Adaptation to Climate Change in Agriculture: An Exploration of Technology and Policy Options in India

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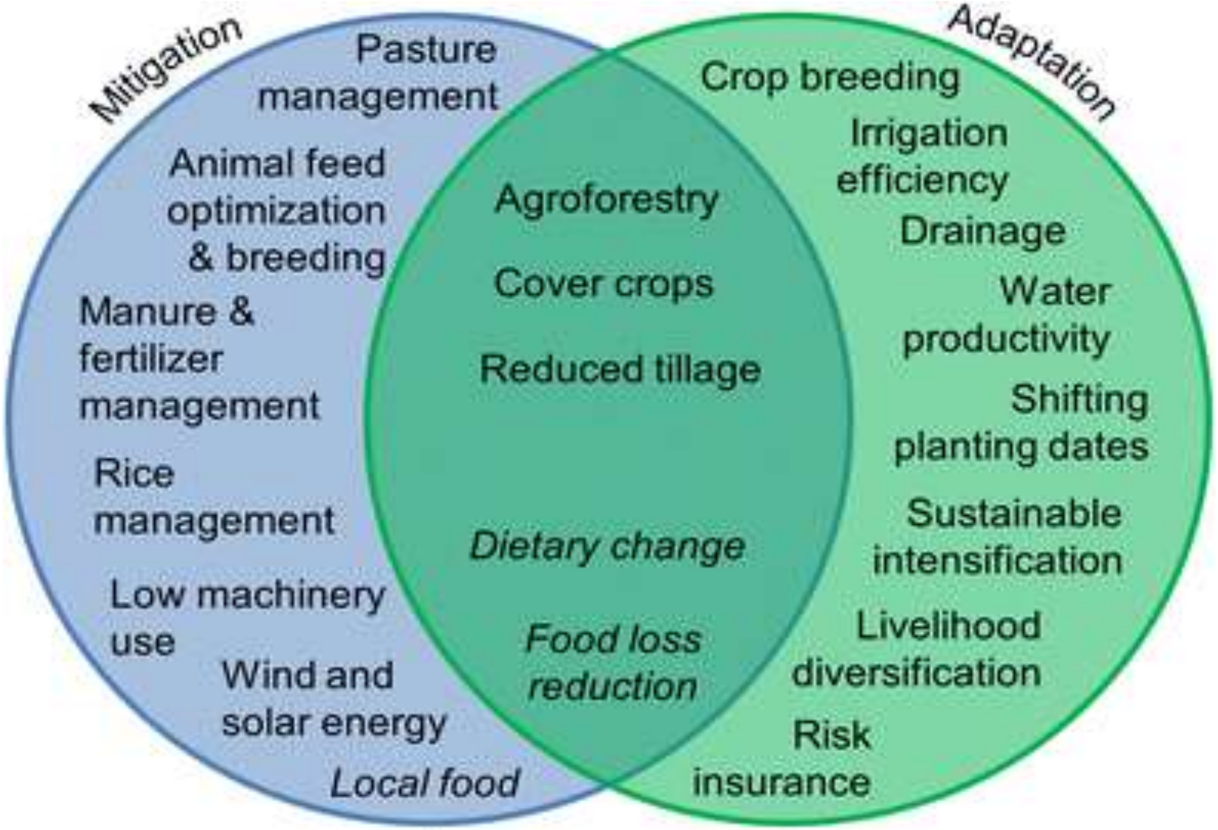
- Adaptation as a mechanism to address climate change impacts
- Biophysical technologies & practices facilitating adaptation for ensuring WEF security.(Three case studies)
- Policies & institutions to promote adoption of climate smart interventions
- Concluding remarks



Agriculture and Climate Change

- Agriculture is the Nature's Carbon and Water based industry in which major impacts of climate change are being transmitted through changes in Hydro-cycle, adversely impacting the water Demand and Supply equation . Agriculture& CC have TWO-WAY RELATIONSHIP
- Mitigation and Adaptation are the

  two mechanisms to meet the challenge
- Mitigation addresses the causes

  of climate change
- Adaptation addresses

  the impacts of climate change

Issues Involved in Adaptation Planning & Implementation

- Quantification of vulnerability of farming enterprises (crops, livestock, fish) to climate change; likely limits to adaptation; and how adaptation can be achieved through:

  - Available incremental yield increasing technologies , reduction in food loss & waste, diet modification

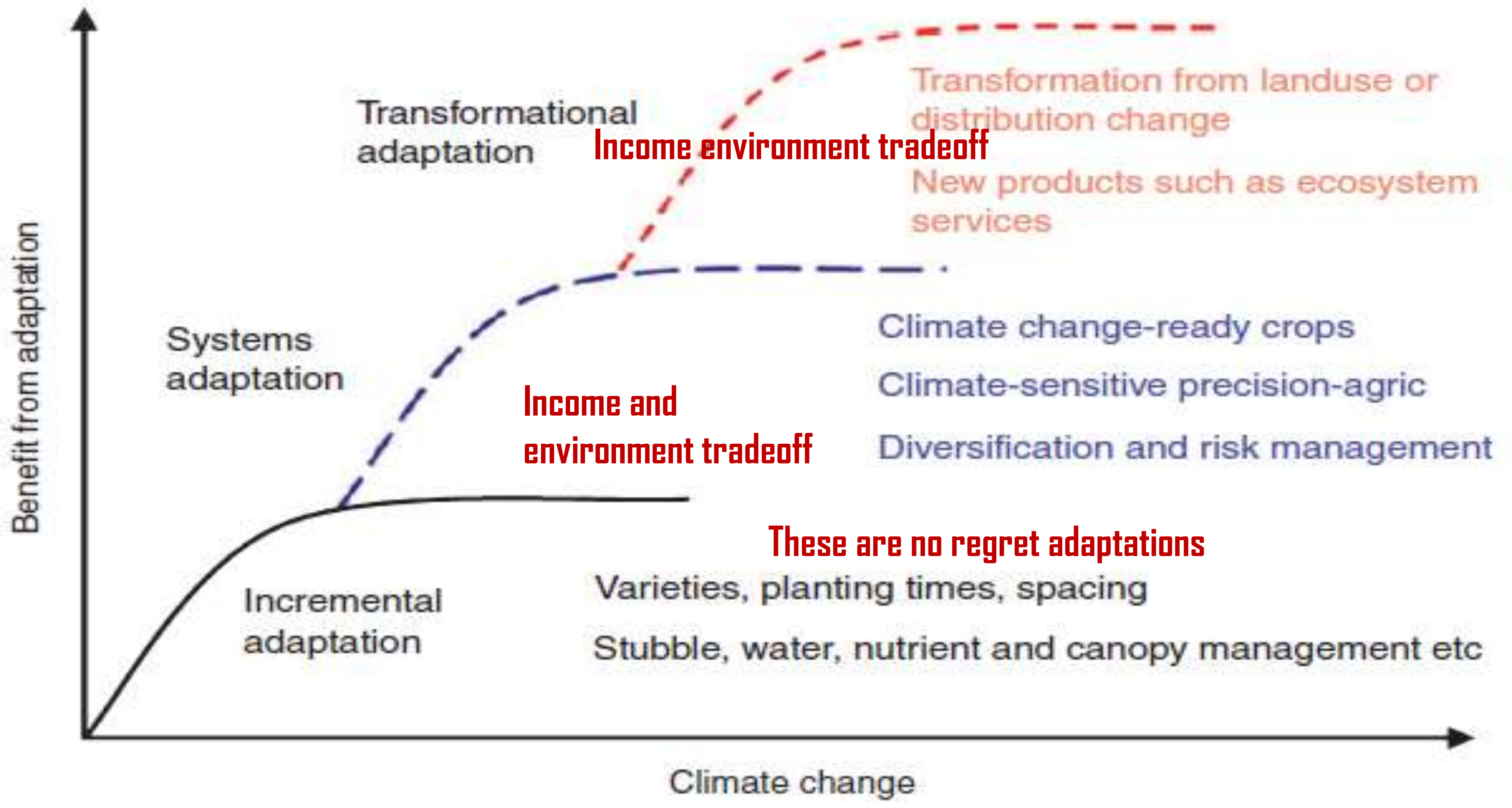
  -Development of new systemic technologies , practices and delivery approaches for better management of climate variability (Climate-ready crops, maintaining micro-climates around crops ,seasonal climate forecasting technology, Technologies for identifying hot spots)

  -Transformative adaptation: Land use changes,3-D Sea farming, Ecosystem services, Artificial photosynthesis, Migration of population

- Identifying the stage, when transformational change may be needed; the options and their consequences; and how to support decision making process

- Ensuring that adaptation actions do not increase the national emissions footprint.

Benefits from adaptation actions change with intensity of climate change(Howden,2010)



Complexities for Adaptation in Agriculture & Food Sector

Agriculture & food systems are multidimensional: Biophysical systems, Economic systems, Social systems. and Institutional . These dimensions interact from Local to Global scale; Global to Local scale.

An adaptation option for one sector can put new pressures on another sector.

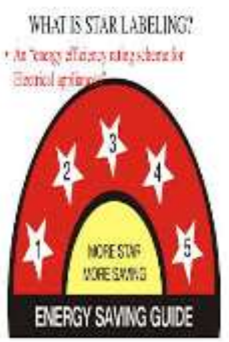
FURTHER

- Impacts are region specific
- Impacts are crop specific
- Adaptations are, to some extent, Farmer specific

Therefore "one size fits all approach" is not feasible. A basket of options has to be developed.(Adaptation Futures,2010)

Current Incremental Biophysical Technologies

Level of adoption: ZT-3 m,LL-2m , MI-8 m



CASE STUDIES

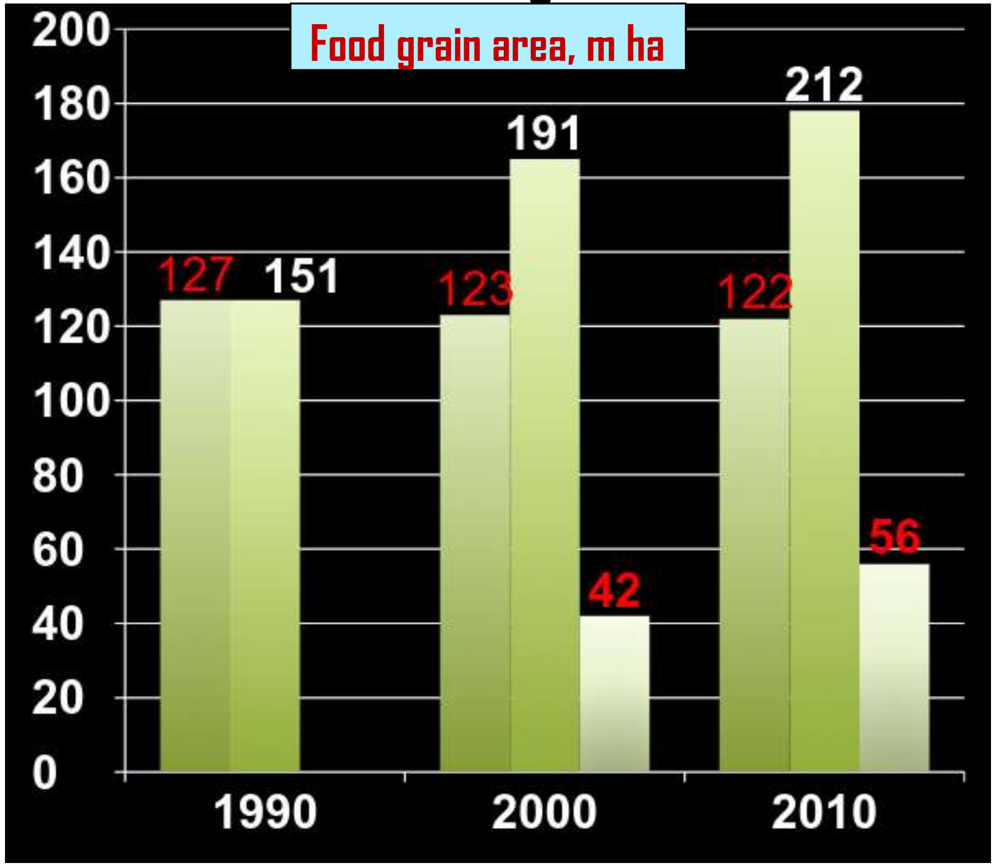
I) Impact of Green Revolution Technologies on Production, Productivity, Reduction in Carbon foot prints, and Adaptation-led mitigation

II) Adaptation through diversification by reallocation of crop areas & Incremental technologies

III) Assessing the influence of socio-economic factors on choice of climate smart technologies through Willingness To Pay method

Changes in Production and Productivity due to Incremental Green Revolution Technologies' adoption (Tyagi et al,2019)

(Due to Increase in Irrigation and Fertilizer use)



	1990	2010
Irrigation (mha)	68	85
Fertilizer (kg/ha)	58	144

Food grain production-40.4% increase

- 1990: 151 mt
- 2010: 212 mt

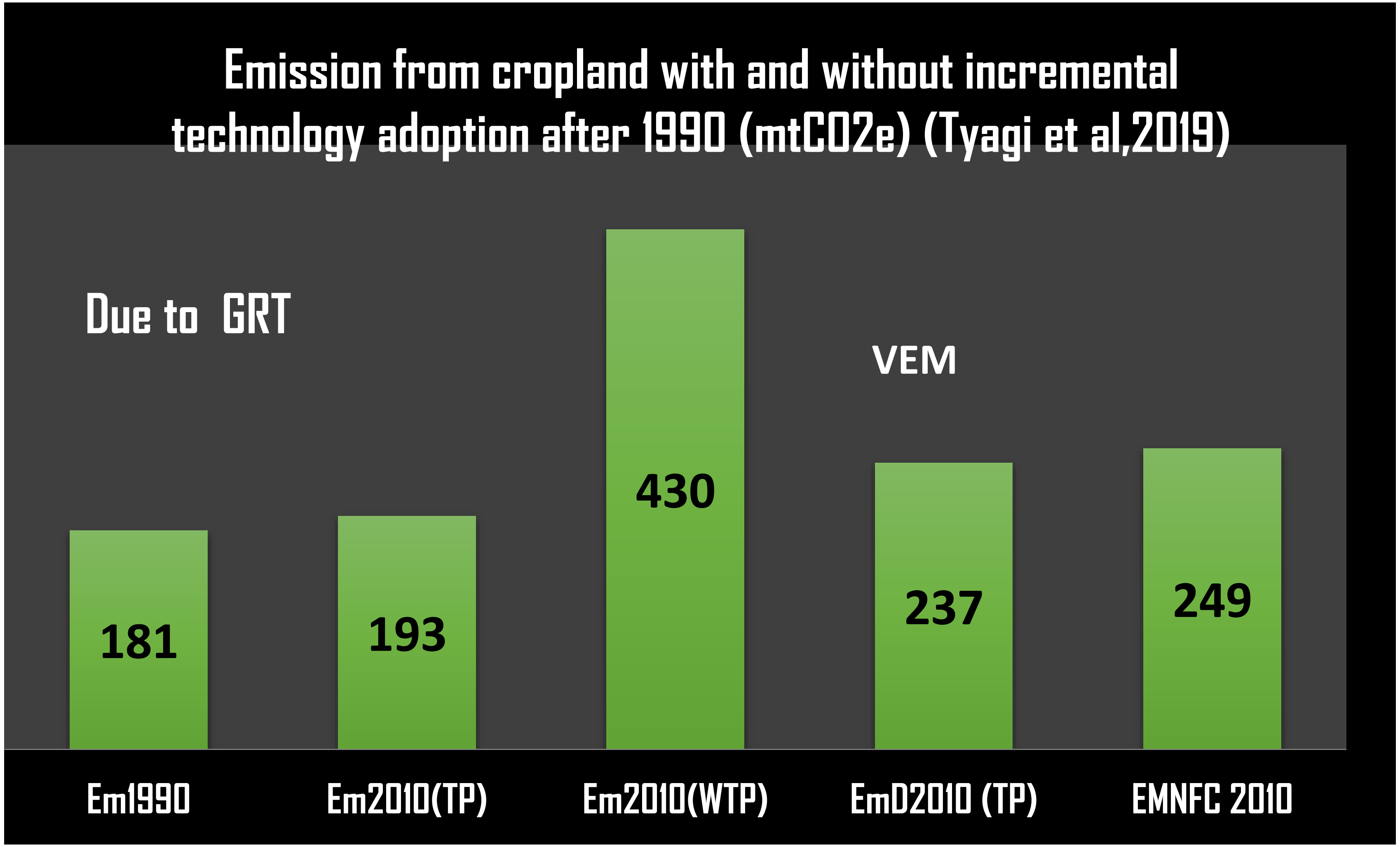
Productivity-46 % increase

1990: 1.19 t/ha

2010 :1.74 t/ha

Avoided deforestation by year 2010=56 m ha & brought resilience

Proves Borlaug's hypothesis-Agricultural innovations spare land



Food grain carbon foot prints, (ton CO_{2e} per ton FG)

1990=1.196

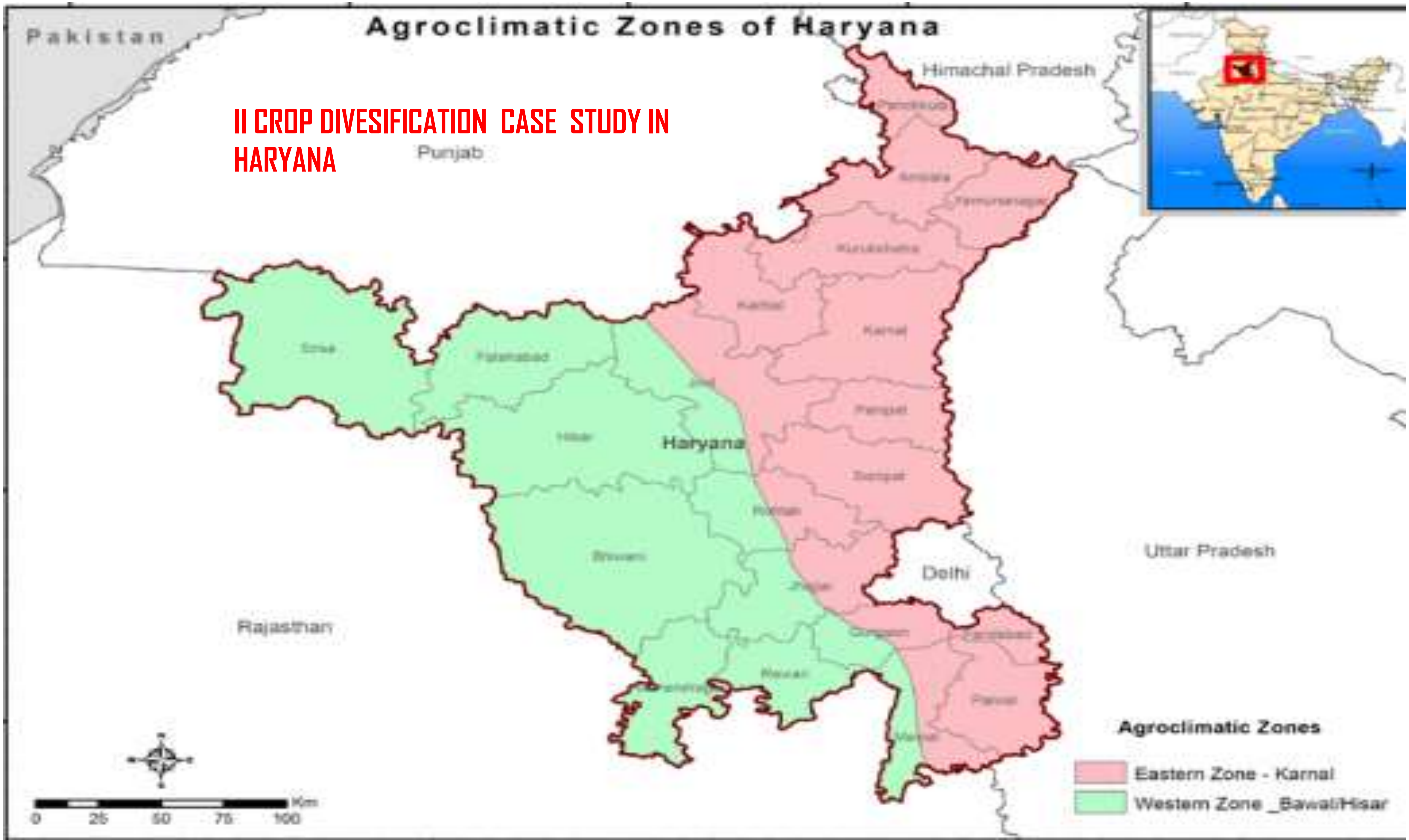
2010=0.907

MI_{AFC}=0.948

MI_{NAFC}=0.539

Implementation of GRTs(TP) led to virtual emission mitigation (Em) by 237 MtCO2e & introduced resilience in farming

II CROP DIVESIFICATION CASE STUDY IN HARYANA



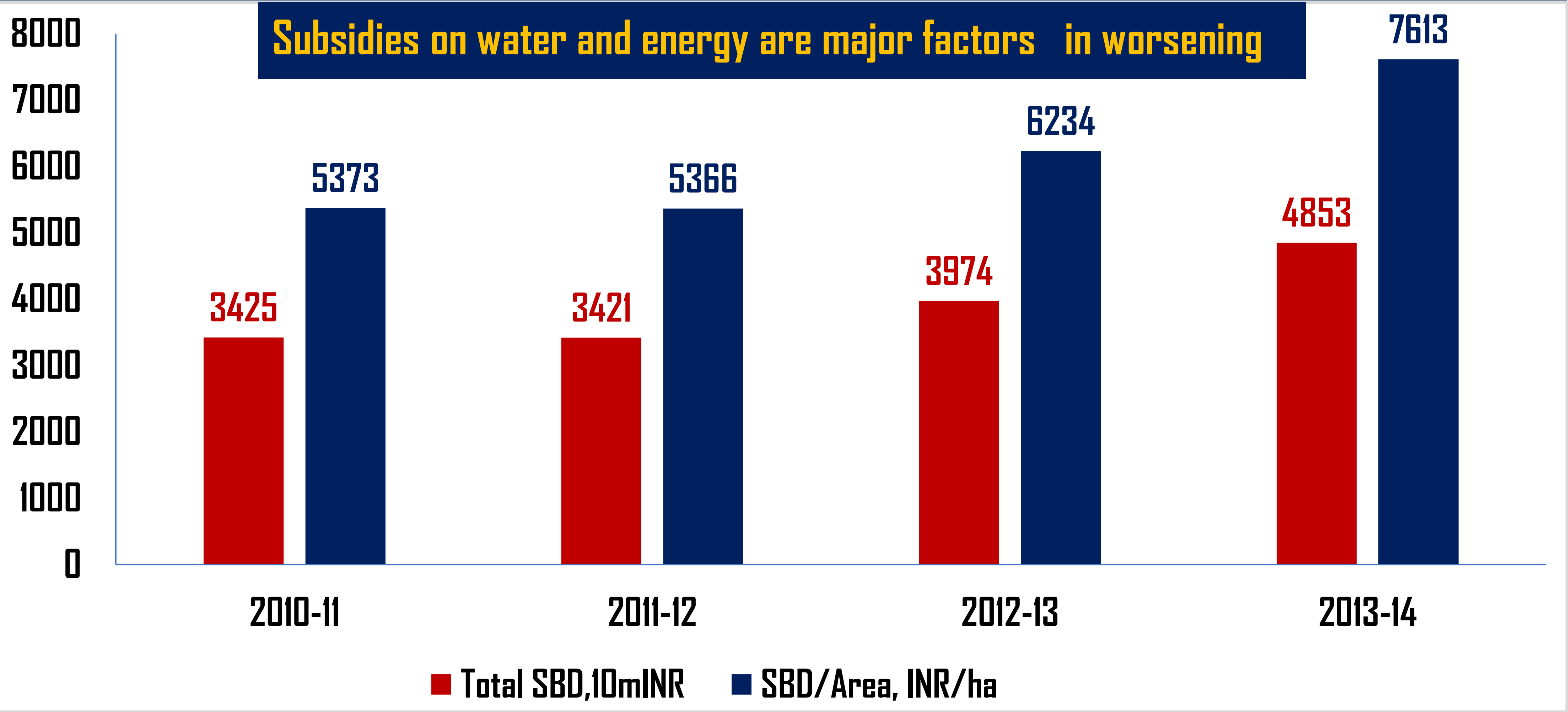
Case of Government policy supported maladaptation

Change in important water use indicators in Haryana

Item	1970-71	2014-15	Increase
Area irrigation,1000ha	15.32	29.73	1.94
Groundwater irrigation, 1000ha	5.8	18.18	3.13
Groundwater draft, BCM	2.6*	12.75(9.8)@	4.90
Electric pump sets, 1000 Number	104	557	5.35
Electricity used in irrigation, MkWh	476(1980-81)	7436	15.62
Average water table, m	9.19(1974)	15.8	1.72
Area under rice,1000ha/yield(T/ha)	259(1.7)	1278(3.11)	4.9 (1.8)
Area under wheat,1000ha	1129(2.07)	2628(3.98)	2.33 (1.92)
Area under cotton,1000ha	193(0.36)	647(0.51)	3.35 (1.42)

* Computed on the basis of number of electricity pumpsets in proportion to 2012-15;@=GWR

Increasing total and per ha subsidy(SBD) burden due to electricity driven tube wells in Haryana (Adopted from Sharma, etal,2015)

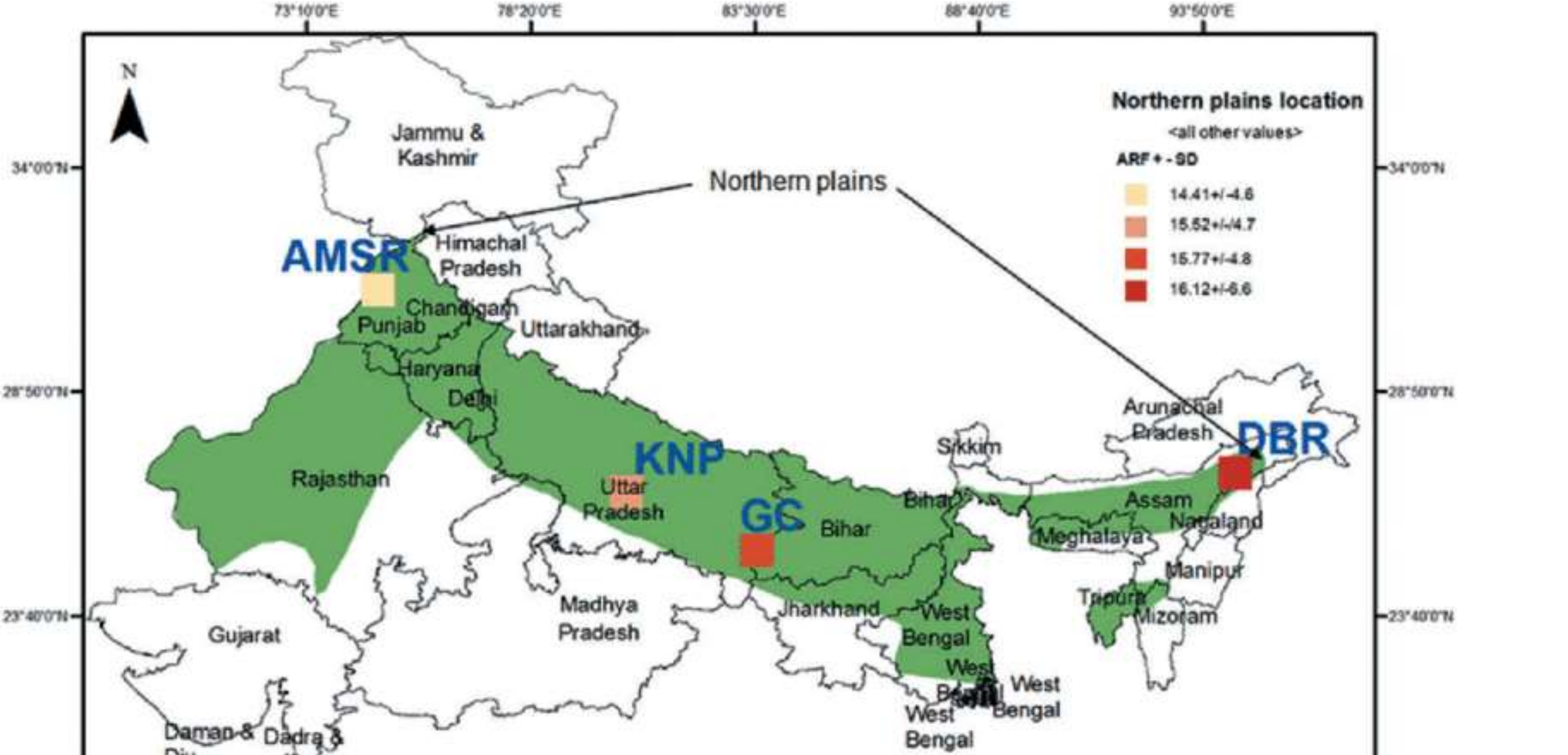


Adaptation through Crop Diversification & Agro-Technology Intervention for Harmonization of WEF Security in Haryana (Tyagi& Joshi,2019)

Intervention	Reduction in groundwater draft (BCM)	Energy (Million kWh)	GHG reduction (Million tonCO2e)
Diversification through reduction in rice, wheat, cotton area, & increase in pulses, oilseeds, and arid horticulture	5.3 3 (54 %)	Energy saving: With existing pump-sets 1434 With BEE labelled pump-sets 2213 million kWh	With existing pump-sets 1.5 With BEE labelled pump-sets 3.38
Introduction of zero till and laser levelling in entire irrigated area	2.27(23%)		
Micro-irrigation in sugarcane, wheat, cotton, fruits & vegetables	2.27(23%)		

Area reduction (%) & Reallocation:Rice-30 (Reallocated to Maize: Pearl millet: 80:20) ; Wheat-15 % (Reallocated to Veg.: Pulses & Oilseeds:12.5:87.5), Cotton -23 % (Reallocated to Arid zone fruits: Pulses ::67: 23)

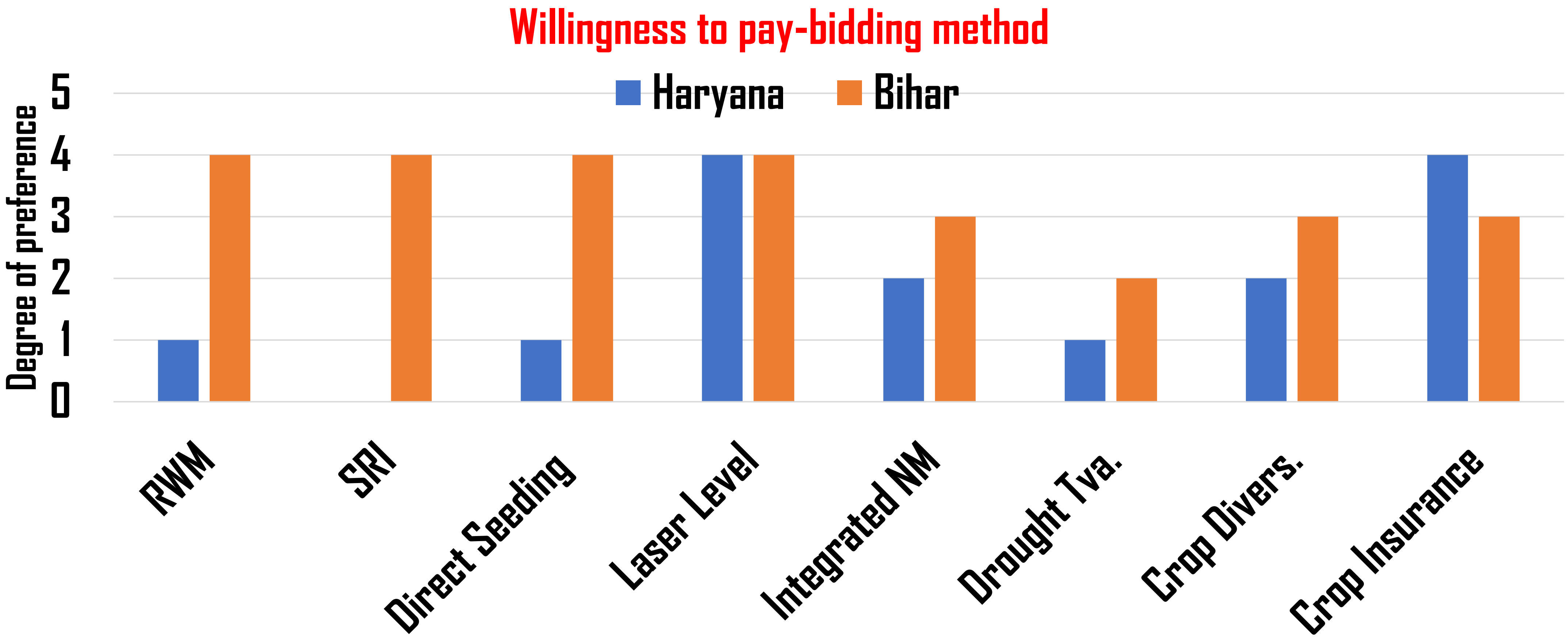
III. CCAFS Progamme on Climate Smart Villages in Haryana & Bihar



Climate Smart Agriculture

Water Smart Technologies	Laser levelling, Micro-irrigation, Irrigation scheduling ,SRI etc
Energy Smart Technologies	Zero tillage, Direct seeded rice, Laser levelling
Nutrient Smart Technologies	INM, LCC, GM
Weather Smart Technologies	Crop insurance (CI), Weather advisories (Institutional)
Knowledge Smart Technologies	Stress tolerant crops (ST) Diversification(CD)-Field, Farm, Region, Country, Global

Socio-economic factors affect technology adoption (Taneja et al,2019)



Emerging Potential Environmentally Friendly Agro-Technologies

- Plant Gene Technology
- Agribots
- Precision Farming (based on satellite imagery and advanced sensors and GPS)
- Farm-based bio-factories(will need only sun , sugar, algae and nutrients, and can be located anywhere.
- LED indoor crop technology(harvest 20-25 times a year by using "light recipe" , using 85 percent less energy.

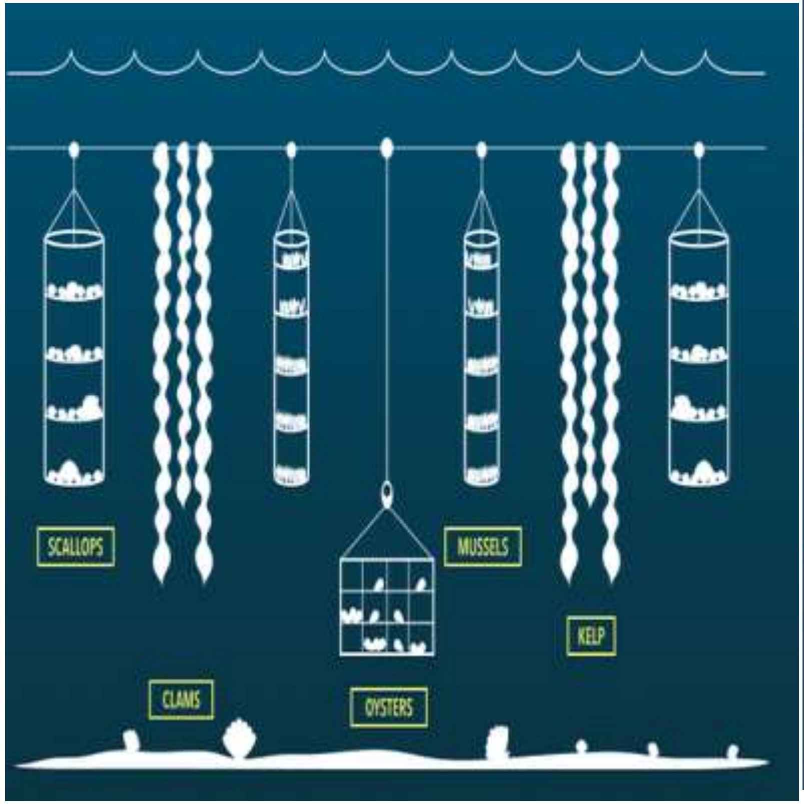
Vertical 3-D sea farms for ecological restoration and economic revival

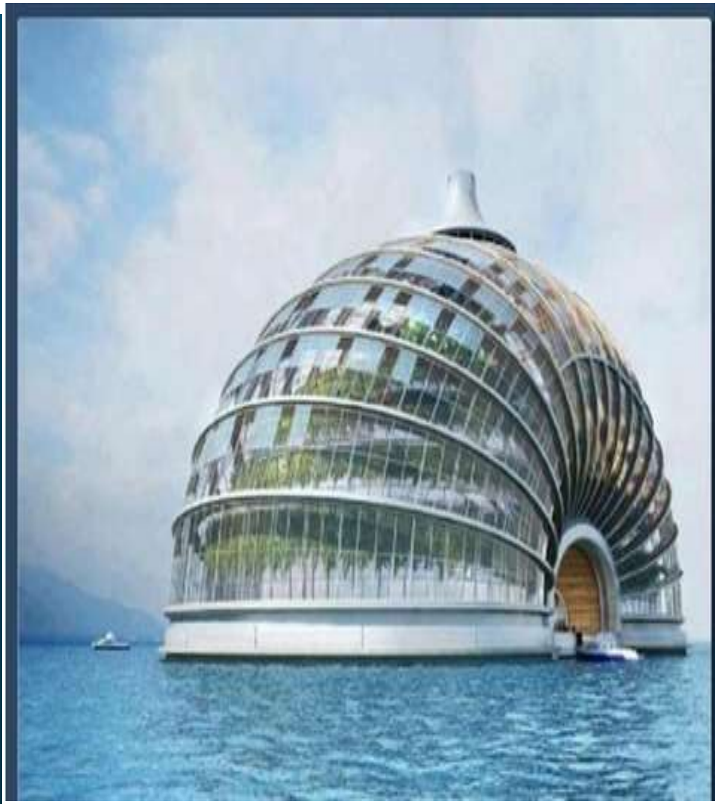
Seaweed farming is zero input activity. It receives ,everything it needs, from sun and the sea

Surface floating farming

3-D open sea farming

3-D close sea farming





POLICIES

India's National Action Plan on Climate Change

- National Mission for Sustainable Agriculture: The focus areas are integrated farming, water use efficiency, soil health and resource conservation
- National Solar Mission: 100 GW by 2022.
- National Mission for Enhanced Energy Efficiency: BEE labeled pump sets
- National Water Mission: Goal to increase water use efficiency by 20 % through pricing, differential entitlement and other measures. Micro-irrigation, Recycling
- National Mission for a Green India: Enhanced annual CO2 sequestration by 50 to 60 million tons in the year 2020, Increase forest cover from 23 % to 33 % of India's territory
- National Mission on Strategic Knowledge for Climate Change: Establishing research networks, knowledge networks, capacity for modelling the regional impact

Dimensions of National Mission for Sustainable Agriculture

	Stated dimension	S N	Stated dimension
1	Improved crop seeds, livestock & fish cultures	6	Agricultural insurance
2	Water Use Efficiency	7	Credit support
3	Pest Management	8	Access to Information
4	Improved farm practices	9	Markets
5	Nutrient Management	10	Livelihood diversification

The policy shift is slowly taking place

- Subsidy on efficient technology : Micro- irrigation, Laser levelling, Zero till machine, Irrigation pumps, Agricultural crop insurance
- Mainstreaming of technology promotion in action programmes: PMKSY, NMIM, PMCIS
- Emphasis on : ICT, Space technology, Weather advisory services, Mechanization, PHT, Processing
- Change in land ownership rules : Promote contract farming, Land leasing to overcome small farm size constraint

Concluding Remarks(I)

- Biophysical adaptations are linked to increase in efficiency of (Land, Water, Energy, Germplasm &Chemicals .
- The existing agro-technologies help attaining higher productivity, reduction in cost of production, and offer 15–20% higher income . But there are adoption Gaps
- There prevails a competitive subsidy politics in respect of water & energy pricing ,which hinders adoption of appropriate biophysical interventions.
- When opportunities for incremental adaptations get limited, transformative options such as changes in land use and resource allocation become critical, but have tradeoffs of cost and income (Haryana Case Study)

Concluding Remarks(II)

- Diversification by reallocation of crop areas to promote ecologically compliant cropping may still require a crop pricing policy support, as is being extended to rice and wheat for ensuring level playing field.
- In place of subsidies, incentives linked to adoption of efficient land/ water/energy/chemical/weather information technologies would be preferable.
- 3-D vertical sea farming holds promise for land& water scarce India
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- Knowledge gaps in technology development and appropriate policy support needs urgent attention in financial allocation for data generation at smaller grids

THANK YOU