Conservation Agriculture and Ecosystem Services: Integrating Power of Practices, Policies and People (PPP) is a Must for Impact at Scale

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Presentation structure

- Key challenges in agriculture
- What CA is all about ?
- Overview of CA-history, adoption etc
- CA practices in South Asia
  - ✓ Meta analysis results
  - ✓ Evidence base on multiple wins
- Some examples of CA and ecosystem services
- Examples on SDGs
- Cost effective climate Change mitigation
- Policies
- Integrating with Socio-ecological system

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Agricultural Issue, Concerns

Manmade

- Monotonous cropping systems (eg rice-wheat)
- Out of place cropping systems
- Intensive tillage
- Residue burning
- Flood Irrigation
- Blanket nutrient use and broadcast application

\+

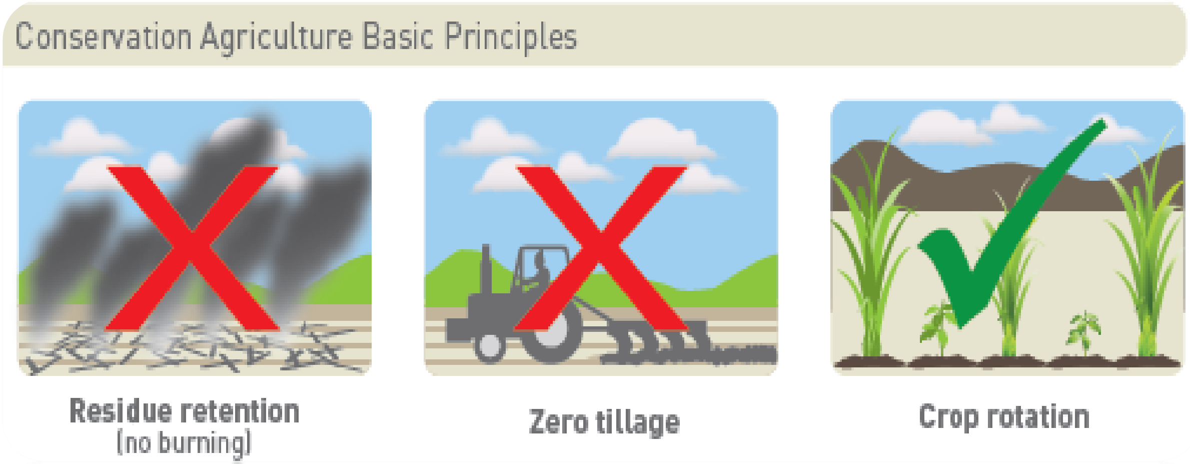
Nature made

- Abiotic stresses- temperature (terminal heat, cold), monsoon variability, water stresses (dry spell, excess rains), salinity
- Biotic stresses- pest outbreak, Phalaris, diseases etc
- Climate change induced weather risks

- Continued depletion of water
- Soil health deterioration
- GHGs/Global Warming
- Yield gaps & Low farmer's profit

Twin Challenge: Doubling Farmer's income with sustaining natural resources under emerging climatic risks

Part of Solutions: Conservation Agriculture



CA ++ (Adapted component technologies)

- Micro-irrigation/fertigation
- Precision nutrient management
- Weed management
- Scale-appropriate mechanisation
- Solar energy
- GxExM

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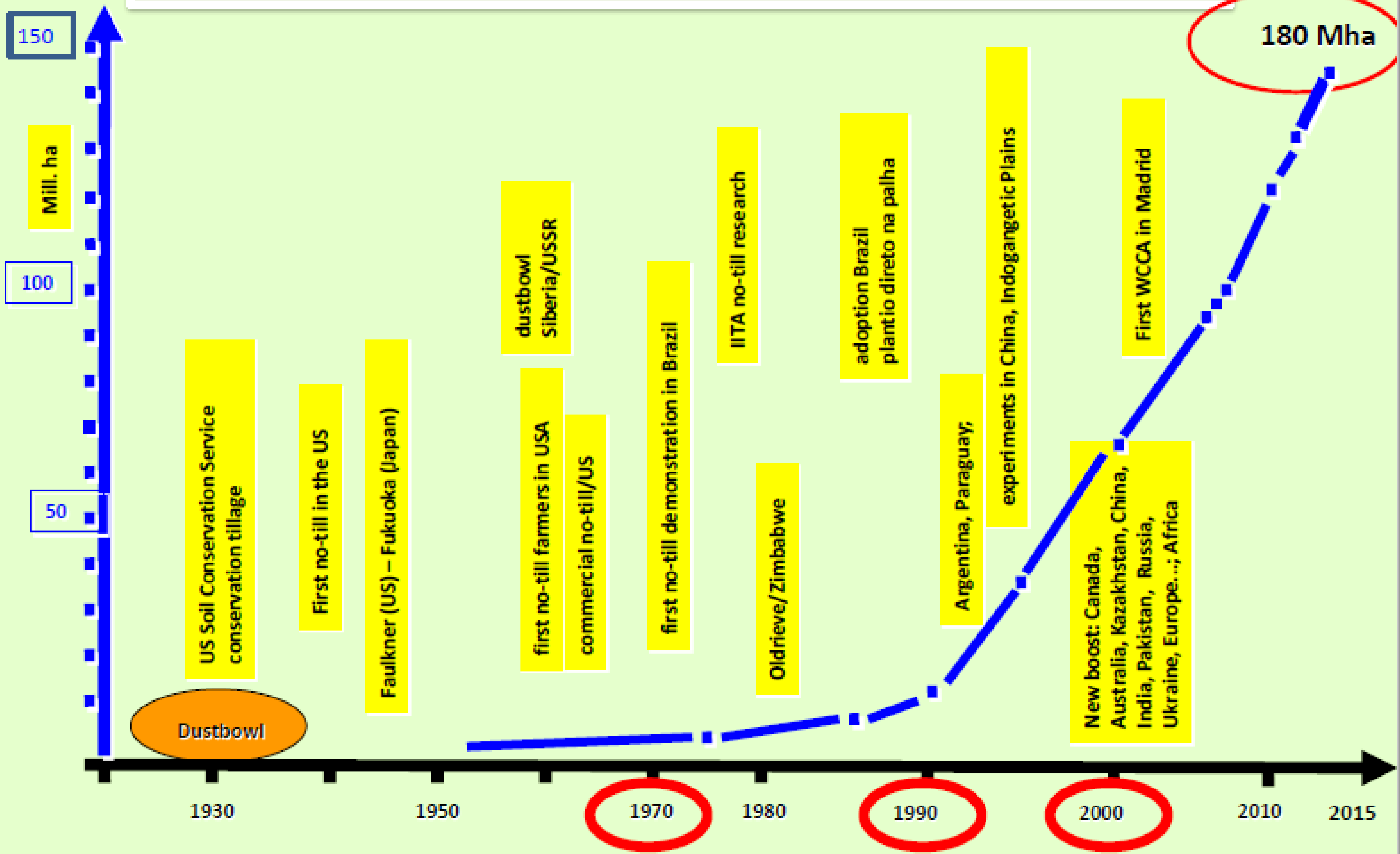
History and Adoption of CA (2015/16). Since 2008/09 increasing at 10 M ha annually



Source: Kassam et al (2017)

Area of cropland under CA by continent – 2015/16

(source: FAO AquaStat: www.fao/ag/ca/6c.html & personal database)

Continent	Area (Mill. ha)	Per cent of global total	Per cent of arable land of reporting countries
South America	69.9 (49.6)*	39.0 (40.9)#	63.2
North America	63.2 (40.0)	35.2 (58.0)	28.1
Australia & NZ	22.7 (12.2)	12.7 (86.1)	45.5+
Asia	13.2 (2.6)	7.4 (408)	3.8
Russia & Ukraine	5.2 (0.1)	2.9(5000)	3.3
Africa	2.7 (0.5)	1.5 (447)	2.0
Europe	2.5 (1.6)	1.4 (56.3)	3.5
Global total	179.5 (107)* ( )* 2008/9	100 (69.2)# ( )# % change since 2008/09	12.5 (7.4)* %global cropland + includes non-cropland

~50% in developing regions, ~50 % in industrialized regions

Source: Kassam et al (2017)

Asia --13.2+ Mha in 2015/16
(2008/09 - 2.6 Mha, 408% increase)

Countries now reporting CA area:

South Asia: *India*, *Pakistan*, Bangladesh,

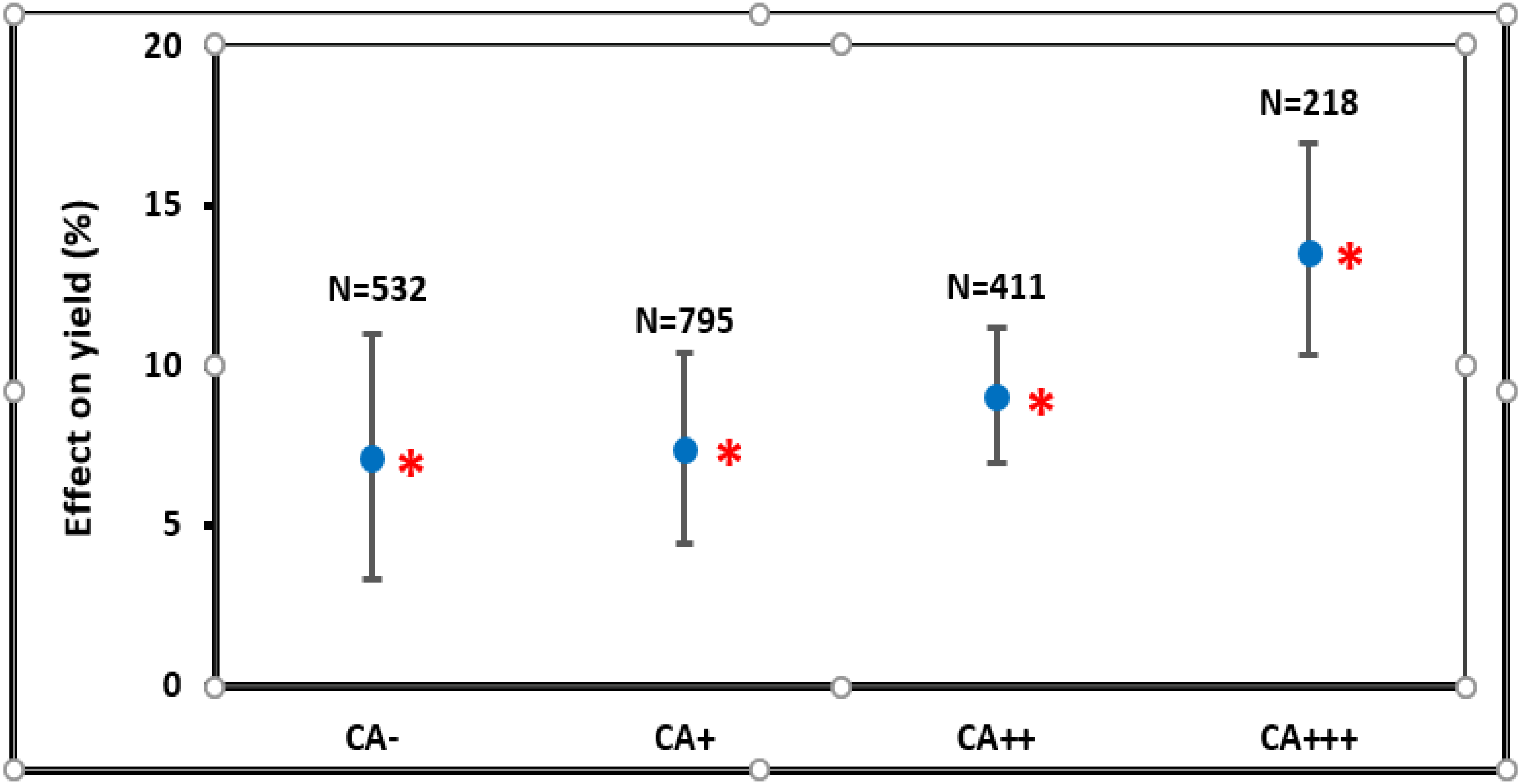
Southeast & East Asia: Laos, Cambodia, Vietnam, *China*, North Korea

Central Asia: *Kazakhstan*, Uzbekistan, Kyrgyzstan, Tajikistan

West Asia: *Iran*, Turkey, Azerbaijan, Lebanon, Syria, Iraq

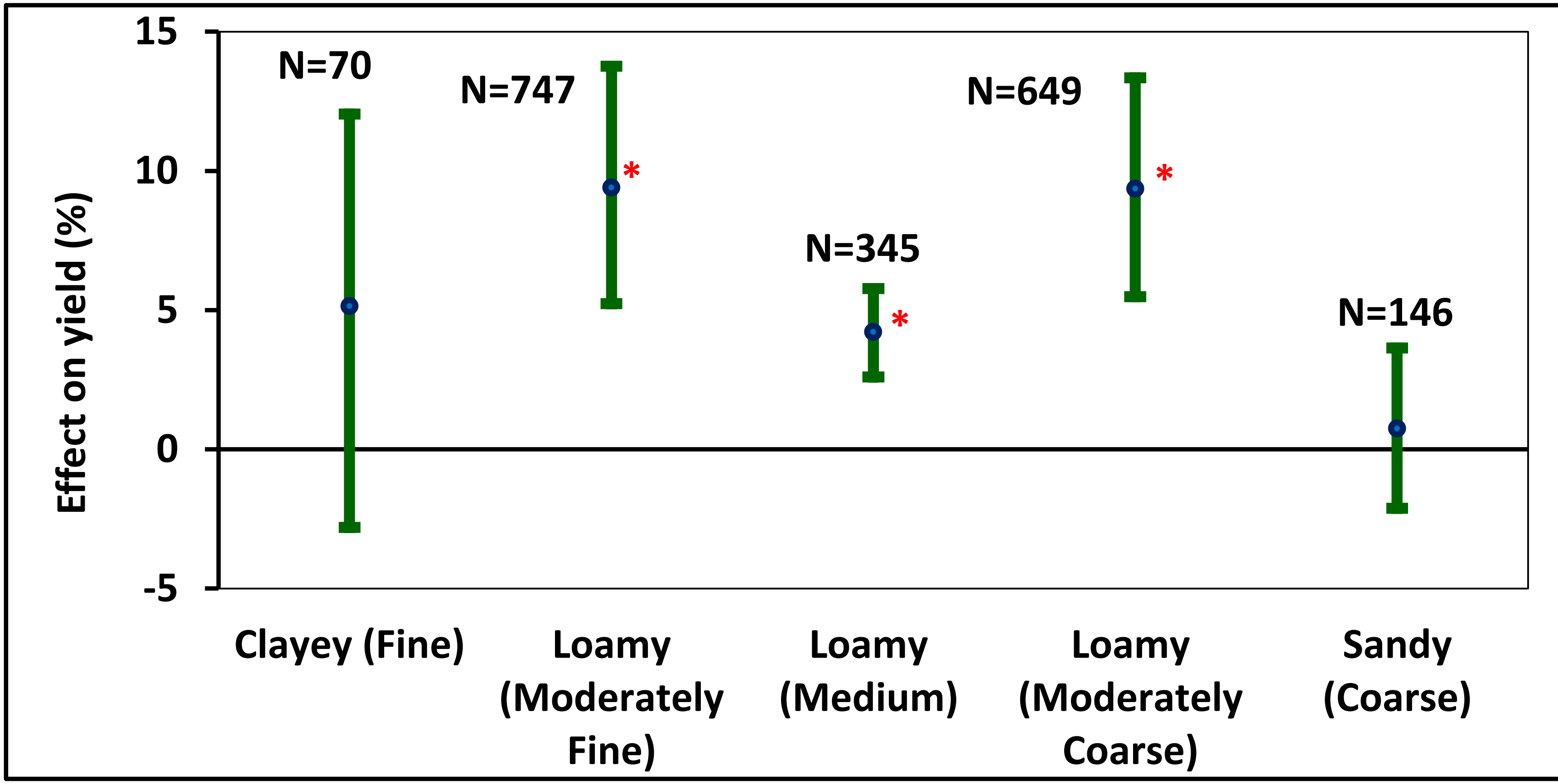
Source: Kassam et al (2017)

Meta-data analysis of CA research in major cereal based systems in South Asia: Yield response to different elements



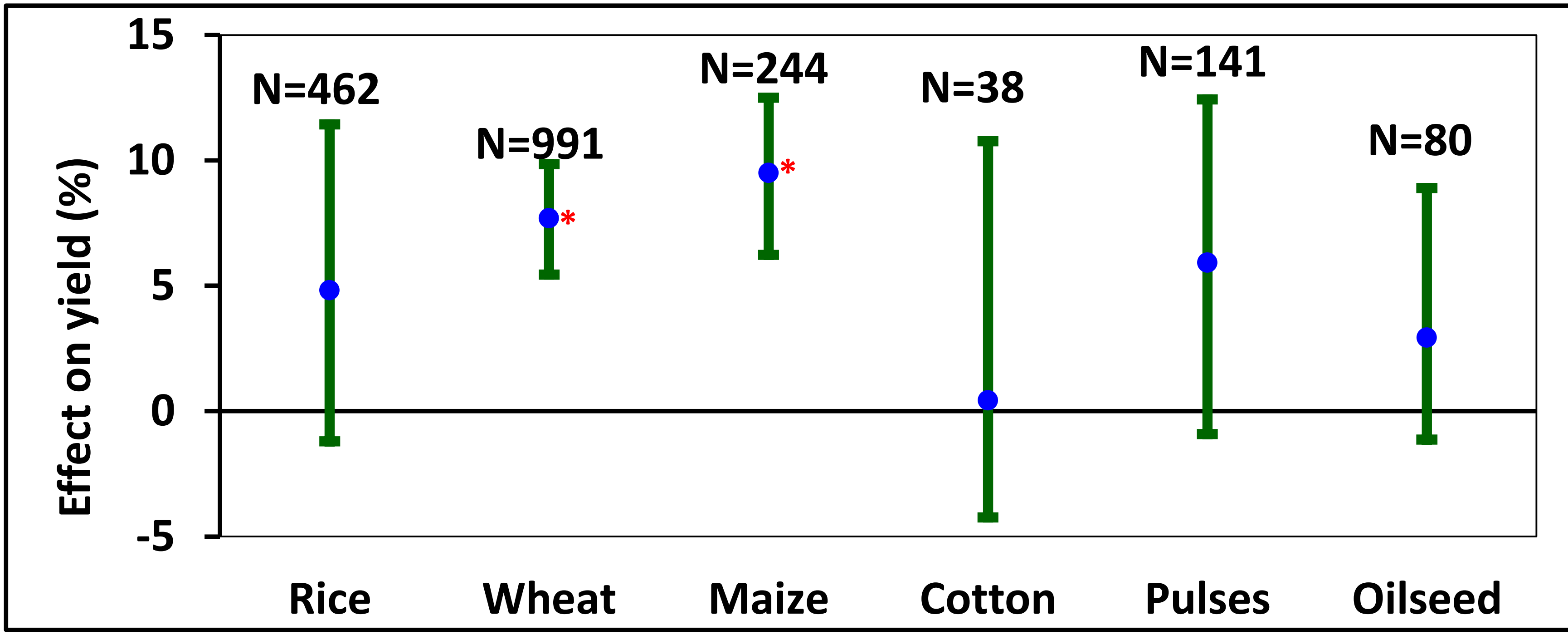
Source: Jat et al (Forthcoming)

Meta-data analysis of CA in South Asia: Yield Gain/Loss in different soil types



Source: Jat et al (Forthcoming)

Meta-data analysis of CA in South Asia: Yield gain/loss in different crops



Source: Jat et al (Forthcoming)

Meta-Analysis of Alternate Rice Production Systems

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SCIENTIFIC REPORTS

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A global analysis of alternative tillage and crop establishment practices for economically and environmentally efficient rice production

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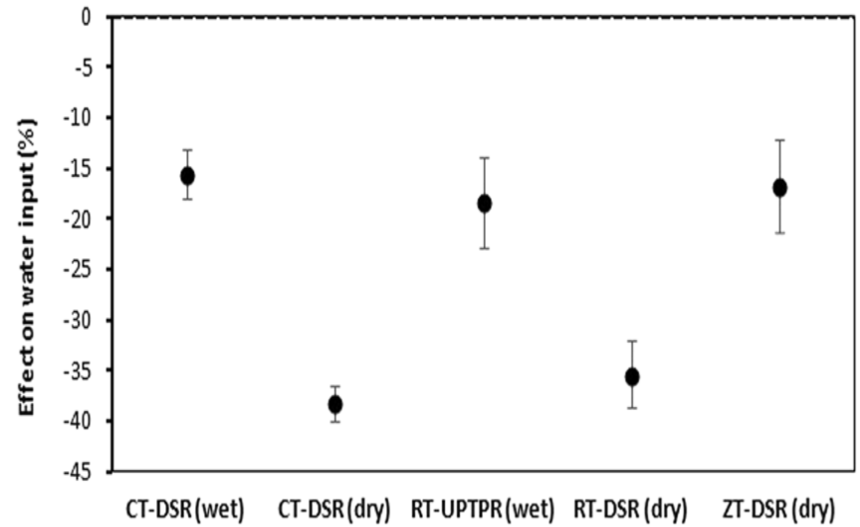
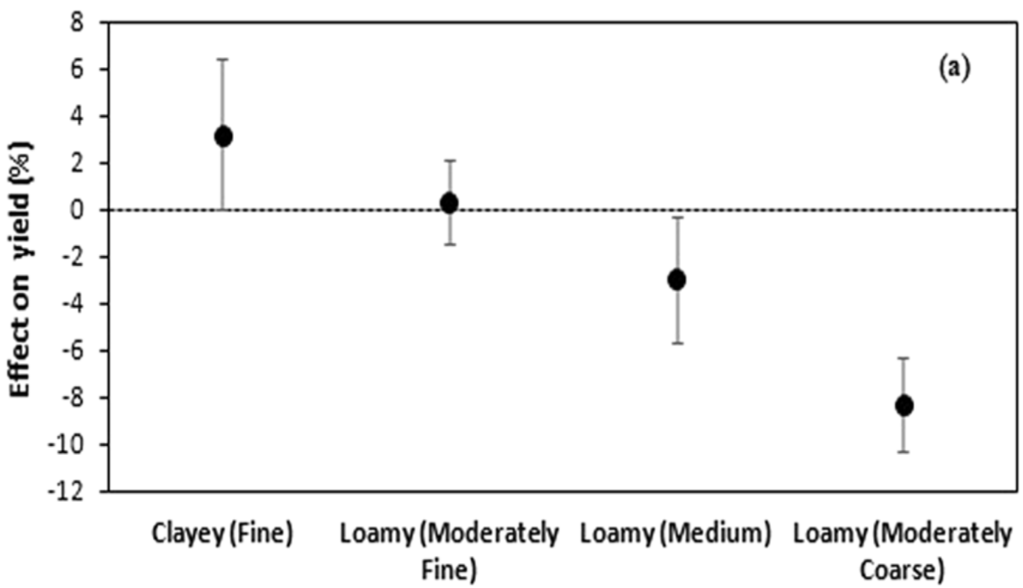
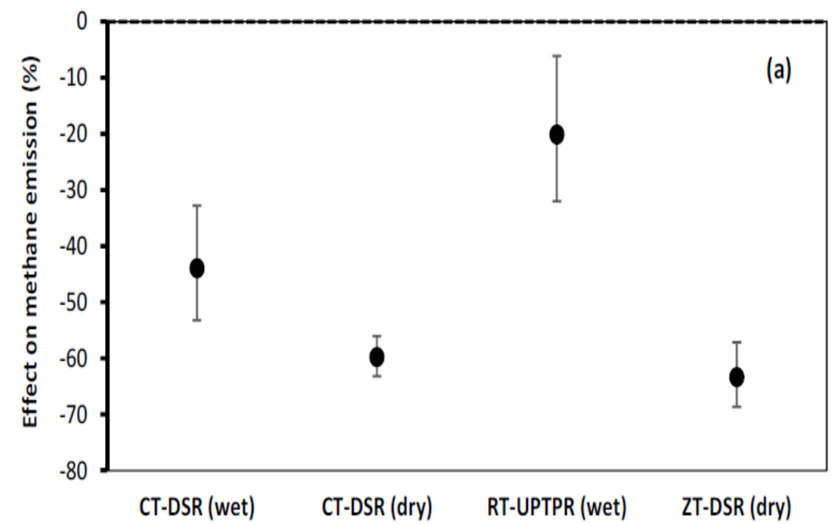
Debashis Chakraborty[1], Jagdish Kumar Ladha[2], Dharamvir Singh Rana[3], Mangi Lal Jat[4], Mahesh Kumar Gathala[5], Sudhir Yadav[2], Adusumilli Narayana Rao[6], Mugadoli S. Ramesha[2] & Anitha Raman[6]







Nature Scientific Reports 7: *9342 (2017)*

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CA based in Intensive Cereal Systems in NW India: Productivity, Profitability, Soil quality and Environmental footprints (8 yr average)

Scenario	Productivity (Mg ha^{-1})	Irrigation water (mm ha^{-1})	Energy requirement (MJ ha^{-1})	Net return (USD ha^{-1})	Organic carbon (%)	Total GWP (t CO_2 eq ha^{-1})
Conventional RW	12.40	2557	75225	1361	0.45	6.3
CA based RW	13.17 (6)	1868 (-27)	57833 (-23)	1629 (20)	0.90 (100)	4.9 (-22)
CA based MW	14.09 (14)	738 (-71)	39376 (-48)	2122 (56)	0.84 (87)	4.5 (-29)

*In parenthesis= % change over conventional system

ICAR-CSSRI-CIMMYT Collaborative Research

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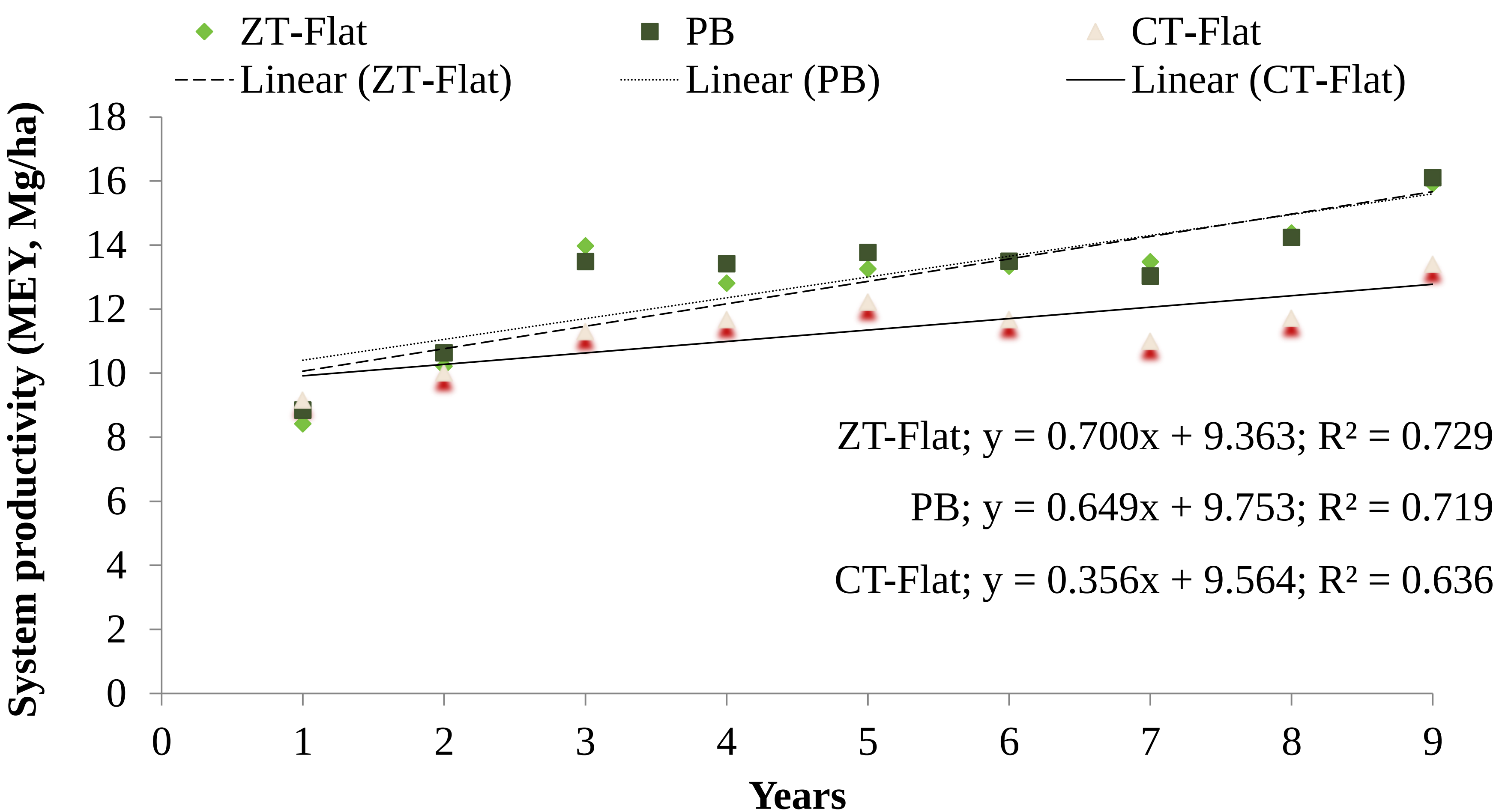
Yield Trends-Maize-Wheat Rotation



Sourcve: Parihar et al ICAR-IARI, New Delhi

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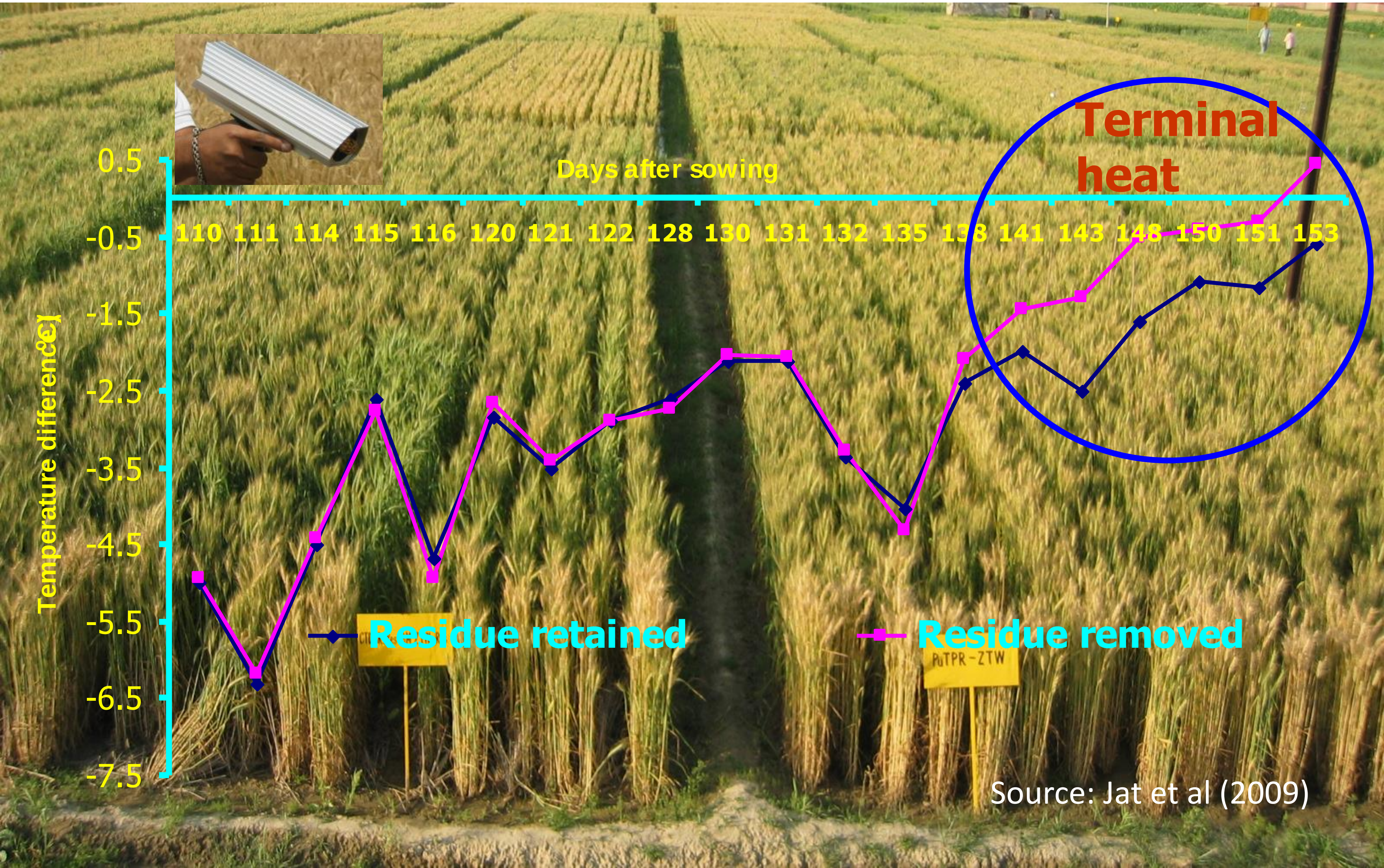
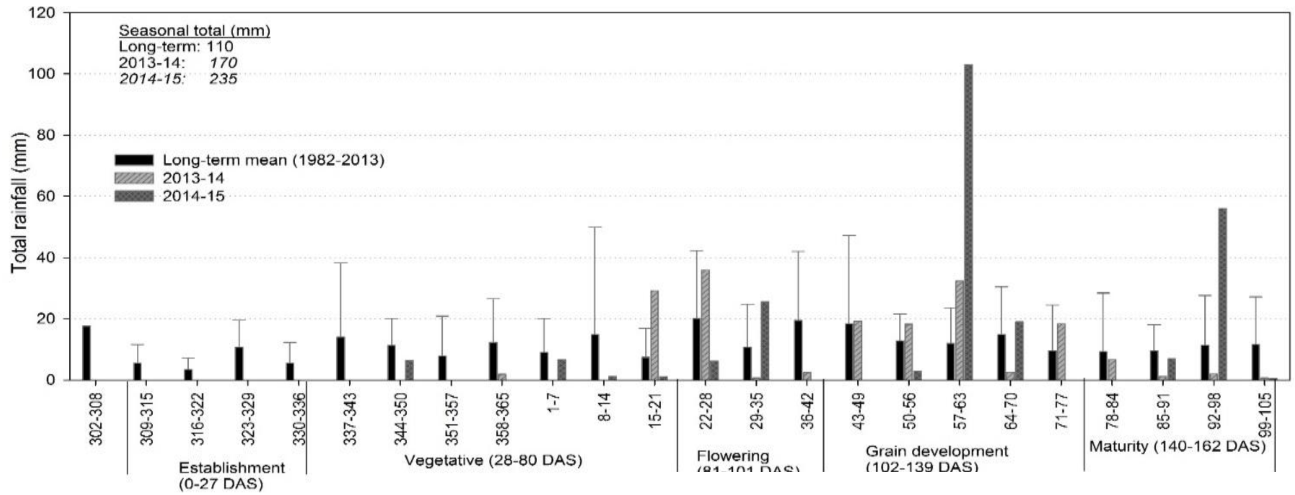
CA in Wheat Systems Adapting to Terminal Heat

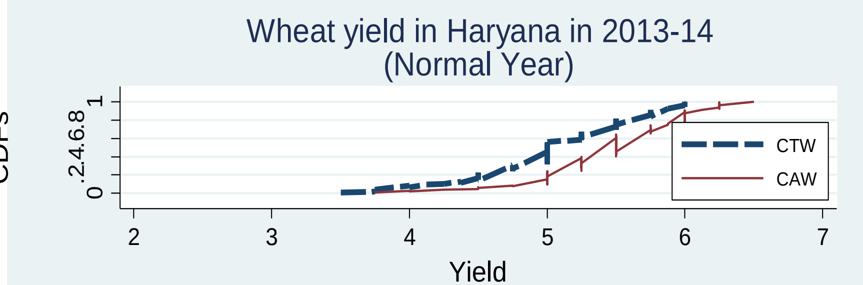


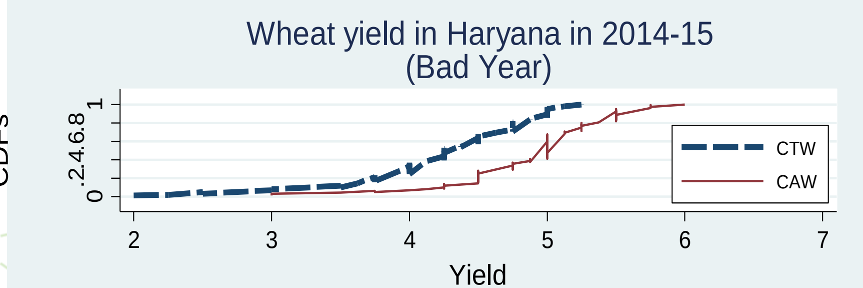
Source: Jat et al (2009)

Performance of Wheat Under Extreme Climate Risks *(Excess Rains at Wheat Grain Filling in 2014-15)*

Landscape Scale Evidence on How CA is Climate Smart : a case of climate risks in wheat during 2014-15 in Western IGP







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Conservation agriculture-based wheat production better copes with extreme climate events than conventional tillage-based systems: A case of untimely excess rainfall in Haryana, India

CrossMark

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CA in Maize Systems: Adapting Climate Risks (200+ mm in 3 days in end of June 2017) in Haryana, India

Water, nitrogen

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CA in Maize Systems: Adapting Climate Risks (200+ mm in 3 days in end of June 2017) in Haryana, India

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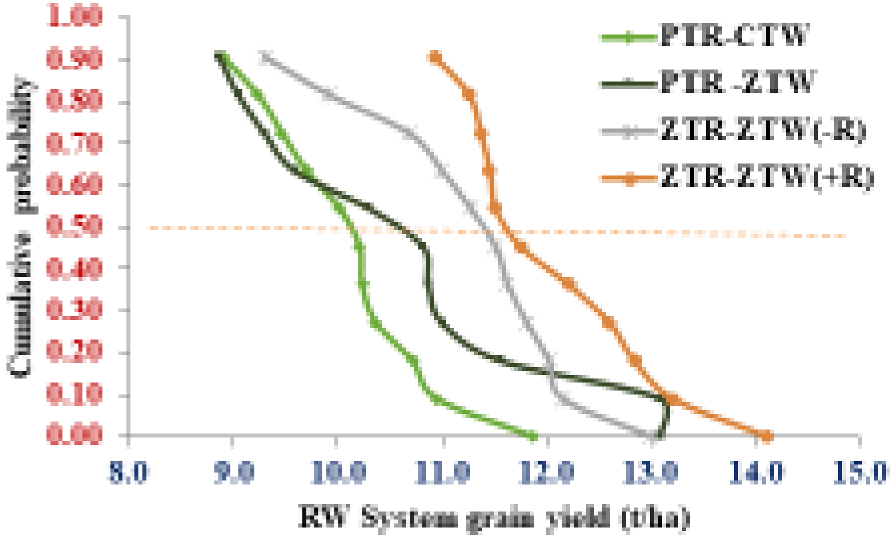
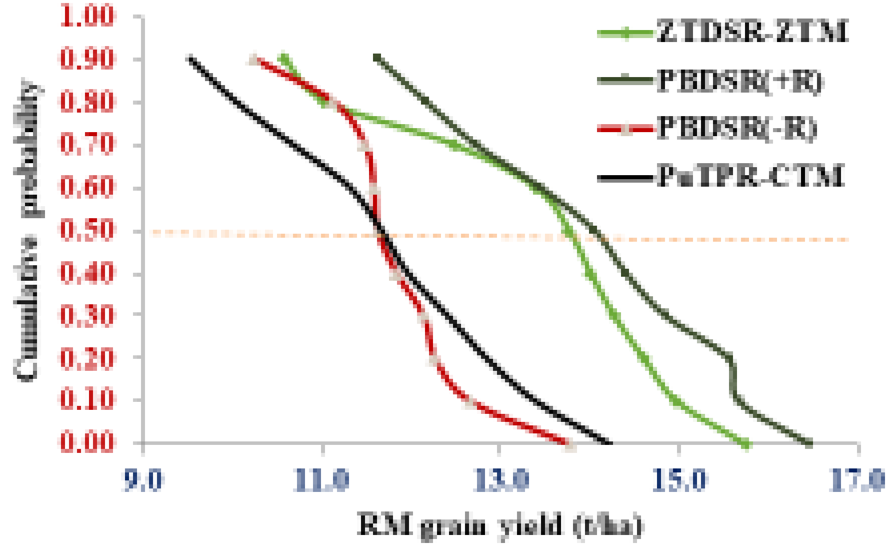
Long-term Trials on CA in Eastern IGP: Yield changes with different management scenarios at varying probability (11 years)

Rice-Wheat System



Rice-Maize System



- **In long-run, CA (no-till + residues) provides more stable yields at higher probability levels**
- **Partial CA (no-till without residue as well as no-till-conventional till cycle) are prone to lower yield stability at high probability even compared to conventional till based management**

Source: Jat et al (2019)

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Addressing Water-Energy-Food (FEW) Nexus in NW India

(Layering CA with Fertigation, Solar energy)

System magt	Irrigation method and energy source	System yield (t ha^{-1} yr^{-1})	System net income (USD ha^{-1} yr^{-1})	System water use (cm ha^{-1} yr^{-1})	System energy use (kWh ha^{-1} yr^{-1})
ZTDSR-ZTW	SSD with solar power	12.33c	2094	96d	3663
ZTDSR-ZTW	Flood	11.94c	2000	167e	6151
TPR-CTW	Flood	12.18c	1909	181f	6686
PBM-PBW	SSD with solar power	13.67a	2357	29a	1249
PBM-PBW	Furrow irrigation	13.24ab	2318	49b	1714
CTM-CTW	Flood	12.56bc	2087	59c	2027

- CA + micro-irrigation within RW system: same yields with 85 cm /ha/yr less water, half energy use and USD 185/ha/yr higher income
- CA + micro irrigation in MW system: 1.5 t/ha/yr more yield, 152 cm water saving with one quarter energy use and USD 450 /ha/yr more profit compared to conventional RW system in NW India

Collaborative research of CIMMYT-BISA-PAU, Ludhiana, Punjab

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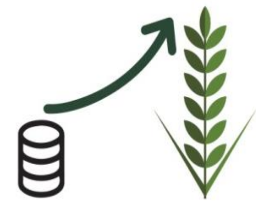
Some Examples for Ecosystem Services

Evidence of Ecosystem Services from CA in Irrigated Rice-Wheat System

Improved soil health
(SOC 0.5 t/ha/yr)

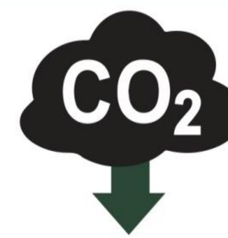
More crop per drop: ***Save irrigation water Rice-wheat-mungbean: 40-50 ha-cm/yr***

Reduced weather risks
(High adaptability and Low CV in crop yield)



More profit: Lower costs and higher yields
(Profit 12000-15000/ha/yr)

Reduce Chemical load
(20-25 kg N/ha, Less herbicide)



Lower GHGs emission
(~1 t CO2-eq/ha/yr)

Residue Management

Monetary cost of converting biomass into soil organic matter/soil organic carbon (C).

Ingredients	Amount (kg)	Price (US$ kg^{-1})	Total price (US$)
Residues	62,000*	0.038	2,350
Nitrogen	833	0.67	558
Phosphorus	200	1.94	388
Sulfur	143	0.57	82
		Total	3,384

*Assuming conversions of biomass C at 35%, and C combustion in residues of 45% = (10^4 kg ÷ 0.35) ÷ 0.45 = 62,000 kg.

Cost calculations for 10 t C

Total Cost= US$ 3384
Monetary gains= US$2057
Net cost= US$ 1327 (US$ 0.13/kg)
C Sequestration per ha = 300 kg
Cost of C per ha = ~ US$ 40/ha

Source: Lal (2014)

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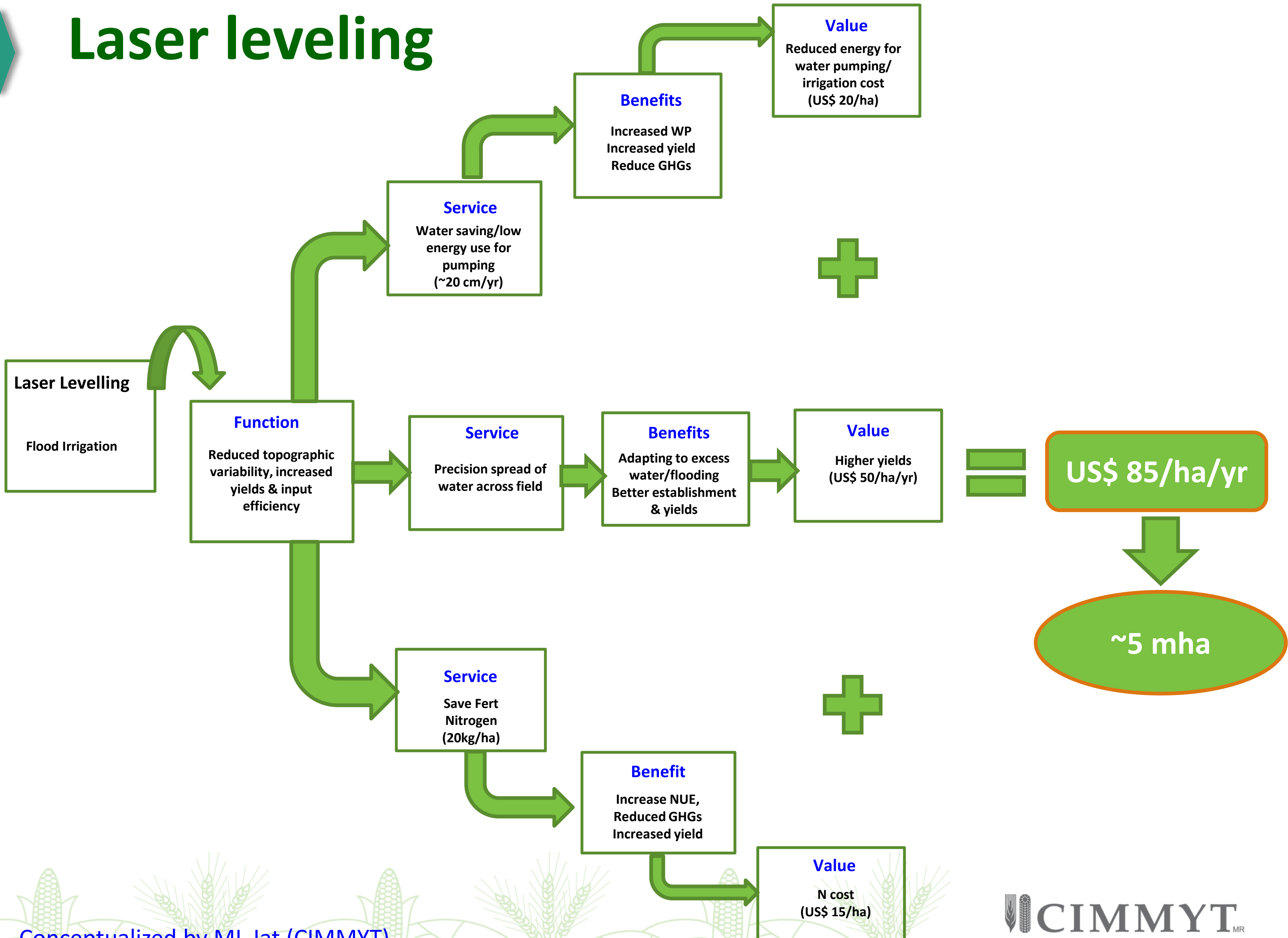
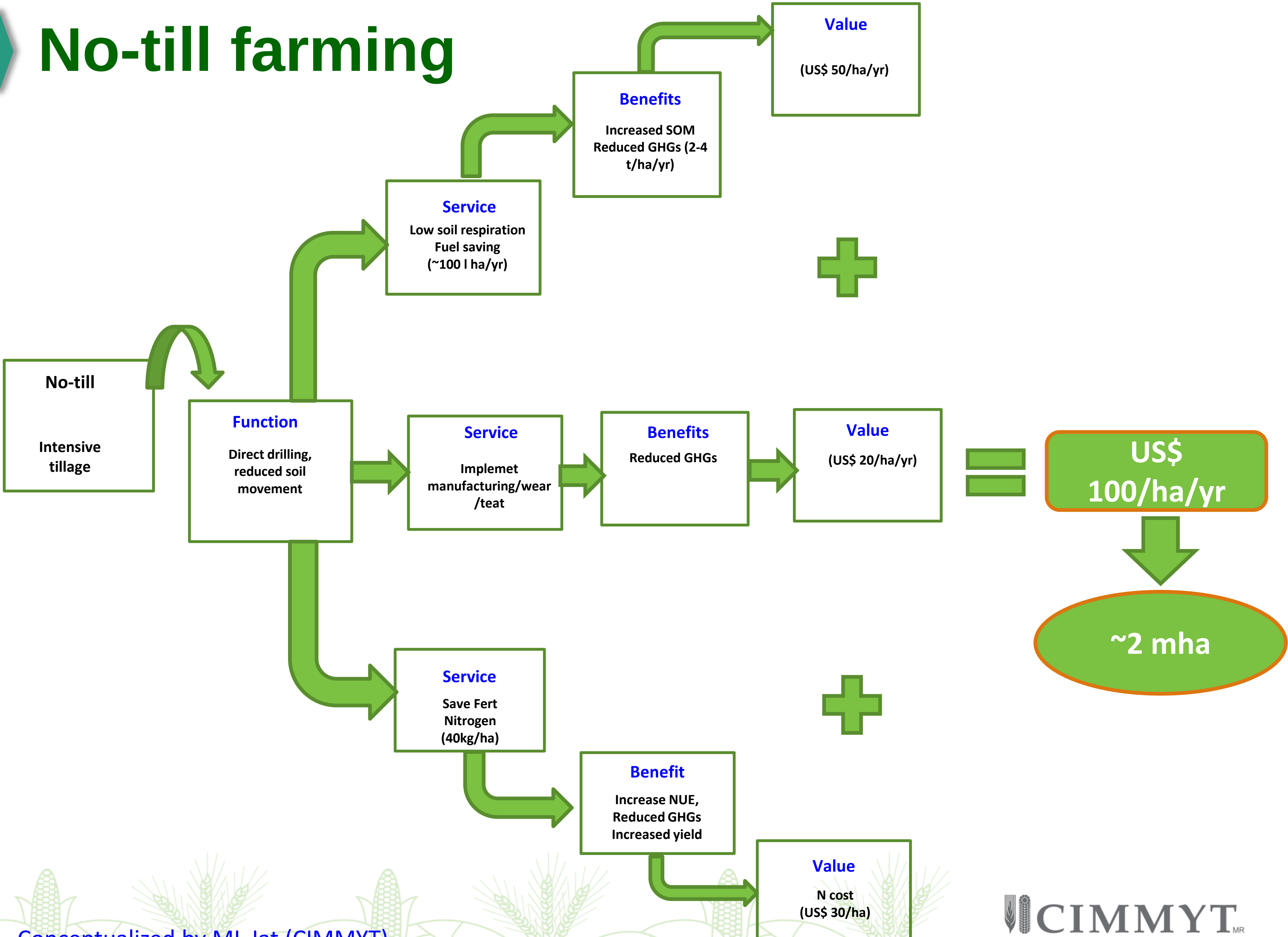
Laser leveling



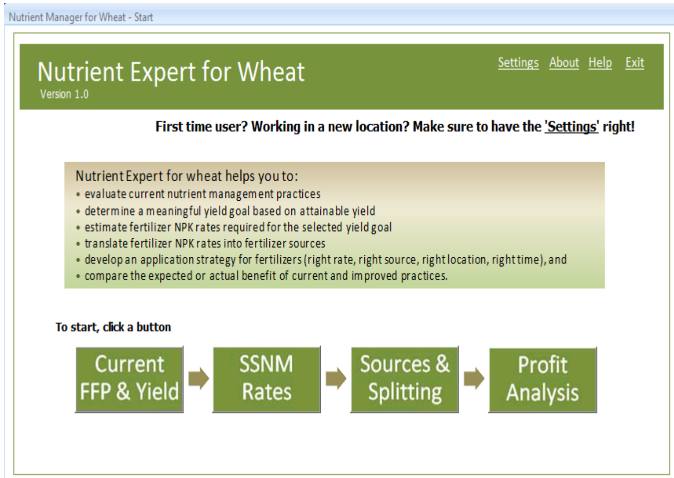
Conceptualized by ML Jat (CIMMYT)

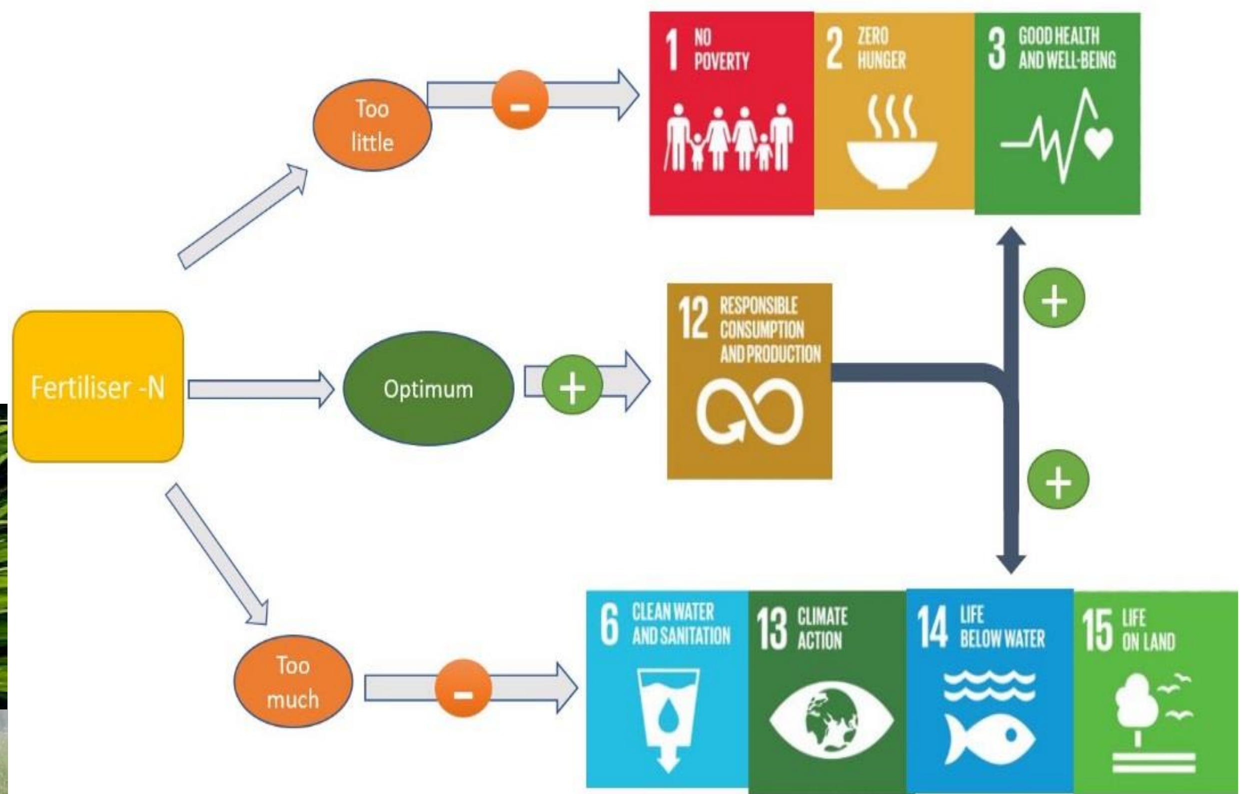
No-till farming



Conceptualized by ML Jat (CIMMYT)

Nitrogen and Sustainable Development Goals





Source: Stirling et al (2018), CIMMYT

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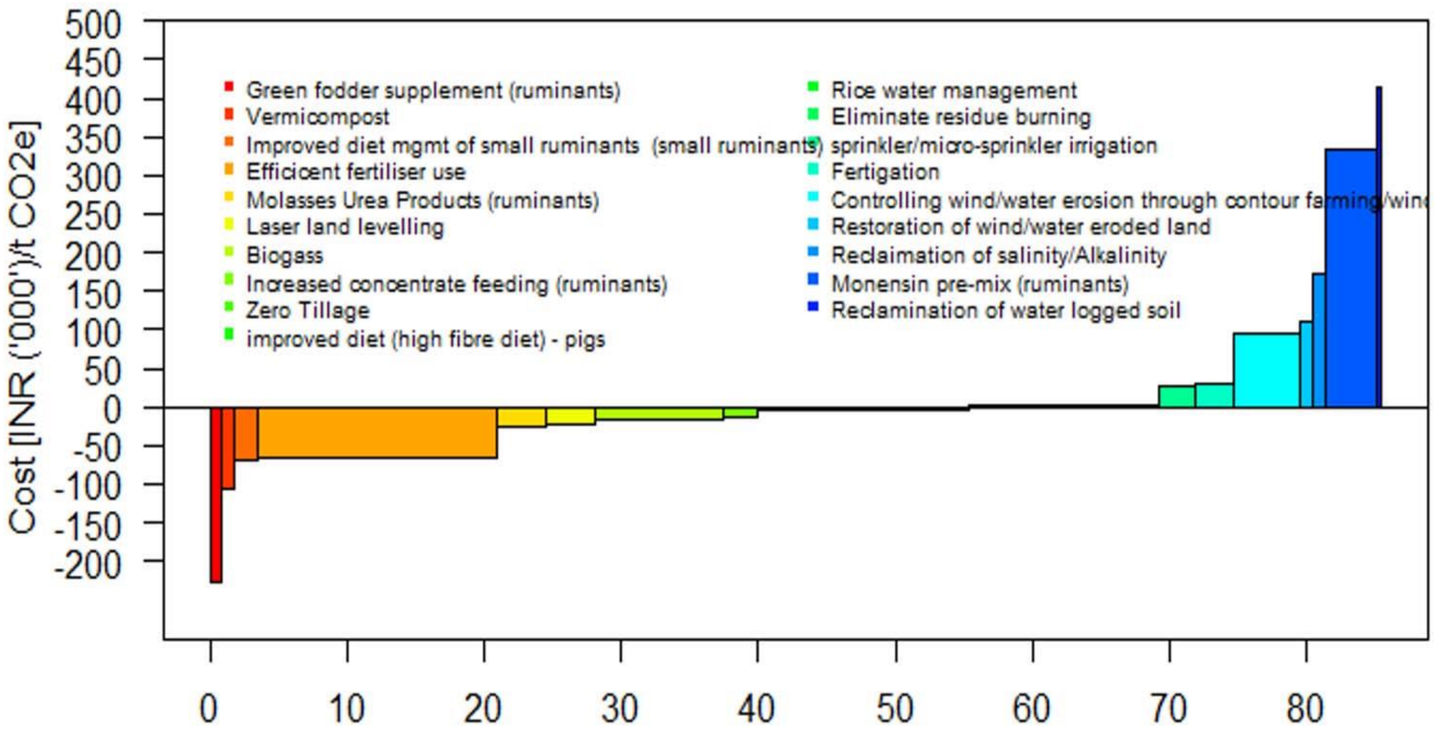
Evidence on Cost-effective opportunities for climate change mitigation in India



- All options are climate smart
- Technical Mitigation potential = 86 $MtCO_2e$/year
- 80% of mitigation potential achieved via cost saving options

Sapkota, Vetter, Jat et al: Science of the Total Environment (2019)

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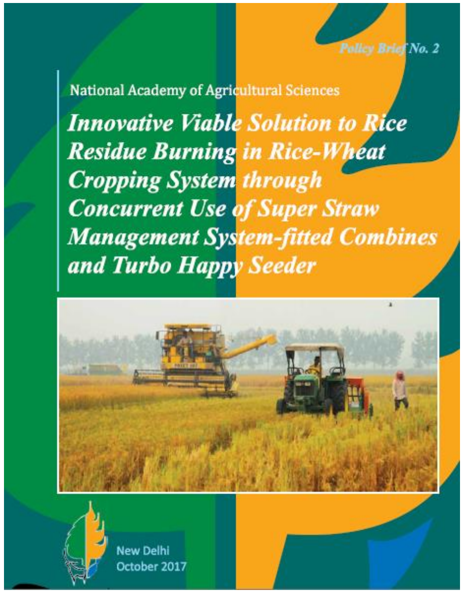
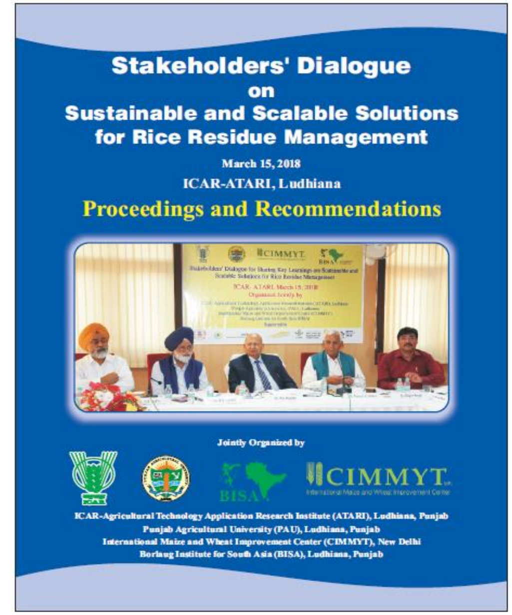
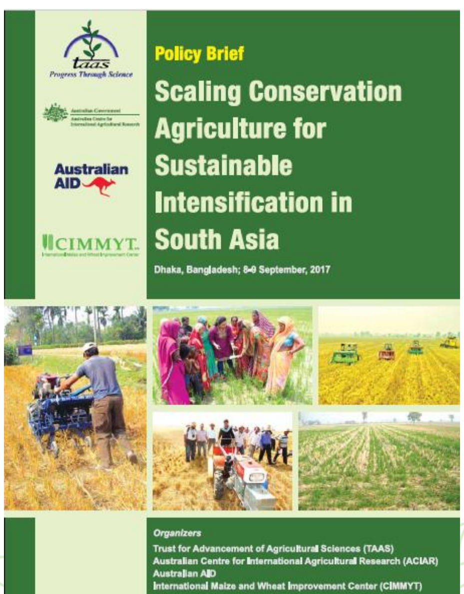
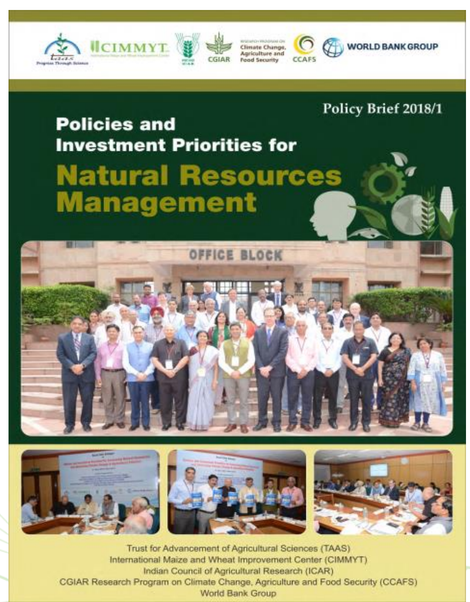
Right Policies Are Critical










THE TIMES OF INDIA

Centre okays Rs 1,151-crore plan to tackle stubble burning

Home › Cities › Delhi › Union Budget 2018: To end stubble-burning and fight pollution, a scheme for farmers

Union Budget 2018: To end stubble-burning and fight pollution, a scheme for farmers

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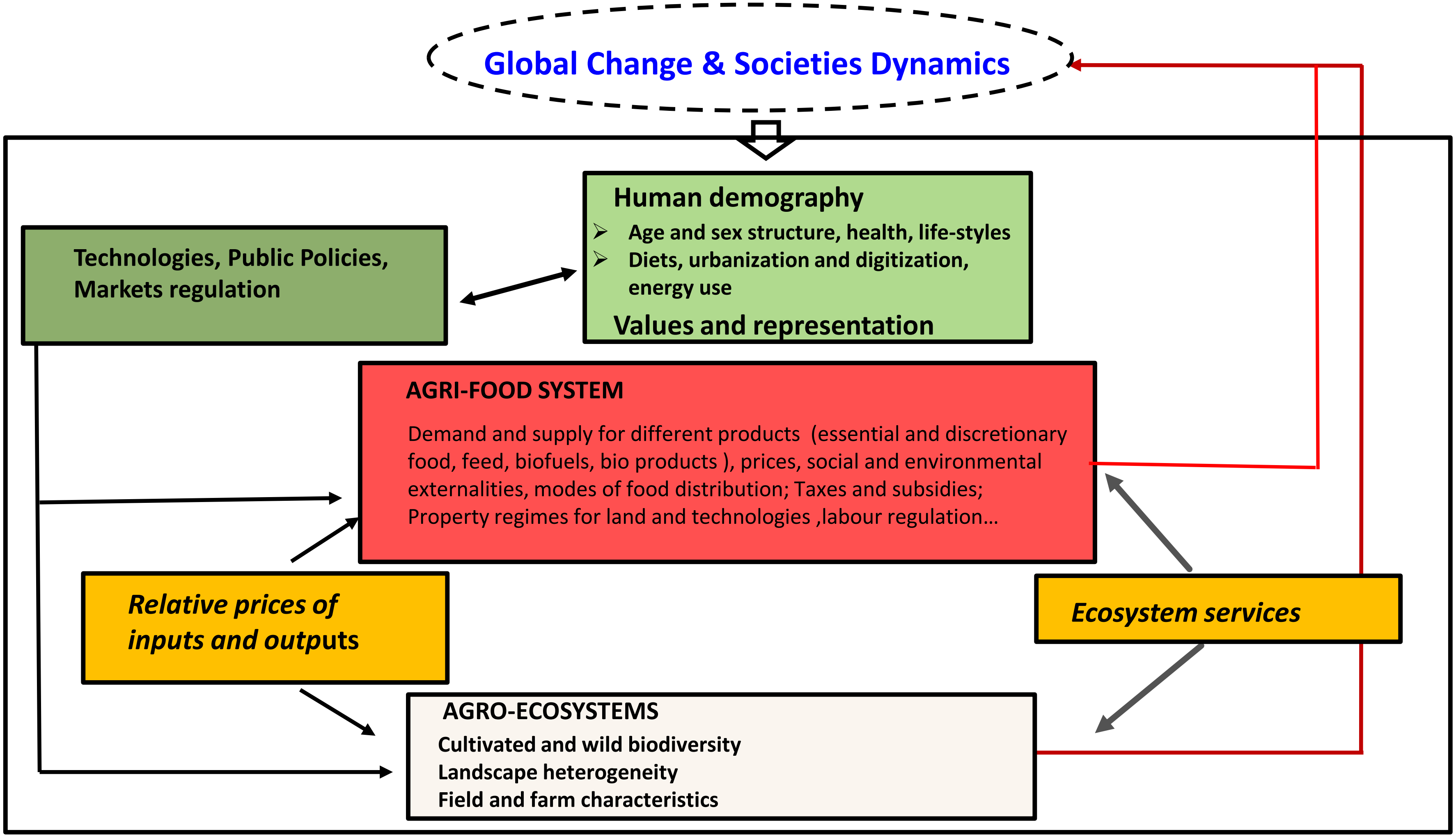
Integrating with Socio-ecological system is a Must

Interaction between Agro-ecosystems, Agri-food systems and Socio-Ecosystems (Hubeau et al. 2016)



- **Beyond public policies, social processes having major environmental effects**
- **These processes determine the relationship between supply and demand, through the agri-food system, affecting the dynamics of local, regional and global agroecosystems**
- **understanding and integration of environmental impacts of diets by consumers is a major mechanism determining the relationship between societies and agro-ecosystems, promoting some types of agricultural production**

Thank you for your interest!

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