Climate Change

The International Journal

ISSN 2394-8558 EISSN 2394-8566

PRESENTATION

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Geospatial Technology for Climate Change Impact Assessment of Mountain Agriculture

Publication History

Received: 26 November 2016

Accepted: 31 December 2016

Published: January-March 2017

Citation

Patel NR. Geospatial Technology for Climate Change Impact Assessment of Mountain Agriculture. *Climate Change*, 2017, 3(9), 344-371

Geospatial Technology for Climate Change Impact Assessment of Mountain Agriculture

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Global Challenges and Issues

CO_2 (ppm)
(1950 : 29; 2009 : 380; 2050 : 480)

Deforestation (mha/yr) –

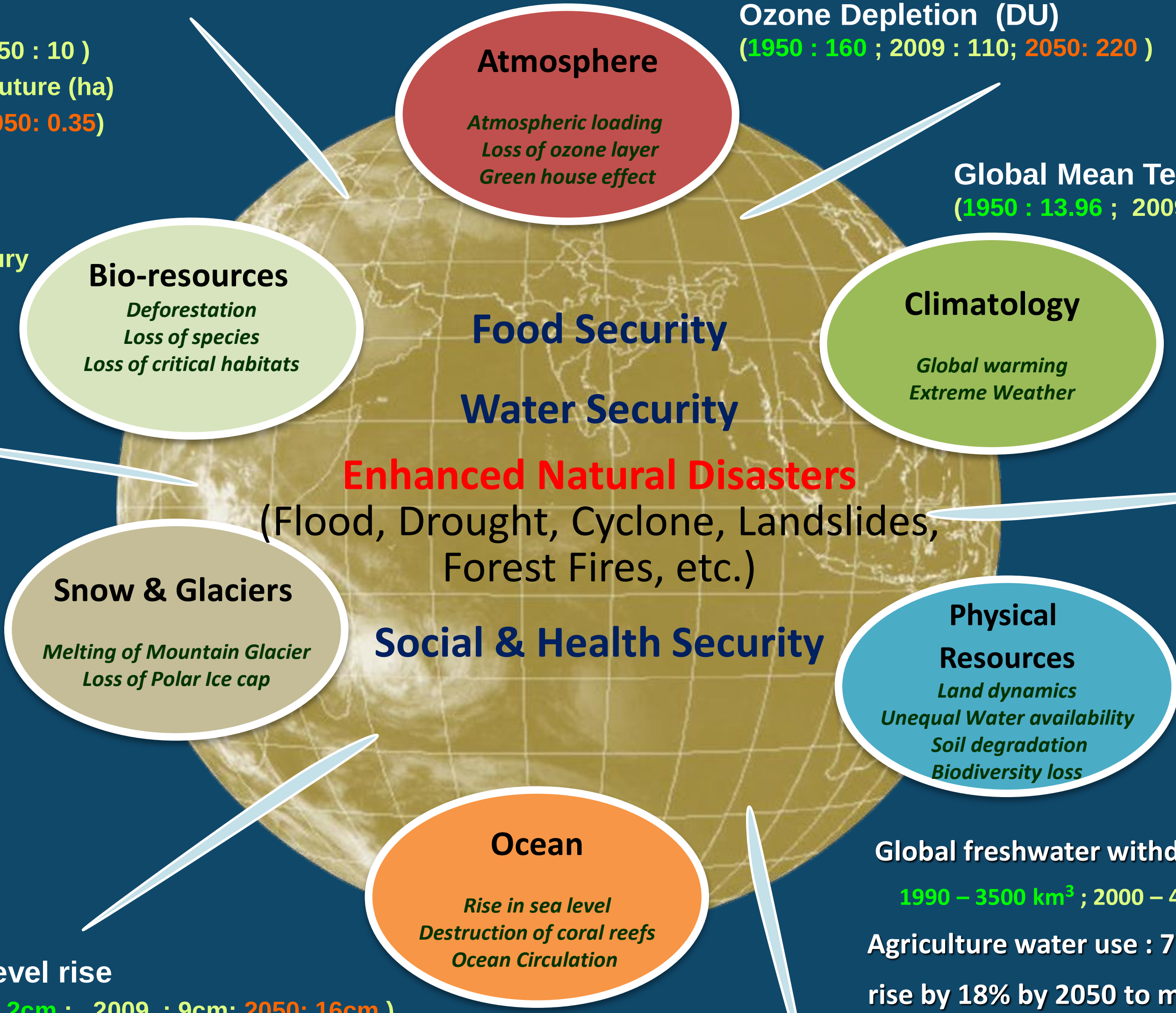
(1950 : 15 ; 2007 : 13; 2050 : 10)
Per capita forest present & future (ha)
(1950: 1.13; 2007: 0.62; 2050: 0.35)

Species loss -
Present : 40-200 / day;
5-20%; lost during last century

Projected : 2050 : 15-35%;

Ozone Depletion (DU)
(1950 : 160 ; 2009 : 110; 2050: 220)

Global Mean Temp (^oC)
(1950 : 13.96 ; 2009: 14.59; 2050:16.30)



Average glacier Thickness change (cm / yr)
1990 – 40 ; 2050– 95;

Sea level rise
(1950 : 2cm ; 2009 : 9cm; 2050: 16cm)
27 % of coral reef destructed

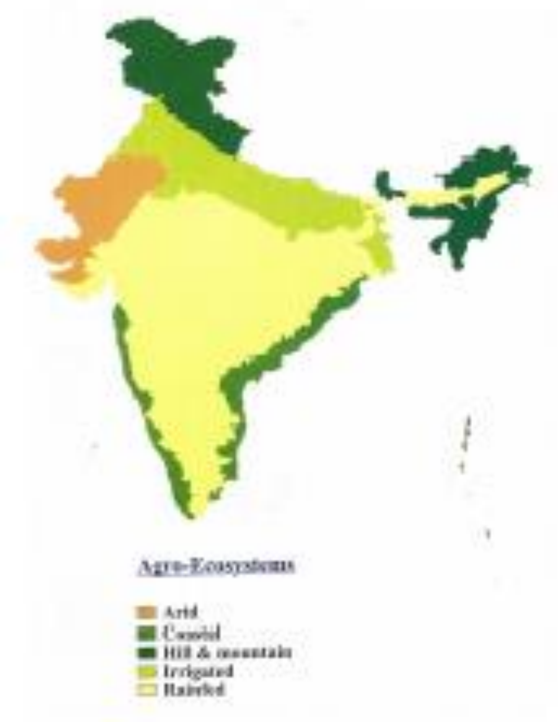
Global freshwater withdrawals
1990 – 3500 km^3 ; 2000 – 4430 km^3
Agriculture water use : 70%, Expected rise by 18% by 2050 to maintain agriculture production ;
26% global wetland lost

Himalayan ecosystem in context of climate change

- The Himalayan mountain ecosystem is vital to the ecological security of the Indian landmass and occupies the strategic position of entire northern boundary (North-West to North-East) of the country.

- Himalayas are prone to adverse impacts of global climate changes on account of both natural causes and anthropogenic emissions

- Mountain regions have experienced above-average warming in the 20th Century (IPCC 2007)



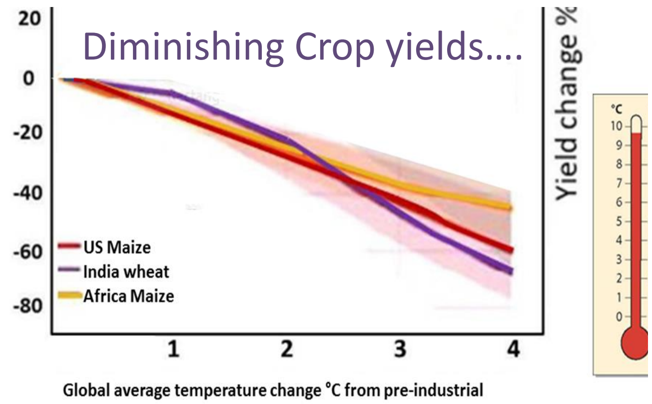
- Climate change is likely to adversely impact the Himalayan eco-system through increased temperature, altered precipitation patterns, episodes of drought, and biotic influences.

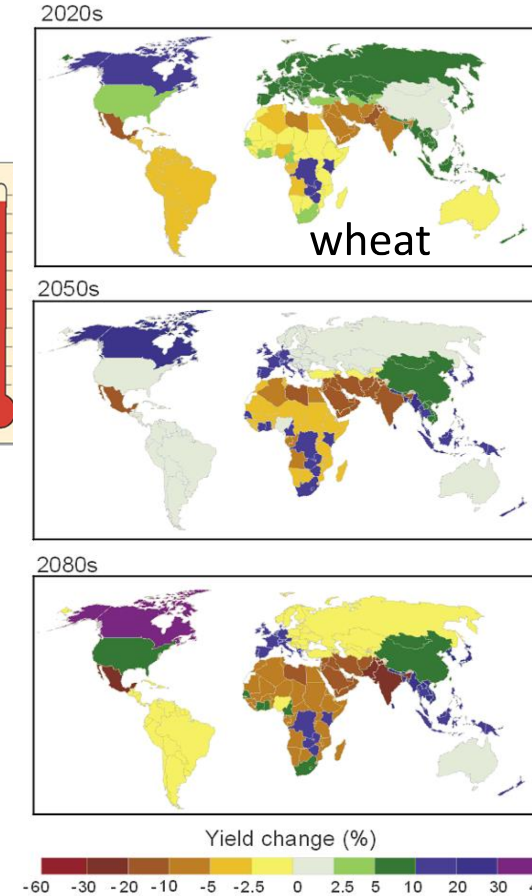
- Research on climate change and its impact on various sectors (e.g., forests, water, agricultural resources, etc.) is meager

Climate Change impact : Mountain Agriculture Focus

According to the IPCC AR5 (2014) crop model projection

- All crops in all regions decline with global warming
- Global food production is at risk at 1.5ºC
- Above +1.ºC, all crops in all regions will tip into declining yields, except temperate rice that declines at 2.0C.





(Source: NASA/GISS)

Will these projections hold true for mountain ecosystems ?

Heterogeneity in climate
Diverse and fragile ecosystem
Poor crop management

North-West Himalaya (NWH)

CC indicators

- 1 - 1.5° C (last 100years)
- 3 - 5° C (by 2100)
- 3 times more warming than Plains
- Increased precipitation

CC Impact on agriculture

- Decline in yields (wheat/maize)
- Shift in apple belt to upward
- Incidence of pests/diseases

Unknowns

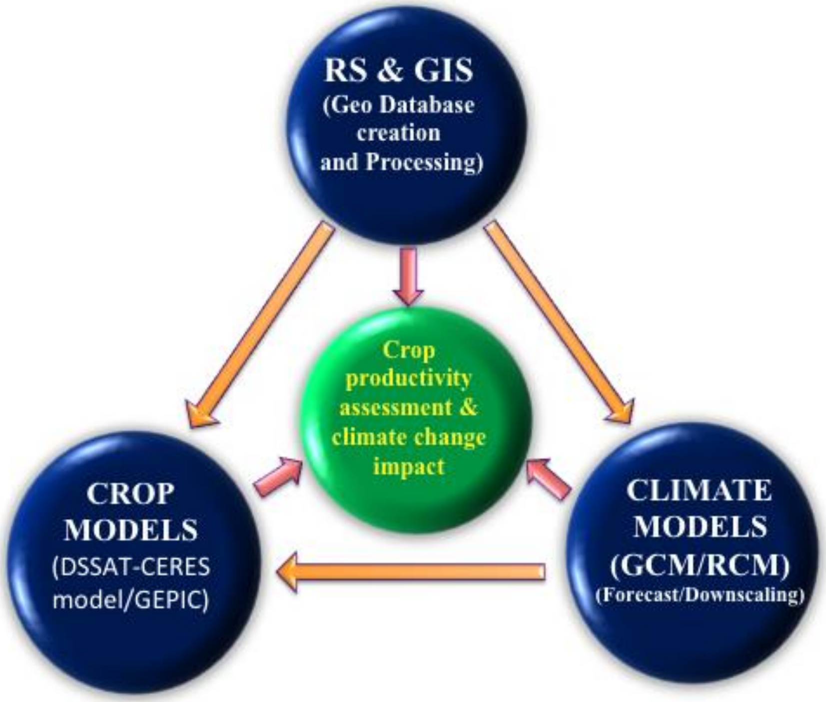
- Regional yield response to CC
- Shift in cultivating areas
- Shift in land suitability zones

Modern tools of Agroclimatic risk assessment ………….

Geographical information system (GIS) is a tool to to store, analyze, display both point and spatially referenced data. The integrated use of GIS and crop models combine the spatial perspective of GIS with more stronger representation of temporal plant processes by simulation models

Crop models

Softwares or in-built programs that simulate behaviour of plant as function of environment and management conditions.
Predict potential climate change impact, water us and helps in formulating adaptation strategies



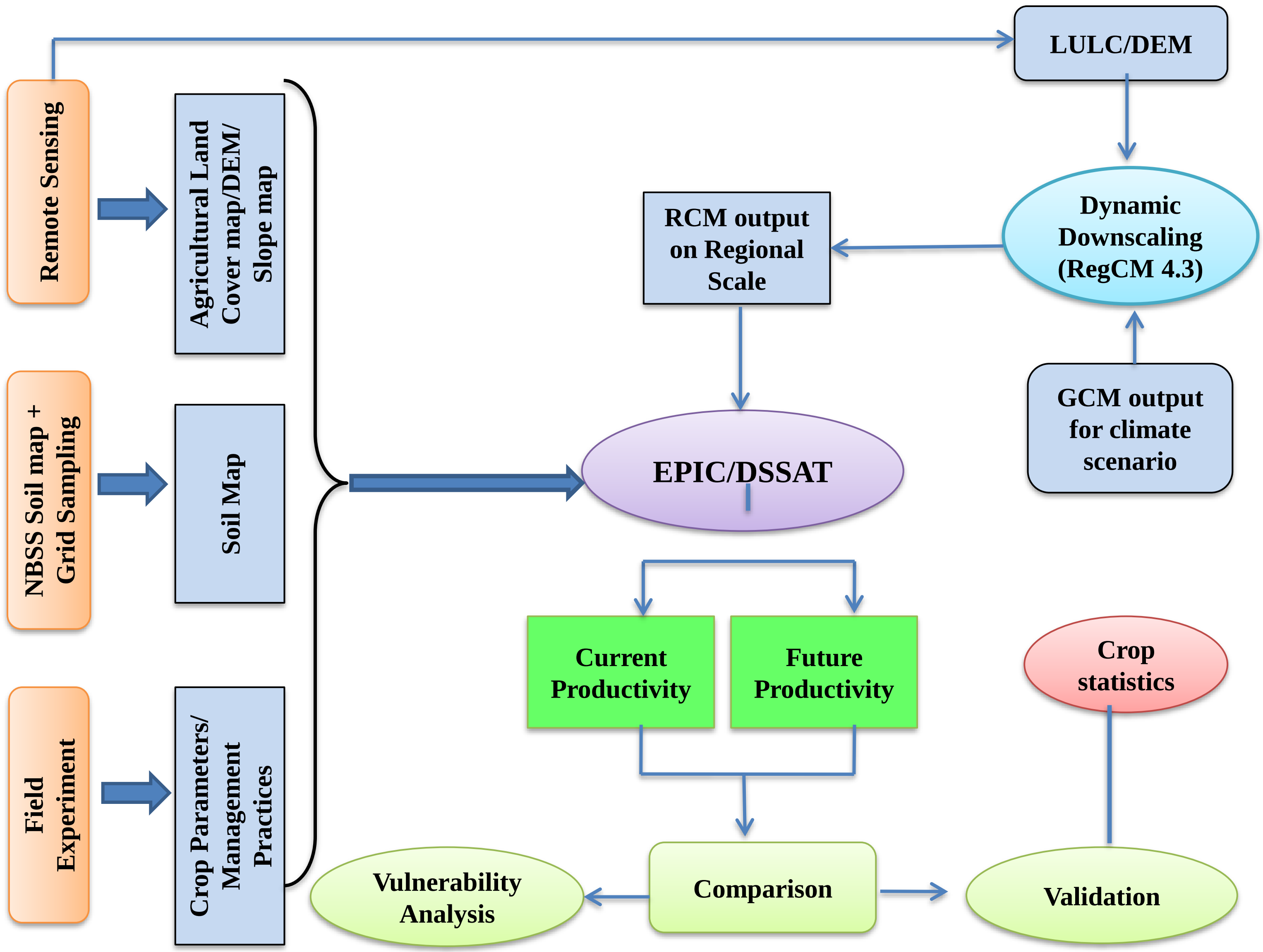
Climate models

GCMs have been used to predict climate scenarios and impacts in many cases using the downscaling approach.

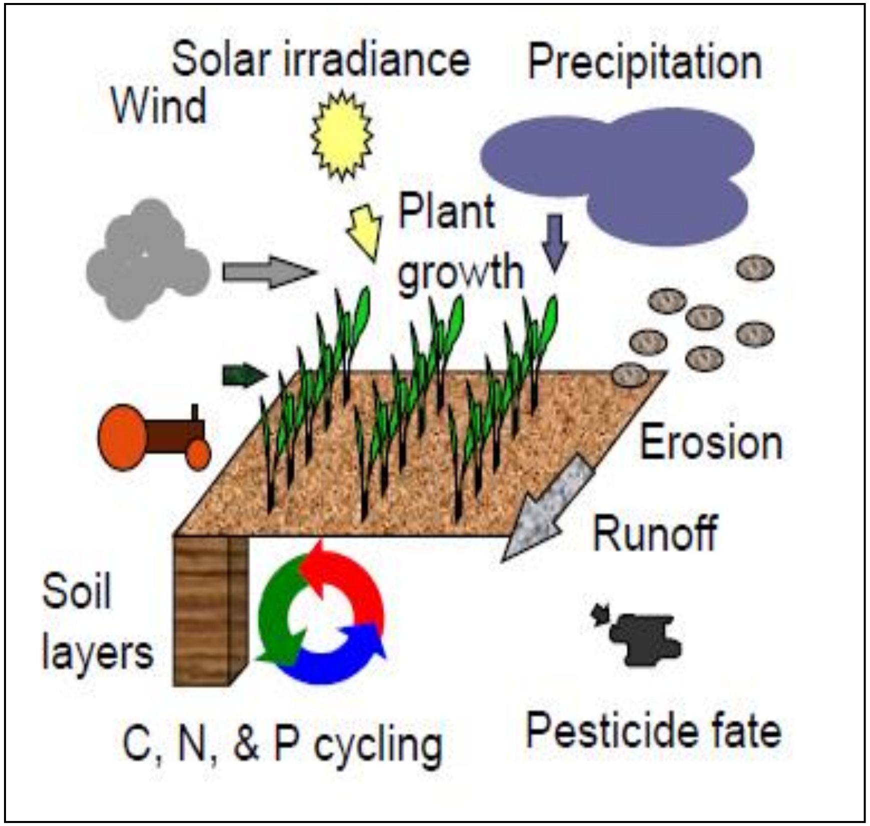
GCM/RCM output is key grided input to both crop model and GIS

Integration of climate & crop models with geomatic tools provide new dimension to development of early warning system & will support food security assessment

Schematic flow of climate-crop modeling in Himachal Pradesh



EPIC : A Process based model



GEPIC is the GIS based EPIC model for regional Analysis.

EPIC is a process-based model built to describe climate-soil-management interactions at point or small watershed scales

Key processes simulated

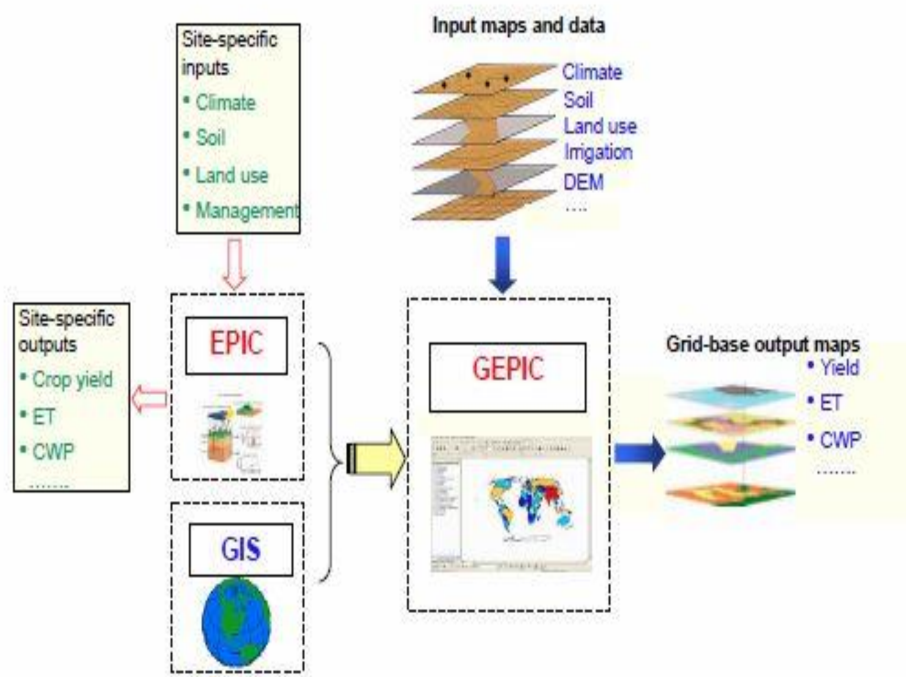
Weather

- Plant growth
- Light use efficiency, PAR
- CO2 fertilization effect
- Plant stress

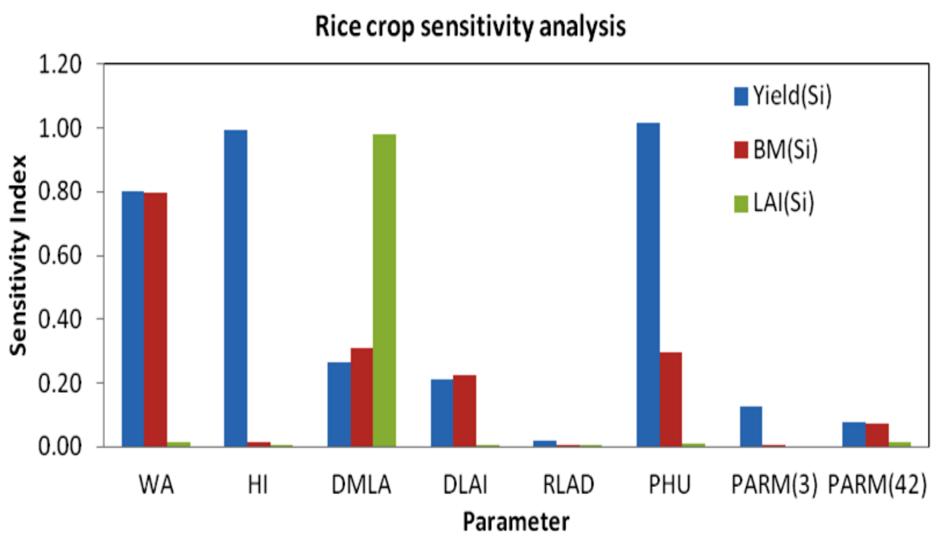
- Erosion by water (RUSLE model)
- Hydrology (SCS–CN method)
- Soil temperature and heat flow

- Soil Carbon Sequestration (Century derived equation)
- Plant environment control: fertilizers, irrigation, pesticides

GIS based EPIC crop model & Framework



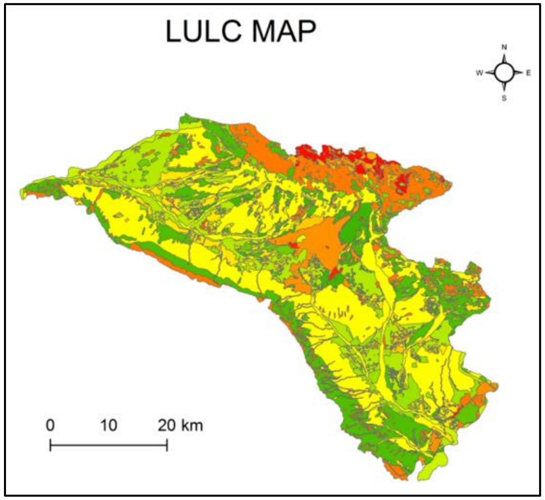
Calibration of model parameters & sensitivity

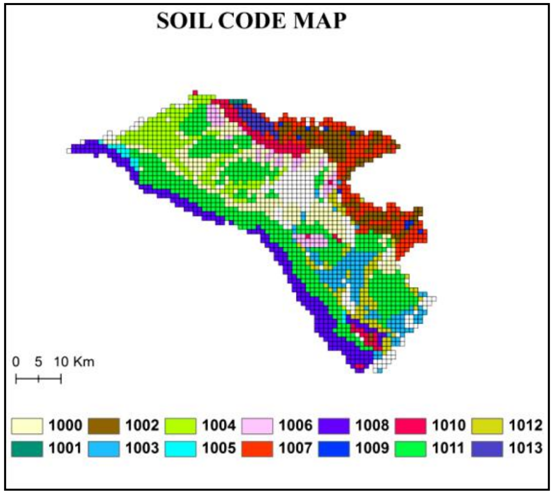


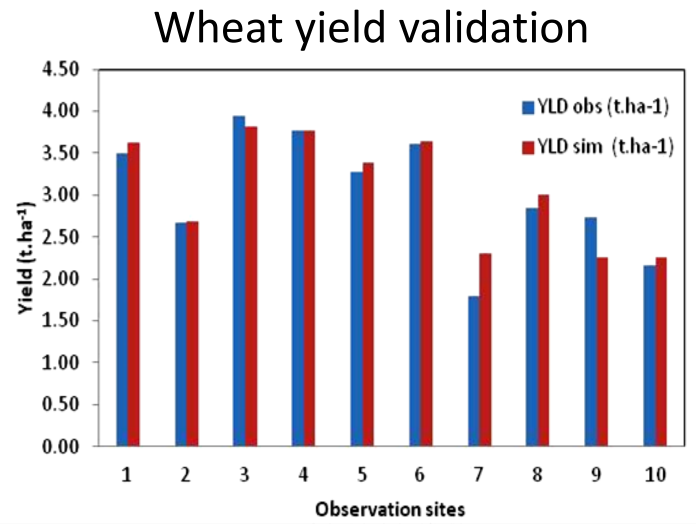
Spatial and non-spatial model input

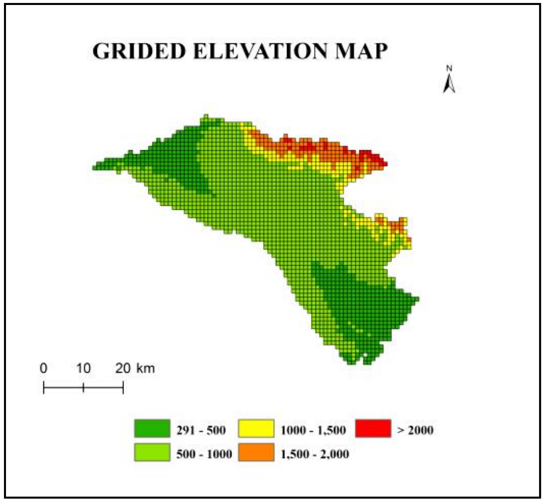
Input Data	Parameters	Source
Climate **(Current & Future scenario)**	Tmin, Tmax, Precipitation	• Weather station data World Clime (1x1 km) • Base line • A2a&B2a Scenario data for 2020,2050,2080
Soil	Depth, HSG, Texture, OC, Bulk density,Coarse Fragment.	NR-Census Report (DDN) Field Measurement & laboratory analysis.
Management	Date of planting and harvesting , fertilizer use , tillage practices.	Field observations and queries to farmers
Topography	Elevation , slope, geo-location	DEM (SRTM 90m)
Crop	Crop area and distribution , LAI	LULC map

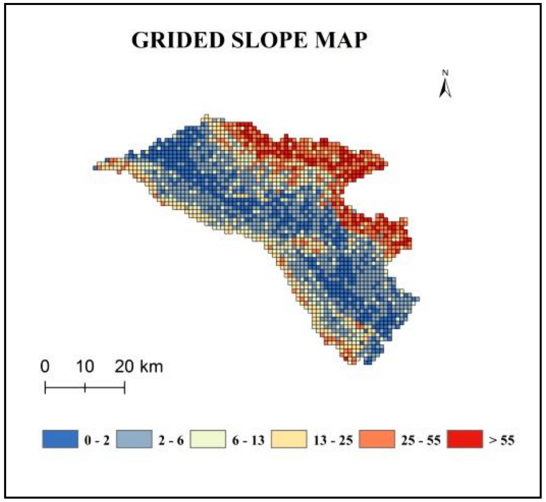
Geospatial model input & validation at site level (Dehradun Valley)

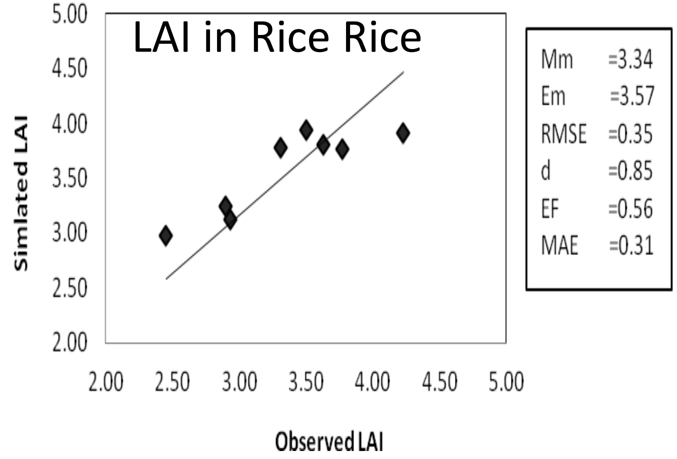












Model input data

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3	**Management**	Date of planting and harvesting , fertilizer use , tillage practices.	Field observations and queries to farmers
4	**Topography**	Elevation , slope, geo-location	DEM (SRTM 90m)
5	**Crop**	Crop area and distribution , LAI	LULC map

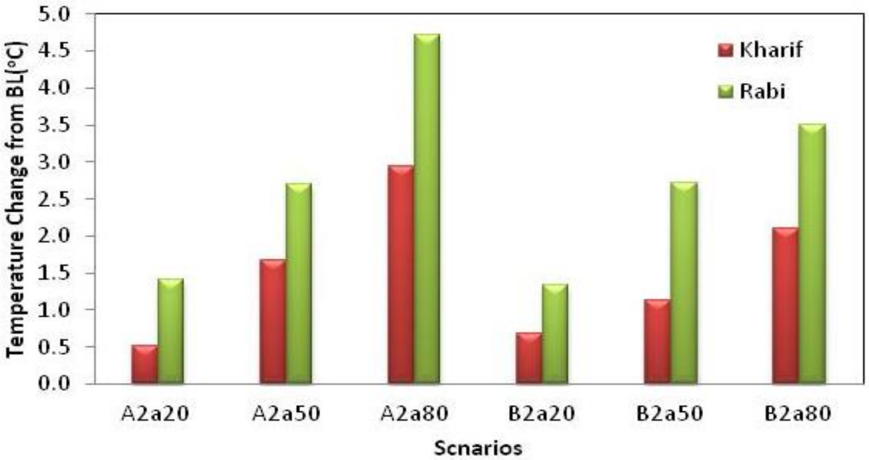
Analysis of Climate change indicators

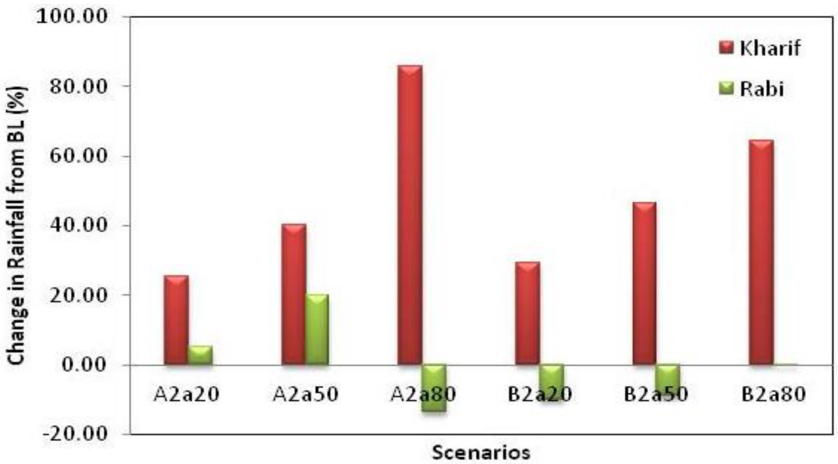
Period	Temp. mean BL (°C)	Change in Mean temperature (° C)					
		A2a20	A2a50	A2a80	B2a20	B2a50	B2a80
Annual	21.47	1.03	2.37	4.10	1.02	2.07	2.97
Kharif	24.86	0.52	1.67	2.94	0.69	1.13	2.11
Rabi	16.68	1.41	2.71	4.72	1.34	2.72	3.50

Period	Rainfall-BL (mm)	Change in Rainfall from baseline (%)					
		A2a20	A2a50	A2a80	B2a20	B2a50	B2a80
Annual	1973.24	24.96	35.24	70.23	21.01	40.69	54.14
Kharif	1604.15	25.46	40.30	85.76	29.08	46.42	64.38
Rabi	188.66	5.26	20.00	-13.70	-10.07	-9.08	-0.50

Atmospheric CO_2 Concentration

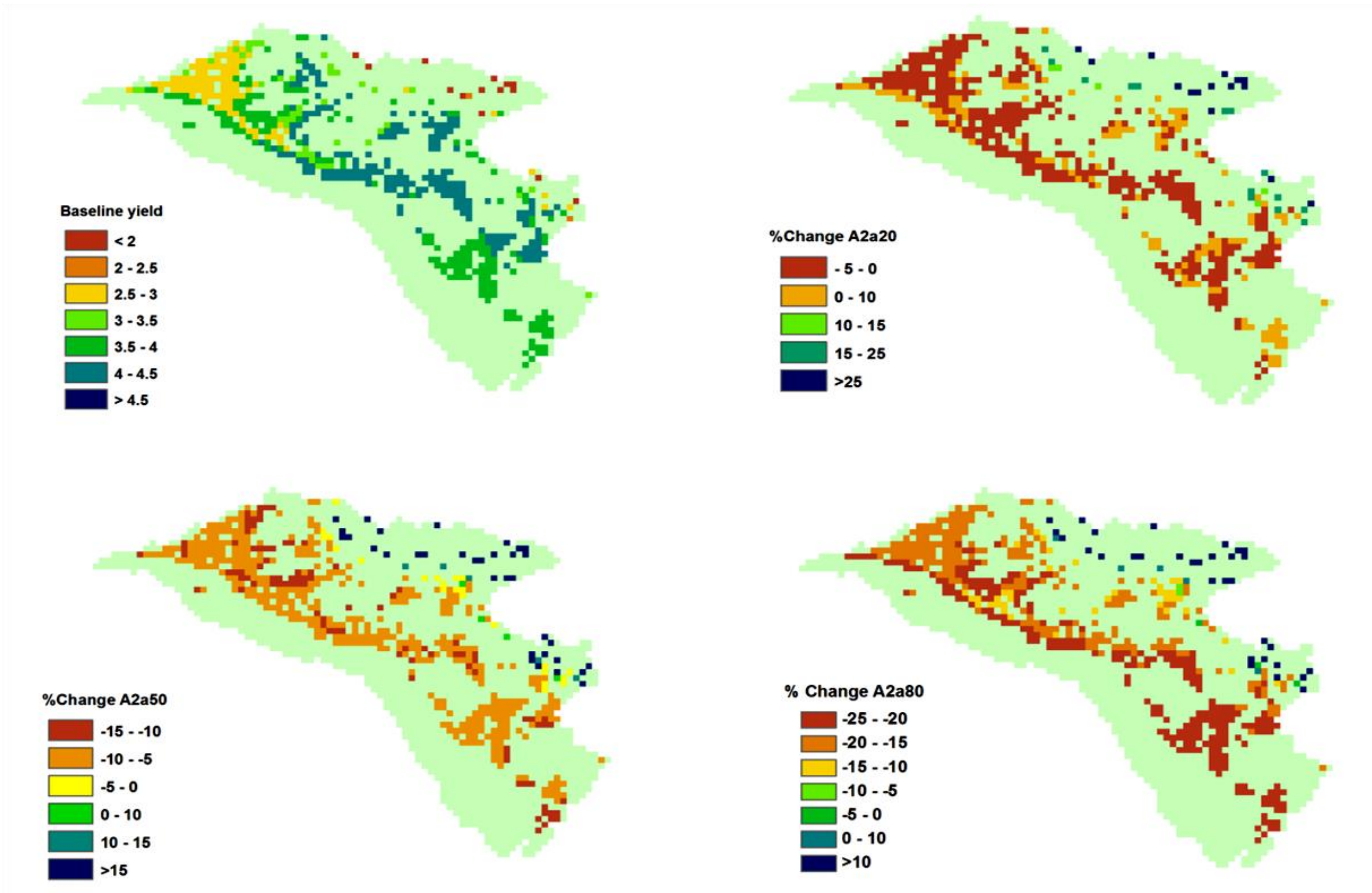
BL	A2a20	A2a50	A2a80	B2a20	B2a50	B2a80
361	432	590	709	422	422	561





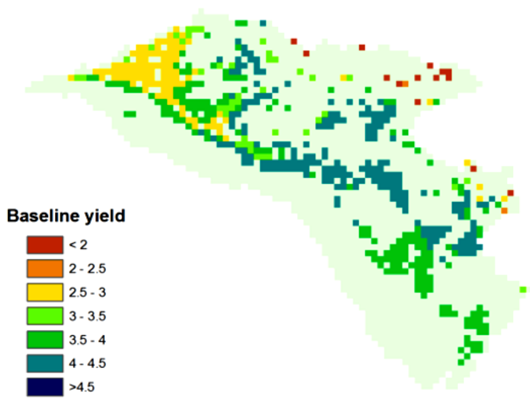
Rice crop- *A2a scenario without CO_2 fertilization*

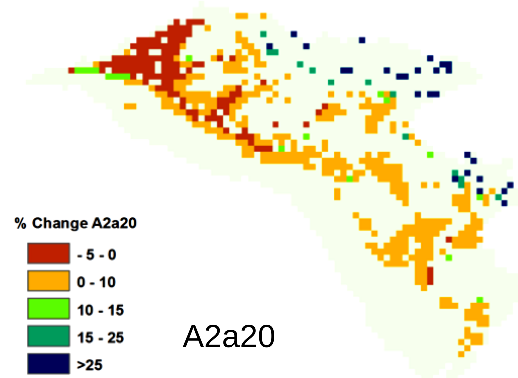
Scenario	Period	Mean (%)	SD (%)	P5 (%)	P50 (%)	P95(%)
A2a(NF)	2020	**-1.03**	1.94	-4.76	-0.38	1.33
	2050	**-9.01**	2.01	-10.72	-9.49	-5.97
	2080	**-19.22**	3.12	-24.14	-20.00	-14.05

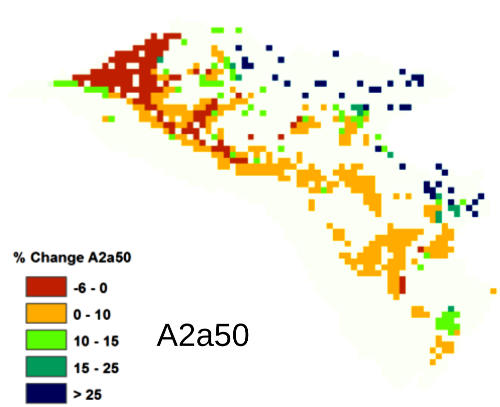


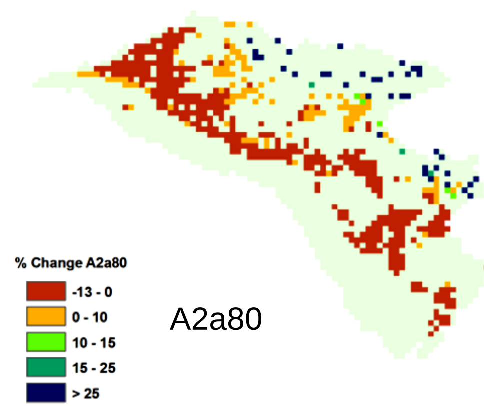
Rice Crop-*A2a Scenario with CO_2 fertilization*

Scenario	Period	Mean (%)	SD (%)	P5 (%)	P50 (%)	P95(%)
A2a	2020	5.22	4.02	-1.95	6.76	9.69
	2050	5.07	6.14	-4.63	6.98	12.96
	2080	-2.39	4.64	-8.55	-2.21	6.25



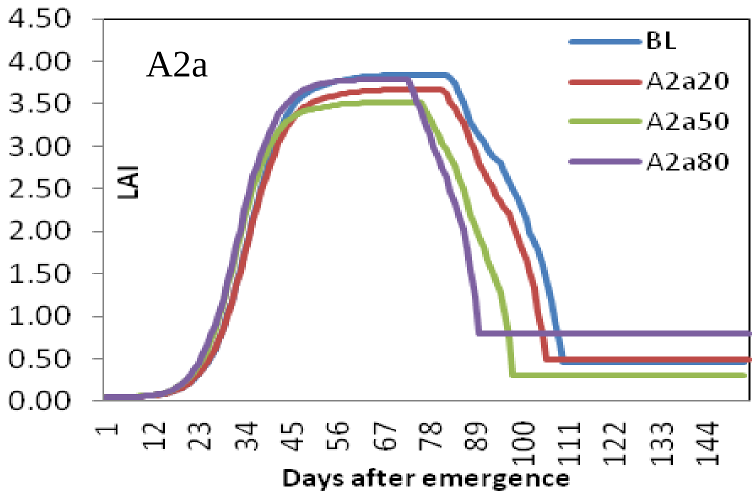


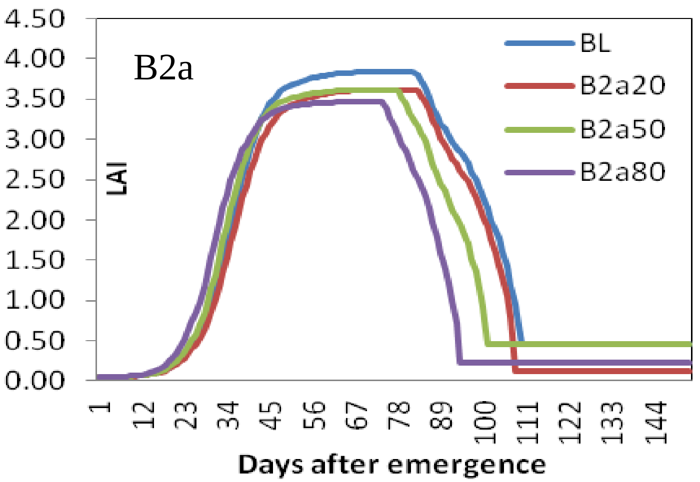




Effect of climate change on crop duration in rice over Doon Valley

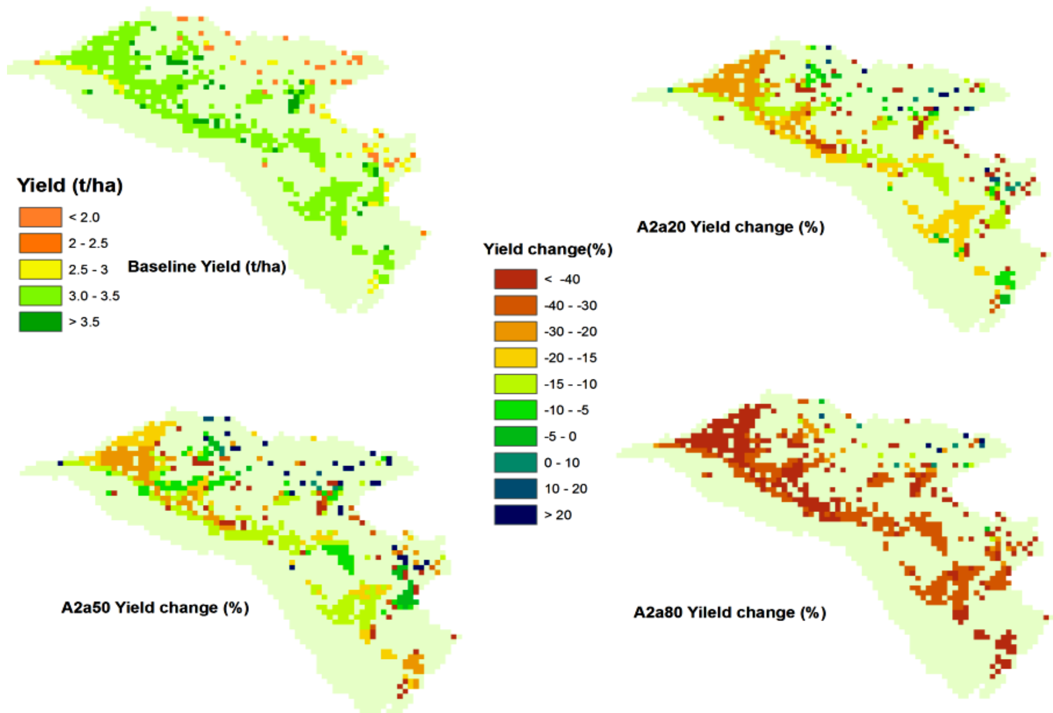
Scenario	DOP	DOM	Duration	Reduction in crop Duration
Base line	10-Jul	02-Nov	115	……
A2a20	10-Jul	28-Oct	110	5
A2a50	10-Jul	21-Oct	103	12
A2a80	10-Jul	12-Oct	94	21
B2a20	10-Jul	31-Oct	113	2
B2a50	10-Jul	24-Oct	106	9
B2a80	10-Jul	17-Oct	99	16





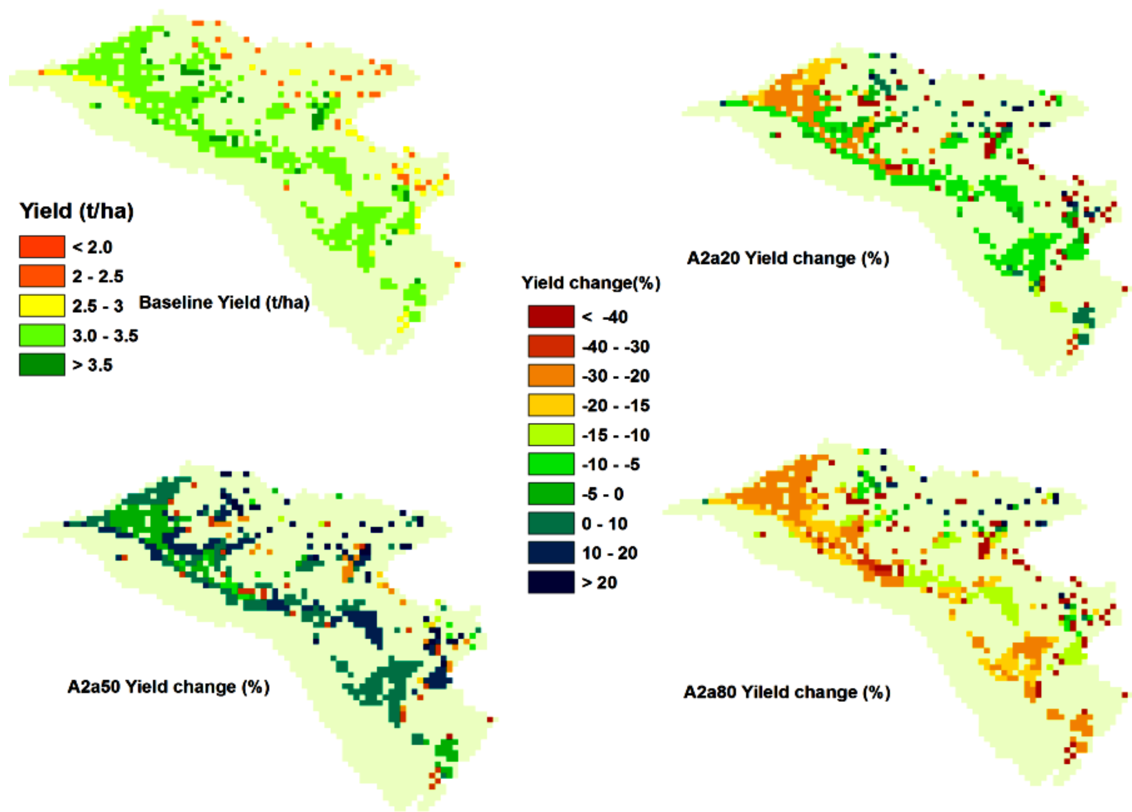
Wheat crop- *A2a Scenario without CO_2 fertilization*

Scenario	Period	Mean	SD	P5	P50	P95
Baseline Productivity ($t.ha^{-1}$)		3.17	0.33	2.97	3.17	3.73
A2a(NF)	2020	-21.15	13.53	-54.03	-16.51	-6.00
	2050	-15.72	15.41	-44.66	-14.68	-3.04
	2080	-42.34	10.81	-68.51	-39.76	-30.66



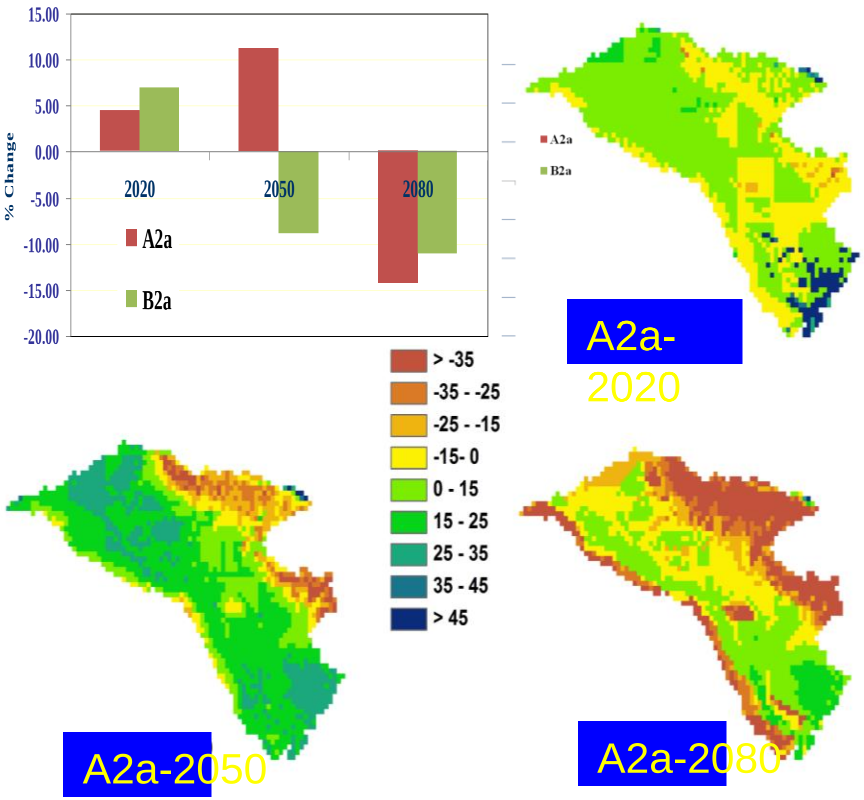
Wheat crop- *A2a Scenario with CO_2 fertilization*

Scenario	Period	Mean	SD	P5	P50	P95
Baseline Productivity ($t.ha^{-1}$)		3.17	0.33	2.97	3.17	3.73
A2a	2020	-13.93	14.76	-49.79	-8.84	2.48
	2050	4.13	19.00	-31.59	5.50	19.63
	2080	-23.72	14.27	-58.40	-20.19	-8.55

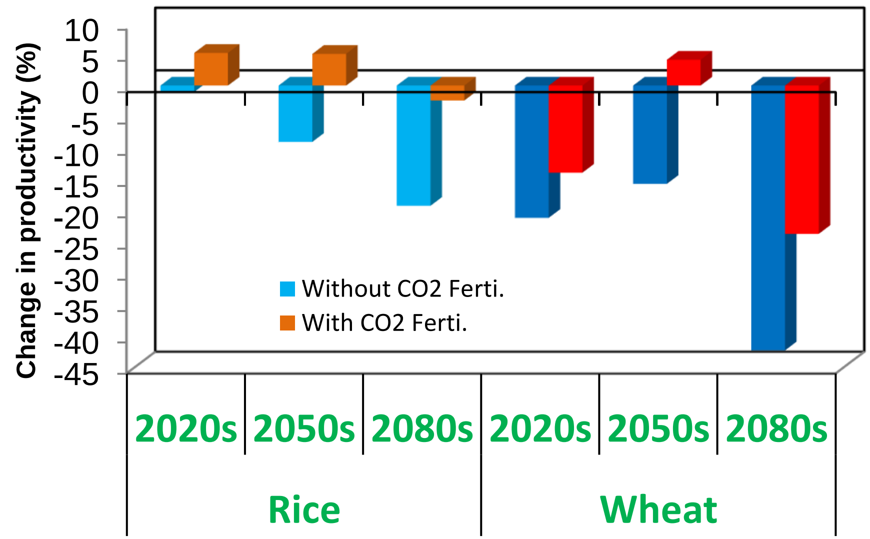


Productivity Changes in Doon Valley in future climate scenarios

Percent Change in Maize Productivity



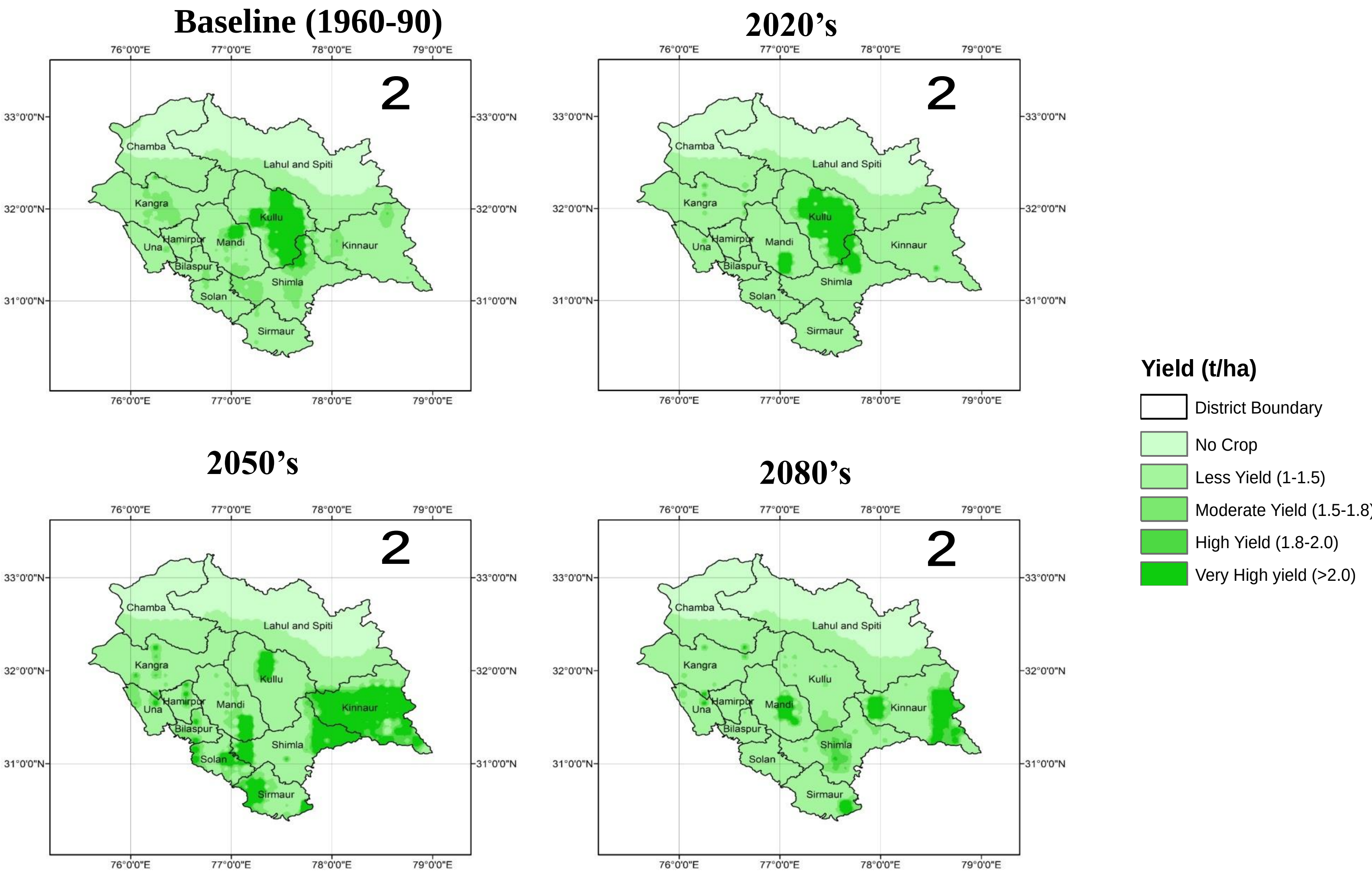
positive/Negative changes in crop yields



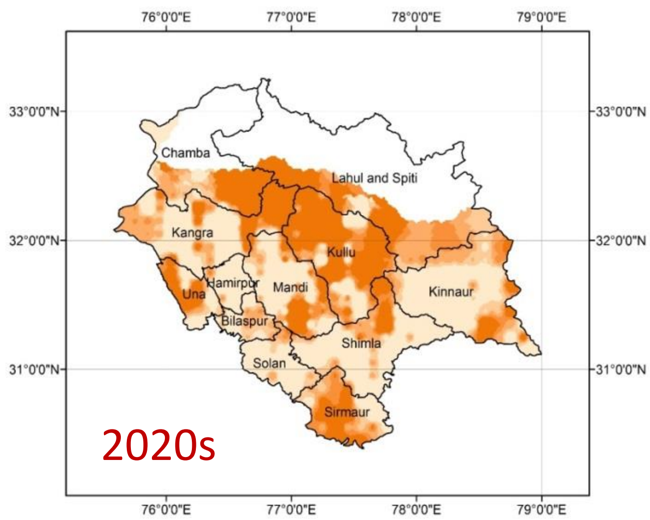
Decline in crop yields (%) in 2080s without CO_2 ferti.

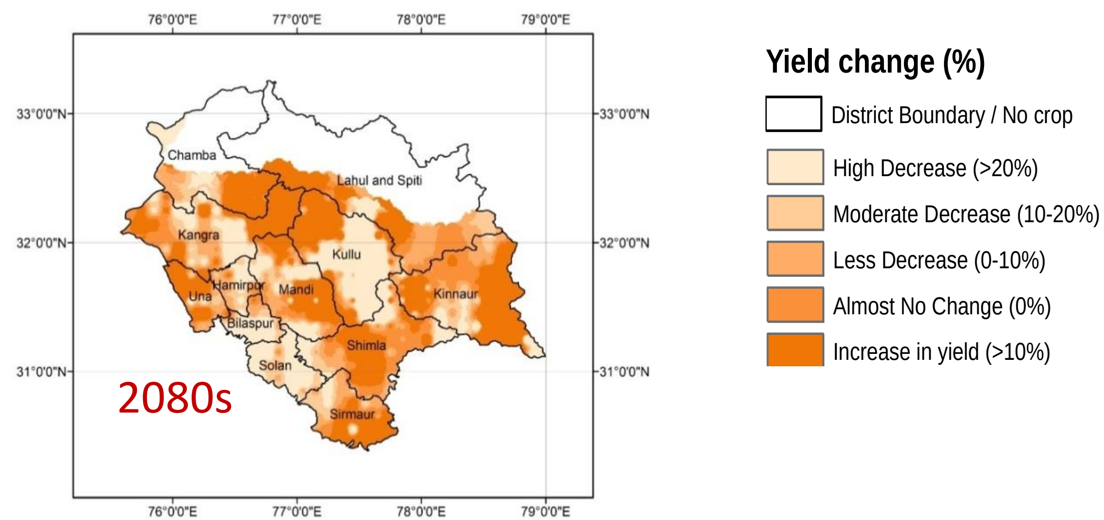
Wheat >	Rice >	Maize
40	20	14

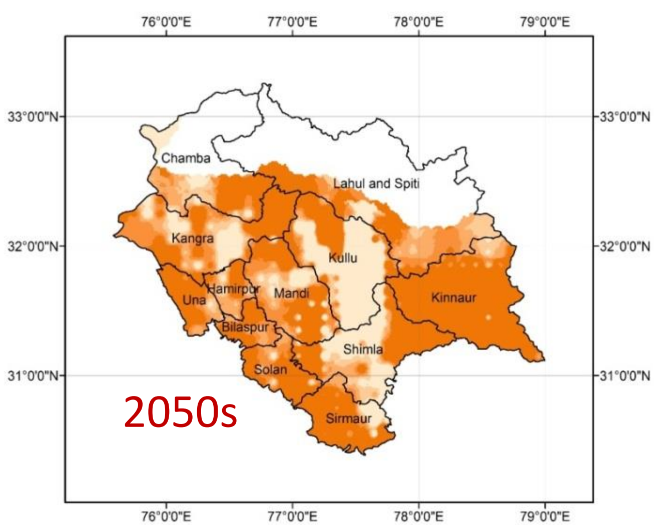
Simulated wheat yield in future climate scenarios using GEPIC



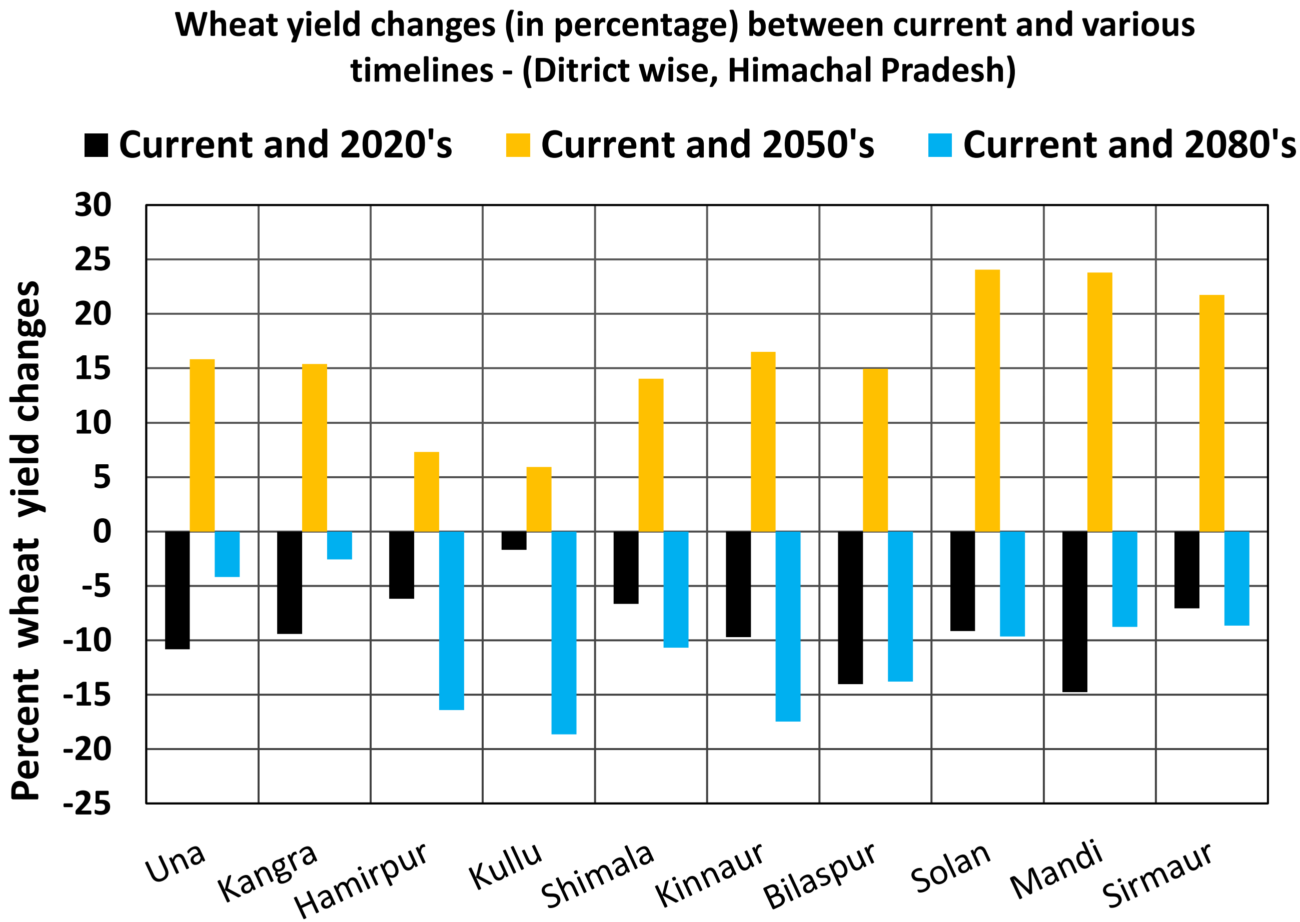
Changes in wheat yield under climate change scenarios (GEPIC Model simulation over HP)





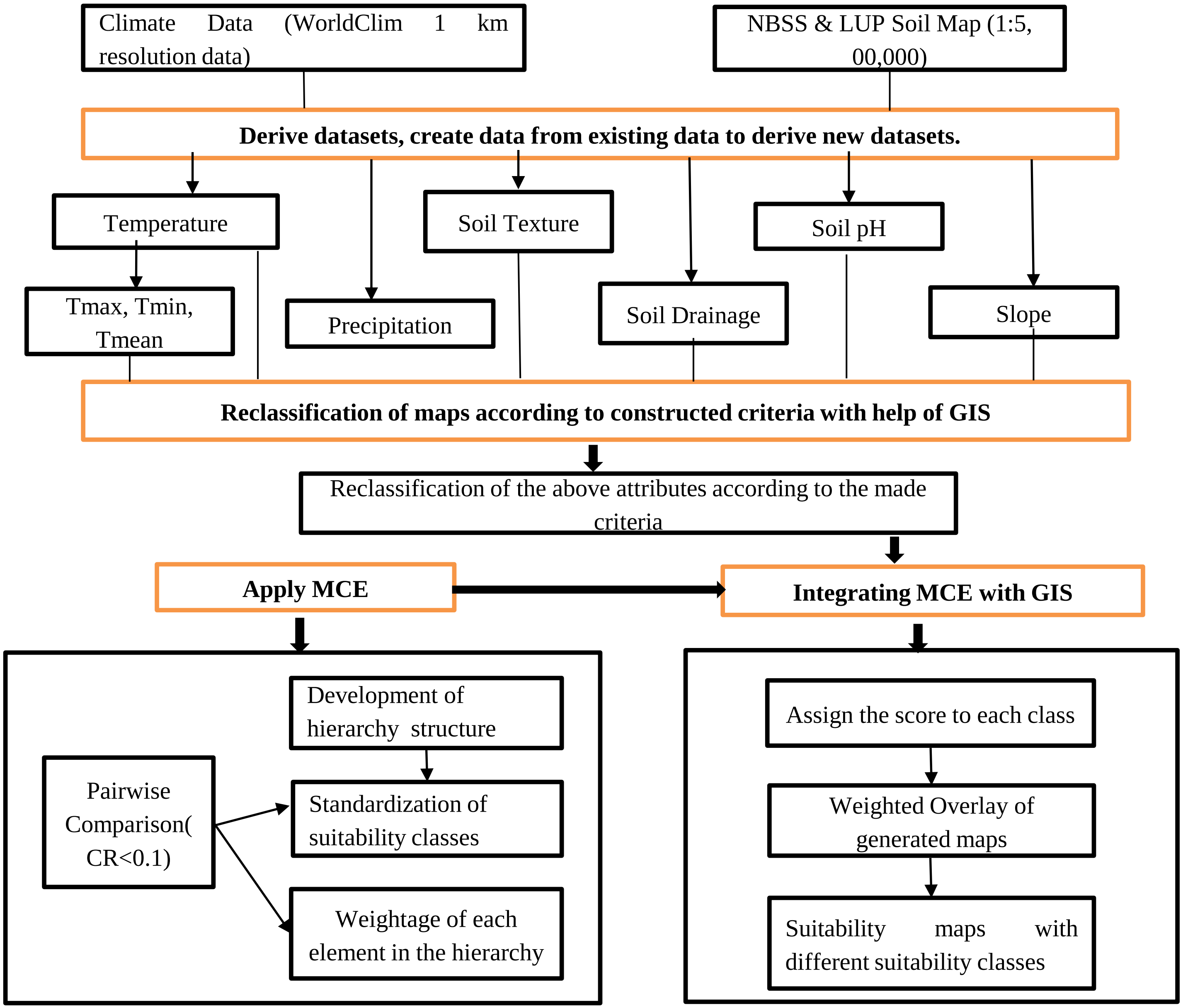


- Overall changes in wheat yield of whole HP is negative in 2020s and 2080s.
- Decline in 2020s and 2080s by 9 and 11 %, respectively.
- However, increased in 2050s by 15%

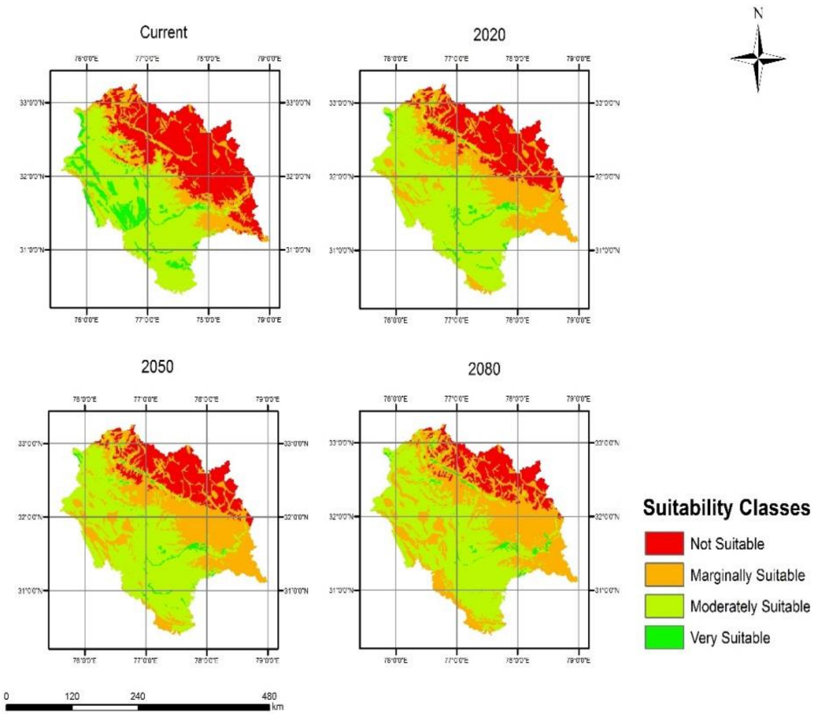


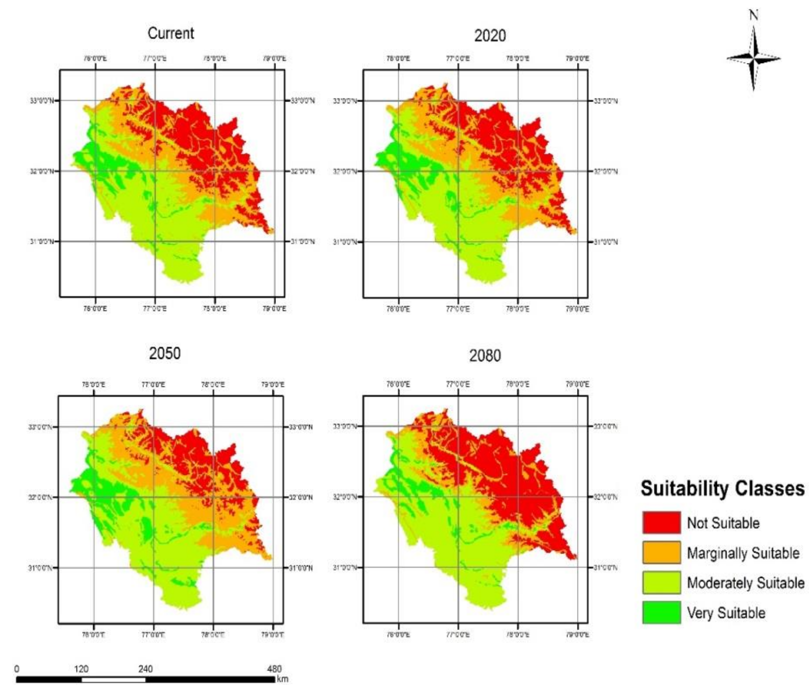
- Overall, the majority of districts in Himachal Pradesh will witness decline in wheat yield in 2020s.
- However, there will a positive sign of increase in 2050s due to favorable climate conditions.
- Later in 2080, extreme warming will have substantial reduction in wheat yields

Land suitability of Maize and Wheat in Climate change scenario: A MCE approach



Land suitability of maize and wheat in climate change scenario





Maize

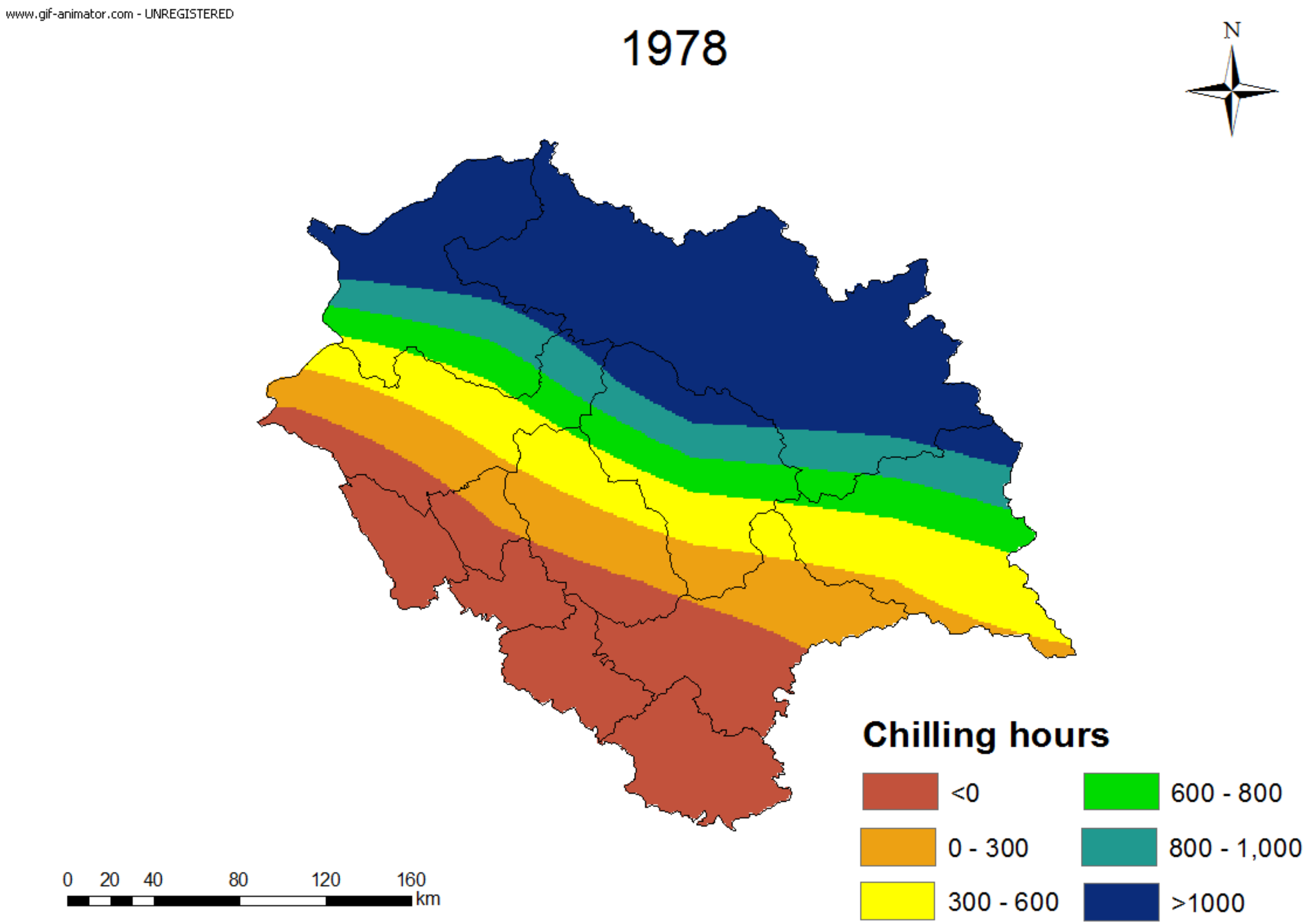
Suitability Class	Current Area(km^2)	2020 Area (km^2)	2050 Area(km^2)	2080 Area (km^2)
Highly Suitable	4277	1157	944	834.2
Moderately Suitable	23597	26366	25993	25730.4
Marginally Suitable	9680	16482	19704	22248.1
Not Suitable	17992	11540	8905	6734.3

Wheat

Suitability Class	Current Area(km^2)	2020 Area (km^2)	2050 Area(km^2)	2080 Area (km^2)
Highly Suitable	4508	5210	6064	3499
Moderately Suitable	22103	21145	22345	23638
Marginally Suitable	15369	16328	17756	8999
Not Suitable	13566	12862	9376	19409

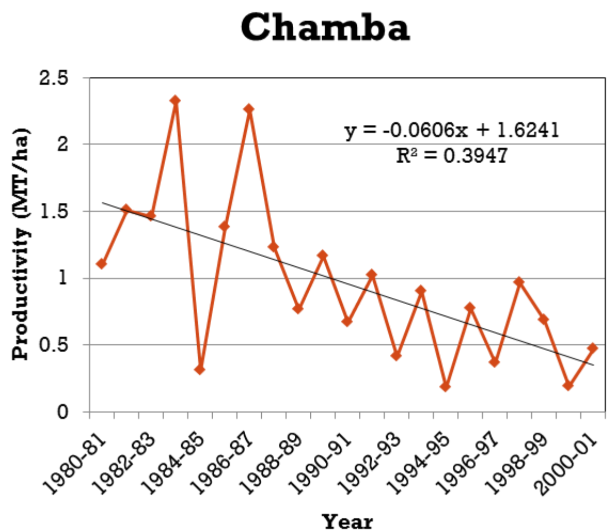
According to MCE, suitable areas for winter wheat will increase till 2050 and then it will decrease, Non-suitable areas shows decreasing trend up to 2050 but increases drastically in

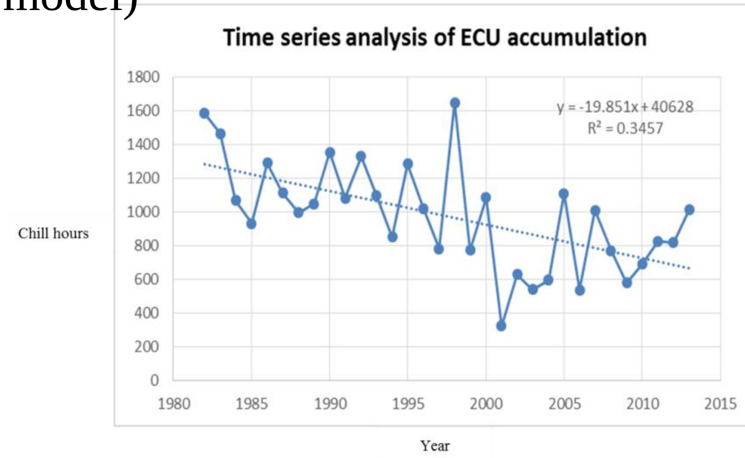
Spatial distribution of accumulated Chill Units from year 1978-2013



Shift in apple suitability based on chilling units in H.P.

(UTAH chill unit model)





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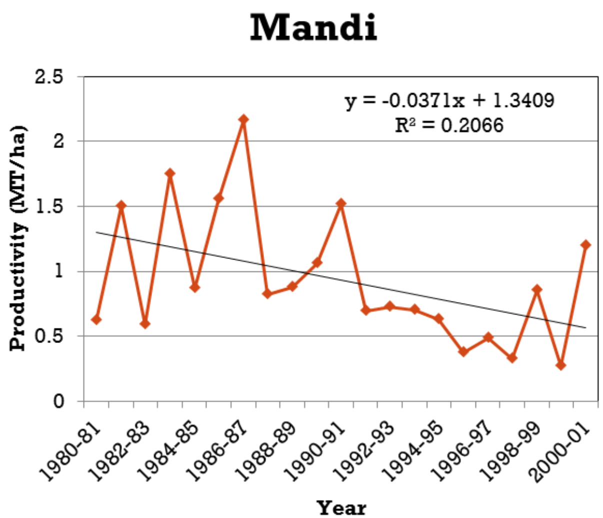
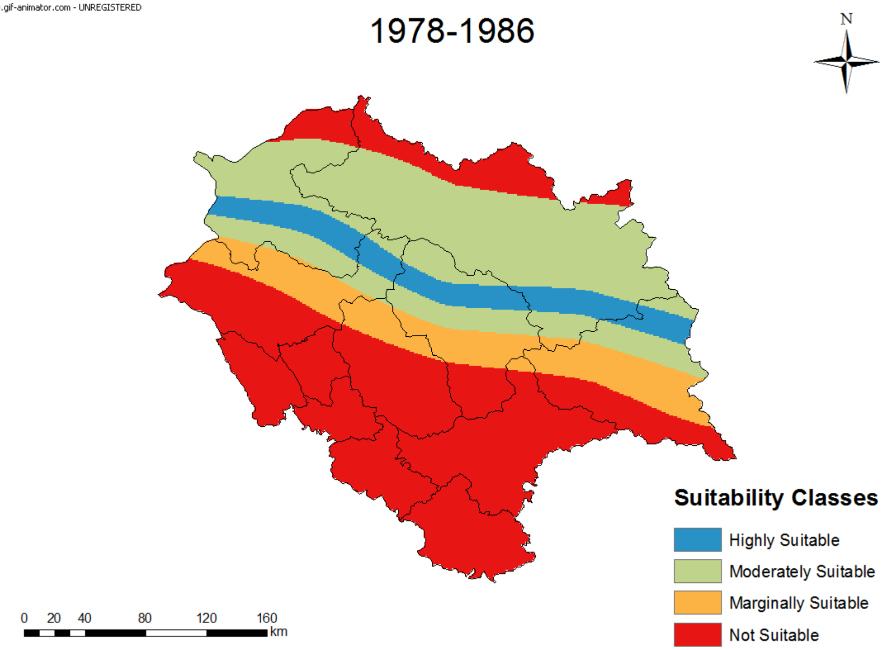
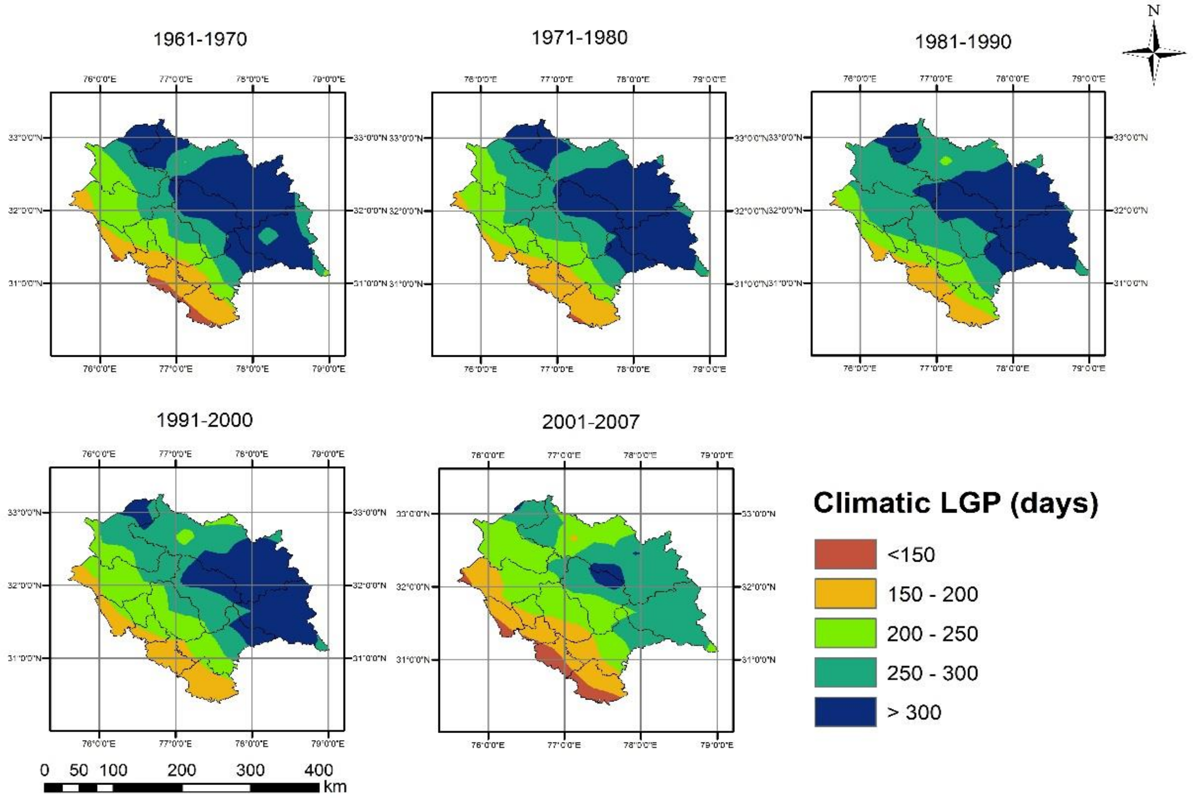




Effective chill unit (ECU) accumulation has decreased significantly from 1997 to 2013 and this decreasing trend is continued to affect apple cultivation. Suitable areas for apple cultivation shifting towards high-altitude in Himachal Pradesh

Climatic LGP analysis for five decades from 1961 to 2013 (Aphrodite climatic data)

LGP : It begins when RF > ½ PET and ends when RF< ½ PET plus number of days required to deplete 100mm moisture storage



- Areas under adequate length of growing period (period in terms of water availability for crop production) showed declining trend from 1971 to 2007.
- The decreasing trend may seriously affect land suitability zones for food grain crops

Summary

- Integrated use of climate scenario from Global Circulation model (GCM), crop models and geospatial data (e.g. topography, soil and land cover) within GIS could improves spatial representation of climate induced projection of crop productivity and land suitability changes in future climate scenarios
- To address heterogeneity issue over mountain ecosystem, down-scale climate output or higher spatial resolution climate models being helpful to provide more accurate predictions for future climate scenarios.
- With temperature increasing and precipitation fluctuating, water availability and crop production will surely decrease in the extreme warming scenarios in future.
- Crop water productivity may decrease in the future. Improving water productivity and keeping more stable food-water availability linkage will be vital for food security.

More crop per drop

More jobs per drop

Innovations, Interventions …

Right of the poor farmer…

Food Security in India is best described in million person years of jobs and livelihoods rather than in million tonnes of food grains

- MS Swaminathan, 2001