

Meeting sustainable intensification goals in agriculture

Cameron M. Pittelkow

Assistant Professor
Department of Crop Sciences
University of Illinois, USA
cmpitt@illinois.edu



**XIII Conferencia Internacional
de Arroz para América Latina
y el Caribe**

**“Alianzas para la sostenibilidad
de la producción arrocerá”**

Mayo 15 al 18, 2018 – Piura, Perú

Outline

- Background
- Global context for Sustainable Intensification (SI)
- Research example: Rice in Uruguay
- Opportunities for accelerating SI efforts
- Example platforms and tools

Graduate school



IRRI




University of Illinois

US Midwest: sustainable N management

Pittelkow Lab


Department of Crop Sciences, University of Illinois at Urbana-Champaign (UIUC)

Home
People
Projects
Publications
Prospective Students
Contact us
Current Opportunities




Sustainable Intensification

Our work aims to increase crop productivity while reducing environmental impacts.




Cropping systems analysis

We conduct holistic assessments of cropping systems using a number of sustainability indicators.



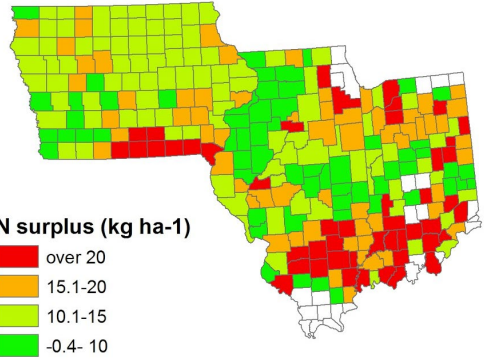
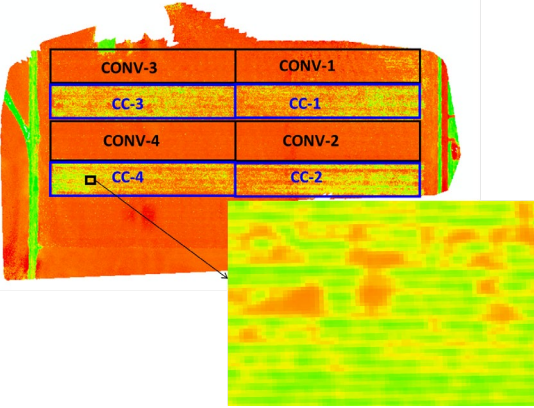
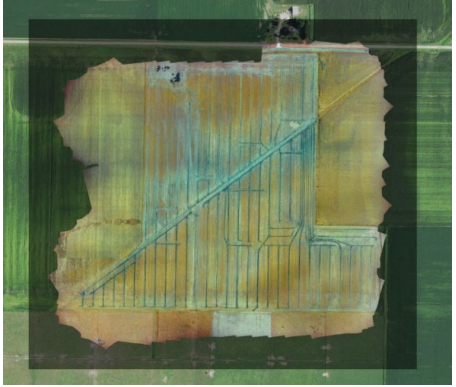
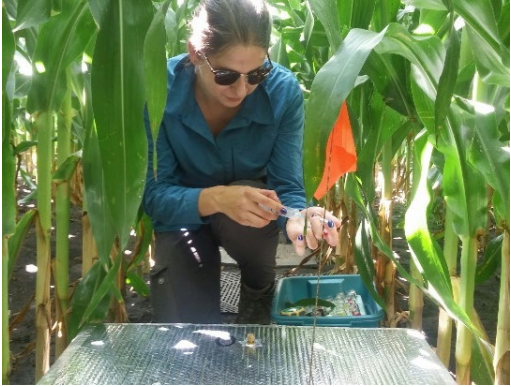
Greenhouse gas emissions

We monitor soil greenhouse gas emissions to reduce the global warming potential of agricultural management practices.



Nitrogen management

We evaluate strategies to maximize nutrient use efficiency and minimize nitrogen losses to the environment.



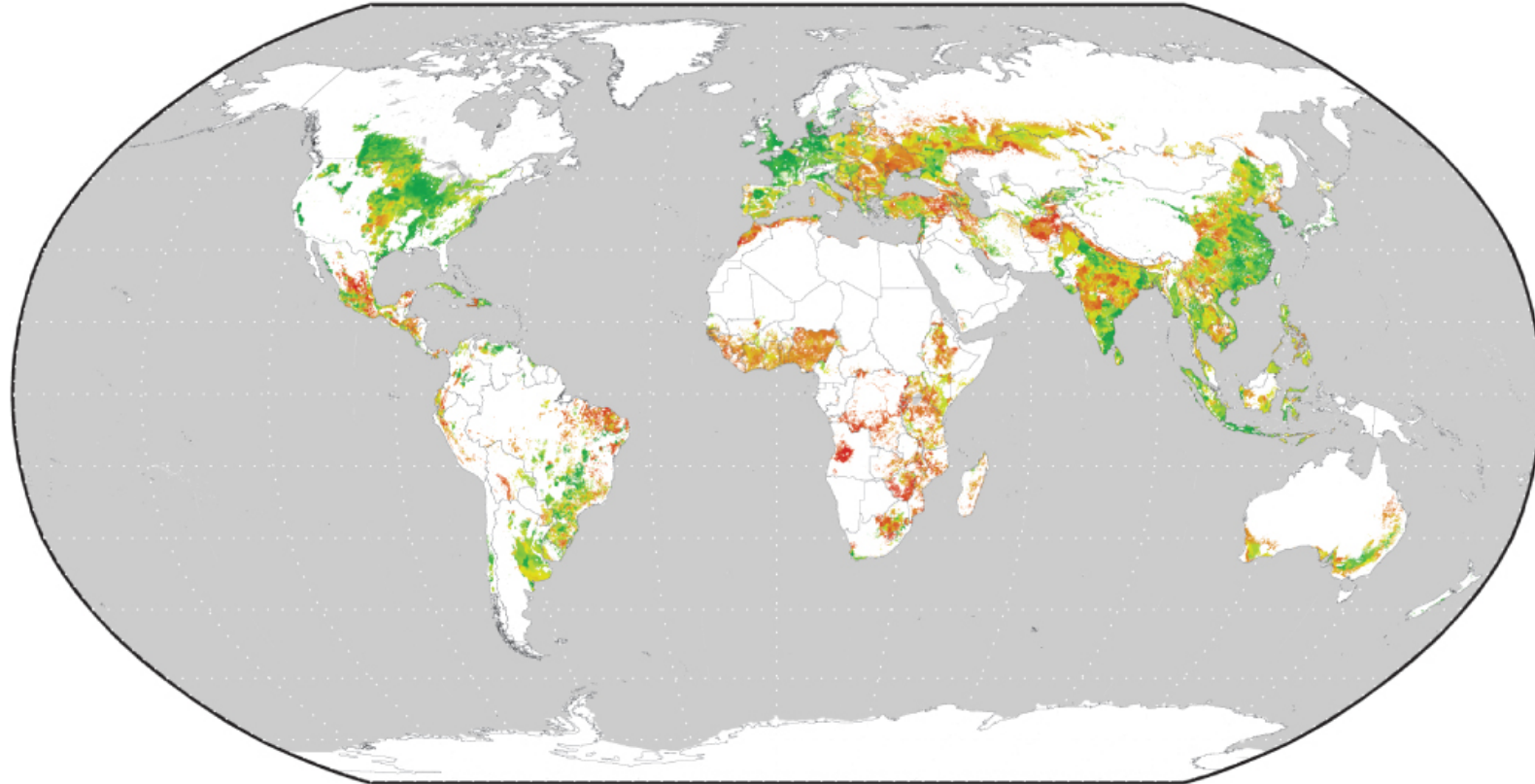
Goals for this presentation

- Bring in an outside perspective
- Share experiences with SI research/metrics as an agronomist
- Discuss alliances/partnerships for impact

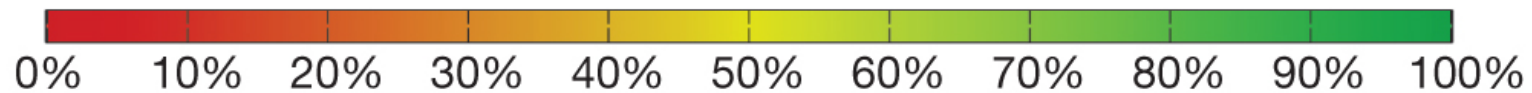
Outline

- Background
- Global context for Sustainable Intensification (SI)
- Research example: Rice in Uruguay
- Opportunities for accelerating SI efforts
- Example platforms and tools

Yield gaps for rice, wheat, and maize



Major cereals: attainable yield achieved (%)



Environmental concerns

Energy consumption



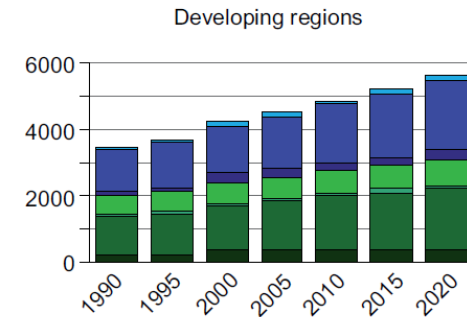
Water resources



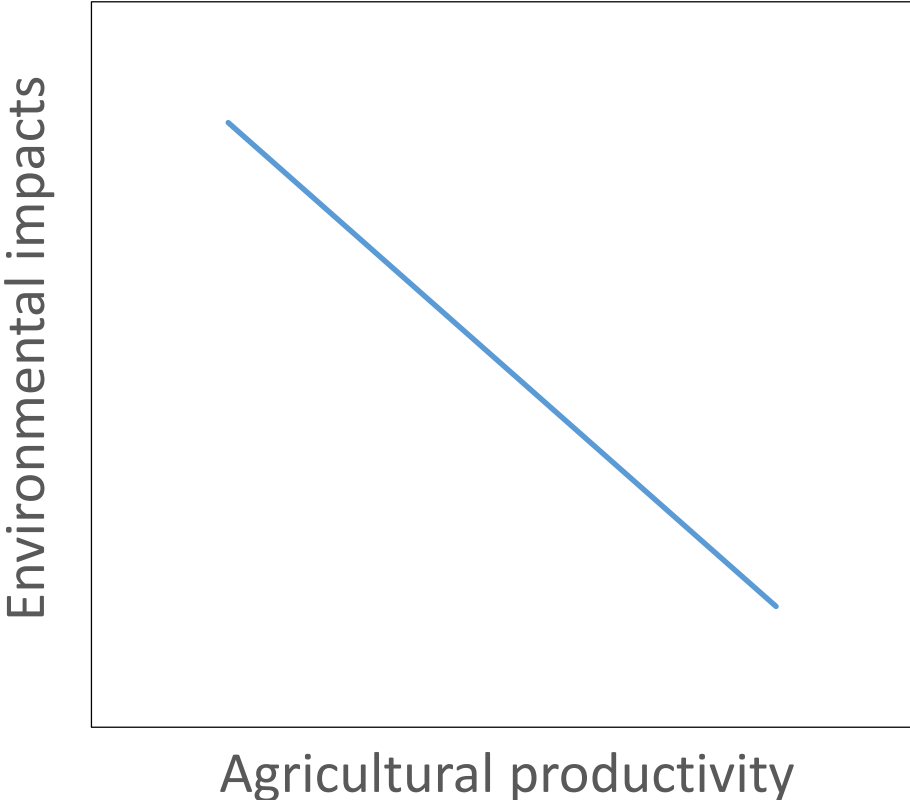
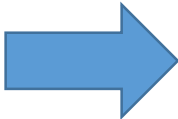
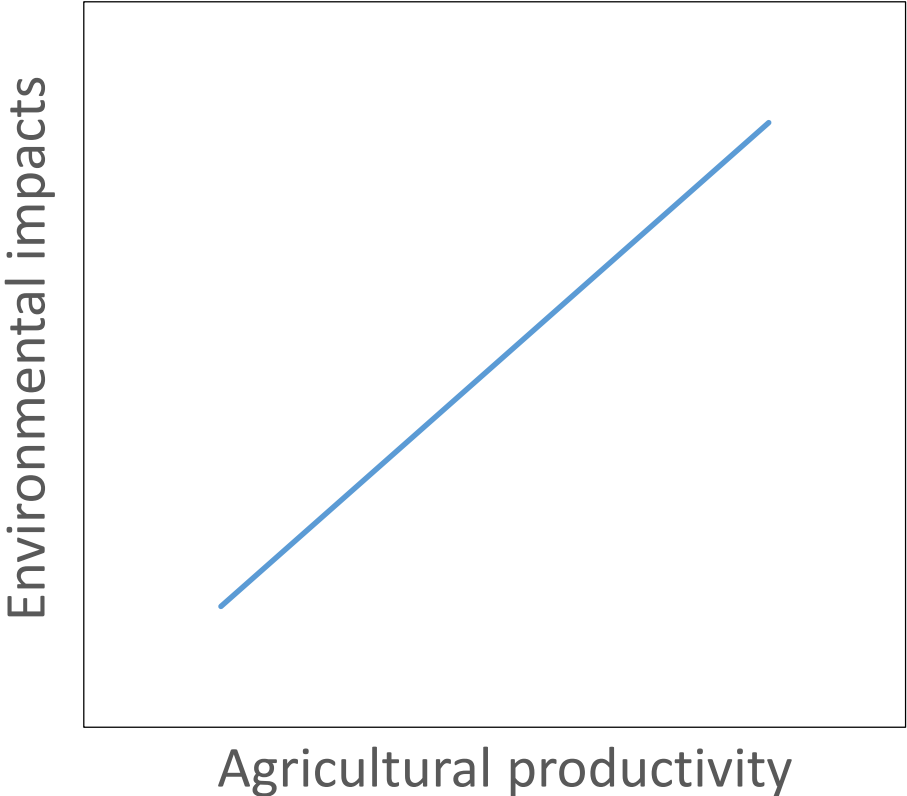
Nutrient pollution



Greenhouse gas emissions and climate change



The challenge: sustainable intensification

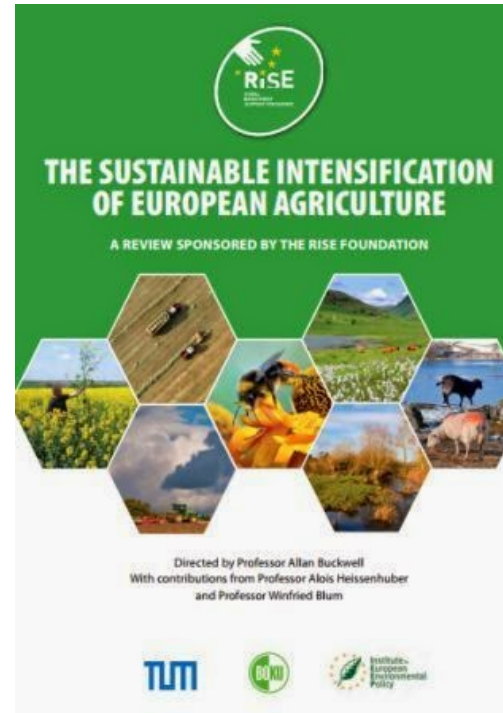
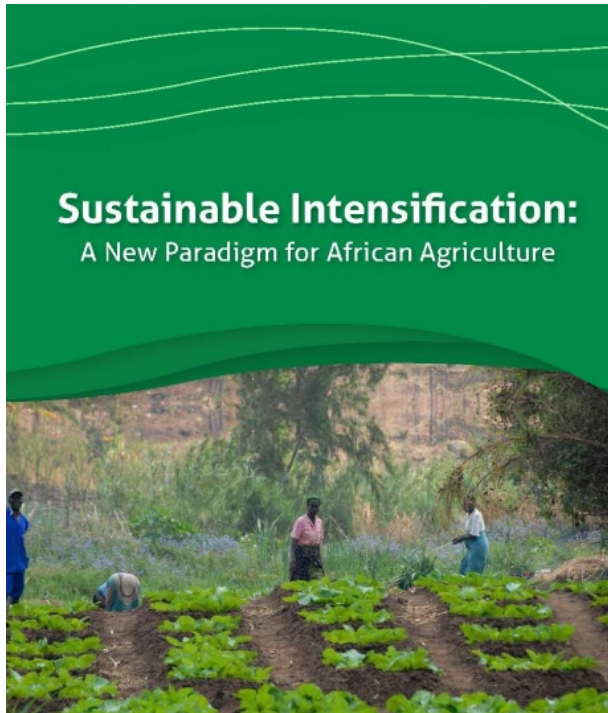


Premises underlying SI

- 1) Increased production
- 2) Higher yields per unit area to avoid the environmental costs of agricultural expansion
- 3) Equal emphasis on food security and environmental sustainability
- 4) Denotes a goal but does not specify how it should be attained

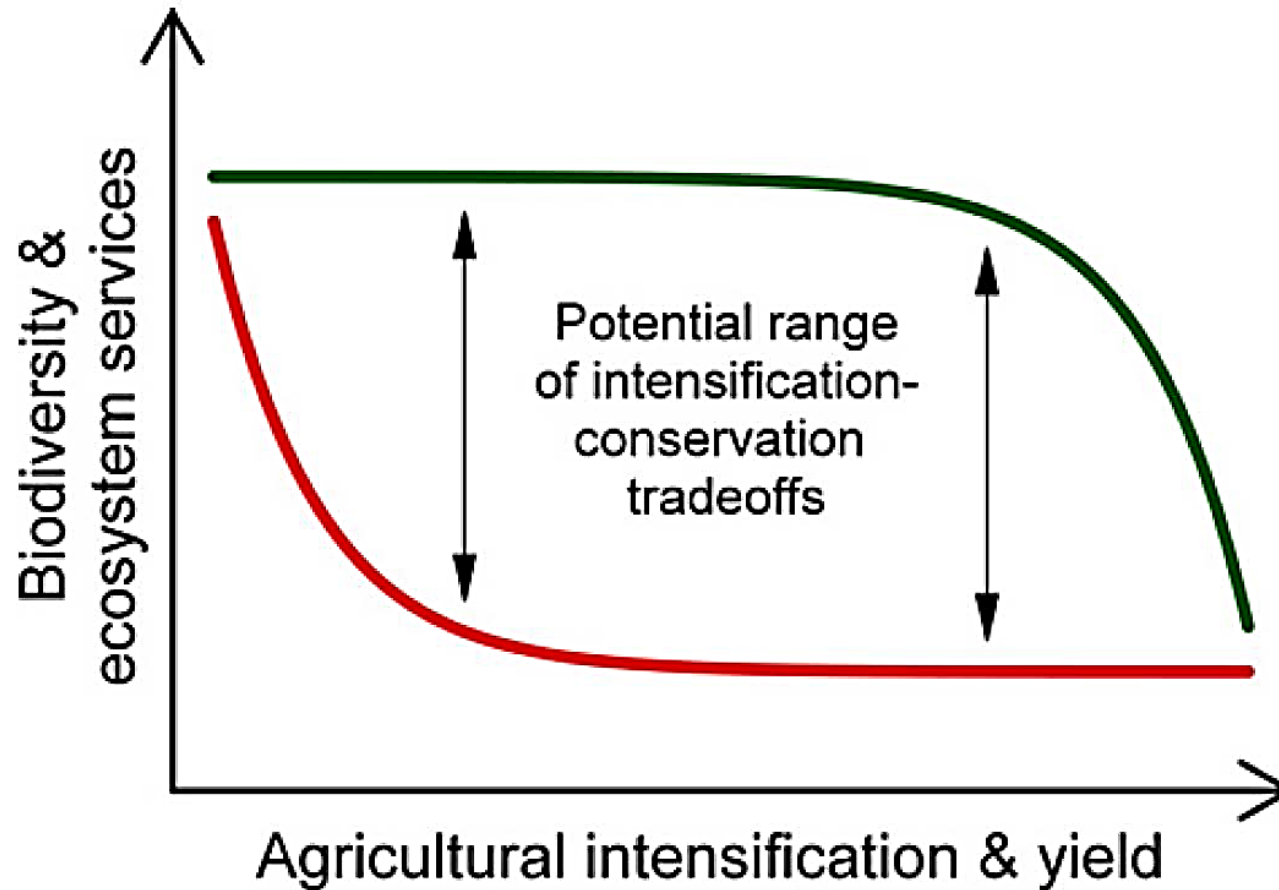
The missing elements? Social equity, human health and well-being

Progress?



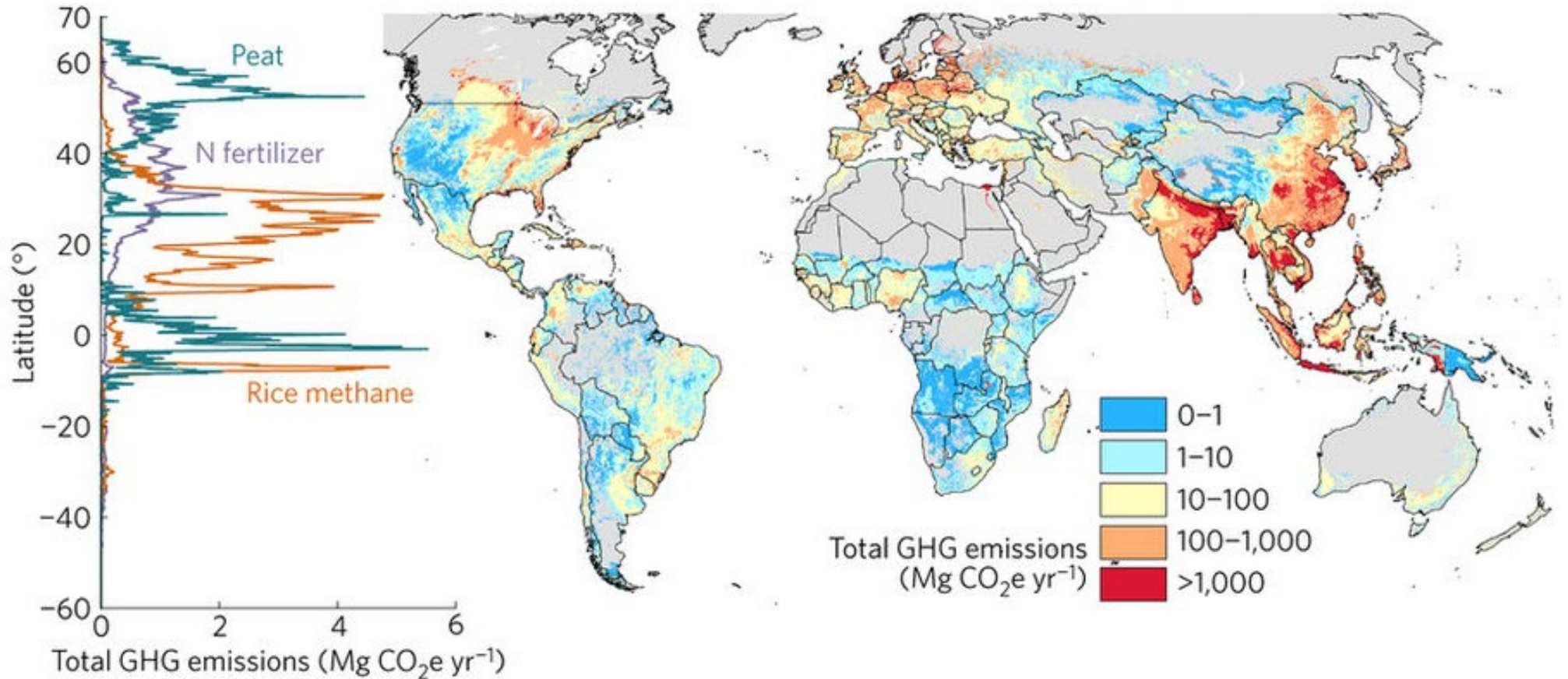
Despite much emphasis at international scales, there are limited large-scale examples evaluating whether it is possible to achieve these often conflicting goals

The reality: systems are complex



- C footprint
- Energy consumption
- Water use efficiency
- Soil quality
- GHG emissions
- Nutrient losses
- Water quality

Leverage points: GHG emissions



Outline

- Background
- Global context for Sustainable Intensification (SI)
- **Research example: Rice in Uruguay**
- Opportunities for accelerating SI efforts
- Example platforms and tools

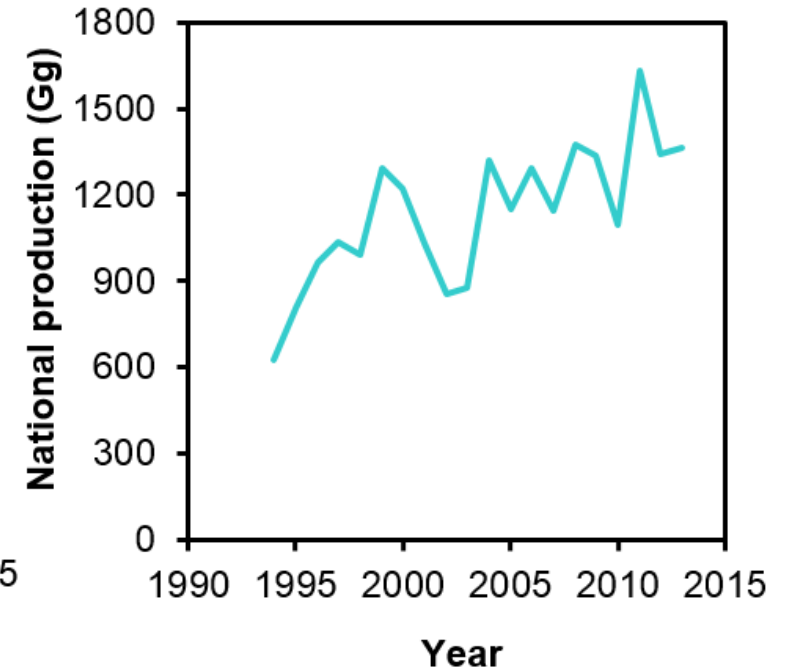
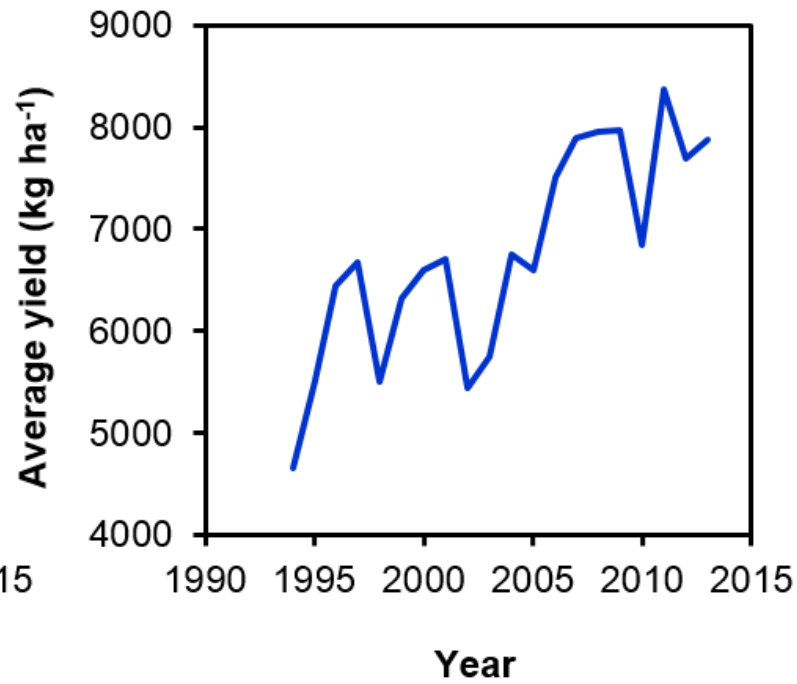
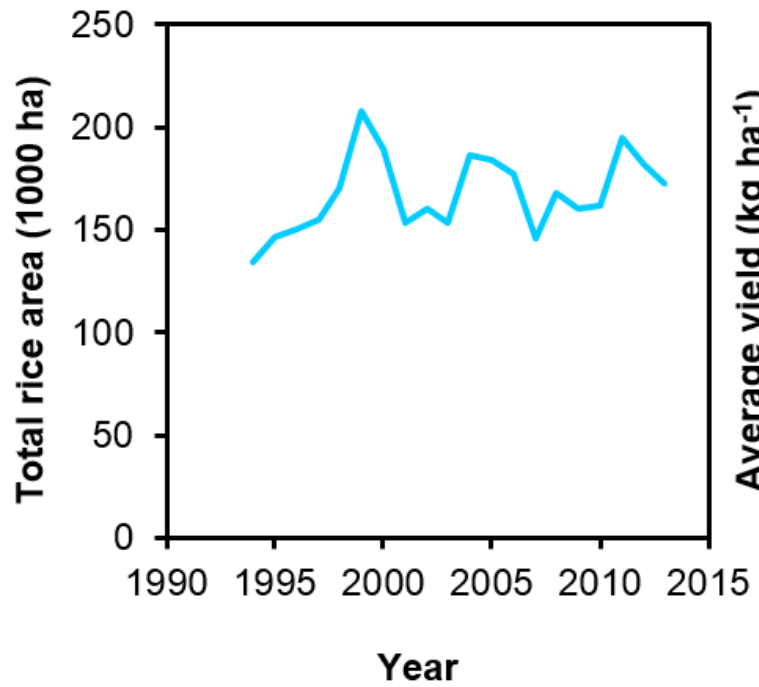
Rice systems in Uruguay



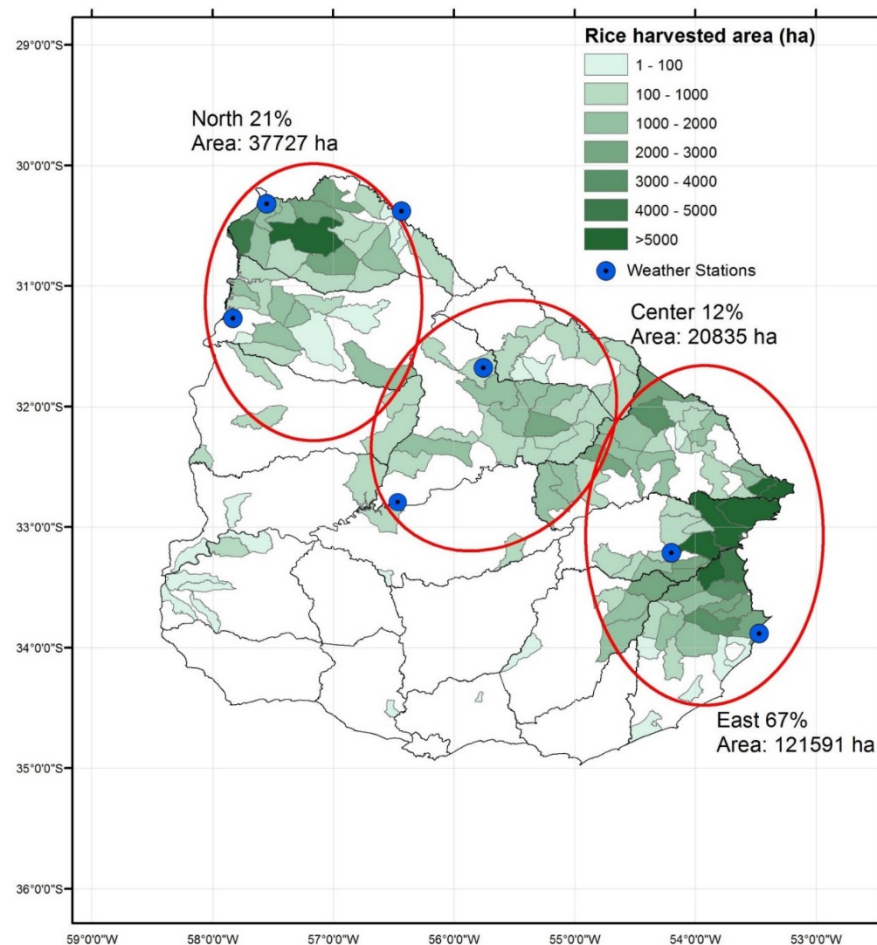
INIA: Álvaro Roel, Gonzalo Zorrilla, José Terra, Sara Riccetto, Ignacio Macedo, Camila Bonilla



Increased production



National assessment



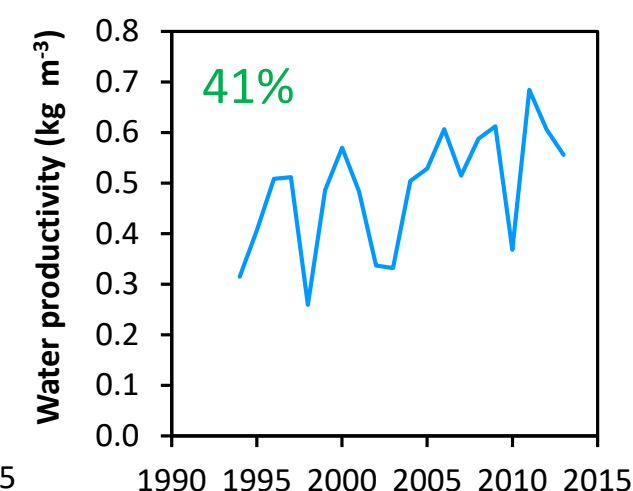
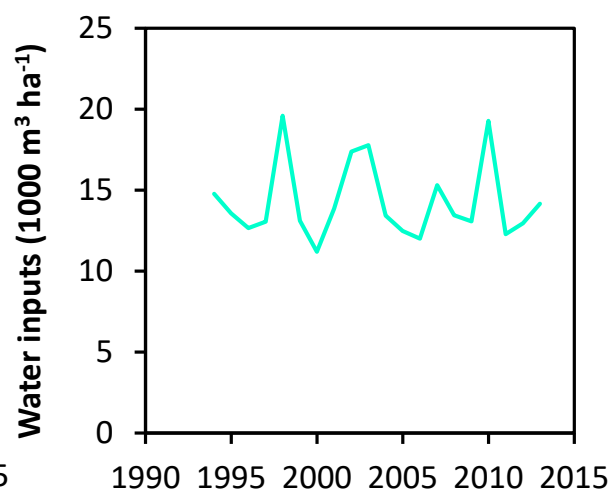
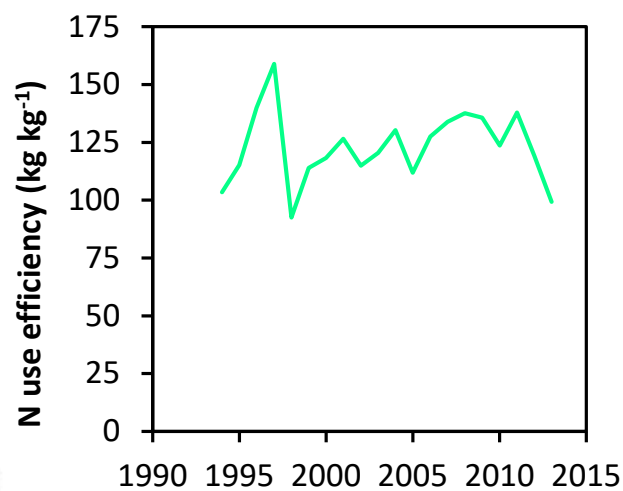
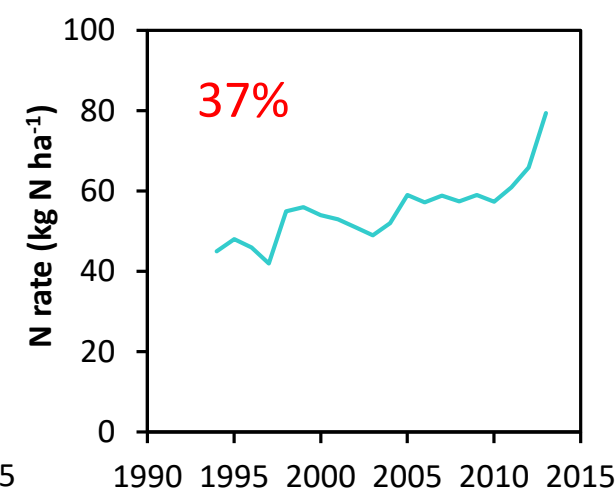
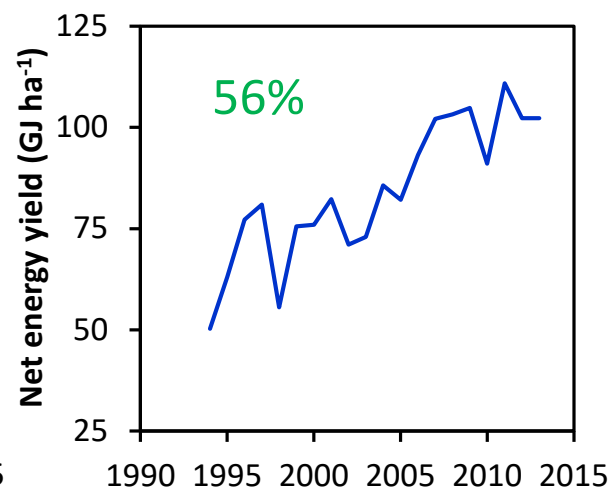
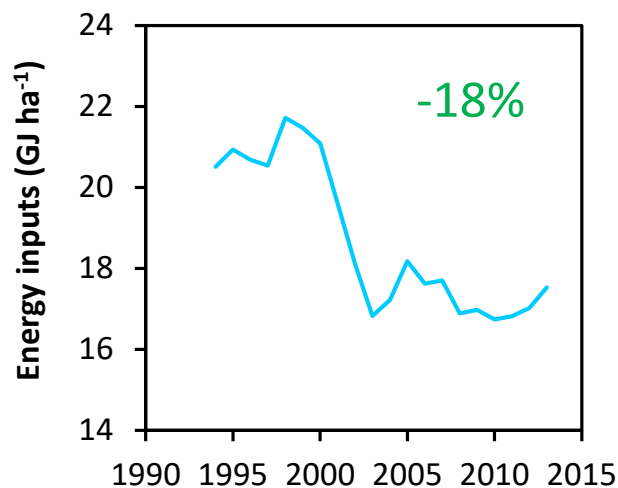
- 1) Estimate the sustainability impacts of rice intensification
- 2) Evaluate synergies and tradeoffs among indicators

Methods

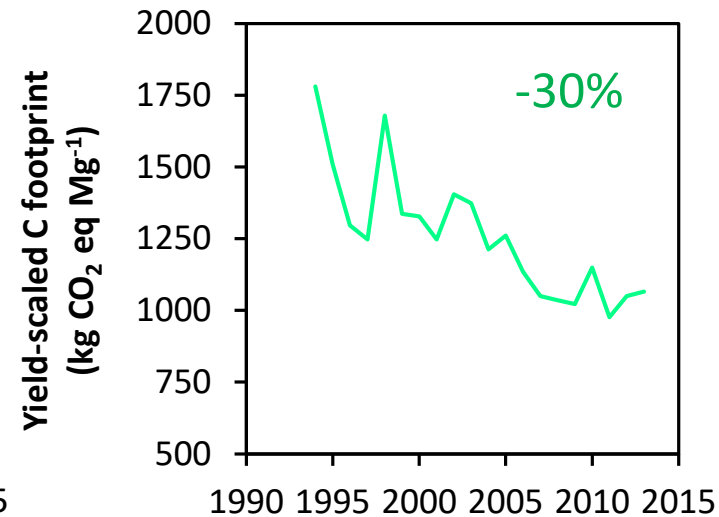
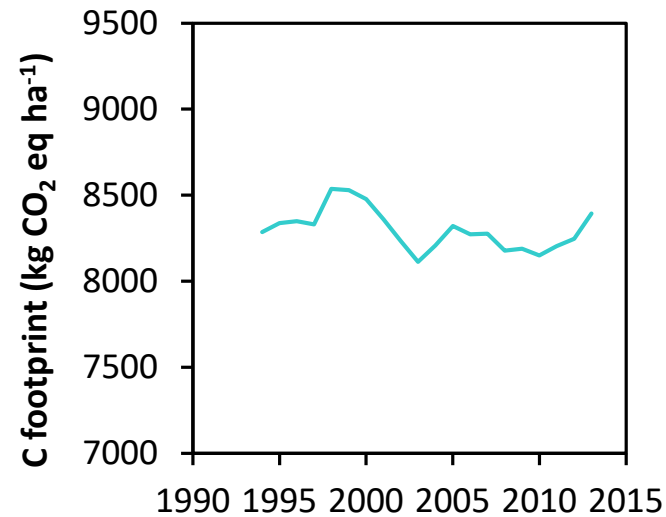
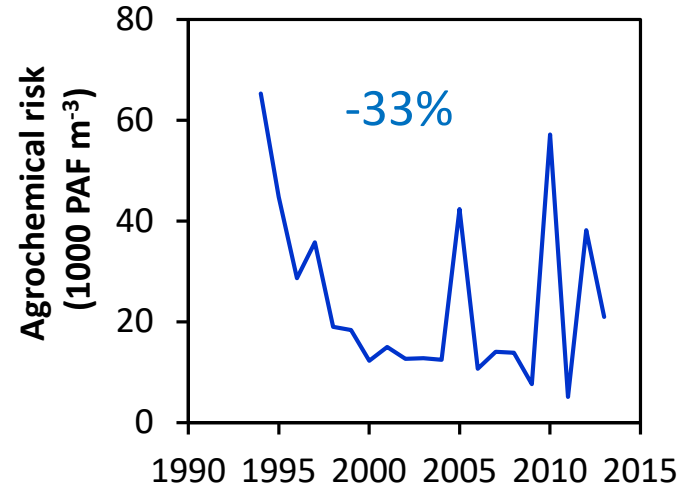
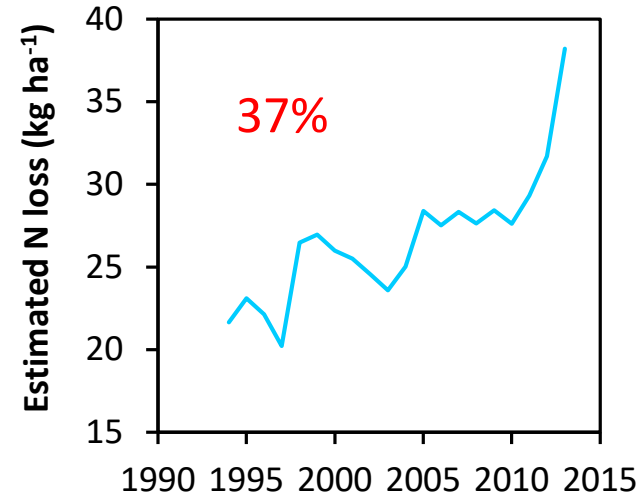
Sustainability indicators	
Yields	Water productivity
Net energy yield	Agrochemical contamination risk
Nitrogen use efficiency	Carbon footprint

- Twenty year study period (1993-2013)
- National statistics (DIEA)
- INIA-rice industry working group statistics
- Reported information, conversion factors, or empirical data from the literature

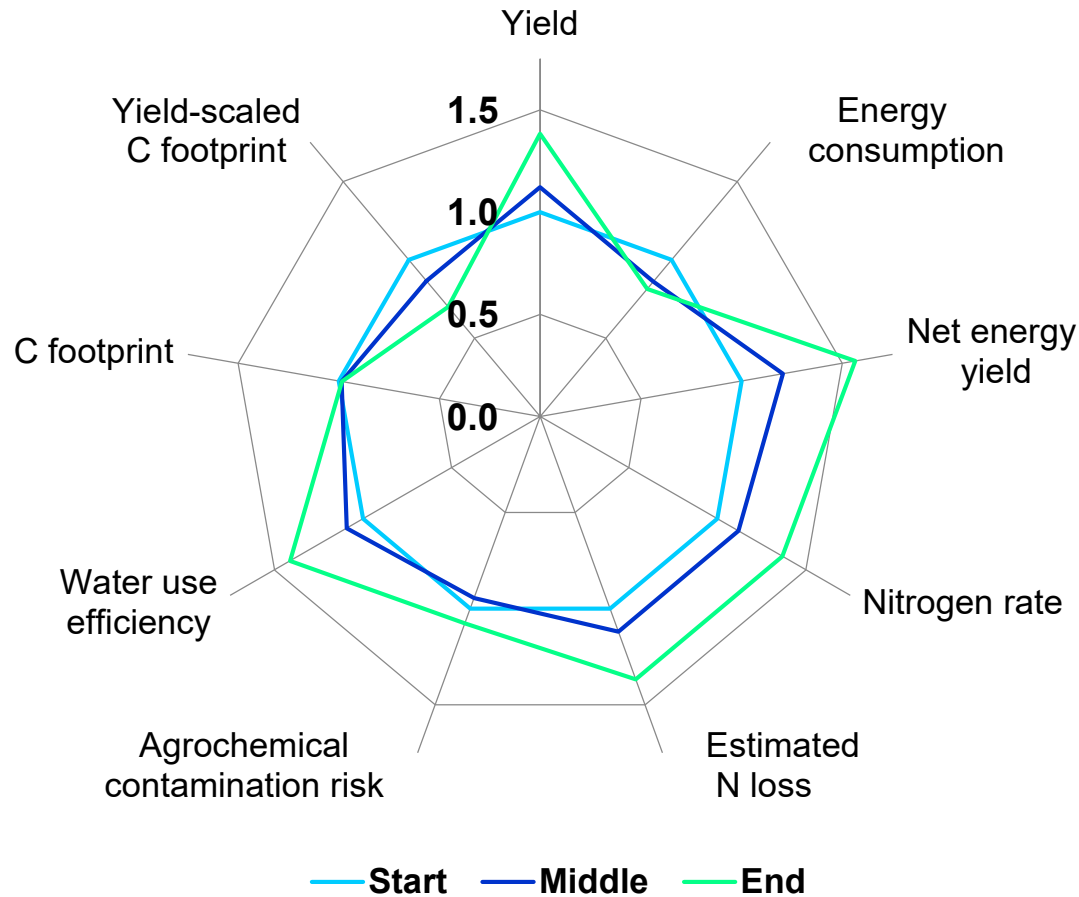
Resource use efficiencies



Environmental indicators



Integrating metrics



- Increased energy efficiency while decreasing yield-scaled C footprint
- Concerns: N losses, agrochemical contamination risk, CH₄ emissions

Next steps

- Ongoing work with INIA and PhD student (Meng-Chun Tseng)
- Breaking the yield ceiling project with on-farm trials
- Participatory research design
- Explore environmental costs associated with future yield increases



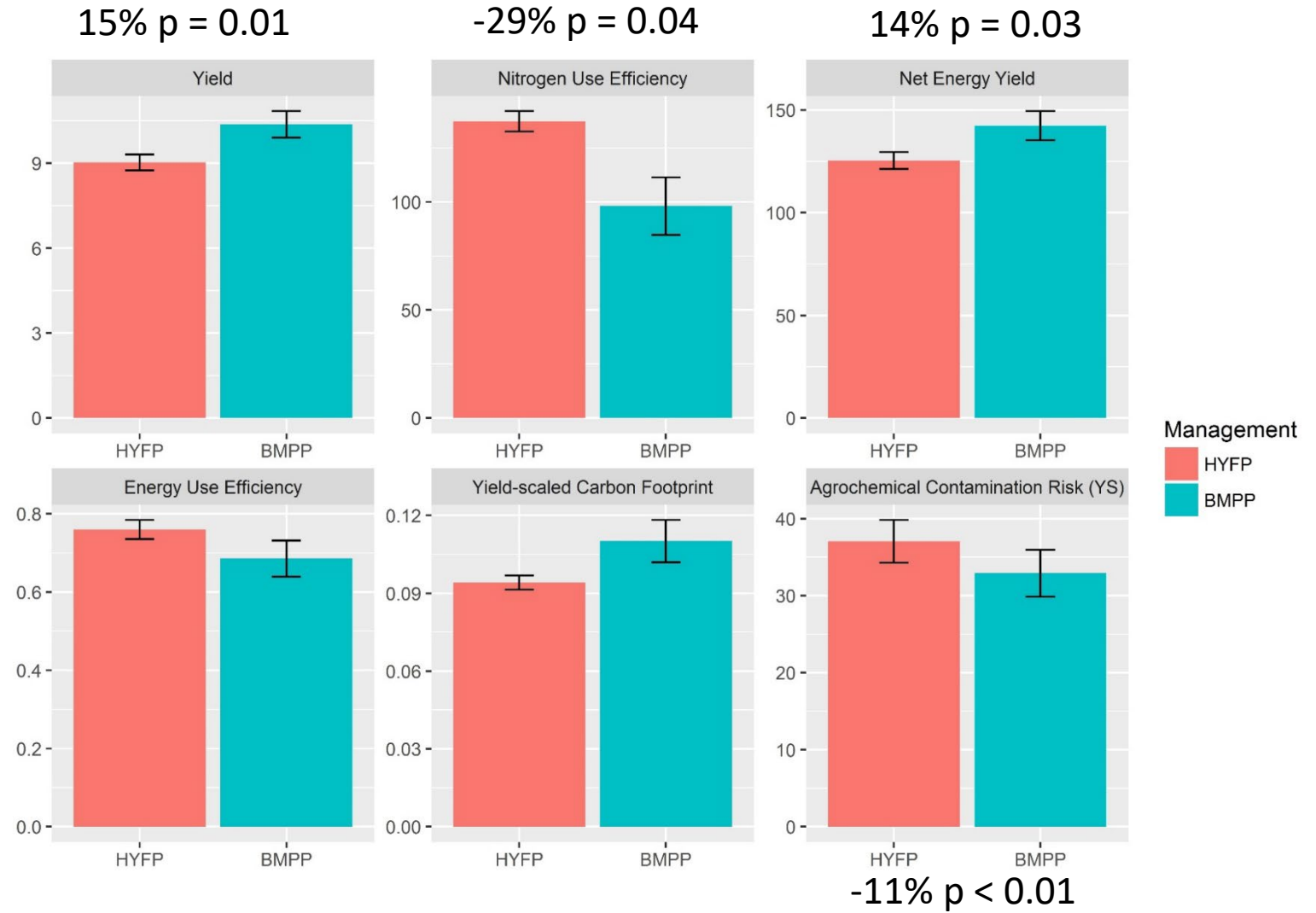
Treatments and preliminary results

		Yield
	Treatment	Mt ha ⁻¹
1	HYFP	11.62
2	+ Improved Cultivar	1.5%#
3	+ Seed Technology	-0.8%
4	+ Fertilization	0.9%
5	+ Micronutrient	-0.3%
6	+ Plant Protection	-1.0%
7	BMPP	12.10
8	- Improved Cultivar	-4.3%
9	- Seed Technology	2.3%
10	- Fertilization	-2.0%
11	- Micronutrient	1.2%
12	- Plant Protection	2.7%

Treatments and preliminary results

		Yield	NUE	Net energy yield	Energy use efficiency	Yield-scaled C footprint	Yield-scaled agrochemical contamination risk
	Treatment	Mt ha ⁻¹	kg yield kg applied N ⁻¹	GJ ha ⁻¹	kg yield MJ ⁻¹	kg CO ₂ e kg yield ⁻¹	PAF m ³ kg yield ⁻¹
1	HYFP	11.62	167.55	165.27	0.973	0.075	29.75
2	+ Improved Cultivar	1.5%#	1.5%	2.3%	2.2%	-1.8%	-1.8%
3	+ Seed Technology	-0.8%	-0.8%	-0.1%	4.0%	-3.0%	-21.8%
4	+ Fertilization	0.9%	-18.9%	0.1%	-10.4%	15.3%	-1.3%
5	+ Micronutrient	-0.3%	-1.2%	0.4%	0.0%	0.1%	-0.7%
6	+ Plant Protection	-1.0%	-1.2%	-1.4%	-1.2%	1.0%	1.1%
7	BMPP	12.10	147.59	171.06	0.93	0.081	25.36
8	- Improved Cultivar	-4.3%	-3.9%	-3.7%	-1.3%	1.9%	-8.9%
9	- Seed Technology	2.3%	2.1%	2.7%	0.6%	-1.3%	9.6%
10	- Fertilization	-2.0%	14.6%	-0.6%	8.4%	-10.0%	0.2%
11	- Micronutrient	1.2%	-4.3%	1.6%	-0.6%	0.3%	-3.1%
12	- Plant Protection	2.7%	3.1%	2.7%	2.6%	-2.9%	-4.1%

On-farm validation



Reflections



- Outcomes can change drastically depending on indicators included
- Little data available for comparison with other regions
- Once yield ceiling is approached, SI appears to become more difficult

Questions raised



- Acceptable levels of accuracy?
- How to define system boundaries in space or time (e.g. rotations)?
- Need for robust baseline data to improve estimates (e.g. long-term field trials)

Outline

- Background
- Global context for Sustainable Intensification (SI)
- Research example: Rice in Uruguay
- Opportunities for accelerating SI efforts
- Example platforms and tools

Key opportunities for SI at a global scale

1. Benchmark system performance
2. Explore thresholds for efficiency and set targets
3. Develop methods to account for tradeoffs (but keep it simple)

nature Vol 466|29 July 2010

OPINION



Monitoring the world's agriculture

To feed the world without further damaging the planet, **Jeffrey Sachs** and 24 food-system experts call for a global data collection and dissemination network to track the myriad impacts of different farming practices.

Agriculture must be transformed. Although global food production is increasing, today's farming systems undermine the well-being of communities in many ways. For instance, farming has destroyed huge regions of natural habitat and caused an untold loss of ecosystem services, and it is responsible for about 30% of greenhouse-gas emissions^{1,2}. Already, about 1 billion people are undernourished. Yet to feed the global population expected by 2050, more than 1 billion hectares of wild land will need to be converted to farmland if current approaches continue to be used³.

A key step towards making agriculture sustainable is evaluating the effects of different farming systems around the world. Historically, agricultural strategies have been assessed on the basis of a narrow range of criteria, such as profitability or yields. In the future, the monitoring of agricultural systems should address environmental sustainability, food security (people's access to food and the quality of that food), human health, and economic and social well-being.

We propose establishing a global network to monitor the effects of agriculture on the environment, across major ecological and climatic zones, worldwide. This would involve stakeholders — policy-makers, farmers, consumers,

corporations, non-governmental organizations, and research and educational institutions — coming together to develop a set of metrics that quantify the social, economic and environmental outcomes of various agricultural strategies. A network of monitoring organizations would then collect the appropriate information, and the resultant, freely available data could inform agricultural management, policy and research priorities.

Comparing apples and oranges
The current monitoring of agricultural systems captures only certain effects of farming, by focusing on narrow criteria. Several examples illustrate the need to monitor multiple variables. In the United States, recent investment in the biofuel ethanol has reduced imports of petroleum⁴. But it has also required expensive

subsidies, reduced supplies of food and feed grains, spurred deforestation in other regions and perhaps even increased greenhouse-gas emissions overall⁵.

Similarly, many consumers, farmers and policy-makers praise organic farming as an ecologically friendly system, but they should consider the additional land and livestock needed to produce 'green manure', the economic cost of producing food in this way and the net effect on greenhouse-gas emissions⁶. In addition, farming genetically modified crops is widely thought to entail certain risks, but these should be assessed alongside the potential benefits, such as reduced pesticide use and higher crop yields^{7,8}.

A further problem with the current system is that the data collected are rarely comparable across ecological zones because of inconsistencies in methodologies or in the spatial scale at which observations are made^{9,10}. Agronomists, for example, tend to measure yields from fields that generally range from less than 1 hectare to 200 hectares, whereas landscape ecologists may monitor the way habitats are interconnected over geographical areas of many thousands of hectares. Moreover, some farming systems, such as traditional pastoralist systems, are often under-represented in monitoring efforts¹¹.

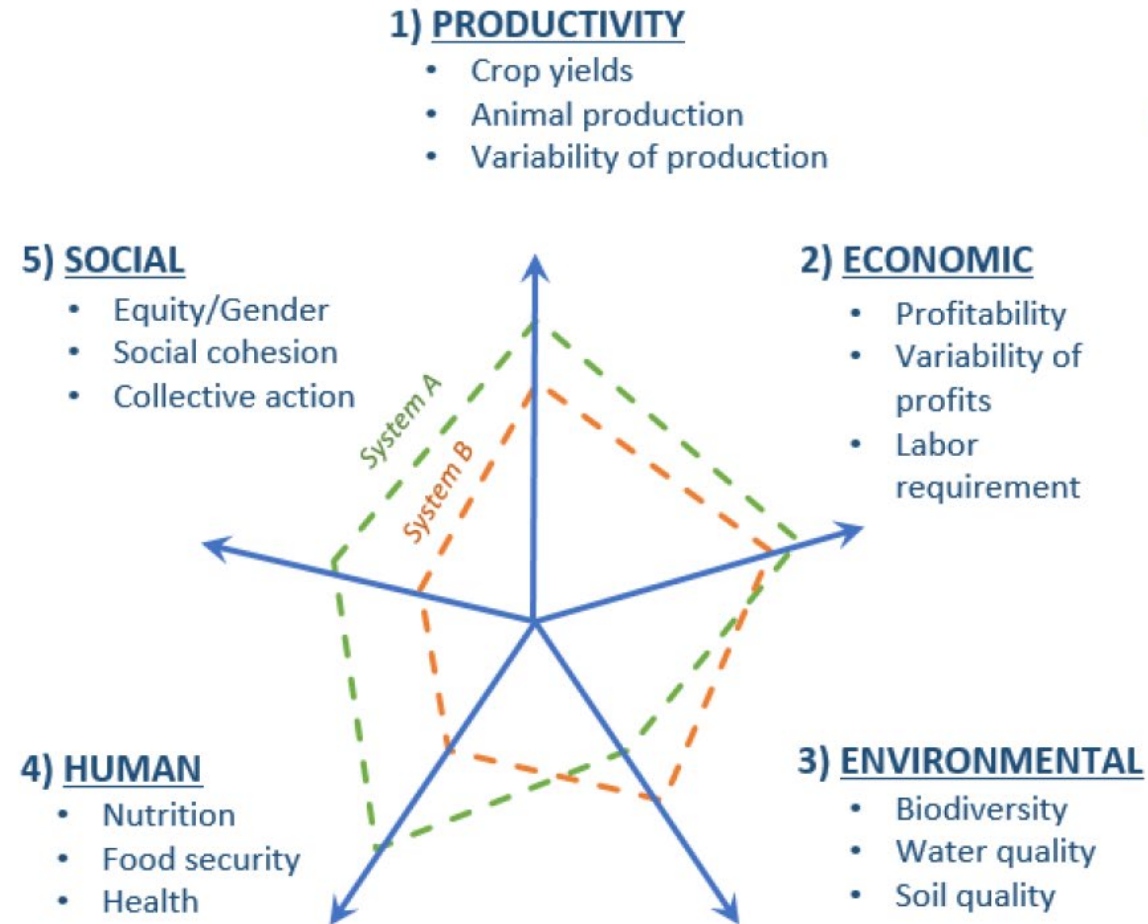
To facilitate cross-site comparisons and global modelling, data should be collected for

SUMMARY

- Agriculture is assessed at different scales, using inconsistent methods and narrow criteria
- A common set of metrics must be collected at comparable scales
- The resultant, freely available data should inform farming practices worldwide

558 © 2010 Macmillan Publishers Limited. All rights reserved.

1. Benchmark system performance



Landscape + Scale



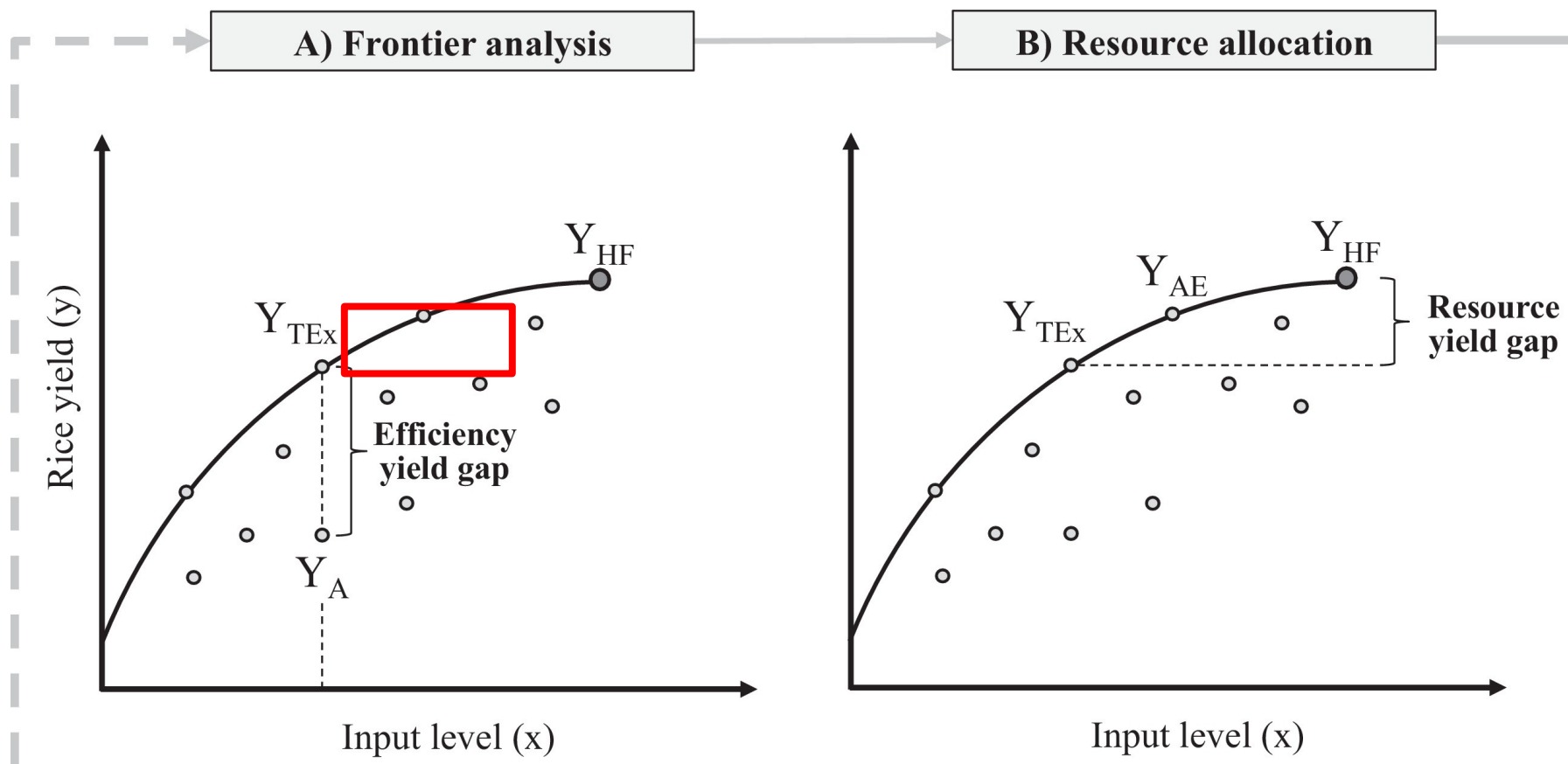
Farm/Household Scale



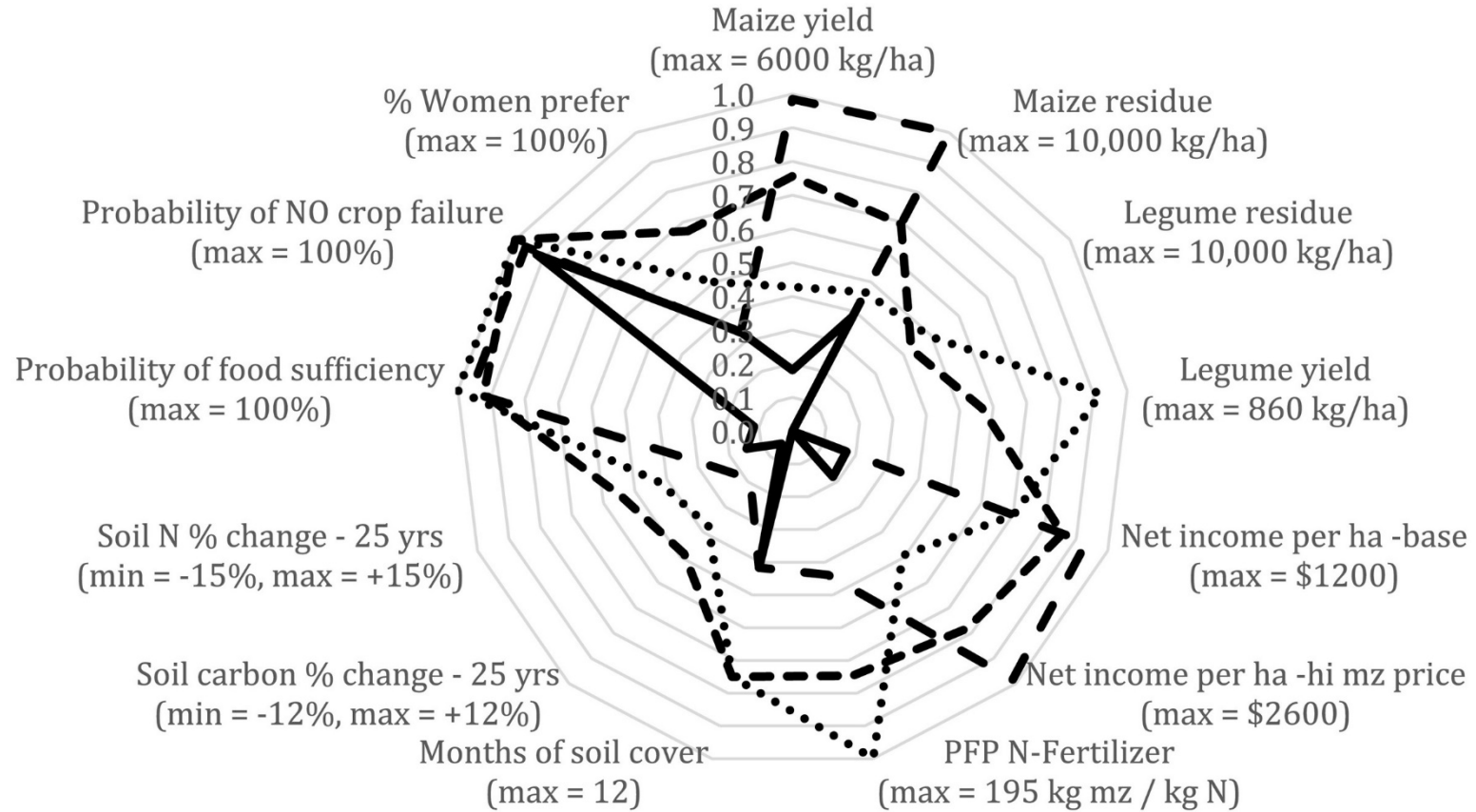
Field/Animal Herd Scale



2. Setting targets



3. Simple tools for assessing tradeoffs



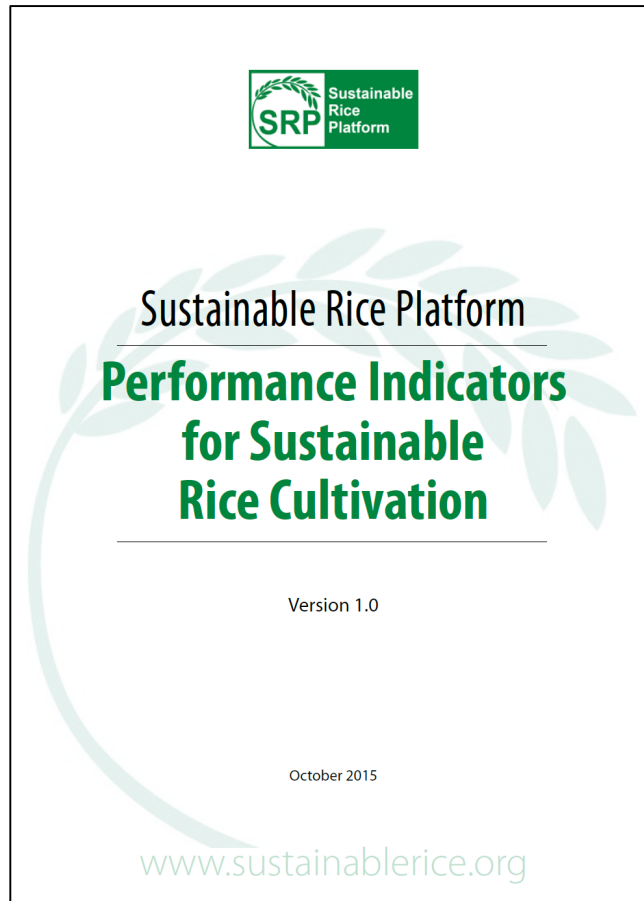
Outline

- Background
- Global context for Sustainable Intensification (SI)
- Research example: Rice in Uruguay
- Opportunities for accelerating SI efforts
- Example platforms and tools

Alliances to support SI progress

- Harmonized frameworks for evaluation
- Effective monitoring systems to track progress
- Multi-disciplinary from the start
- Some incentive for farmer participation

Sustainable Rice Platform



- Global initiative for rice-based systems
- Key developers include food retailers
- Simple set of indicators to measure efficiency across diverse systems and environments

Indicators

Name of Indicator	Measurement	Source
SRP Guiding Principle: Improved Livelihoods		
1. Profitability: net income from rice	USD/ha/crop cycle USD/ha/year	Farm records Household survey
2. Labor productivity	kg paddy rice/no. of days USD net income from rice/no. of days	Farm records Household survey
3. Productivity: grain yield	kg paddy/ha	Farm records Household survey
SRP Guiding Principle: Consumer Needs		
4. Food safety	kg safe milled rice/kg milled rice × 100	Laboratory test
SRP Guiding Principle: Resource-Use Efficiency		
5. Water-use efficiency: total water productivity	kg paddy/L (rainfall + irrigation)	Farm records Household survey
6. Nutrient-use efficiency: N	kg paddy/kg elemental N kg elemental N removal/kg elemental N input	Farm records Household survey
7. Nutrient-use efficiency: P	kg paddy/kg elemental P kg elemental P removal/kg elemental P input	Farm records Household survey
8. Pesticide-use efficiency	Balanced scorecard	Farm records Household survey
SRP Guiding Principle: Climate Change Mitigation		
9. Greenhouse gas emissions	Mg/CO ₂ eq/ha	Farm records Household survey
SRP Guiding Principle: Labor Conditions		
10. Health and safety	Balanced scorecard	Household survey
11. Child labor	Balanced scorecard	Household survey
SRP Guiding Principle: Social Development		
12. Women's empowerment	Balanced scorecard	Household survey

Fieldprint[®] Calculator, USA

Fieldprint[®] Calculator

Home | Fieldprint Calculator | Fieldprint Projects | National Report | Resources | News | Blog

Understanding and Communicating Sustainable Agriculture

The Calculator is a free and confidential tool developed for corn, cotton, rice, wheat, potatoes and soybean growers. It allows growers to better understand and communicate how management choices affect overall sustainability performance and operational efficiency.

The Calculator estimates field level performance on the following sustainability indicators:

- Land Use
- Conservation
- Soil Carbon
- Irrigation Water Use
- Water Quality
- Energy Use
- Greenhouse Gas Emissions

Calculating "Fieldprints"

Management information entered into the tool are analyzed and transformed into a "Fieldprint", which graphically represents the farmer's unique operation. It helps farmers visualize and assess how efficiencies and environmental impacts fluctuate based on various management decisions. Farmers can also compare their performance against local, state and national averages developed using publically available data.

Powerful tool, simple to use

The Fieldprint[®] Calculator is simple to use, though the technology behind it is very complex. The Calculator uses datasets and methodologies developed by multiple sources, including the Natural Resources Conservation Service of the United States Department of Agriculture.

Available Online

Calculate your unique "Fieldprint" today and identify opportunities for a more sustainable tomorrow. Detailed directions are available

[Calculator Login](#)

Home | About Us | Contact Us | Members | Privacy Policy | Sitemap | Follow us on:

© 2015 Field to Market[®]. All Rights Reserved.

Field to Market Members

Field to Market brings together a diverse group of grower organizations; agribusinesses; food, fiber, restaurant and retail companies; conservation groups; universities and agency partners to focus on promoting, defining and measuring the sustainability of food, fiber and fuel production.

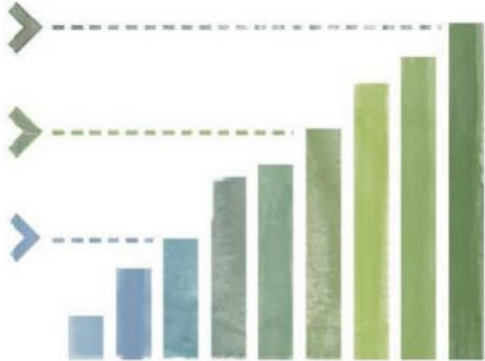


Goals of calculator



Benchmarking

Sustainability Performance



Catalyzing

Continuous Improvement




Enabling

Sustainability Claims

Goals of calculator

On this page, you will locate your field and enter information about its soil and your crop rotation, management system, transportation, and drying practices. This information will be used to calculate your Fieldprint for a variety of indicators on the following tabs.

Instructions

- You are currently on the Start Tab which is where you will enter all field data. For help throughout the Calculator, please click on the blue  for further instructions or definitions.
See More...

Load Sample Field

Click this button to load a sample field that will allow you to explore the Calculator with demonstration data based on a real farm in Missouri.

Field

Field:

Units:

Include Wind Erosion Prediction System (WEPS) model execution: Yes No

Note: Running the Wind Erosion Prediction (WEPS) model will add 10-30 seconds per year of data entered causing longer than normal results processing times. Selecting "No" will turn WEPS off. Please click on "?" for more information.

Save

Location

Soil

Crop Rotation

Management

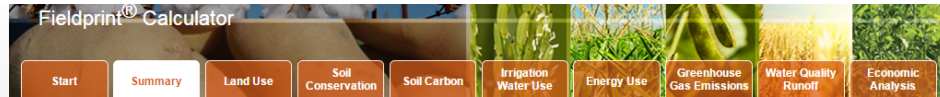
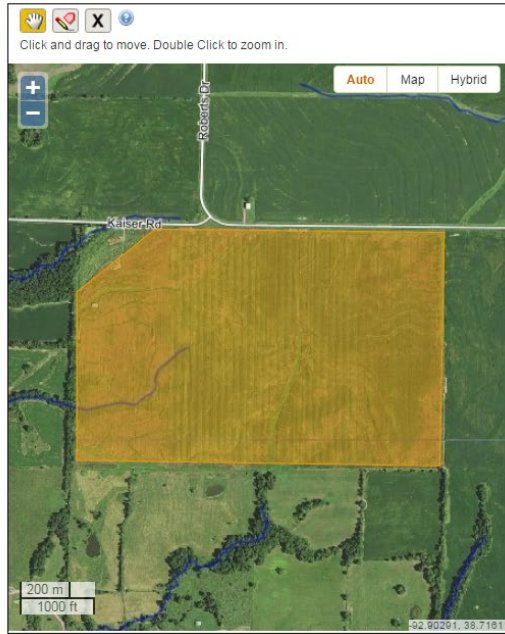
Product Transportation/Hauling

Drying

Planted But Not Harvested

Conservation Practices

Farm Demographics

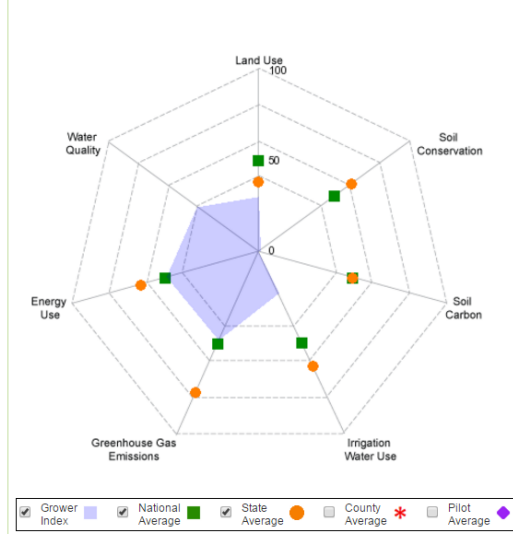


To go back to previous tabs, please use the tabs rather than your browser's Back button.

Latest Calculator Update: **Bug Fix: Mar 17, 2016**

Summary

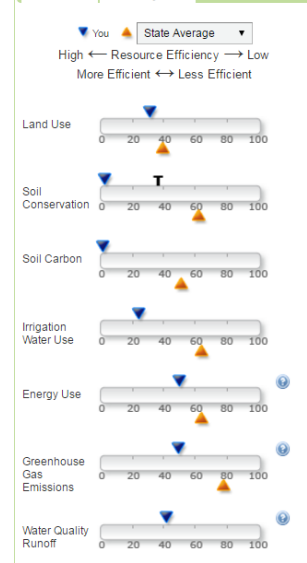
2012 Corn 2011 Soybean



The Fieldprint values shown for a selected crop on the slider bars are plotted on the above Spidergram. The Spidergram axes are relative indices representing your resource use or impact per unit of output in each of the five resource areas. Lower values closer to the center indicate a lower impact on each resource.


Create Report

2012 Corn 2011 Soybean



The values on the slider bars are relative indices, where lower values (0) indicate greater efficiency and/or lower impacts on the particular resource area and higher values (100) indicate lower efficiency and/or higher impacts on the particular resource area.


Carbon offset protocols (USA)

Voluntary Emission Reductions in Rice Management Systems, v1.0 – Midsouth Module 


Voluntary Emission Reductions in Rice Management Systems – Midsouth Module


Version 1.0


Prepared by:


Terra Global Capital, LLC

With support from:


 Environmental Defense Fund

 White River Irrigation District

 Applied Geosolutions, LLC

February 2014

Page | 1

 **VCS** | VERIFIED CARBON STANDARD
A Global Benchmark for Carbon

Approved VCS Methodology VM0022

Version 1.0, 5 March 2013
Sectoral Scope 14

Quantifying N₂O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction

©2013 Michigan State University

Conclusions

- Baseline knowledge of key indicators and tradeoffs is low
- Realistic expectations for SI may depending on existing yield gaps
- Environmental indicators will need continuous improvement

- The imperative of SI is common knowledge
- Next generation is being trained to tackle these issues
- Successful examples and frameworks for evaluation exist

Questions?

