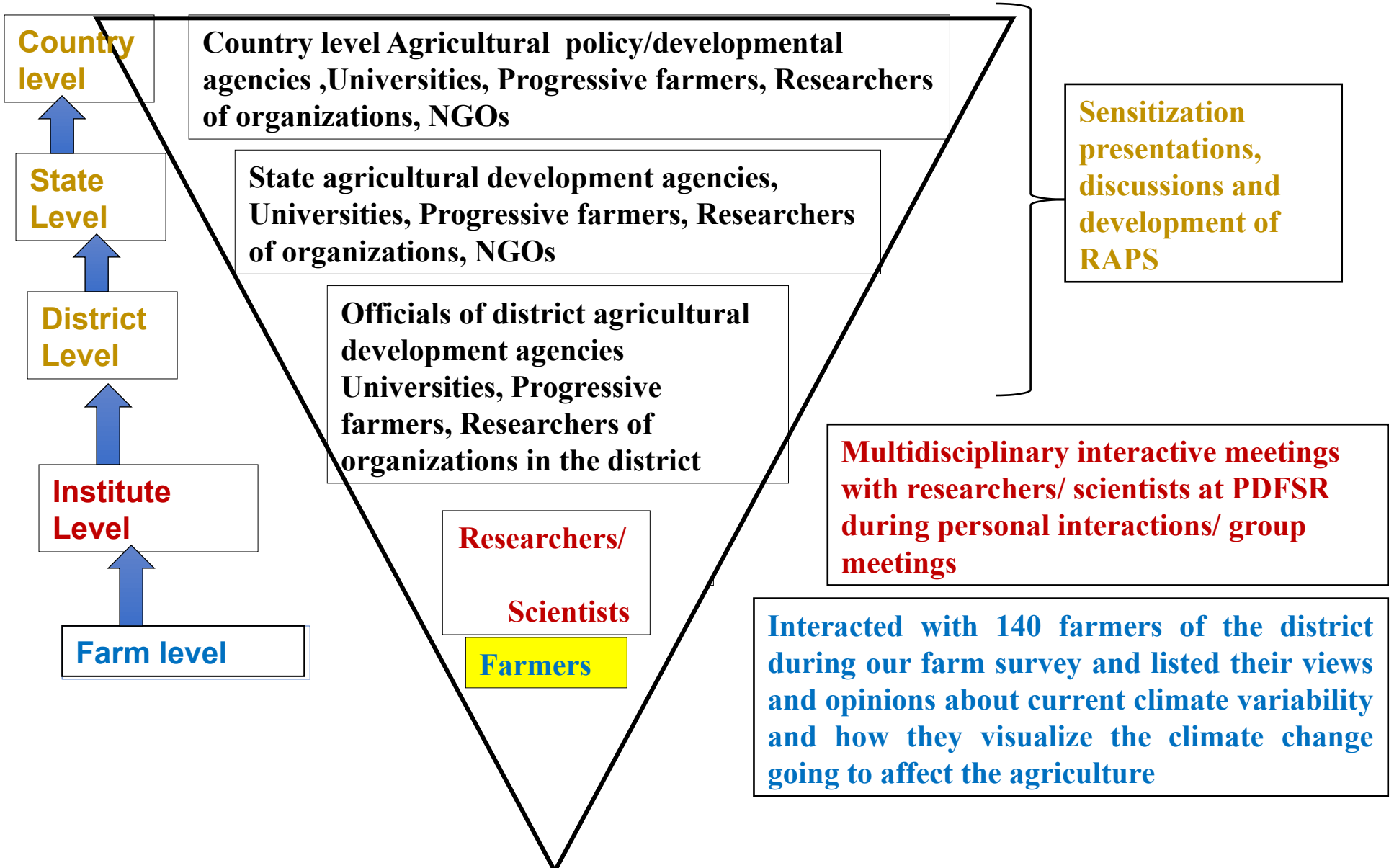
	Jan	Feb	Mar	Apr	May	June	July
G-4.5	-70.8	-10.9	6.4	5.3	0.0	46.7	14.9
A-4.5	-15.2	2.6	41.6	12.3	21.7	63.6	10.4
I-4.5	75.0	12.2	39.9	-48.4	-20.8	-26.2	13.1
K-4.5	-4.5	-8.1	59.1	-8.4	-11.4	-18.0	7.6
O-4.5	-29.5	19.8	-60.9	-12.6	32.0	-4.6	7.2
M-8.5	-55.5	-20.6	-19.3	-11.8	42.7	29.8	29.5
U-8.5	99.4	-28.7	-5.8	6.0	2.6	38.2	26.5
I-8.5	-54.4	-26.9	-10.5	-44.3	-37.1	-5.5	7.2
E-8.5	-57.7	-23.3	-28.2	12.0	20.2	3.3	-4.3
A-8.5	-13.7	-5.1	1.7	4.8	8.1	13.6	2.4

	Aug	Sep	Oct	Nov	Dec	Rice	Wheat	Annual	
G-4.5	23.1	11.3	6.2	33.2	0.0	21.2	-8.0	19.0	hot/wet
A-4.5	12.9	38.9	-14.5	-47.6	9.4	24.5	5.6	23.6	cool/wet
I-4.5	3.2	25.6	0.0	-36.8	-38.6	5.6	-0.1	4.1	cool/dry
K-4.5	21.1	7.7	-13.7	0.0	-1.7	5.5	5.2	4.7	hot/dry
O-4.5	-12.8	11.4	41.1	103.5	-50.2	2.7	-11.6	3.5	Middle
M-8.5	34.1	15.4	43.8	-37.3	19.8	28.7	-20.7	27.3	hot/wet
U-8.5	28.8	7.4	-8.4	-0.8	-40.4	23.2	7.5	21.6	cool/wet
I-8.5	11.0	12.3	6.5	27.8	13.3	7.0	-24.8	3.6	cool/dry
E-8.5	-2.1	10.4	3.3	-5.0	-50.9	1.0	-20.7	1.0	hot/dry
A-8.5	16.7	27.0	-20.9	-42.8	21.8	11.7	-2.9	10.9	Middle

Parameters for existing farming system used in TOA-MD modeling

			Farming system parameters	
Sr.No.	Parameter	Unit	Rice	Wheat
1	Yield	kg/hectare	3989	3652
2	Price	Rs./kg	21	12
3	Variable cost	Rs/farm	17120	15728
4	Net Returns	Rs/farm	10364	6945
5	SD of Net Returns	Rs/farm	8707	9250.6
6	Farm size	hectare	0.69	0.69
7	CV - Farm size	Percent	71.05	71.05
9	Family size	Number	6.0	6.0
10	CV-Family size	Percent	51.86	51.86
11	Herd size (milking+dry)	Number	1.30	1.30
13	Non-farm Income	Rs/farm	15289.5	15289.5
14	CV-Non farm income	Percent	276.35	276.35
15	Historic yield average@	kg/hectare	3652	3205
16	Survey year Yield	kg/hectare	3870.1	3311.2
17	Yield normalization factor	Number	0.9016	1.0130

Interactions with Stakeholders- Methodology/approach



Sustainable Agricultural Pathway

Better Management of Natural Resources	Govt. Policy – more allocation
Less degradation	Farmers realizes long term gains from efficient resource use
Low cost of Production	Efficient use of on-farm resources
Sustainable mechanization	High tech agriculture – higher energy efficiency
Low income disparity	Farm labor gets good employment in rural

The region becomes food secure on sustainable basis

Unsustainable Agricultural Pathway

Agricultural Intensification	**High population growth**
Higher Exploitation of natural resources	**Less in investment in NRM**
Declining land productivity	**Higher usage of farm inputs**
Out-migration of labors	**Fragmented land and low incomes**
More allocation for subsidies and crop insurance	**High Market and climate risks**

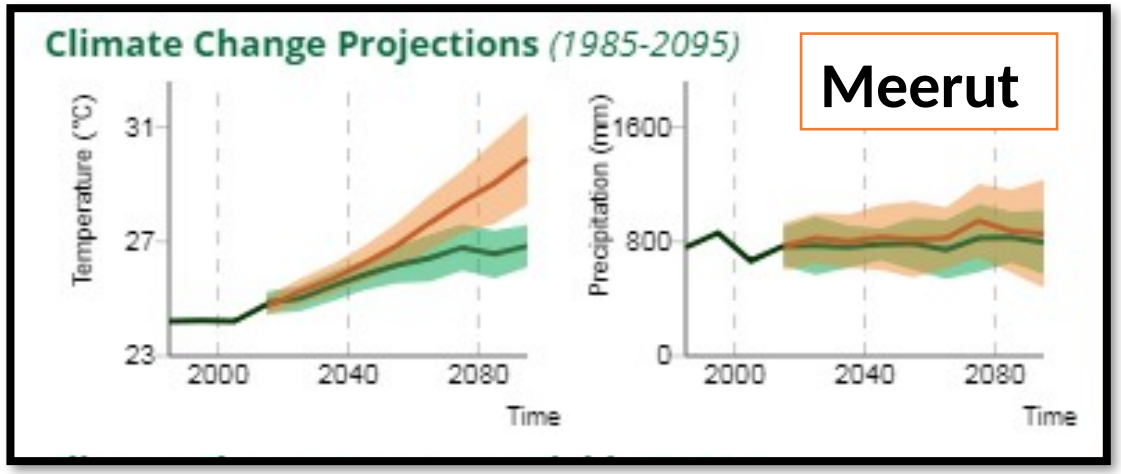
RAPs for socio-economic, technological, biophysical and policy variables for RCP 4.5 and RCP 8.5 scenarios

Parameters	RAPs-4		RAPs-5	
	Direction of change	Magnitude (%)	Direction of change	Magnitude (%)
Family size	Decrease	20%	Decrease	10%
Farm size	Decrease	5%	Decrease	20%
Herd size	Increase	20%	Decrease	20%
Off farm income	Increase	30%	Increase	50%
Variable cost of production	Decrease	10%	Increase	30%
Rice yield trend	Increase	30%	Increase	39%
Rice price trend (without CC)	Increase	10%	Increase	46%
Rice price trend (with CC)	Increase	35%	Increase	97%
Wheat yield trend	Increase	43%	Increase	32%
Mixed crop net returns (without CC)	Increase	30%	Increase	39%
Mixed crop net returns (with CC)	Decrease	10%	Decrease	10%
Wheat price trend (without CC)	Increase	24%	Increase	30%
Wheat price trend (without CC)	Increase	50%	Increase	71%
Livestock milk trend	Increase	304%	Increase	292%
Livestock milk price (without CC)	Increase	21%	Increase	12%
Livestock milk price (with CC)	Increase	23%	Increase	14%

Climate Change Projections

Grey Road

Green Road



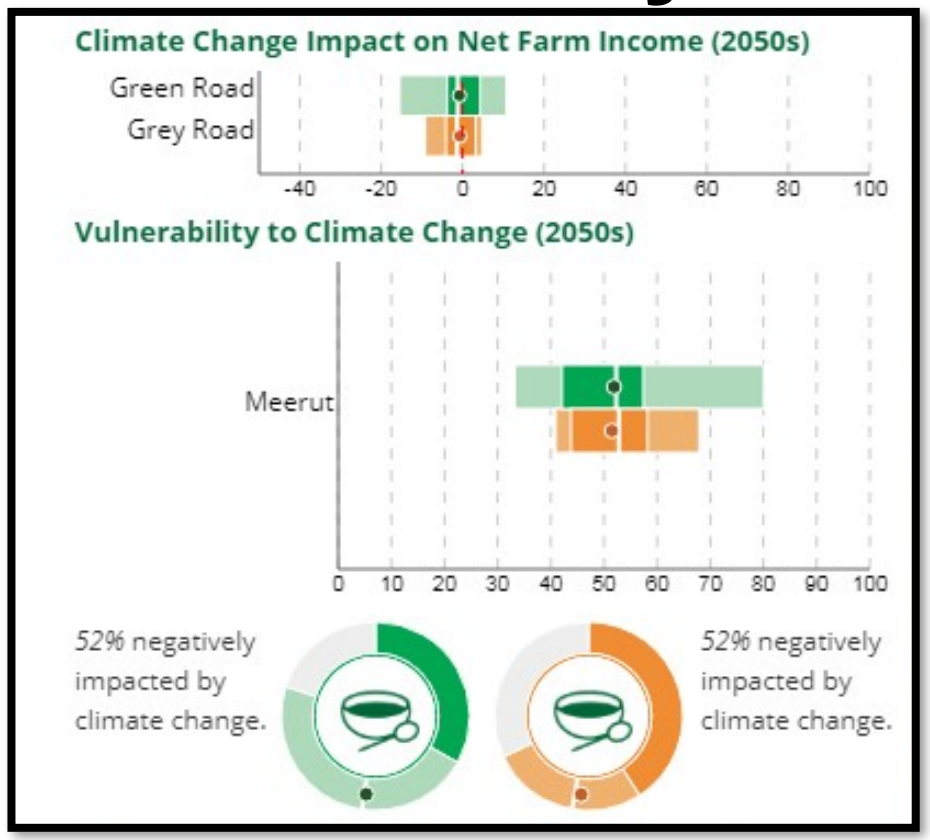
		Meerut
Temperature (°C)	Green	24.9-26.8
	Gray	24.7-29.9
Rainfall (mm)	Green	768-795
	Gray	765-855

Climate Change Impacts

Projected yield changes under Green and Grey agricultural pathways.

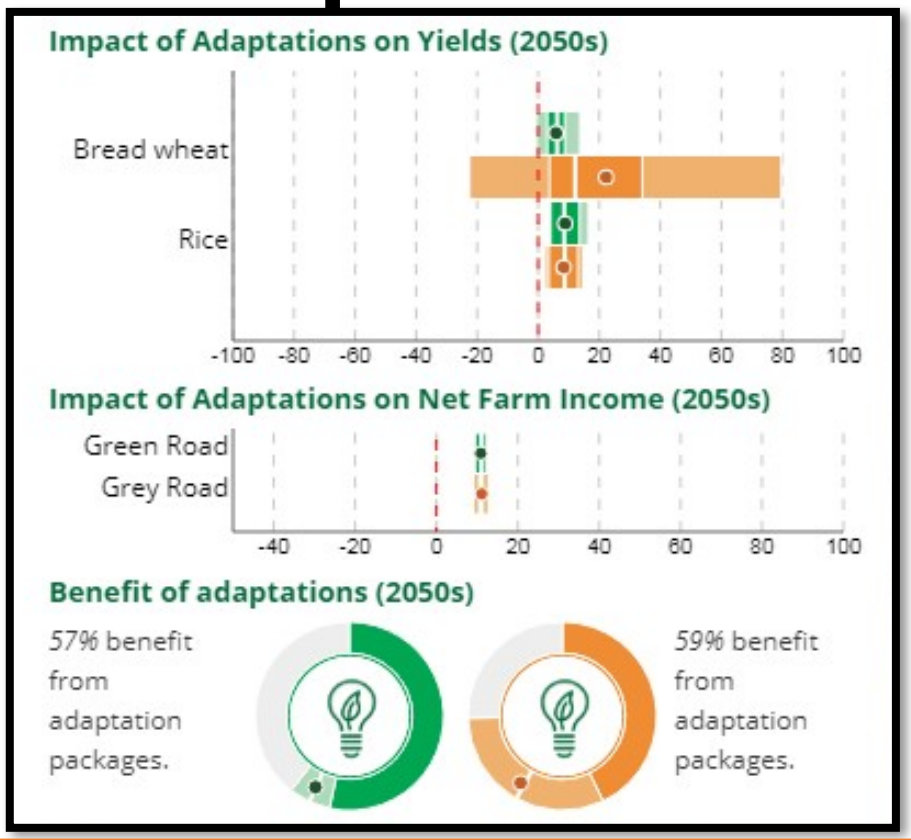
		Meerut
Rice	Green	-1.8:4.2
	Gray	-0.4:6.0
Wheat	Green	-8.7:3.5
	Gray	-11.5:3.7

Vulnerability

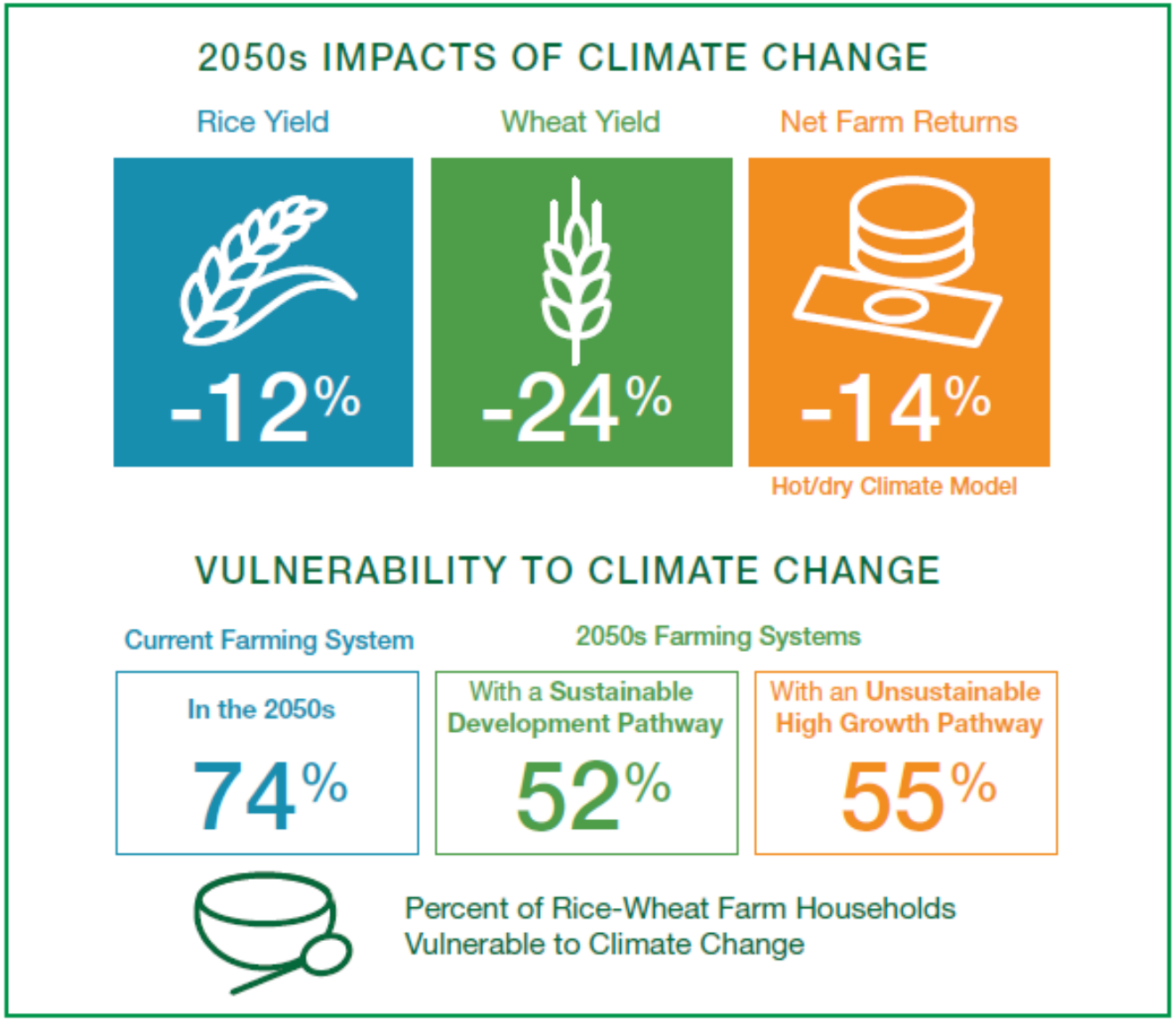


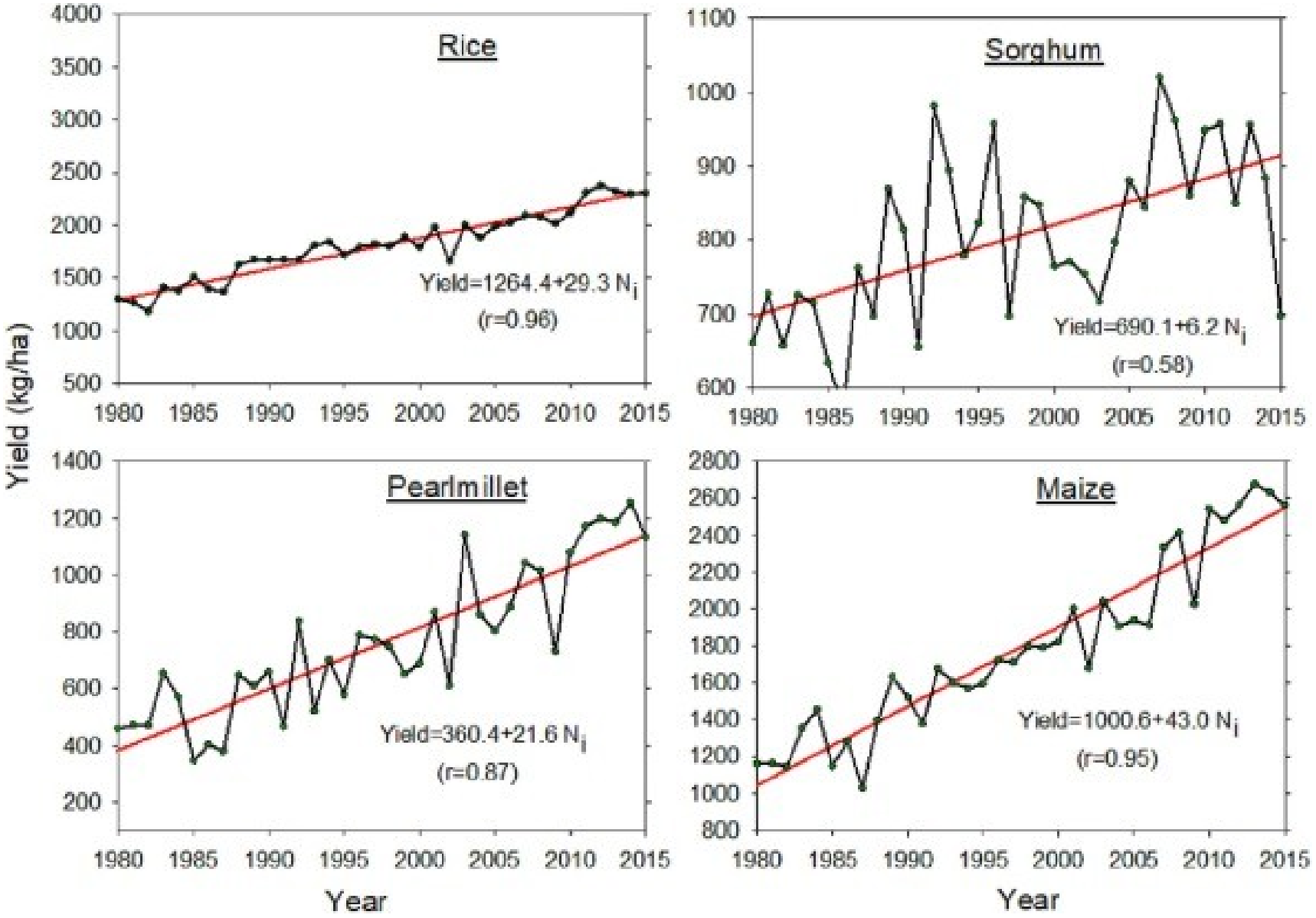
It is found that **52 %** of the farms will be vulnerable in Meerut under sustainable green road pathways (moderate emission) in 2050s.

Adaptations



There will be 57 % of the farms pertaining to Meerut would benefit by adopting the adaptation package in response to climate change under Green pathways.


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
74%
With a Sustainable Development Pathway
52%
With an Unsustainable High Growth Pathway
55%
Percent of Rice-Wheat Farm Households Vulnerable to Climate Change



Variability of actual yield and its trends of rice, sorghum, pearlmillet and maize over India

Monthly and monsoon rainfall during El Niño years and its % deviation from normal.

Year	Monthly and monsoon rainfall (mm)					% deviation from normal				
	June	July	August	September	ISMR	June	July	August	September	ISMR
2002	170.3	121.3	227.8	127.4	646.8	5.1	−54.0	−5.8	−22.8	−22.2
2004	160.0	218.0	242.5	121.2	741.7	−1.3	−17.0	0.3	−26.6	−10.8
2009	89.9	268.8	195.2	148.1	702.0	−45	2.5	−19.2	−10.3	−15.5
Normal	162.1	262.3	241.7	165.1	831.1					

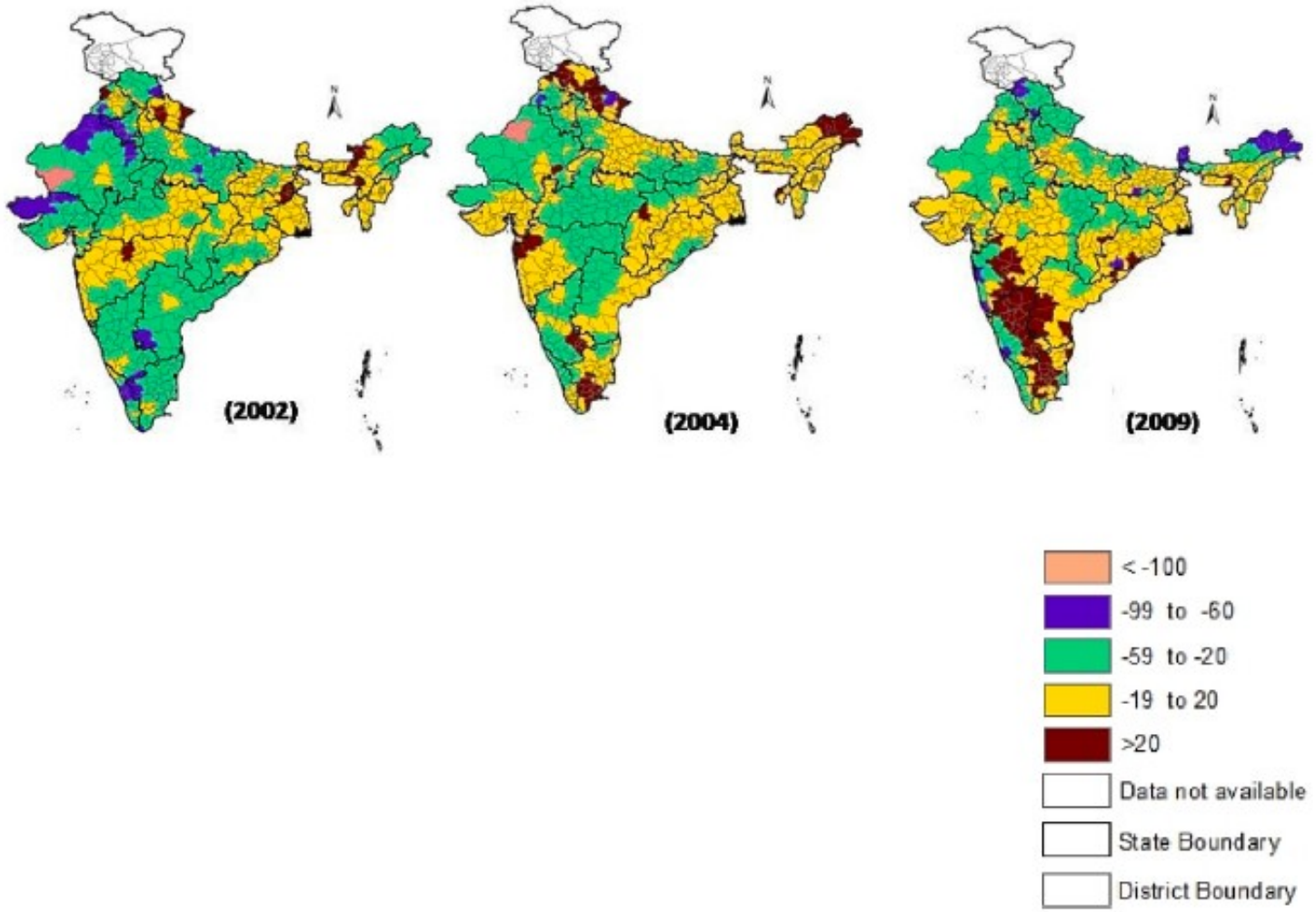
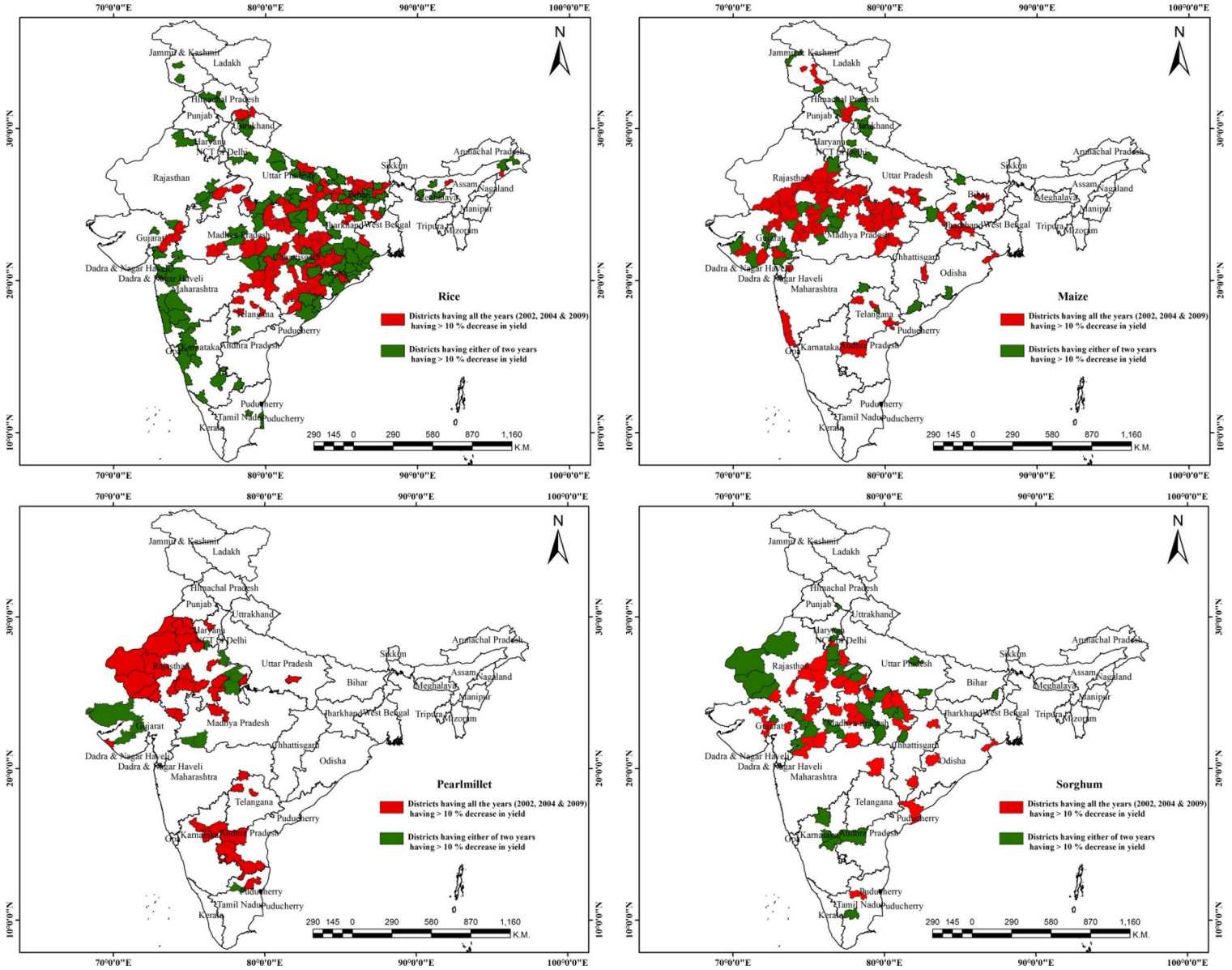


Fig. 4. Spatial variability of per cent change in total monsoon rainfall during El Niño years 2002, 2004 and 2009.



Spatial distribution of vulnerable districts across India with respect to rice, maize, pearlmillet and Sorghum.

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Relevance of climatological information on spatial and temporal variability of Indian Summer monsoon rainfall (ISMR) in recent El Niño years and its impact on four important *kharif* crops over India

N. Subash *, Debashis Dutta, P.C. Ghasal, P. Punia, Vinay Prasad Mandal, Brahmadut, Ved Prakash Chaudhary

ICAR-Indian Institute of Farming Systems Research, Modipuram-250 110, Meerut, Uttar Pradesh, India

Districts having all the El Niño years (2002, 2004 & 2009) having > 10 % decrease in yield and Districts having either of two years having > 10 % decrease in yield for rice

State	Districts having all the years (2002, 2004 & 2009) having > 10 % decrease in yield	Districts having either of two years having > 10 % decrease in yield
Andhra Pradesh	Adilabad, Karimnagar, Medak, Nizamabad, Warangal	Mahaboobnagar, Visakhapatnam, Vizianagaram
Arunachal Pradesh	Tirap	Lohit
Assam	Darrang	Barpeta, Tinsukia
Bihar	Bhojpur, Darbhanga, Jehanabad, Jamui, Kisanganj, Madhubani, Nalanda, Purnia, Samastipur, Saran, Sitamarhi, Supaul	Araria, Aurangabad, Bhagalpur,Begusarai, Buxar, Gaya, Gopalganj, Khagaria, Katihar, Madhepura, Munger, Nawadah, PashchimChamparan, Patna, PurbaChamparan, Saharsa, Vaishali
Gujarat	Dahod, Panchmahal, Vadodara	Bharuch, Gandhinagar, Navsari, Dang, Valsad
Haryana		Jind
Himachal Pradesh		Kangra, Mandi
Jammu & Kashmir		Baramulla, Rajouri
Chhattisgarh	Bastar, Bilaspur, Dintewada, Dhamtari, Durg, Jashpur, Kanker, Kawardha, Korba, Raigarh, Rajnandgaon, Surguja	Janjgir, Koriya, Mahasamund, Raipur
Jharkhand	Dumka, Hazaribag, PurbiSinghbhum	Garhwa, Giridih, Gumla, Pakur, PashchimiSinghbhum
Karnataka		Belgaum, Dharwad, Haveri, Kolar, Udupi, UttaraKannada
Madhya Pradesh	Chhindwar, Gwalior, Harda, East Nimar, Katni, Panna, Rewa, Seoni, Shahdol, Sheopur, Tikamgarh, Umaria	Balaghat, Chhatarpu, Damoh, Hoshangab, Raisen,Sidhi
Maharashtra	Chandrapur, Gadchirol, Gondiya	Bhandara, Nagpur, Nandurbar, Nashik, Pune, Raigad, Ratnagiri, Sangli
Meghalaya		West Garo, West Khasi
Orissa	Balangir, Bargarh, Deogarh, Kalahandi, Malkangiri, Nabarangapur, Nayagarh, Nuapada, Rayagada, Sambalpur, Sonepur	Angul, Bhadrak, Bolangir, Balasore, Dhenkanal, Ganjam, Jajpur, Jharsuguda, Kandhamal, Keonjhar, Khurda, Koraput, Mayurbhanja, Sudargarh
Pondicherry	Karaikal	
Rajasthan	Banswara	Bundi, Dungarpur, Hanumangah, Kota, SawaiMadhopur
Tamil Nadu		Nagapattinam, Perambalur
Uttar Pradesh	Azamgarh, Ballia, Balrampur, Chandauli, Chitrakoot, Deoria, Ghazipur, Mirzapur, Siddharthnagar, Sonbhadra, Varanasi	Aligarh, Allahabad,Budaun, Banda, Basti, Gonda, Gorakhpur, Kaushambi, Kheri, Mau,Pratapgarh, SantKabir Nagar, Shravasti, Sitapur
Uttaranchal	Uttarkashi	Garhwal, Tehri
Total no. of districts	77	103

Future strategies – climate services with respect to agriculture

- Reliable climate information
- Confidence building of farming community
- Use of ICT tools for preparation of dynamic/DSS for preparation of advisory
- Village/block level accurate climate information
- Strengthening collaboration with extension agencies
- More participation of national/international/private participation in dissemination activity


Climate change
Thank You