Integrated Assessment of Climate-change Impacts on Maize Farm Household Incomes in South India: A Case Study from Tamil Nadu

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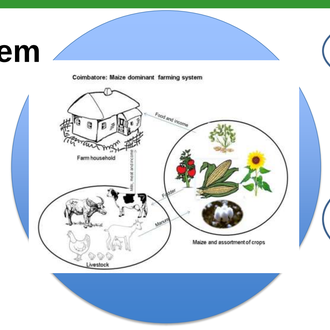
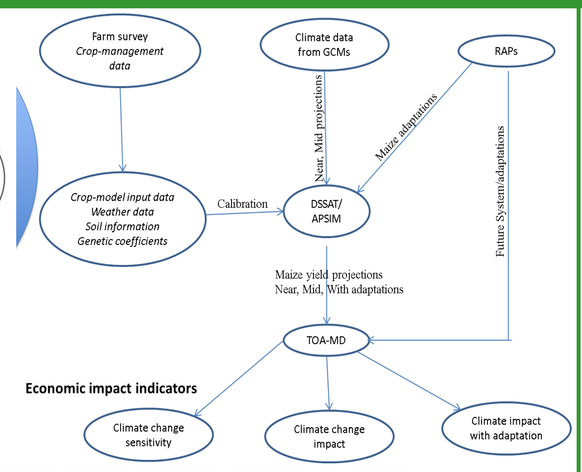
1. Irrigated maize farm system and the analytical protocol

Irrigated maize farm system of Tamil Nadu and the analytical protocol

In Tamil Nadu Maize-sunflower/ Tomato – Maize/ Maize-cotton/ Pulse – Maize is grown in annual rotation.



Livestock such as goat, cow and poultry play a significant role as an alternative livelihood option, regular employment and income generation activity. Farm household, agriculture and livestock components are complimentary and depend on each other on day-to-day basis.



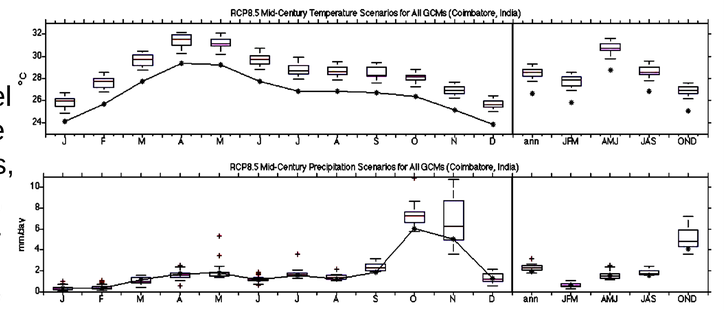
TOA	System 1	System2
Climate	Current	Future
system	Current	Current (C)

System 1	System2
Current	Future
C with trend (t)	C with t

System 1	System2
Future	Future
C with t	Adaptation

2. Climate projections

Future climate projections made using "delta" method for near term, mid and end century. RCP 8.5 used in crop-model simulations for 20 CMIP5 GCMs. For the crop-model and agro-economic analyses, five GCMs viz., CCSM4, GFDL-ESM2M, HadGEM2-ES, MIROC5, and MPI-EMS-MR used. All models show warming, while precipitation response is decidedly more uncertain. While all temperature changes are significant, several GCMs show insignificant precipitation changes, although three of the five selected GCMs show a strongly (positive) significant rainfall response change.



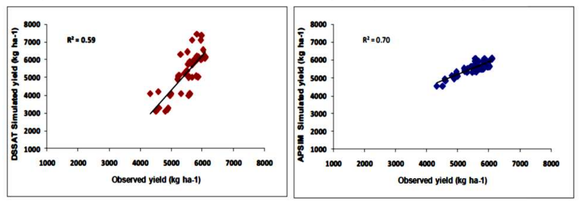
Projected changes in monthly mean temperature and rainfall for RCP 8.5 mid-century in Coimbatore. Black lines and stars indicate the baseline climate and the box-whisker plots show the spread in projections amongst the 20 GCMs taken from CMIP5. Averages for the annual (ann), January to March (JFM), April to June (AMJ), July to September (JAS), and October to December (OND) are shown at the far right of each plot.

3. Crop model projections

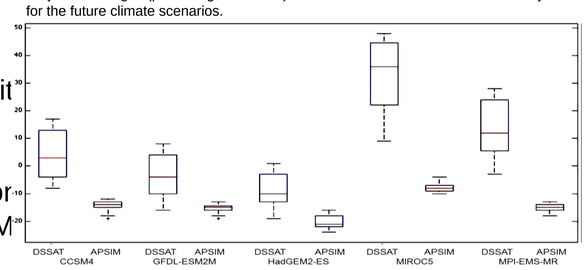
Calibrated DSSAT and APSIM with 2010–11 weather data and farm survey input data used to simulate irrigated maize yield for 60 farms. Strong correlation between simulated and reported yields observed. Historical baseline yield projections (1980–2010) for 60 farms exhibited heterogeneity due to management differences.

Future yield projections of RCP 8.5 mid-century under selected five GCMs for the 60 farms under both DSSAT and APSIM models indicated possibilit of yield decline with varying magnitude. DSSAT simulated positive yield deviation under CCSM4, MIROC5 and MPI-ESM-MR, and negative deviation under GFDL-ESM2M and HadGEM2-ES. In APSIM all GCM forcings projected negative deviation..

Crop model simulated vs reported farmers' maize yields (2010–11 cropping season.



Projected changes (percentage deviation) in APSIM and DSSAT simulated maize yields for the future climate scenarios.

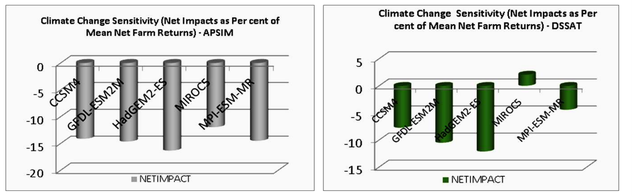


4. Integrated assessment of Climate change sensitivity and impacts

RAPs derived variable values used for TOA integrated assessment

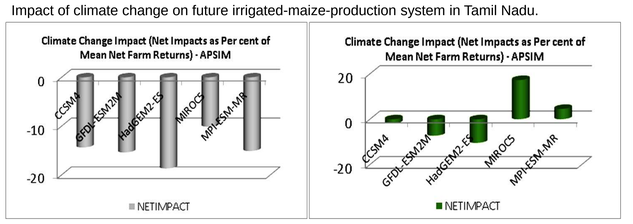
Variable	Q1		Q2	
	System1	system2	System1	system2
HH size	4.38	4.38	3.29 (25 % decrease over Q1)	3.29
Non Farm income	32778	32778	45889 40 % rise as per RAPs	45889
Farm size	1.85	1.85	2.31 (25 % increase over Q1)	2.31
Maize yield	As per survey	crop model based estimation	1.97 times Q1 sys1 Based on IMPACT trend	Crop model based
Yield of other crops (Rs)	62990	50077 10% decrease over sys1	75588 20 % increae over Q1 sys1	68029 10% decrease over sys1
Maize price	10.1 As per survey	10.1	1.4 times IMPACT trends	1.15 times of sys1 Q2 (IMPACT)
Maize var cost	As per survey	Calculated as per protocol	1.97 times of Q1 IMPACT trends and (As per RAPs)	Calculated as per protocol
Var Cost of other crops SD Net	30838 27237	30838 27237	38548 (1.25 times) (As per RAPs) 31550	46257 (20 % rise) 21518
Fixed cost_maize	--	--	--	--
Livestock income Cost SD Net income	69659 30805	66176 (5% decline) 30805 (No change) 16536	76625 (10% rise) 33885 (10 % rise) 18314	72793 (5% decline) 33885 (No change) 18190

Sensitivity of the current irrigated maize-production system in Tamil Nadu to climate change



Sensitivity of Current P System to Climate Change : APSIM simulations relating current system sensitivity consistently indicated lower yields under climate change, lower mean net returns, lower per capita income, and higher poverty levels for System 2 on irrigated maize farms. DSSAT results projected positive impacts. The results were fairly consistent across GCMs between APSIM and DSSAT. Maize-crop yield as such is sensitive to the crop model used to predict yields, followed by climate projections represented by the GCMs.

Impact of climate change on future irrigated-maize-production system in Tamil Nadu.



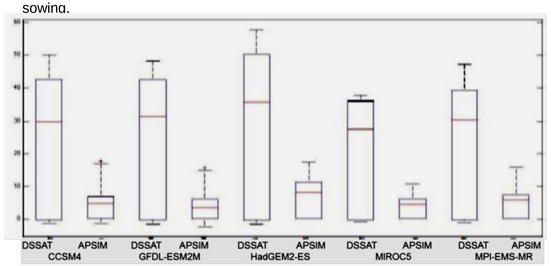
Considering **climate-change impact** , future system returns are projected to be higher, mainly due to improvements in yields, incomes, prices, and non-farm incomes of the system components. There would be higher per capita incomes and poverty rates drastically reduced to less than 5%. except in MIROC5 where there was a negligible decline of 0.05%. Climate-change impacts seem to be influenced by crop models and GCMs in that order.

5. Adaptation package and maize yields with adaptation

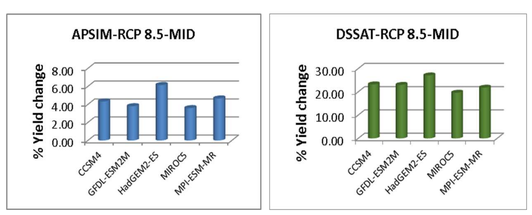
The adaptation package envisaged includes altered sowing dates and the use of water-saving measures through drip irrigation, which does not affect the quantum of water normally available to a maize crop. Water saved is to be used for improving yield of fodder sorghum, which can contribute to increased returns from other crops and livestock.

DSSAT and APSIM simulated maize yields under RCP 8.5 mid-century with changed date of sowing and irrigation infrastructure showed that crop yields would significantly increase in the future. Altering sowing window reduced climate change impact and increased maize yields relative to baseline conditions. All five RCPs used projected positive yield deviations, ranging from 14.82% to 18.37% in DSSAT and 22 3.38% to 5.55% in APSIM.

Per cent Yield change under RCP 8.5 mid-century climate, with altered date of sowing.



DSSAT and APSIM projected changes in maize-grain yields with date-of-sowing (DOS) adaptation compared to climate-impacted future yields without adaptation in Coimbatore.

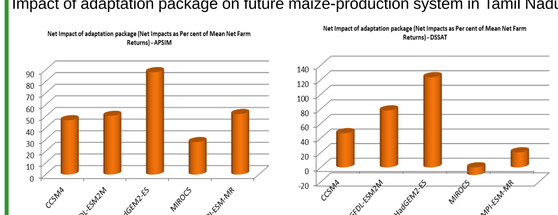


6. Impacts of adaptation

RAPs derived variable values used for TOA adaptation impact assessment

Variable	Q3	
	System1	system2
HH size	3.29	3.29
Non Farm income	45889	45889
Farm size	2.31	2.31
Maize yield	As in Sys2 Q2	Crop model based
Yield other crops (Value Rs)	68029	74832 (10% rise)
Maize price	as in Q2 sys1	as in Q2 sys1
Maize var cost	as in Q2 sys1	As per protocol
Var Cost of other crops	46257	48570 (5% rise)
SD Net	21518	24735
Fixed cost_maize	--	25000 Drip adoption
Livestock income	72793	80073 (10 % increase)
Cost	33885	35580 (5% increase)
SD Net income	18190	19189

Impact of adaptation package on future maize-production system in Tamil Nadu.



The adaptation package proved with implied adoption rate of about or more than 90% in most GCMs and APSIM and DSSAT, except in MIROC5 with lowest rates both for DSSAT with 31.02% and APSIM with 84.09%, since the future projected yield with climate change was highest in MIROC5. APSIM indicated yields increase of 3.59% to 6.15% across the GCMs, while DSSAT projections were in the range 19.64% to 27.09%. Poverty rates of households, per capita incomes levels, and mean farm net returns have shown similar responses when compared to climate-change scenarios as per different GCMs, with and without adaptations.

Net farm returns and per capita income increase across all GCMs, and by using both APSIM and DSSAT, though the magnitudes of the increases differed across GCMs. MIROC5 was again associated with least increase. Adoption of the package increased farm returns, per capita income, and reduce poverty, which indicates the mitigating effects and benefits of an adaptation package to climate change

Acknowledgements

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