Setting external target values of SRP performance indicators for sustainable rice production

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Outline

- Sustainable Rice Platform (SRP) defined performance indicators for rice production
- Overview of major performance indicators across Asia and Africa (irrigated rice production)
- Setting (identifying) external target values for major SRP performance indicators (irrigated rice)
- Three applications of external targets
- Conclusions
- Acknowledgements

Introduction: Why sustainability indicators?

- Being staple food of half of the world population, improving and sustaining the rice systems is central to achieving the SDGs goals, particularly in Asia (and West Africa) where more than 90% of rice is produced

- Achieving sustainable increments in productivity (sustainable intensification) is necessary to produce more food in the long term while minimizing environmental footprint

- Many sustainable intensification assessments focus on only one or two aspects of sustainability (economic, environmental, or social), only a few studies have used multi-dimensional indicators to assess the sustainability of smallholder rice systems

SRP (Sustainable Rice Platform) established in 2011 by IRRI and UNEP. Now is now independent membership organization, established to produce rice sustainably (economic, environmental and social)

Goal 4
Quality Education

Goal 8
Decent Work and Economic Growth

Goal 9
Industry, Innovation and Infrastructure

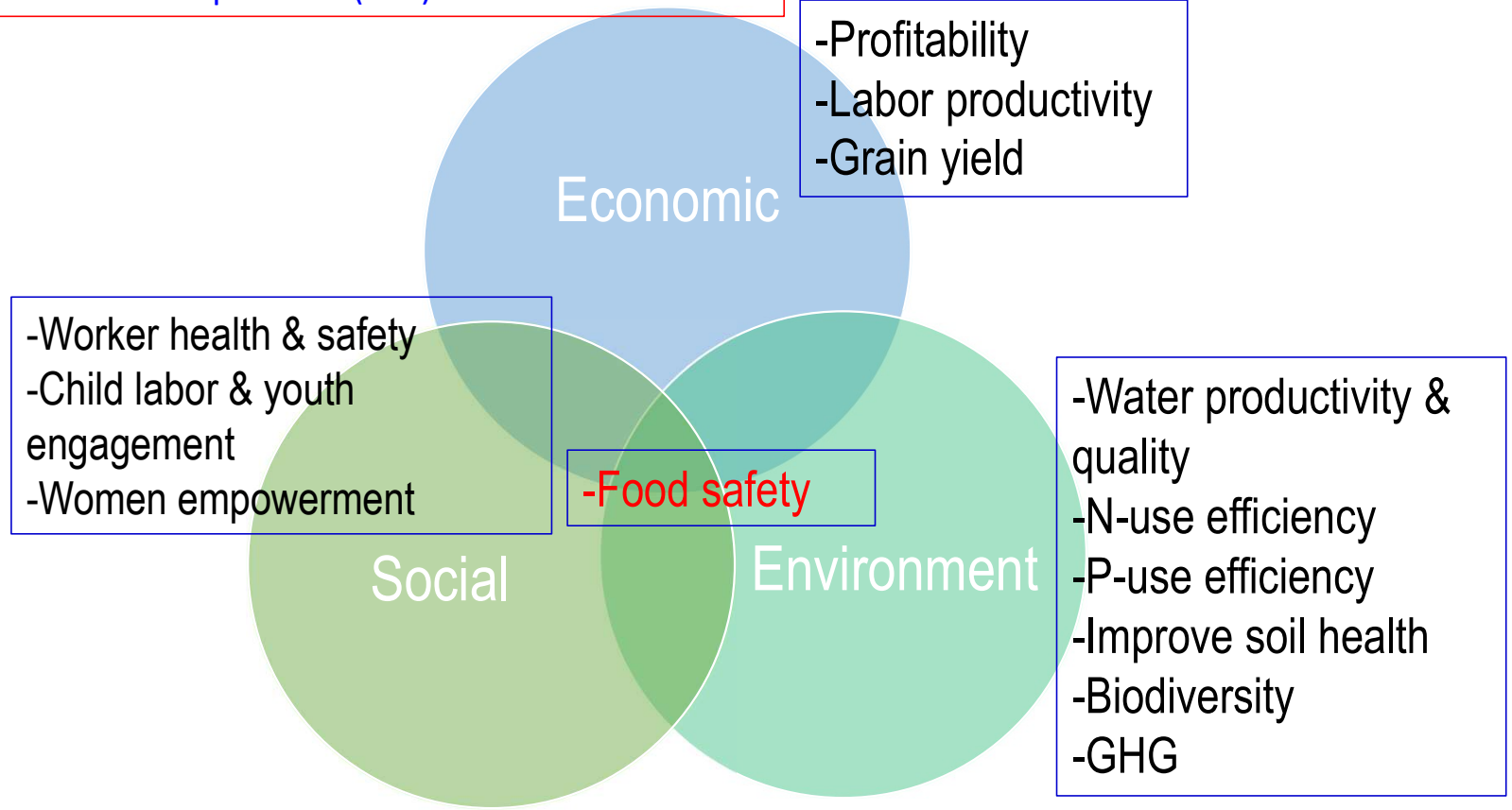
Goal 11
Sustainable Cities and Communities

Goal 12
Sustainable Consumption and Production

Goal 17
Partnerships for the Goals

Three pillars and 12 performance indicators for sustainable rice production

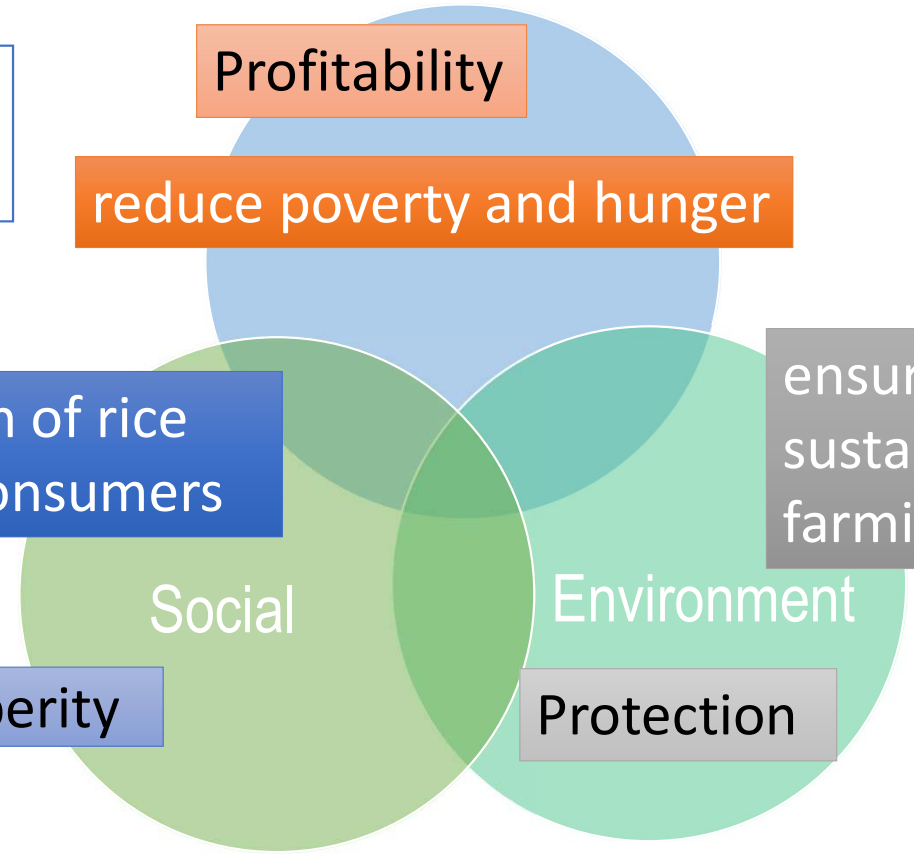
Sustainable rice platform (SRP) defined 12 indicators



Sustainability ideas and mission

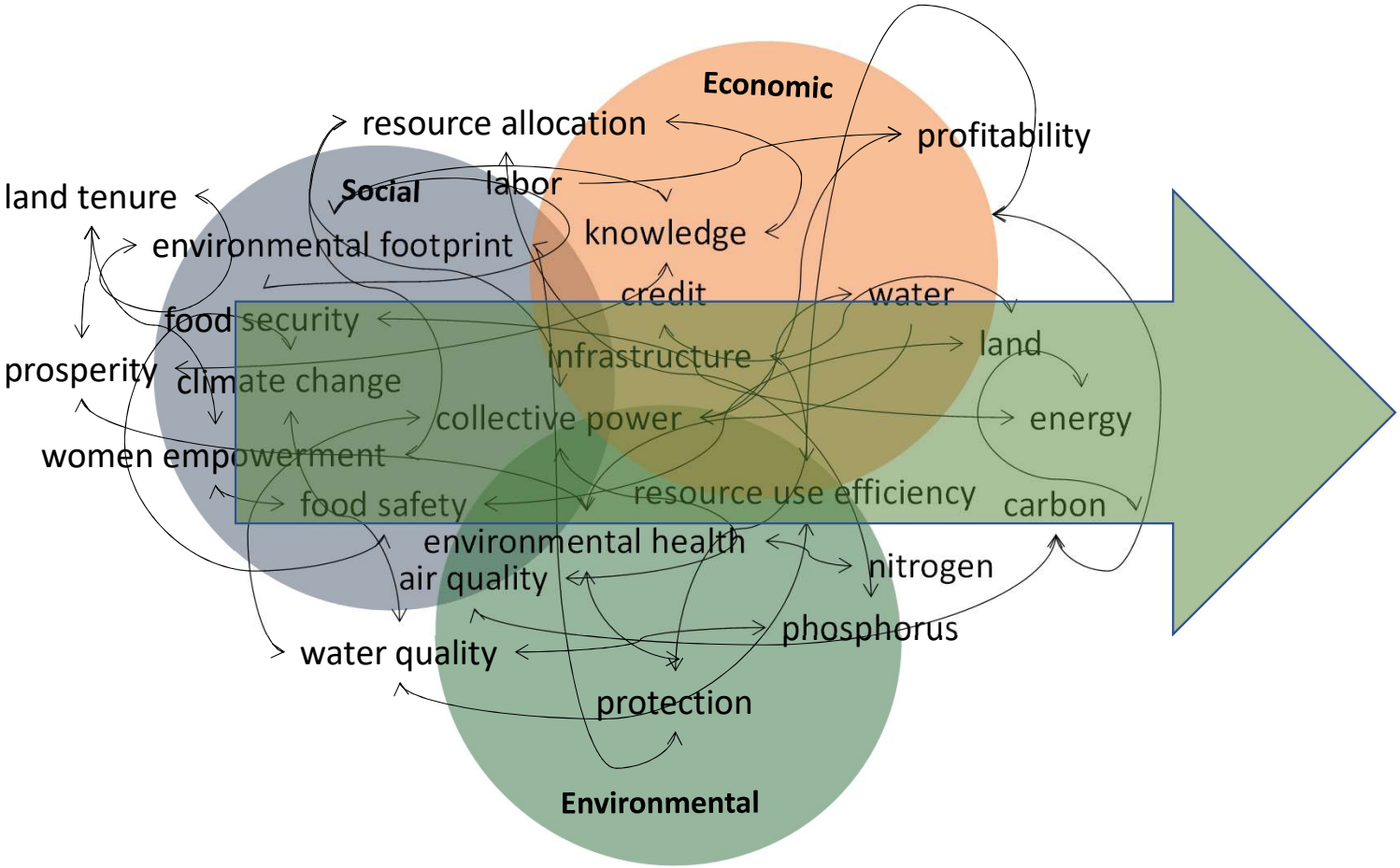
Resource Use Efficiency:
Nitrogen
Water

Environment:
Greenhouse gas emissions
Biodiversity



Reducing environmental footprint

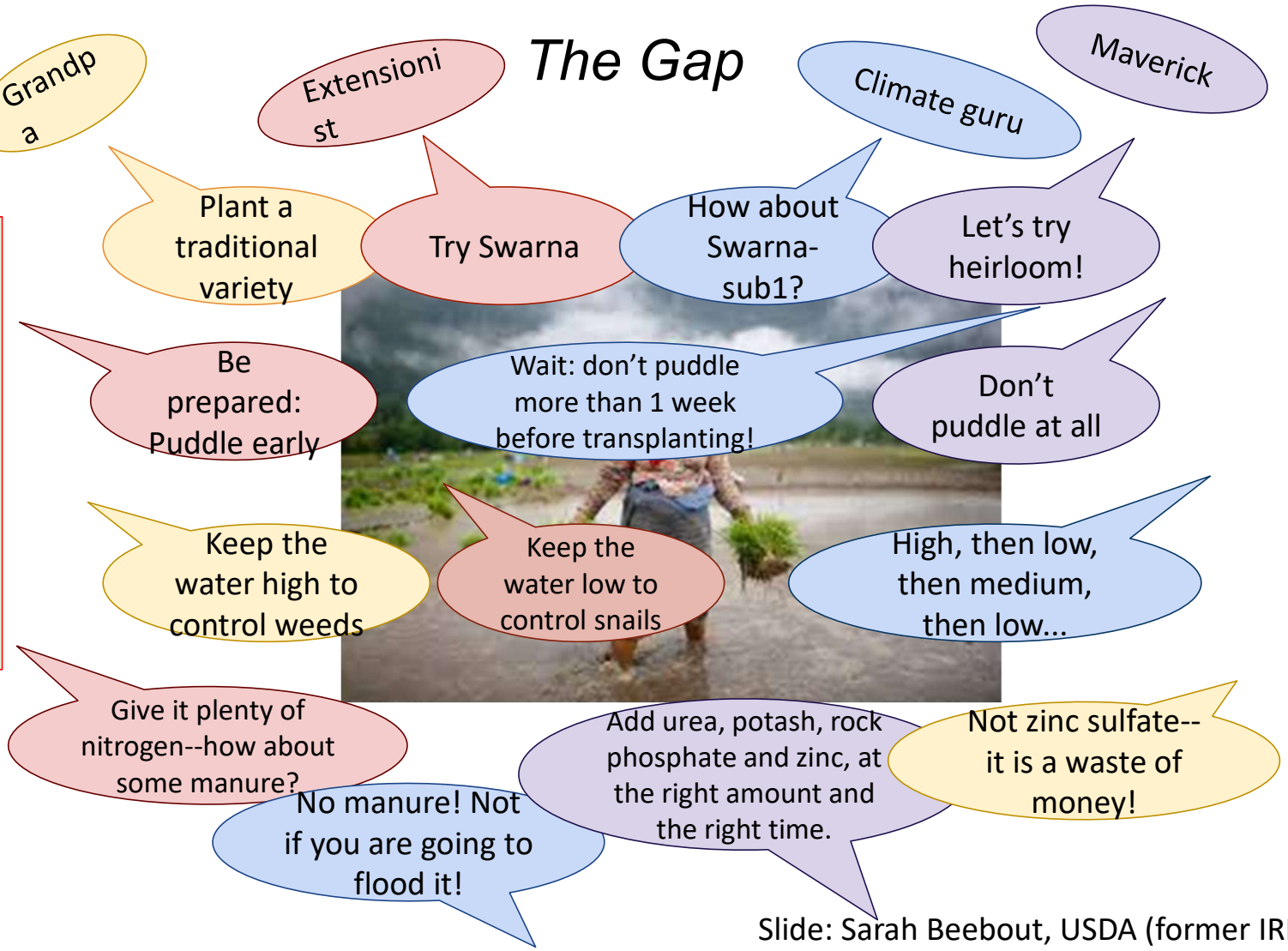
“Sustainability is complex”



Slide: Sarah Beebout, USDA (former IRRI)

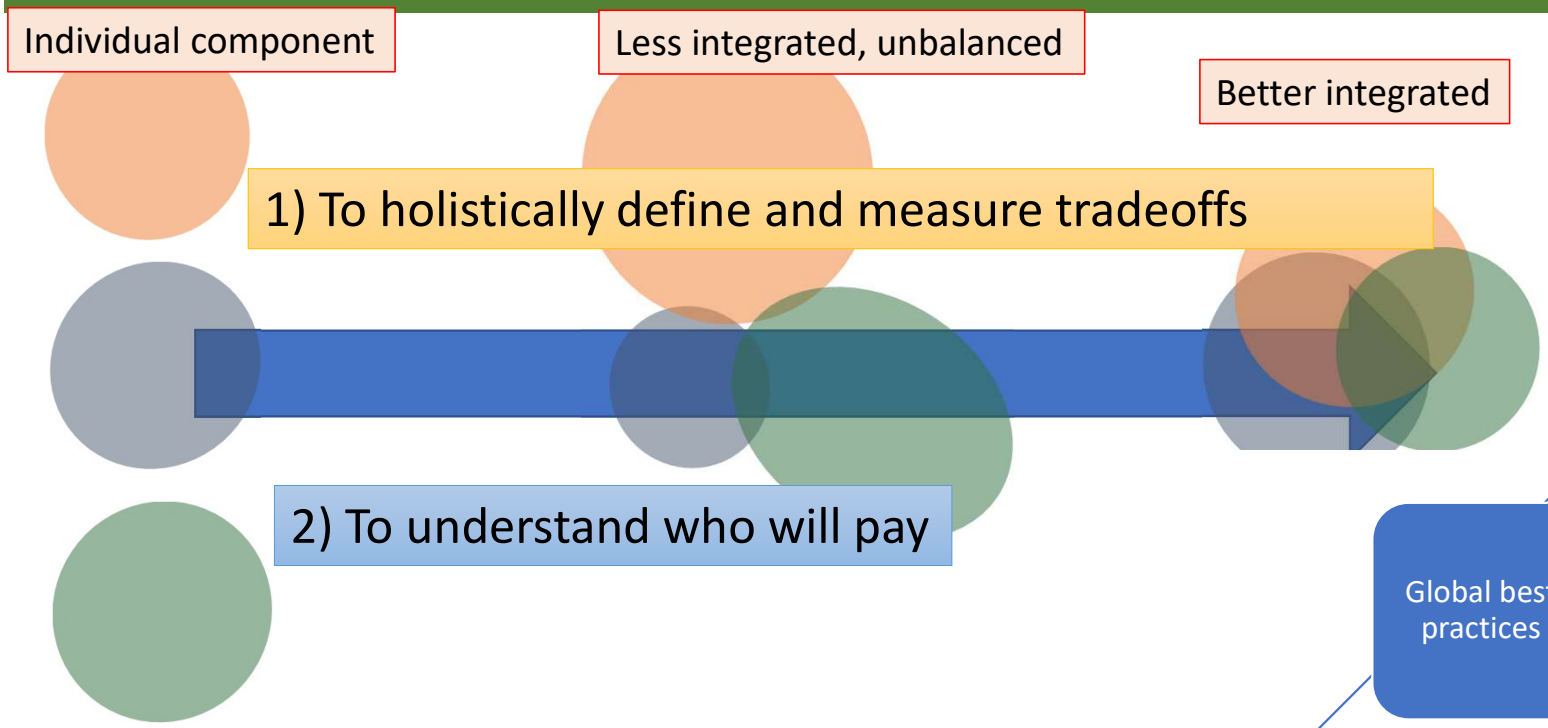
Scattered and individual information, localized issue and suggestions, redundancies

whom to listen, what to do, what not to?

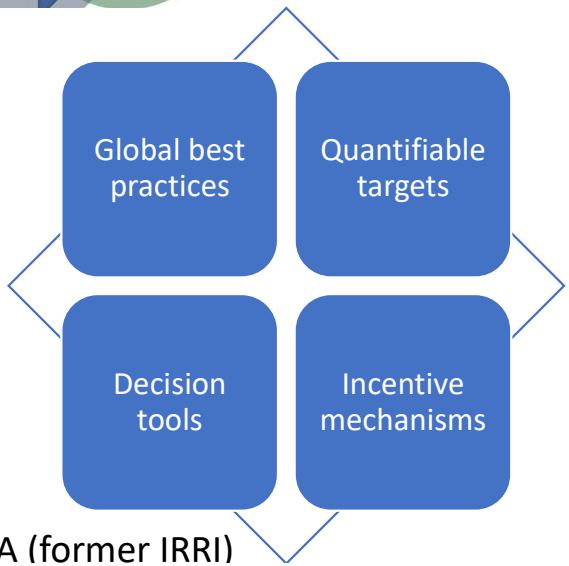


Slide: Sarah Beebout, USDA (former IRRI)

Need to move from individual (production focused) to holistic and integrated sustainable approach!



Why and how??



Aim: To build a robust and credible framework to facilitate large-scale adoption of sustainable practices in the rice value chain

Slide: Sarah Beebout, USDA (former IRRI)

Overview of major performance indicators across Asia and Africa

to evaluate strategies for benchmarking targets for the SRP PIs for irrigated or favorable rainfed rice systems;

Data sources

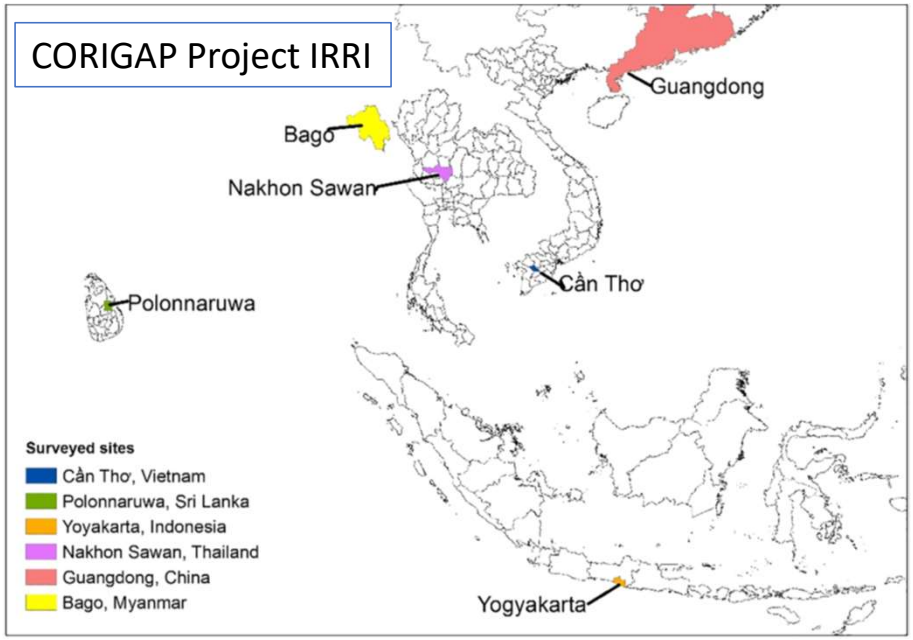
Country	Surveyed region	Year	No. of surveyed household (wet and dry season, respectively)
Vietnam	Can Tho	2015	164, 180
Thailand	Nakhon Sawan	2013	84, 80
China	Guangdong	2012	188, 248
Indonesia	Yogyakarta	2014	180, 176
Myanmar	Bago	2012	100, 100
Sri Lanka	Polonnaruwa	2013	55, 55
India	Odisha	2015	652 (Wet season only)
Nepal	6 Terai districts	2016	1052
12 West African countries		2013-2014	2907

Benin	248
Cameroun	138
Cote d'ivoire	236
Ghana	255
Madagascar	644
Mali	81
Niger	311
Nigeria	243
Senegal	158
Sierra Leone	224
Tanzania	249
Togo	120

5465 households from Asia and Africa

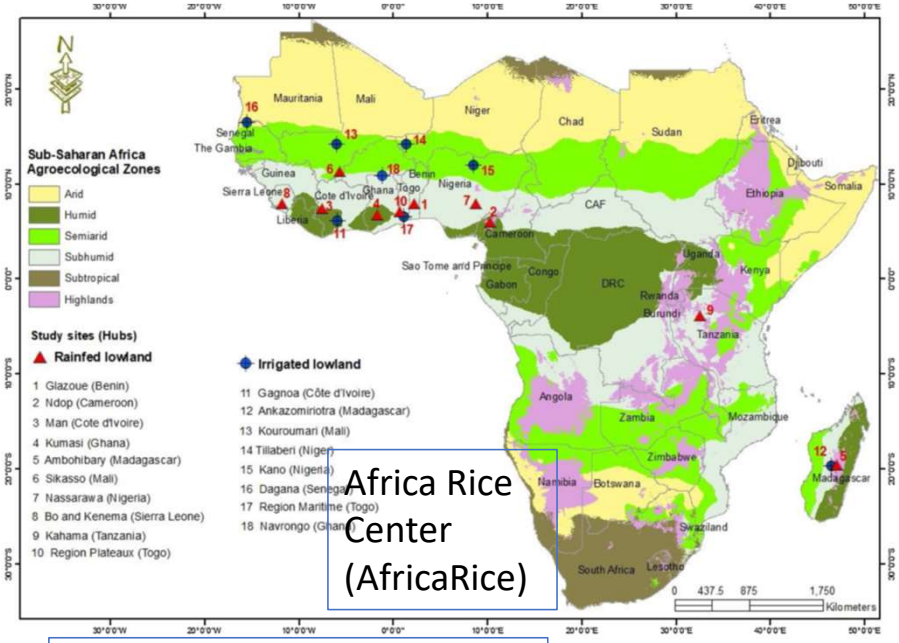
Study sites

CORIGAP Project IRRI

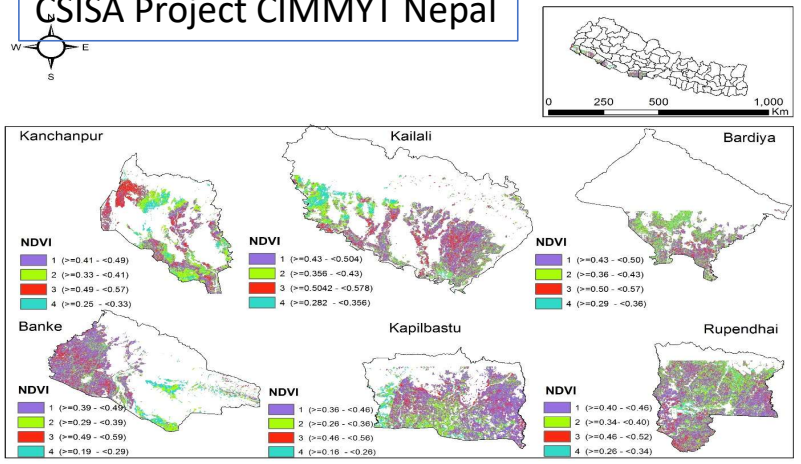


CSISA Project, IRRI

Africa Rice Center (AfricaRice)



CSISA Project CIMMYT Nepal



Key publications in SRP indicators

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Economic and environmental indicators of sustainable rice cultivation: A comparison across intensive irrigated rice cropping systems in six Asian countries

Krishna Prasad Devkota[a,1,*], Estela Pasuquin[a], Abigail Elmido-Mabilangan[a], Rowell Dikitanan[a], Grant R. Singleton[a], Alexander M. Stuart[a], Duangporn Vithoonjit[b], Ladda Vidiyangkura[c], Arlyna Budi Pustika[d], Riefna Afriani[d], Charisma Lia Listyowati[d], R.S.K. Keerthisena[e],

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

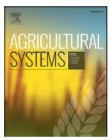
Assessing rice production sustainability performance indicators and their gaps in twelve sub-Saharan African countries

Aminou Arouna[a,*], Krishna Prasad Devkota[a,1], Wilfried Gnipabo Yergo[a], Kazuki Saito[a], Benedicta Nsiah Frimpong[b], Patrice Ygue Adegbola[c], Meougbe Ernest Depieu[d],

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy



Coupling landscape-scale diagnostics surveys, on-farm experiments, and simulation to identify entry points for sustainably closing rice yield gaps in Nepal

Krishna Prasad Devkota[a,*], Mina Devkota[b], Gokul Prasad Paudel[c], Andrew James McDonald[d]

[a] African Sustainable Agriculture Research Institute (ASARI), Mohammed VI Polytechnic University (UM6P), Laâyoune, Morocco

Field Crops Research 229 (2018) 103–114

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

On-farm assessment of different rice crop management practices in the Mekong Delta, Vietnam, using sustainability performance indicators

Alexander M. Stuart[a,*], Krishna P. Devkota[a], Takahiro Sato[a,b], Anny Ruth P. Pame[a], Carlito Balingbing[a], Nguyen Thi My Phung[a], Nguyen Thi Kieu[c], Pham Thi Minh Hieu[c], Tran Hai Long[c], Sarah Beebout[a], Grant R. Singleton[a]

Journal of Cleaner Production 244 (2020) 118835

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Assessing alternative crop establishment methods with a sustainability lens in rice production systems of Eastern India

Krishna Prasad Devkota[a,b], Sudhir-Yadav[a,*], C.M. Khanda[c], Sarah J. Beebout[a], Bidhan K. Mohapatra[a], Grant R. Singleton[a,d], Ranjitha Puskur[a]

Environmental Impact Assessment Review 92 (2022) 106697

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

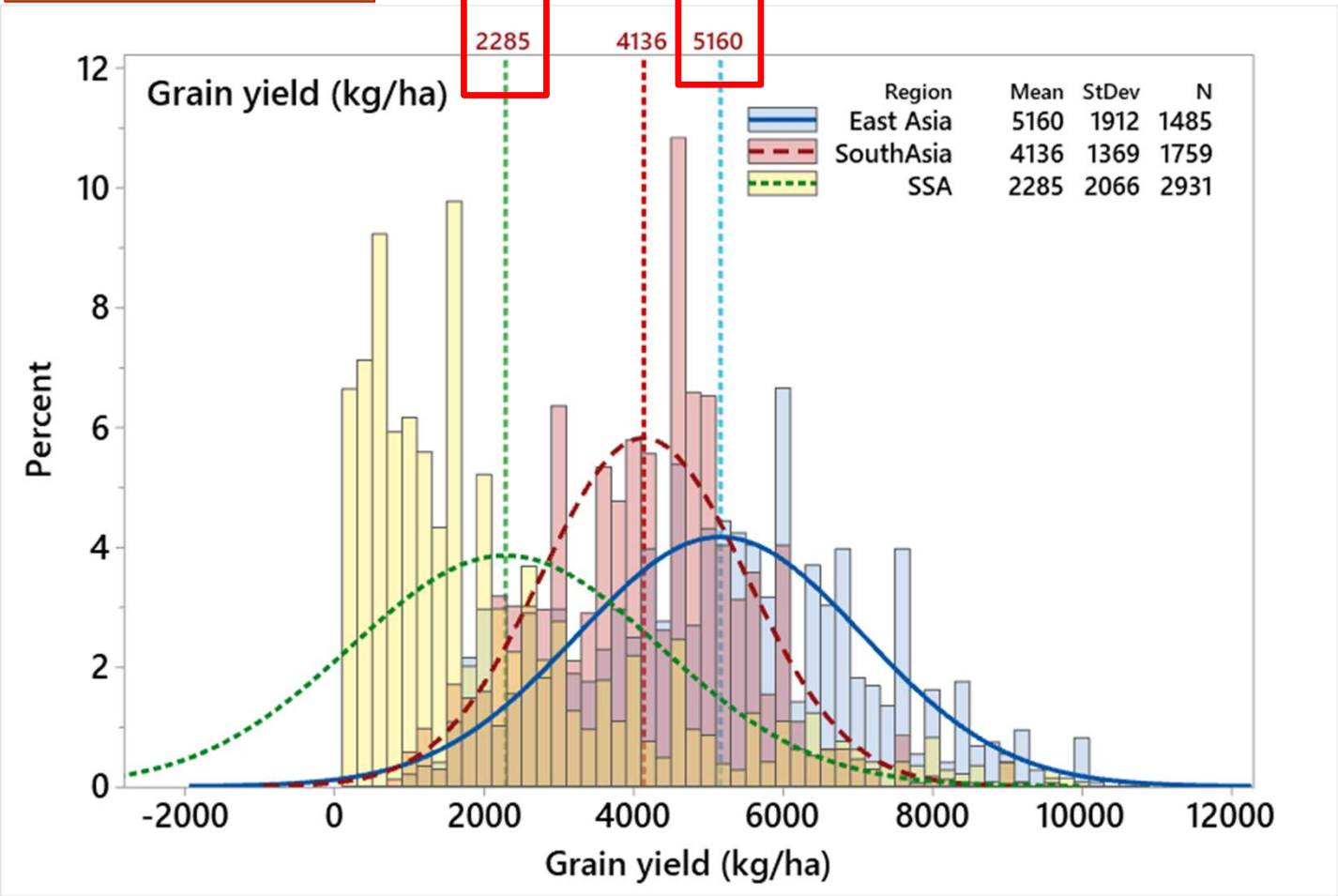
journal homepage: www.elsevier.com/locate/eiar

Setting sustainability targets for irrigated rice production and application of the Sustainable Rice Platform performance indicators

Krishna Prasad Devkota[*,1], Sarah E.J. Beebout[2], Sudhir-Yadav, Michelle Anne Bunquin

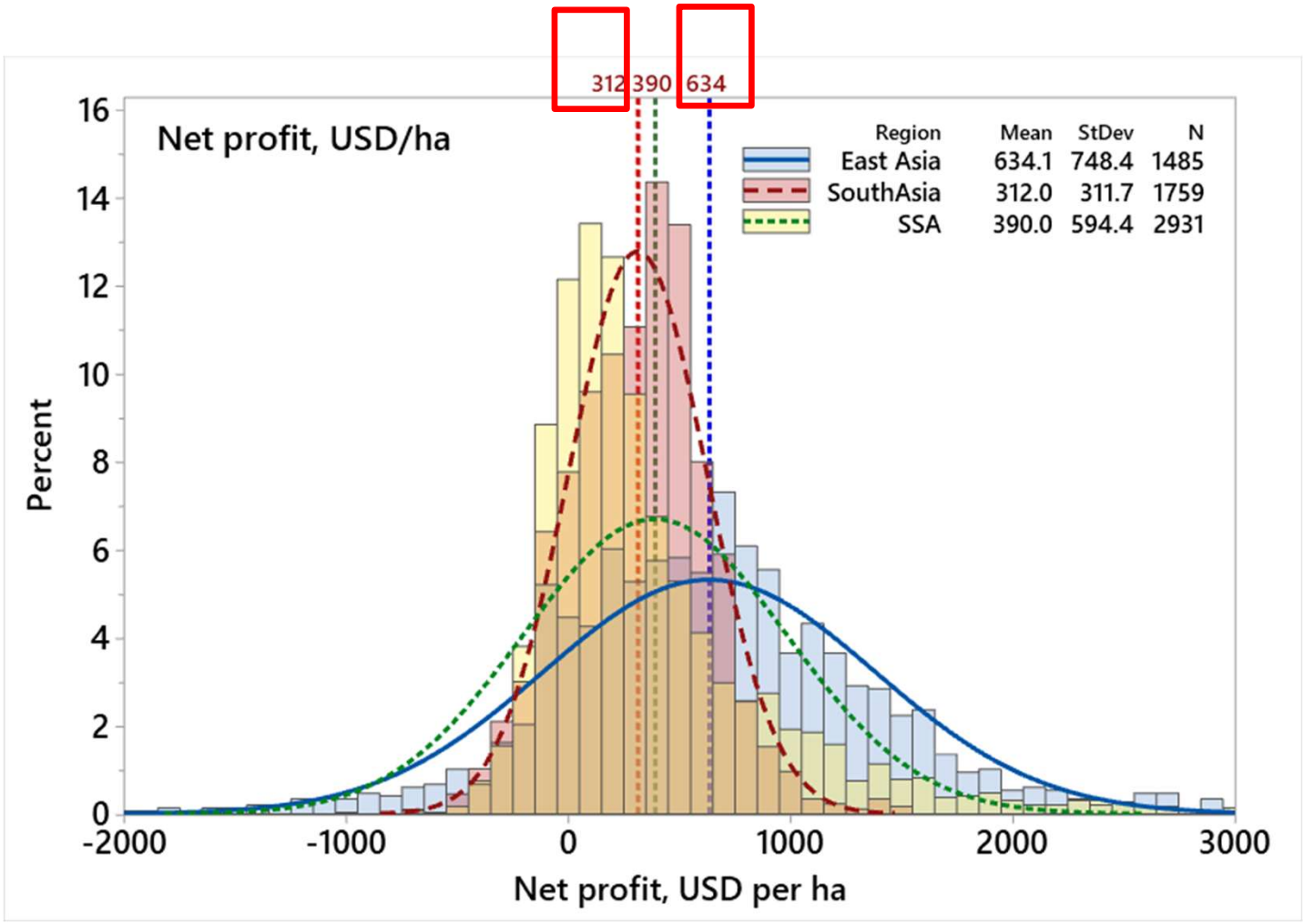
Assessments/comparison of major performance indicators (PIs)

I. Grain yield

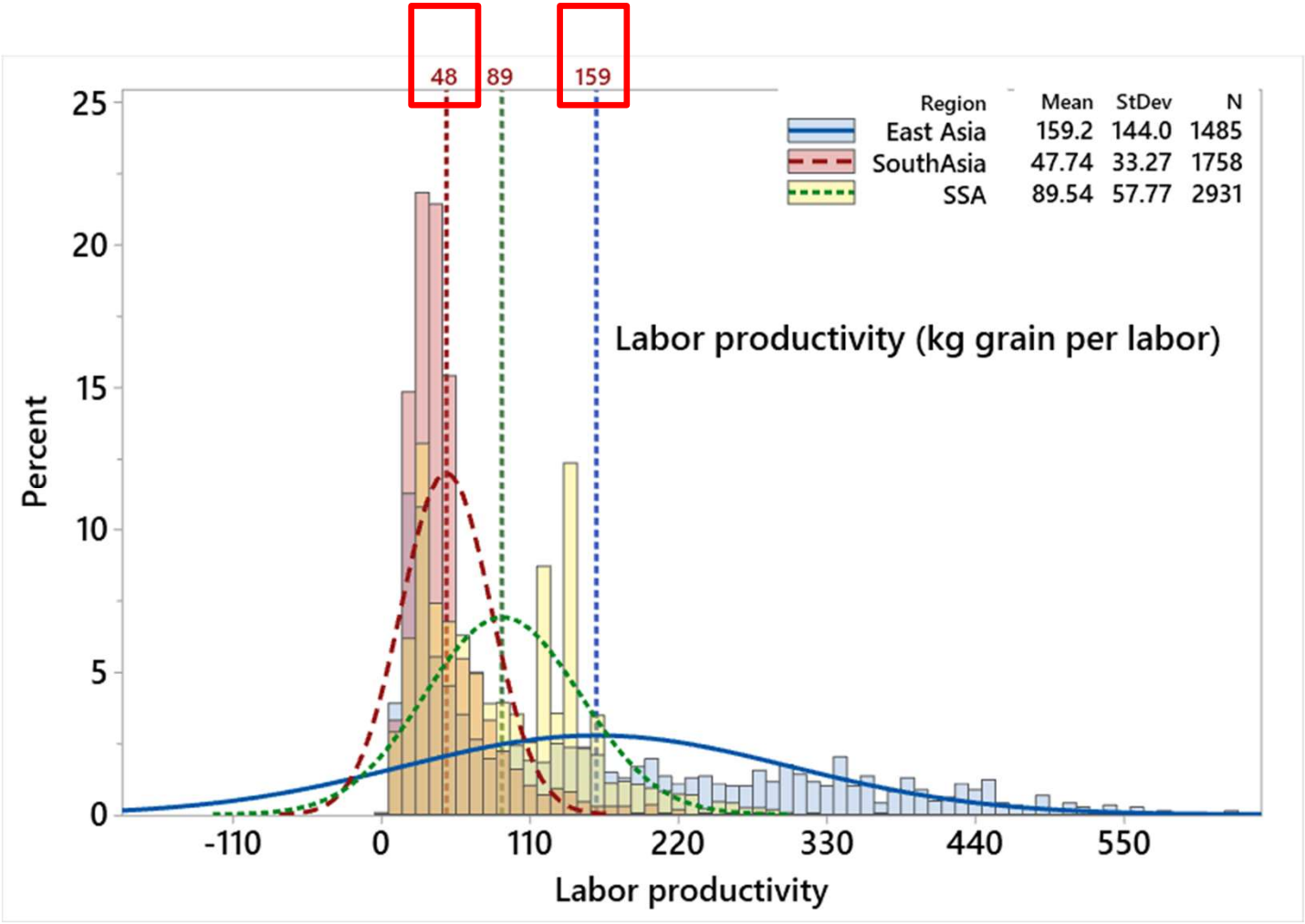


South Asia (3):
Nepal, India, Sri Lanka
East Asia (5):
Vietnam, Indonesia, Thailand, Myanmar, China
SSA countries (12):

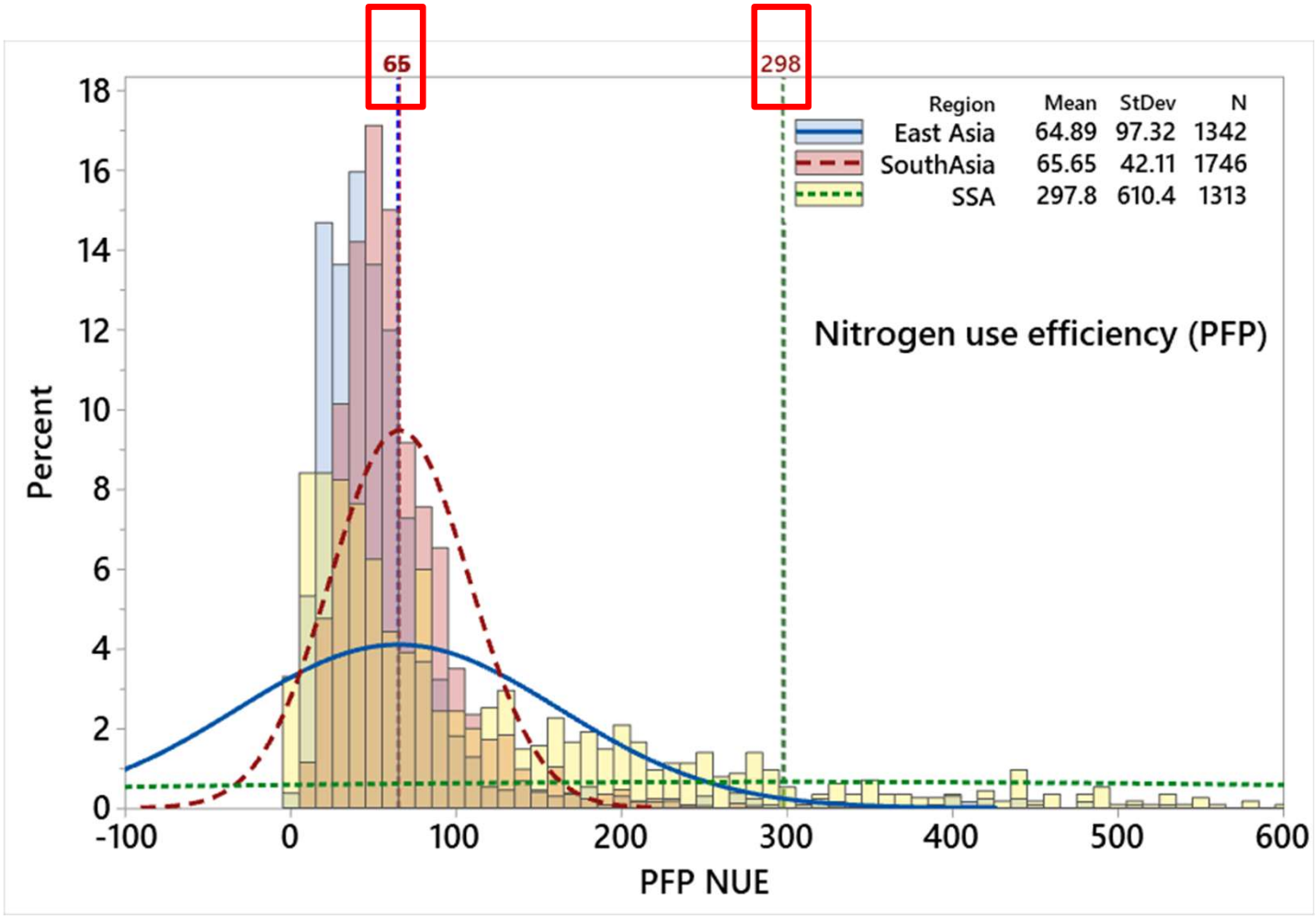
II. Net profit



III. Labor productivity

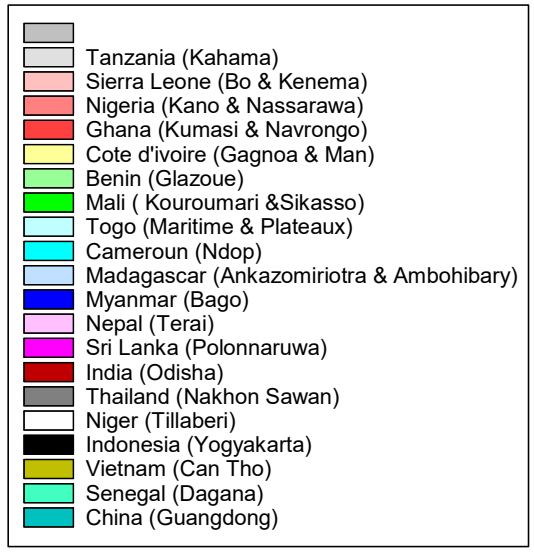


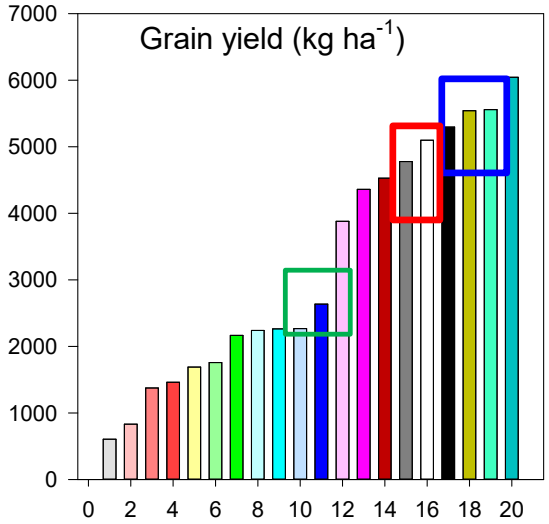
IV. Nitrogen use efficiency

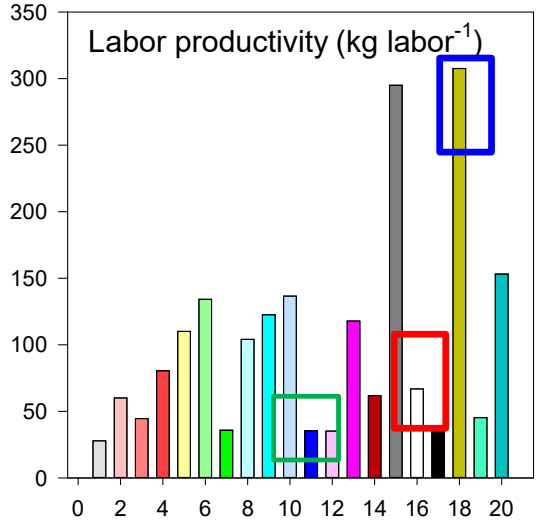


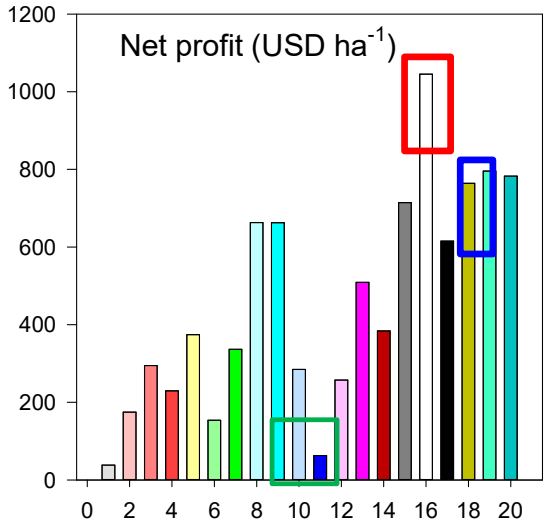
20 countries comparison across 5 PIs

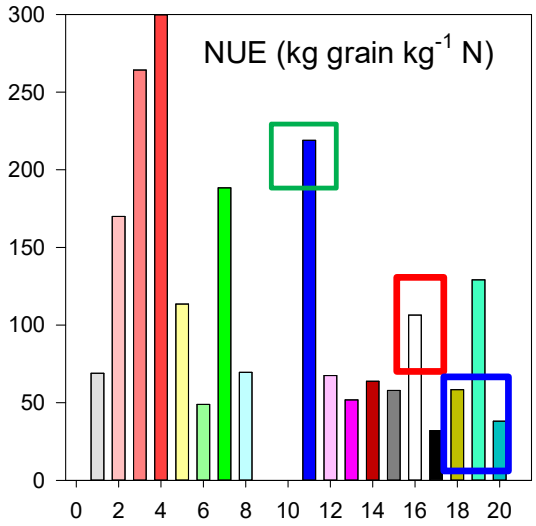
No perfection? Highest economy should not be considered! (cases Nigeria & Vietnam) Look for the trade-off of economic & environmental

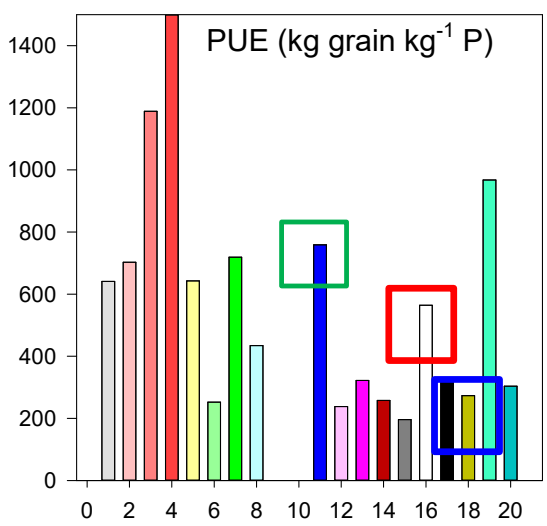












Setting targets of SRP PIs

Objectives

- How much the positive indicators should be increased?
- How much a negative indicators can be decreased?
- How external targets can be applied (3 examples)
    - Extension intervention impact assessment using PIs
    - Wet-seeded rice vs. puddled transplanted rice
    - Providing recommendation/suggestion for individual farmer

Options for setting external reference points as baseline and target values for each SRP PIs

Indicator	Options for setting target
1. Profitability	• B:C ratio >3 • 25% higher than national average • Daily income at PPP • Double the poverty line
2. Labor use efficiency	• 25% higher than national average • 15% higher than reference value • Level of mechanization
3. Productivity: grain yield	• 25% higher than national average • 80% of modeled yield for a specific season, variety or soil fertility category
4. Water productivity	• 25% higher than international reference value • Optimization based on production system and yield target
5. Nitrogen use efficiency (NUE)	• Output:input ratio = 1; or within range of 40-80 kg grain/kg N • Optimization based on yield target
6. Phosphorus use efficiency (PUE)	• Output:input ration = 1; or within 150-400 kg grain/kg P

Options for setting external reference points as baseline and target values for each SRP PIs

Indicator	Corresponding options for setting target
7a. Biodiversity: Pest damage rating	• <20% damaged
7b. Biodiversity: Number of cumulative pesticide applications	• < x
8. Greenhouse gas emissions: methane	• 20% improvement (decrease) from reference practice
9. Food safety	• 100% of samples tested are within acceptable limits
10. Workers health and safety	• Score = 100 on SRP scorecard
11. Child labor and youth inclusion	• Score = 100 on SRP scorecard
12. Women empowerment	• Score = 100 on SRP scorecard

For detail: Devkota et al., 2022, Environmental Impact Assessment Review

1. Grain yield

Top decile or +25% national average

Country	Population mean	Median	Top decile	National average yield from FAOSTAT	National average +25% increment	National average +50% increment	Position of top decile value in % national average increment
Vietnam	5543	5636	7301	5753	7191	8630	25–30%
Thailand	4384	4767	5887	3146	3933	4719	>50%
China	6044	6035	7346	5991¶	7488	8986	2-23%
Indonesia	5238	5009	8400	5134	6418	7701	>50%
Myanmar	2637	2582	3689	3751	4689	5627	5–10%
Sri Lanka	4362	4463	5465	3889	4861	5834	40–45%
India	4530	4688	5500	3790	4738	5685	45–50%

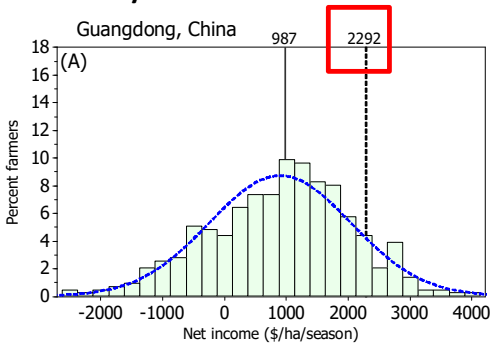
2. Net profit

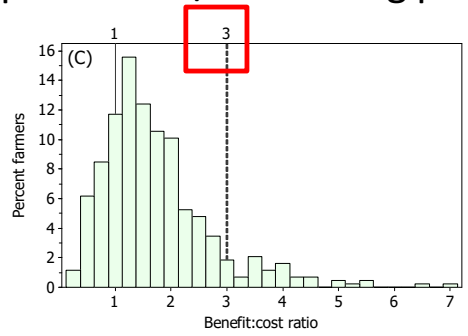
- Net income (= gross income-production cost): Survey da
- B:C ratio (=gross income/production cost): Survey data
- % of national average net farm income: Bordey et al., 20
- Daily income = Net income per season/Purchasing poser

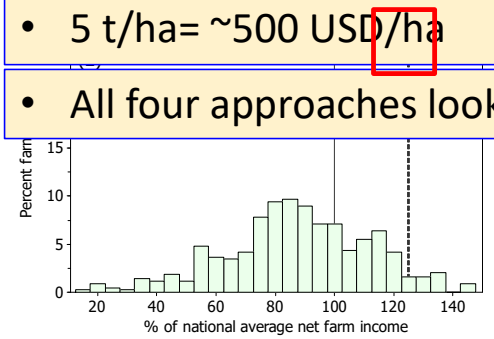
- A great variation of indicators of Net profit across sites

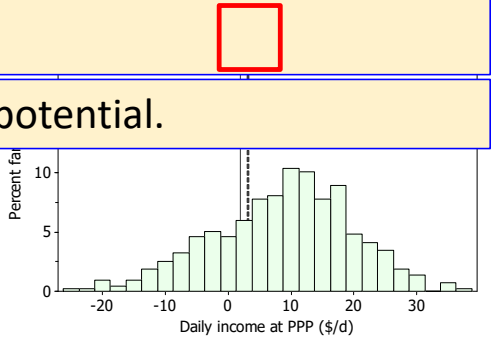
- Grain yield is the proxy for the indicators of profitability
- Farmers with <2 t/ha net profit -82 USD/ha
- 2-3 t/ha= +30 USD/ha
- 3-4 t/ha= + 154 USD/ha
- 5 t/ha= ~500 USD/ha

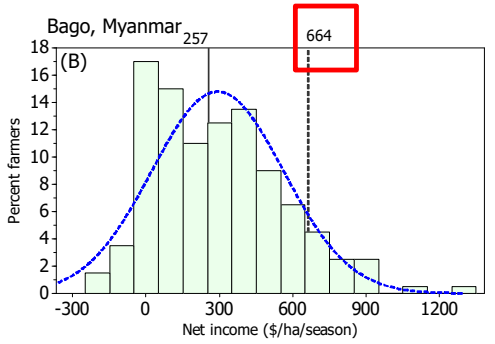
- All four approaches looks potential.

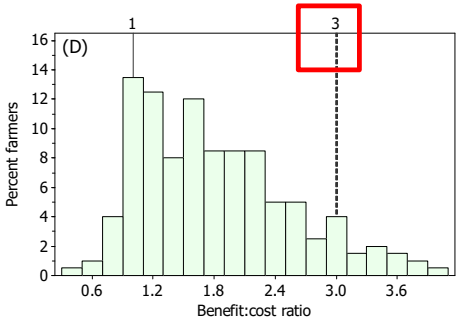


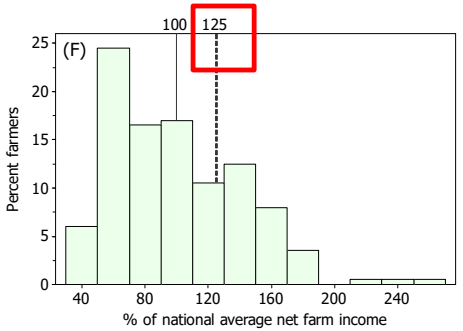


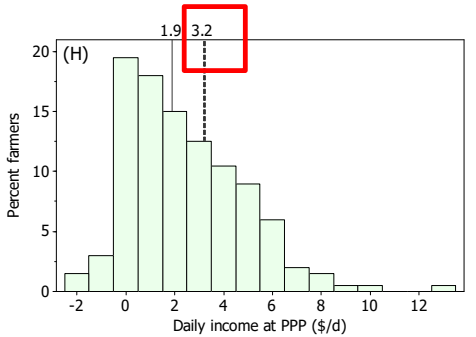








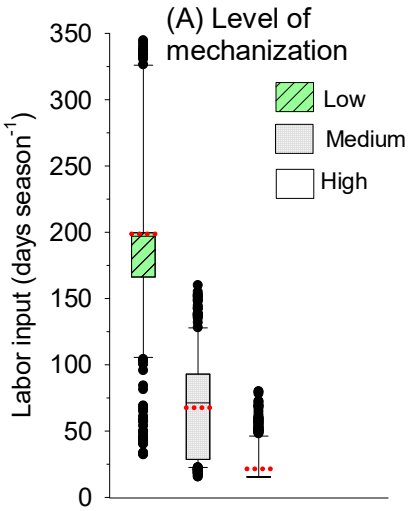




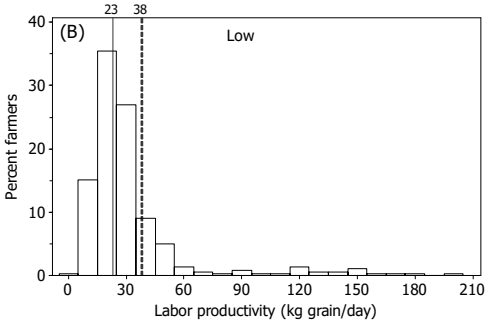
3. Labor productivity

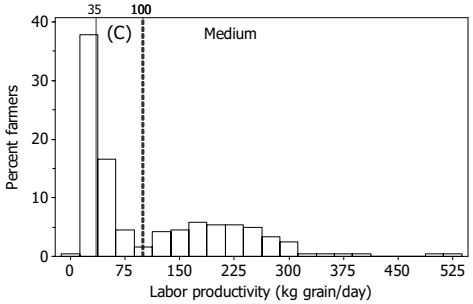
Labor productivity based on mechanization: Vietnam, Thailand, Indonesia and Myanmar

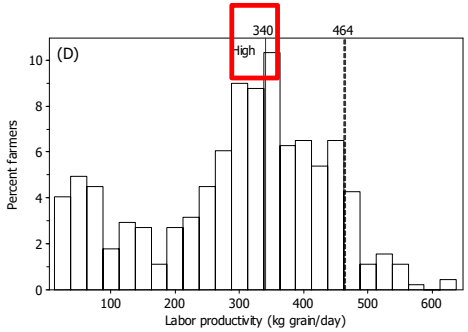
Thailand vs Indonesia a contrasting example

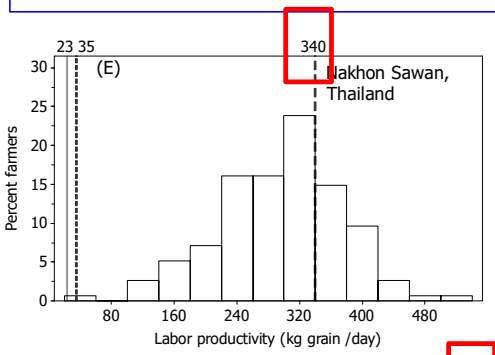


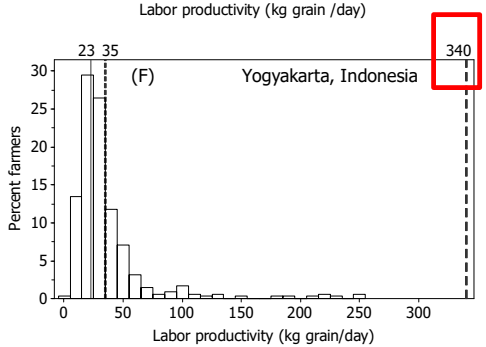
- Wide variability in labor use, ranging from 17 to 97











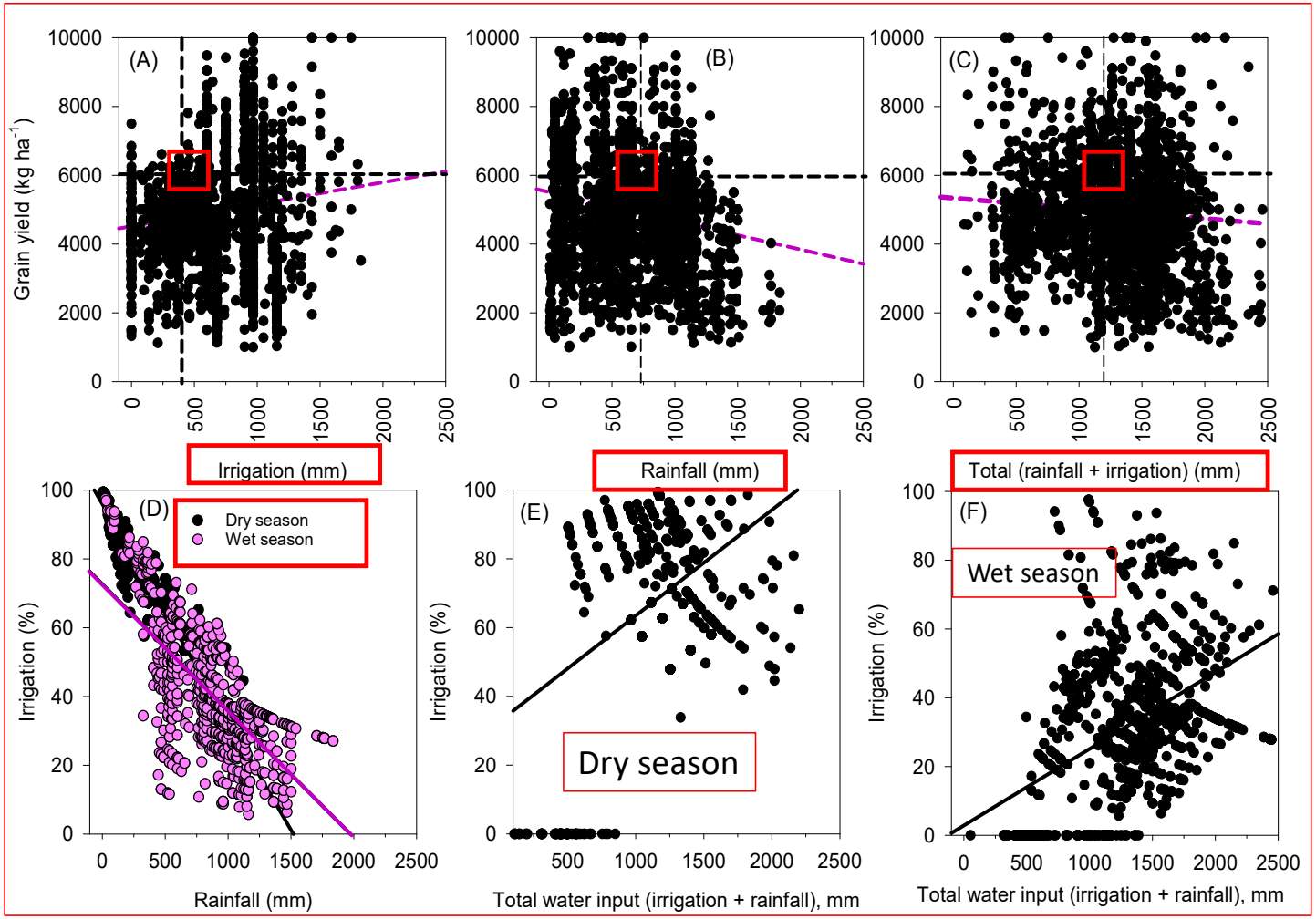
- Target depends on level of mechanization, and it is the key for improving labor productivity
- Top 10% farmers value for each category of mechanization or the median of high mechanization can be the realistic target!

4. Water productivity

For around 6 t/ha yield, approximately 1300–1500 mm total water (irrigation + rainfall) input or 2100-2500 L water is required. A similar value was also proposed for irrigated rice in Asia by Bouman et al. (2007).

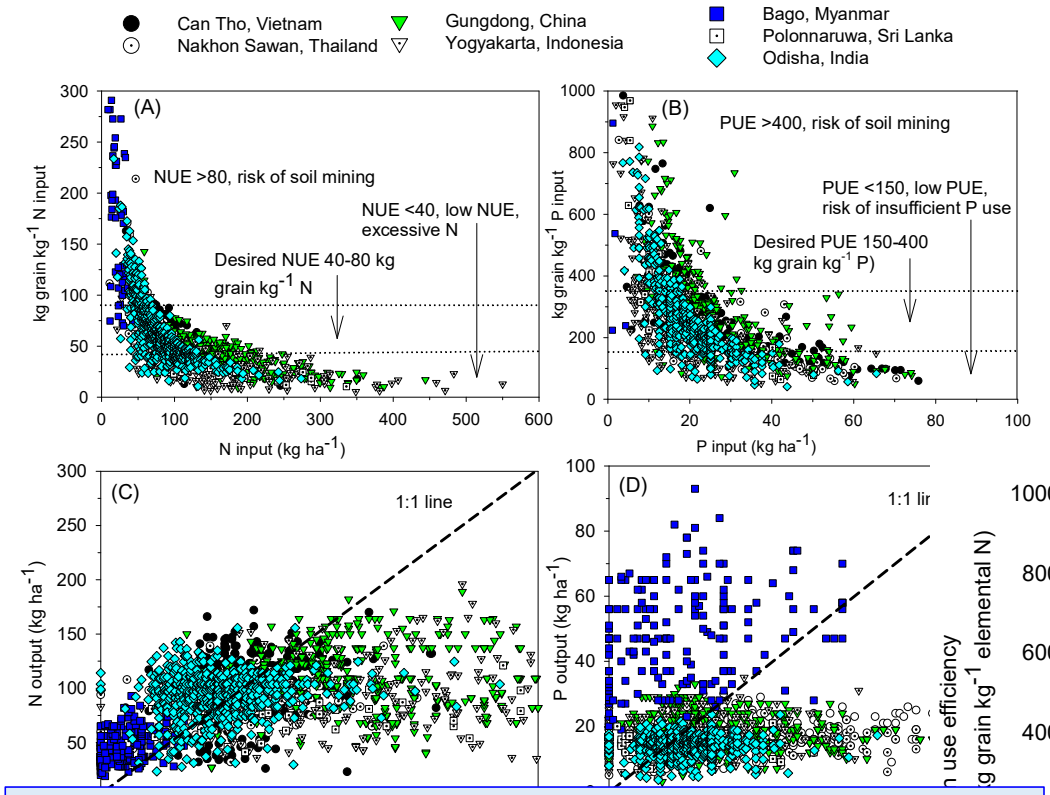
Share of contribution from irrigation: higher during dry season

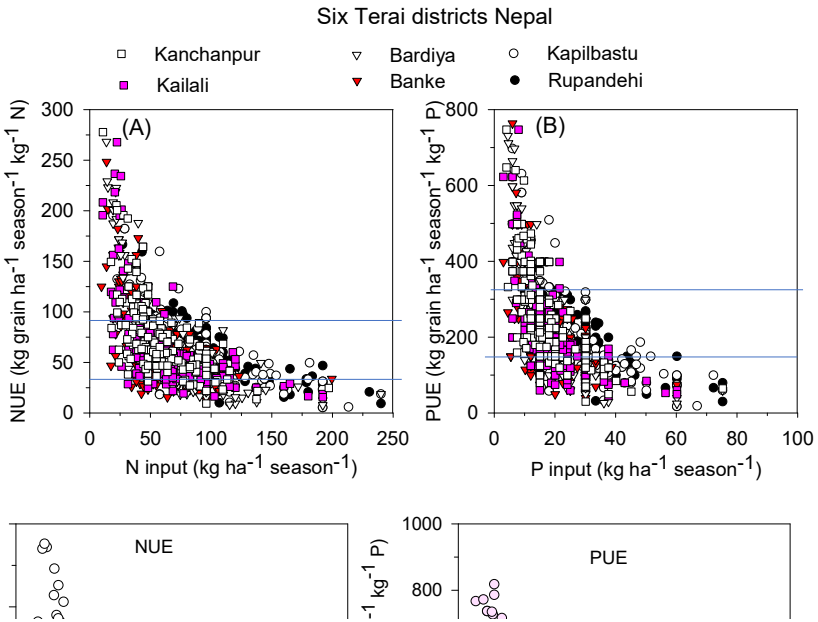
Target: Season-, field-, and yield target- wise optimal irrigation water
As external target value: ~2000 L/kg grain can be the optimal target for irrigated rice

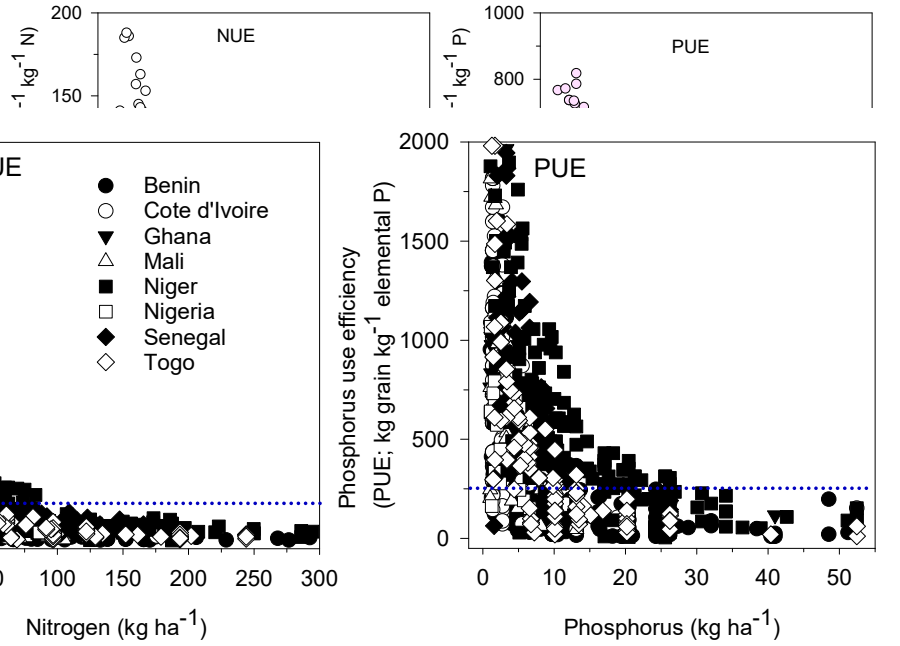


5-6. NUE and PUE

Overapplication: <40 NUE and <150 PUE
Risk of mining: >80 NUE and >350 PUE

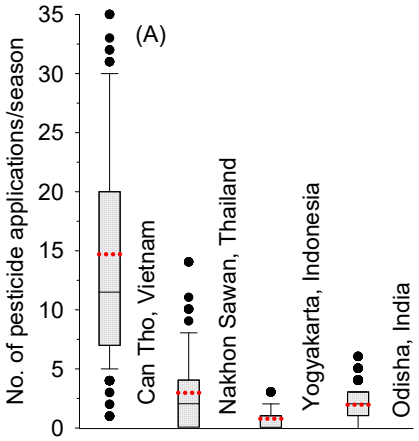


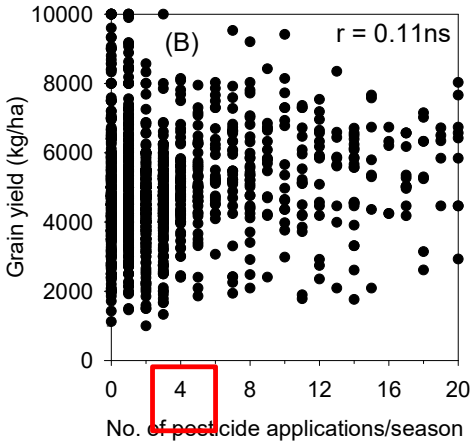


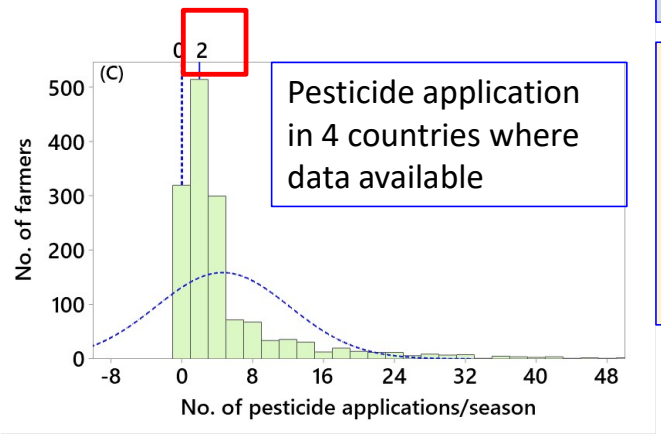


- Fertilizer recommendation by optimizing nutrient use efficiencies, overcoming nutrient imbalance, mining, and over-application
- Two approaches: Optimize PFP or Output:input

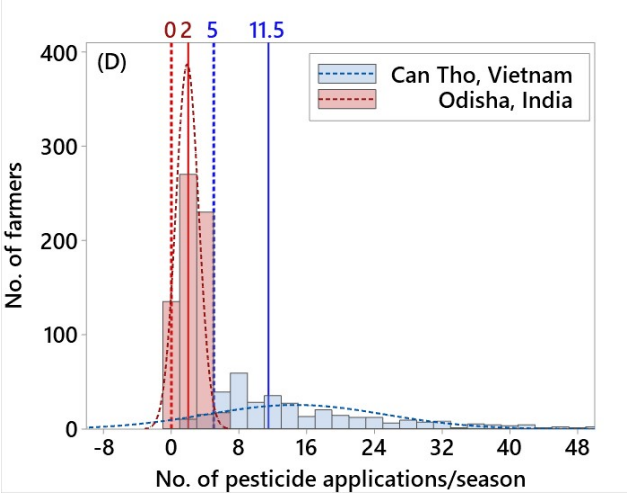
7. Pesticide use (biodiversity)







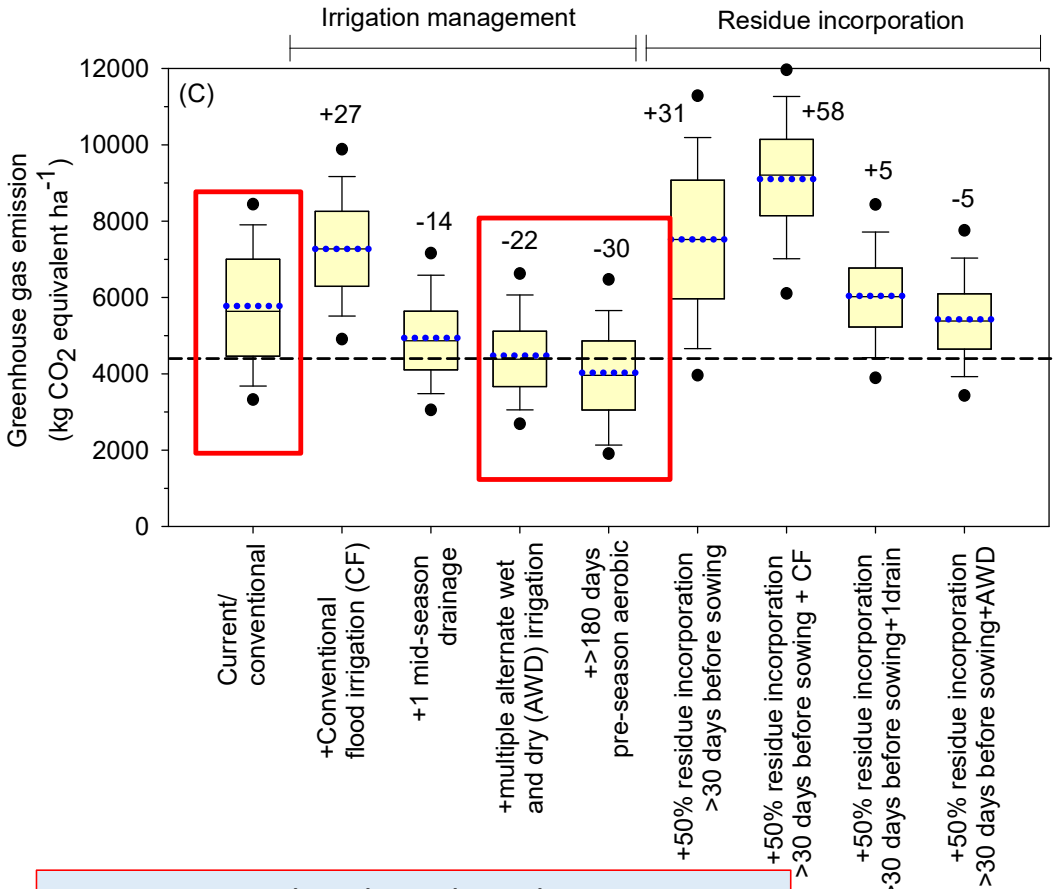
Pesticide application in 4 countries where data available



- A wide variation in the number of pesticide applications for rice production exists across countries

- (lower is better) of 4 in intensive rice production sites (Vietnam) and the 2 applications in one season rice a year sites (Odisha) could be the target values for sustainability.

8. GHG emission

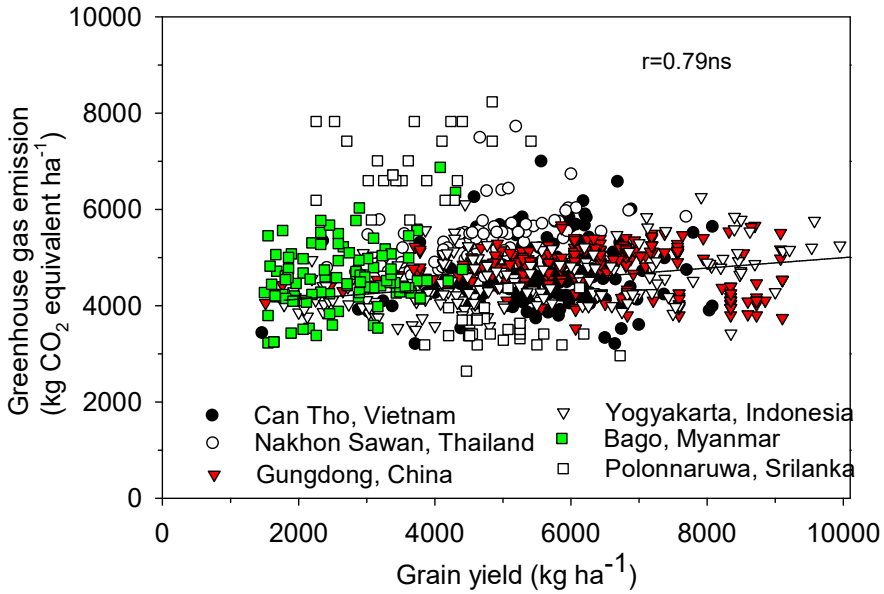


7 country simulated result under 9 scenarios
Detail: EIAR paper

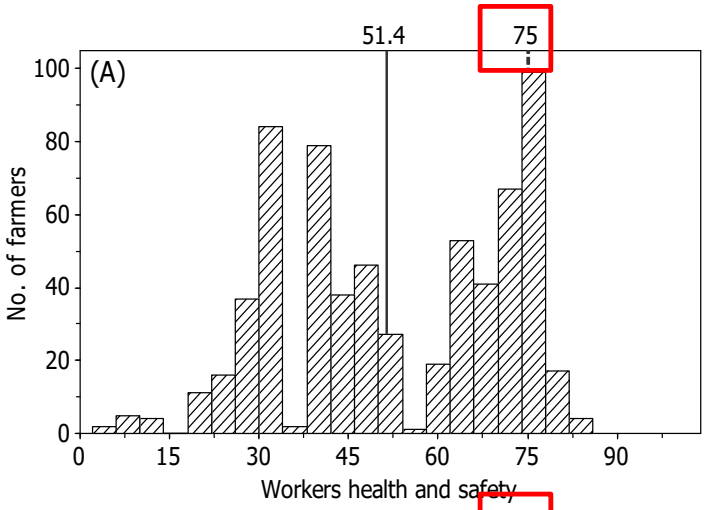
GHG emissions from the rice fields mainly affected by:

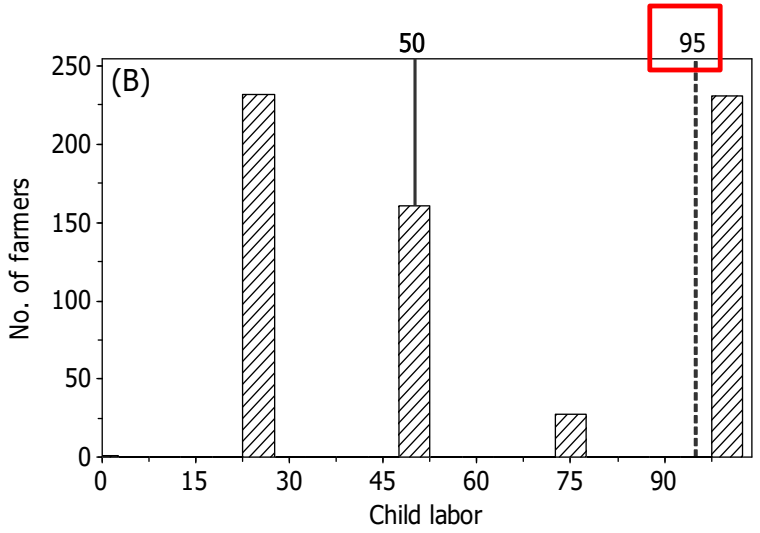
- Pre-rice flooding
- Water management
- Crop residue management
- Fertilizer application

To improve sustainability, the target value of GHG emission could be 20-30% lower than the current average emission for the intensively managed irrigated lowland conditions.



9-11. Social indicators





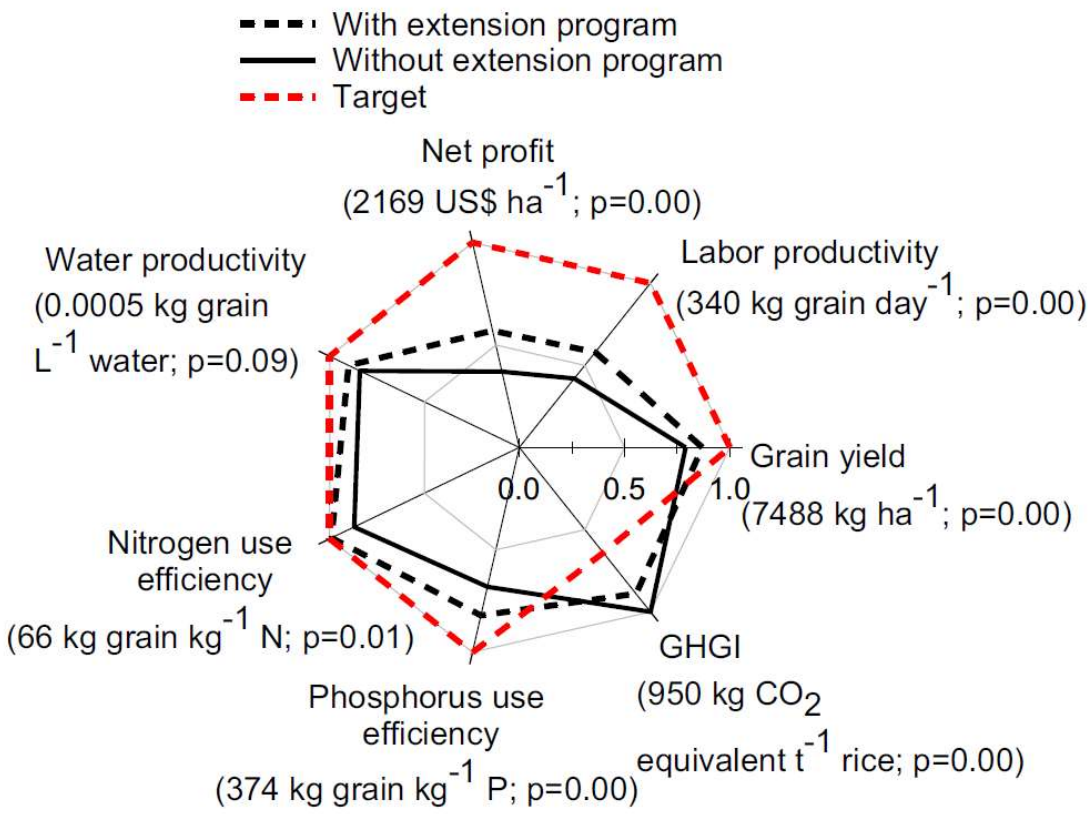
652 household dataset from Odisha, India. Detail: Devkota et al., 2020, Journal of Cleaner Production.

- The target values for social indicators depends on many personal and household level attributes as well as the access to credit, information, technology, etc.

- As external target values, scores of 75 for workers' health and safety, 90 for child labor, and 70 for women empowerment could be set to be achieved after three years of intervention as a similar value was achieved in Odisha

Application of external target values

a) Impact evaluation of 3CT extension program in Guangdong, China

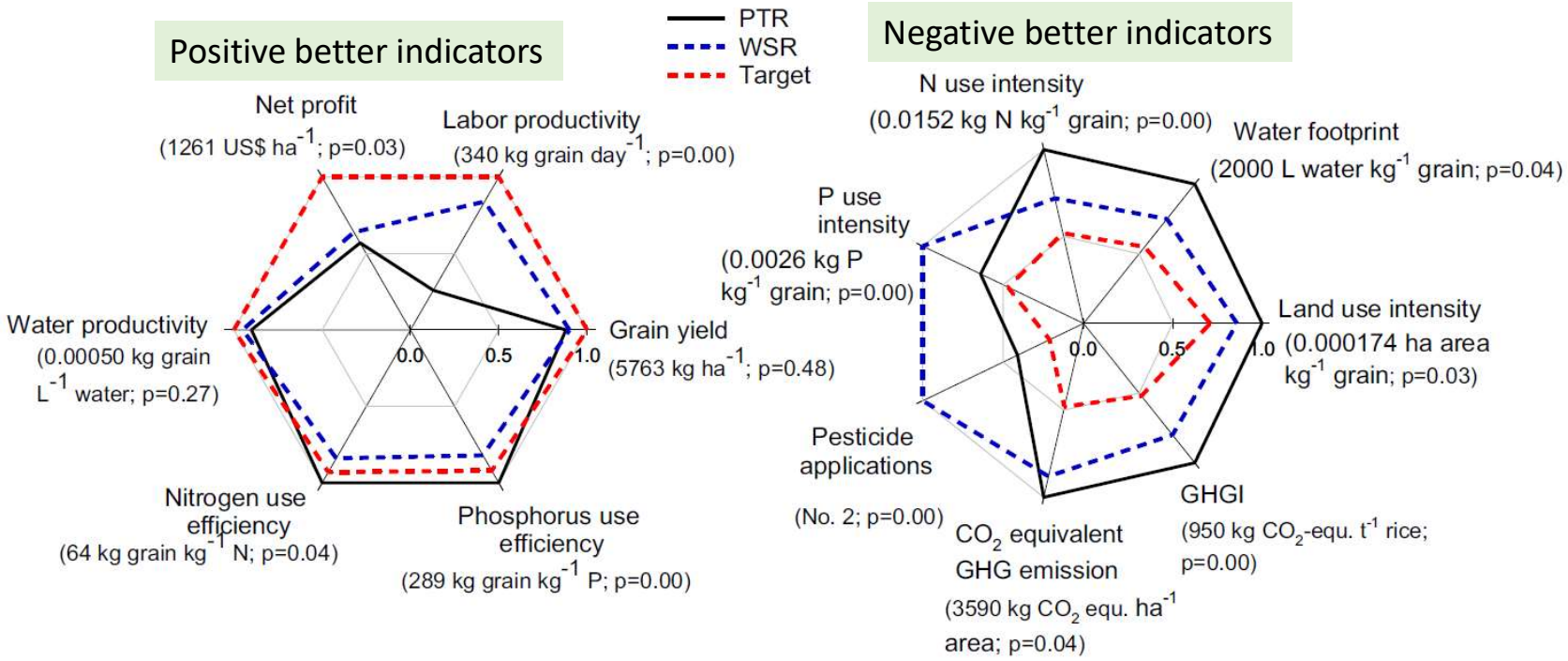


3CTs=

- Efficient use of nutrients particularly N
- Reduce unproductive tillers and lodging
- Reduce spray of fungicide and insecticide

- Yield: regional yield +25% value
- Labor productivity at high mechanization reference value (Fig. presented);
- Net profit at B:C ratio of 3 (Fig. presented);
- Water productivity at 2000 L/kg grain;
- Nitrogen and phosphorus use efficiency at output/input ratio of 1.25; and
- Greenhouse gas emission intensity -25% the median of conventional practices

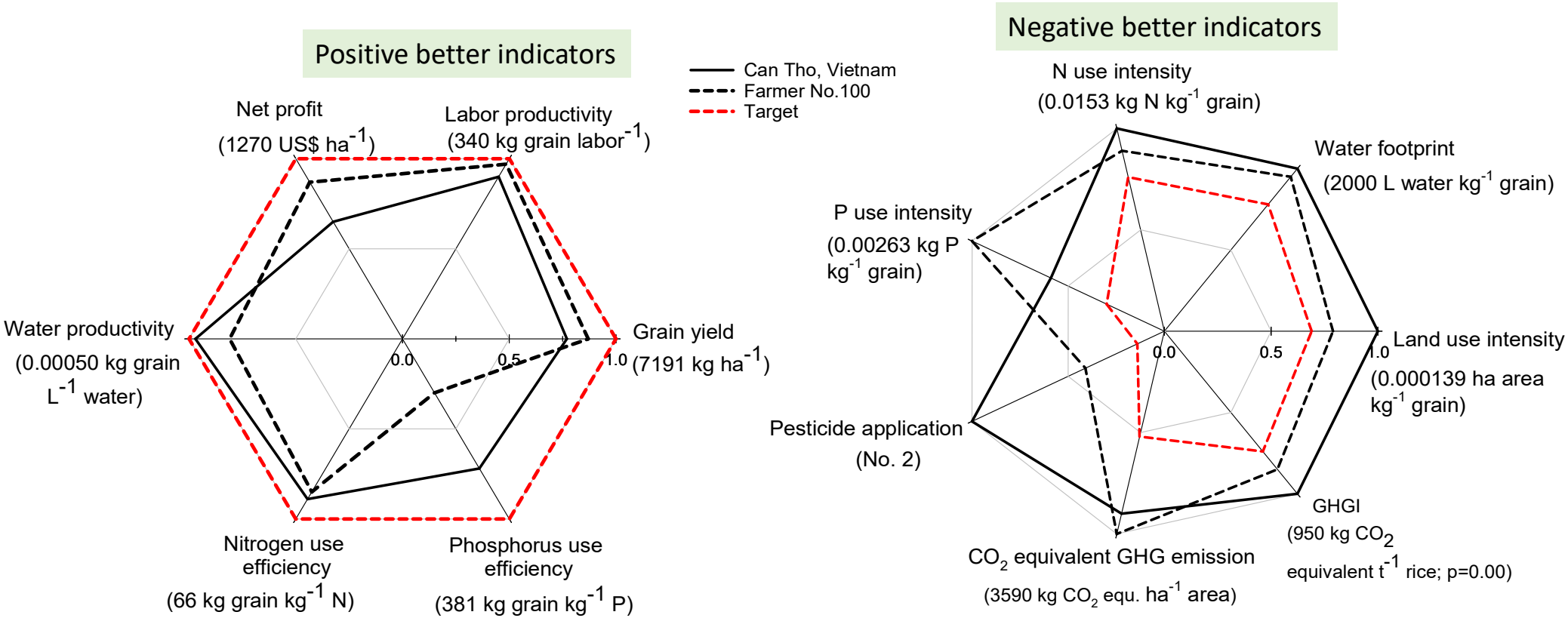
b) Wet-direct seeded rice (WSR) in Vietnam, Thailand, and Sri Lank vs. puddled transplanted rice (PTR) in China, Indonesia, and Myanmar



Grain yield: national yield +25% value
Labor productivity: at high mechanization reference value (340);
Net profit: at B:C ratio of 3
NUE and PUE: at output/input ratio of 1.25;

Water productivity and footprint: at 2000 L water/kg grain;
Pesticide application: at median of four countries
Greenhouse gas emission and emission intensity: the median of conventional practice – 25%.

c) Setting target of individual farmer and landscape level



Yield: National average or provincial yield + 25%”
Labor productivity: average of high level of mechanization
Profitability: benefit:cost ratio of 3
Water productivity: 1269 and 2000 l water/kg grain
NUE & PUE: output:input ratio of 1.25

Water footprint: 2000 L water kg-1 grain (median)
Pesticide: Median of the population
GHG footprint: Conventional -25%

Conclusions

- A large gaps in sustainability indicators exists in rice across many countries and optimization of inputs and efficiency indicators are required to achieve sustainability!
- PIs have been adopted to track and measure the increase in productivity while minimizing environmental degradation in rice cultivation, and has been adopted extensively by several stakeholders across the world.
- Setting target of Sustainable Rice Platform (SRP) established 12 performance indicators can increase growth, efficiency, optimize production resources, improve resilience to climate change, and drive rice farming towards sustainability
- In absence of dataset to set target using top 10^{th} or top 20^{th} approach; proposed external target values can be used to set reasonable target for sustainable rice intensification
- Similar platform, framework, and benchmarking baseline and target of sustainability indicators for other annual and perennial crops standardizing science-based knowledge is essential for improving resilience and sustainability and feed the growing population across Africa, Asia, and the globe

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- ✓ Africa Rice Center (AfricaRice), Cote d'Ivoire
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