TEEB Rice

Anne Bogdanski & Barbara Gemmill-Herren, FAO

TEEB AgFood Expert Workshop, 8.9.2015 Brussels

Project Consortium

- FAO
  - Barbara Gemmill-Herren
  - Renee Van Dis
  - Anne Bogdanski
- Trucost
  - Chris Baldock
  - Rick Lord
- IRRI
  - Finbarr Horgan
- Bioversity
  - Fabrice de Clerk
  - Simon Attwood
  - Marie Soleil

1. Introduction

- Central to the food security of **half the world**
- **144 million** farms grow rice, the majority smaller than one hectare
- **More than 90%** of rice production and consumption is in Asia
- Several **positive and negative externalities** linked to rice production.

2. Study objectives

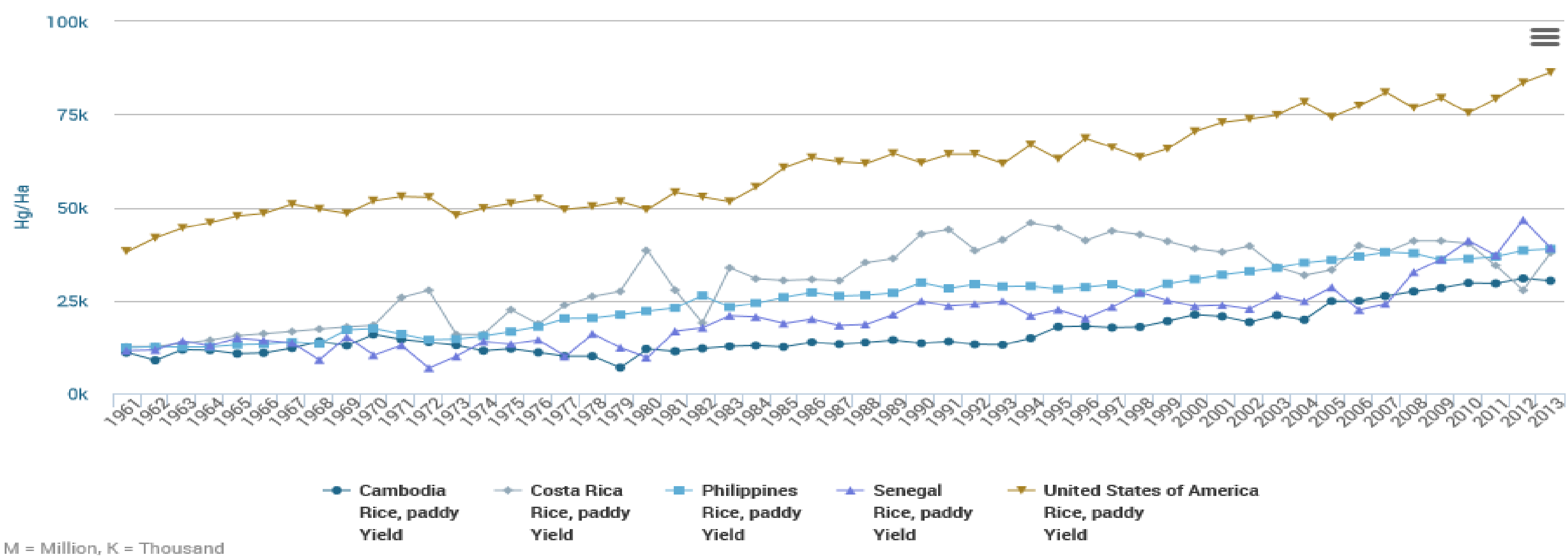
1. To identify visible and invisible costs and benefits of rice agro-ecosystems; i.e. externalities
   - Which ecosystem services are linked to rice production?
   - Which types of environmental impacts does rice production have?

2. To identify and assess those rice management practises and systems which reduce trade-offs and increase synergies
   - How do costs and benefits change with different management approaches?

3. To make these trade-offs and synergies visible
   - Assign biophysical or monetary values to the different options

3. Scope and framework

- **1. Selection of case study countries**
  - Global coverage
    - Philippines, Cambodia, Senegal, Costa Rica and California/USA
  - From low intensified to high intensified production
    - 3.3 tons/ha in Cambodia (2013)
    - 9.5 tons/ha in California/USA (2013)

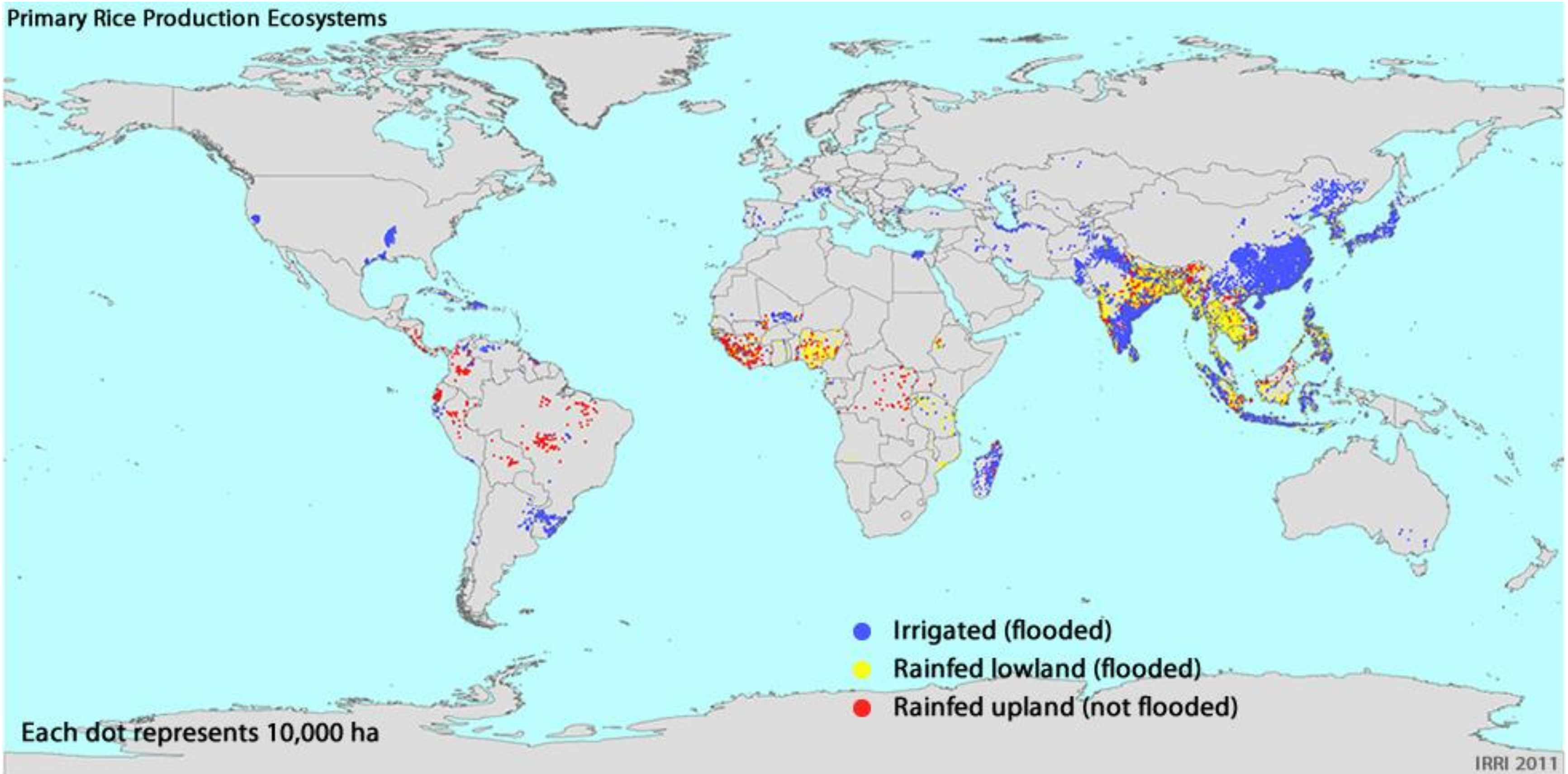


3. Scope and framework

II. Develop typology/structure of rice agriculture

- 1. Level
  - Rice production systems/Rice growing environments
    - Irrigated Lowlands
    - Rainfed Lowlands
    - Rainfed Uplands

- 2. Level
  - Rice management systems and practices
    - 25 different system and practice category comparisons:
      - Business as usual – alternative management practice
      - From land preparation to harvest


Primary Rice Production Ecosystems
Irrigated (flooded)
Rainfed lowland (flooded)
Rainfed upland (not flooded)
Each dot represents 10,000 ha
IRRI 2011

Management practices and systems

Management practices		
1. Preplanting	Land preparation	Dry tillage – puddling
		Land levelling – no levelling
		Minimum soil disturbance – conventional tillage
		No tillage – conventional tillage
2. Growth	Planting	Direct seeding – transplanting
		Dry seeding – wet seeding
	Water management	Low irrigation frequency - high irrigation frequency
		Improved water management - continuous flooding
	Soil fertility management	Reduced mineral fertilizer use - high fertilizer application
		No fertilizer use - high fertilizer application
		Organic fertilizer application - mineral fertilizer application
		Organic fertilizer application - no fertilizer application
		Mineral + organic fertilizer application – mineral fertilizer application only
	Weed management	No weed control - herbicide use
		Biological weed control + hand weeding - herbicide use
		Hand weeding – herbicide use
		Reduced herbicide use – higher herbicide input
	Pest and disease management	Non-chemical pest and disease control - pesticide use
		Reduced pesticide use – higher pesticide input
3. Postproduction	Residue management	Winter flooding – no winter flooding
		Straw incorporation – straw burning
		Straw baling and removal – straw burning
		Straw rolling – straw burning
Management systems		
		SRI – Conventional agriculture
		Organic agriculture - Conventional agriculture

3. Scope and framework

III. Identification of relevant policy/management issues

1. Increase rice yields
2. Maintain water quality
3. Reduce water use
4. Assure groundwater recharge
5. Eliminate the burning of rice residues and thereby maintain air quality
6. Use rice residues as source for energy production
7. Reduce greenhouse gas emissions
8. Provide habitat for aquatic species to increase food provision and dietary diversity, ecosystem functioning and space for recreational activities
9. Maintain the regulation of nutrient cycling and soil fertility
10. Maintain an ecological balance which prevents pest outbreaks

3. Scope and framework

IV. Identification of benefits…

	Dependency	Impact	Visible benefits	Invisible benefits	For whom? (Farmer F, Rural Community RC, Global community GC)	Primary data	Modelled data	Monetary Valuation
Rice grain		x	x		F, RC, GC	x		x
Dietary diversity		x		x	F, RC			
Rice straw		x	(x)	x	F		x	x
Rice husk		x	(x)	x	F		x	x
Biological control	x	x		x	F, RC, GC	(x)		(x)
Ecological resilience (pests)	x	x		x	F, RC; GC	(x)		
Nutrient cycling and soil fertility	x	x		x	F	x		
Carbon storage	x	x		x	F, GC			
Flood control	x	x		x	F, RC			
Groundwater recharge		x		x	F, RC		(x)	(x)
Habitat provisioning	x			x	F, RC	x		
Cultural services		x	x	x	F, RC, GC	(x)		

Externalities

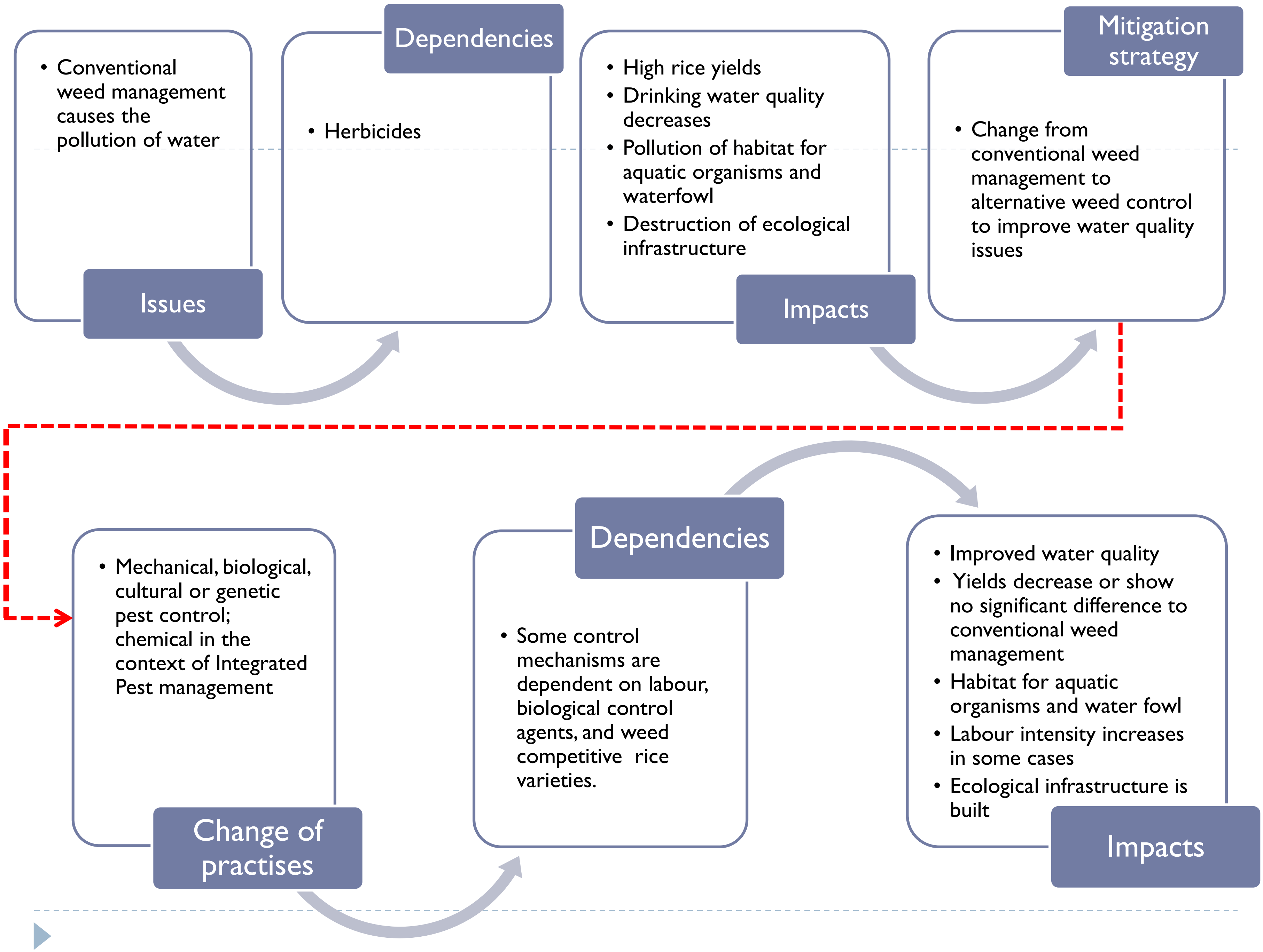
….and costs

	Dependency	Impact	Visible costs	Invisible costs	For whom? (Farmer F, Rural Community RC, Global community GC)	Primary data	Modelled data	Monetary valuation
Water pollution (Pesticide and herbicide run-off)		x		x	F, RC	x		x
Water pollution (Eutrophication)		x		x	F, RC		x	x
Air pollution (fertilizer)		x		x	F, RC		x	x
Air pollution (straw burning)		x		x	F, RC		x	x
Air pollution (combustion for energy)		x		x	F, RC		x	x
Water consumption	x			x	F, RC	x		x
GHG emissions		x		x	F, GC	x	(x)	x
Soil fertility loss		x		x	F		(x)	(x)
Wages	x		x		F	(x)		(x)
Fertilizer	x		x		F	x		x
Pesticides	x		x		F	x		x
Fuel	x		x		F			
Capital costs (e.g. machinery)	x		x		F			
Seeds	x		x		F	(x)		
Irrigation water	x		x	x	F			

Externalities

4. Biophysical quantification

- **I. Development of narrative report**
  - Review of both peer reviewed and grey literature to identify management objectives/trade-offs related to rice farming in each country
  - Identification of management practices and systems related to these trade-offs
  - Development of assumptions/hypotheses how a change in management practice affects different agronomic and environmental variables, incl. ecosystem services



Conventional weed management causes the pollution of water
Issues
Dependencies
Herbicides
High rice yields
Drinking water quality decreases
Pollution of habitat for aquatic organisms and waterfowl
Destruction of ecological infrastructure
Impacts
Mitigation strategy
Change from conventional weed management to alternative weed control to improve water quality issues
Mechanical, biological, cultural or genetic pest control; chemical in the context of Integrated Pest management
Change of practises
Dependencies
Some control mechanisms are dependent on labour, biological control agents, and weed competitive rice varieties.
Improved water quality
Yields decrease or show no significant difference to conventional weed management
Habitat for aquatic organisms and water fowl
Labour intensity increases in some cases
Ecological infrastructure is built
Impacts

4. Biophysical quantification

- **II. Data extraction**
  - Selection of appropriate response variables and indicators
  - Development of standardized template to extract data from peer reviewed journal papers
  - Data extraction
    - 1500 papers have been screened
    - 200 have been included in the narrative report
    - Data from 100 papers has been extracted for the biophysical quantification and monetary valuation
    - 7 response variables and 43 different indicators
    - In total, 1500 data points from 5 case study countries

Examples of response variables & indicators

Response variables	Indicators
Freshwater saving	a. Water use: Decrease of freshwater saving b. Water productivity: Water saving increased, as for the same amount of yield of lower water productivity, water use is reduced c. Water holding capacity: Increase in water saving, as a higher amount of water remains in the soil instead of seepage or run-off
Mitigation of greenhouse gas emission	a. Cumulative CH_4 emission flux: Decrease in mitigation of GHG emissions b. Cumulative N_2O emission flux: Decrease in mitigation of GHG emissions c. Global warming potential: Decrease in mitigation of GHG emissions d. Methyl bromide: Decrease in mitigation of GHG emissions e. Methyl chloride: Decrease in mitigation of GHG emissions f. Methyl Iodide: Decrease in mitigation of GHG emissions
Habitat provisioning	a. Number of waterbird species: Increase in habitat provisioning b. Waterbird abundance: Increase in habitat provisioning

4. Biophysical quantification

- **III. Vote-counting analysis**
  - To synthesize the results from all five case study countries: what are the effects of agricultural management practices and systems on different environmental, agronomic and ecosystem variables?
  - Setting of standardized rules for vote-counting analysis
  - 25 practice and system comparison categories

5. Monetary valuation

- **I. Biophysical Modelling**

- Nutrient and water balance
  - Precipitation during growing period
  - Irrigation water used
- Greenhouse gas emissions from:
  - Methane from rice
  - Volatilization from fertilizer
- N, P, K content of:
  - Synthetic and organic fertilizers
  - Rice
  - Rice straw and husks
  - Rainwater

5. Monetary valuation

II. Valuation methodology

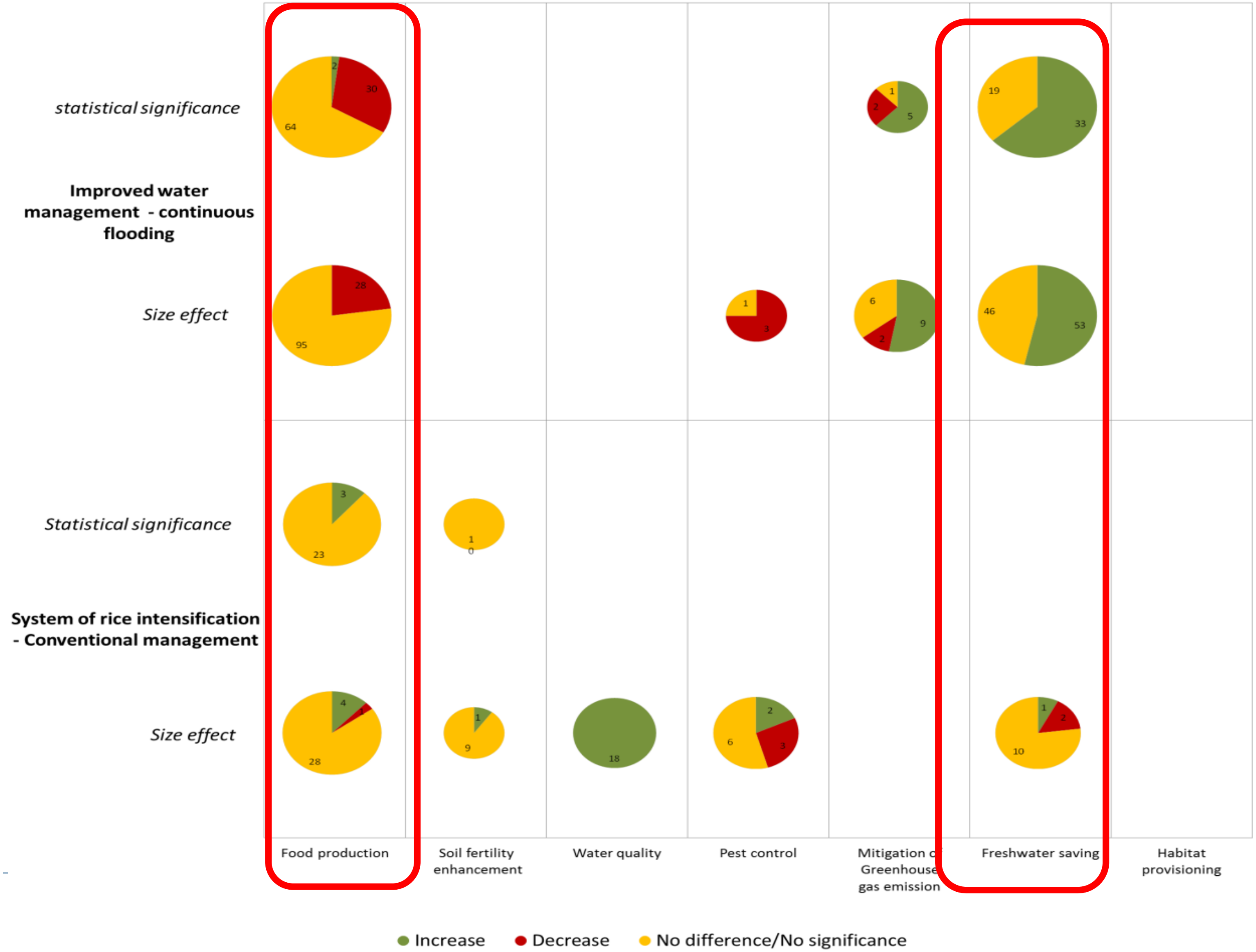
- Applied in rice, animal husbandry and palm oil projects

- Human health impact
  - *Quantification unit*: Disability adjusted life years (DALYs) lost
  - *Monetary valuation*: Value of a life year (VOLY)
- Ecosystem impact
  - *Quantification unit*: Potentially disappeared fraction (PDF) of species
  - *Monetary valuation*: Value of ecosystem services lost due to the disappearance of species

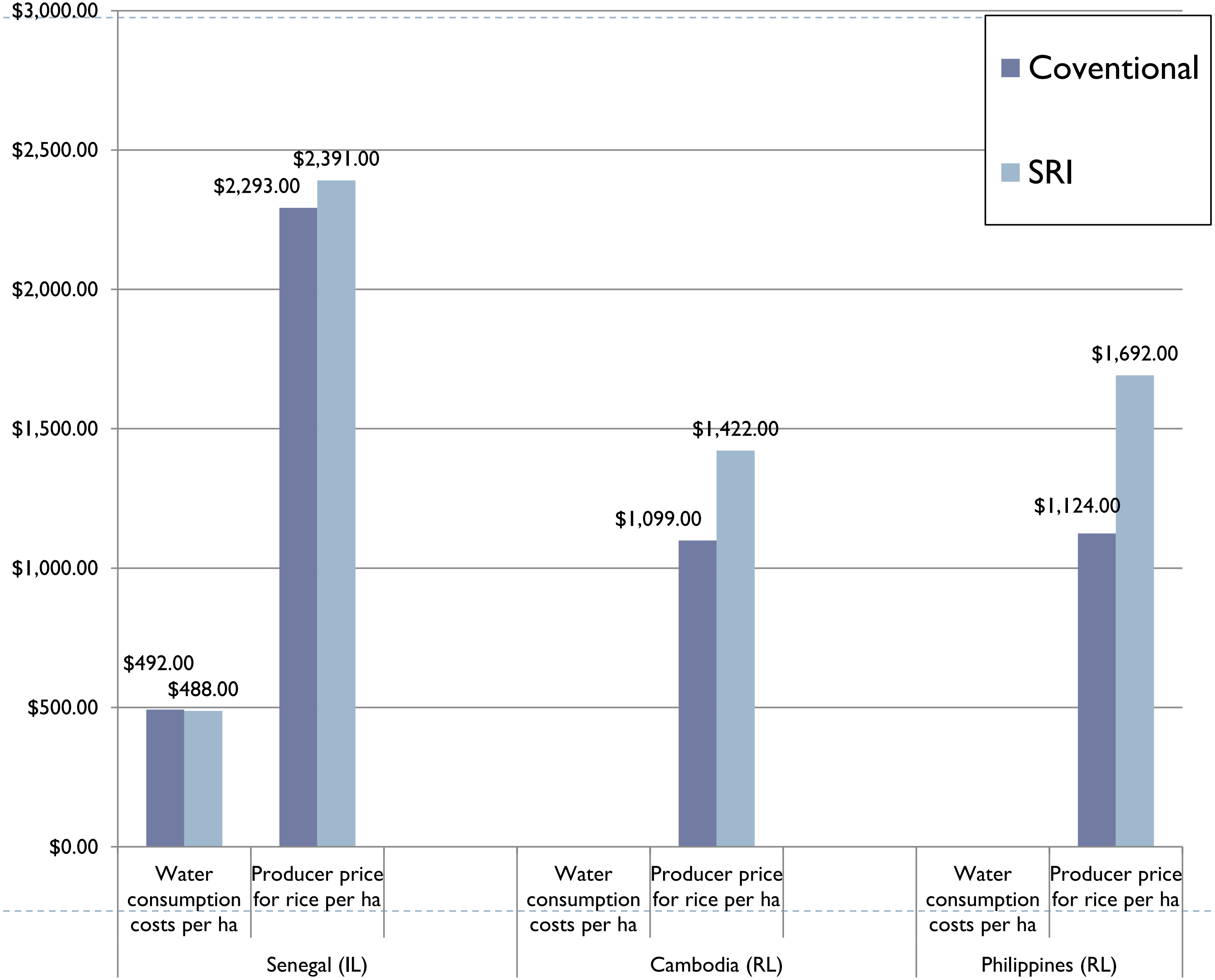
6. Results (Example 1)

- **INCREASE IN RICE YIELDS VERSUS REDUCTION OF WATER USE**
  - Worldwide, 80 million hectares of irrigated lowland rice provide 75% of the world's rice production.
  - 40% of the world's total irrigation water
  - 30% of the world's developed freshwater resources.
  - Water sources increasingly depleted due to competing water uses from the residential and industrial sector
  - Rainfall is becoming more and more erratic due to climate change and variability.

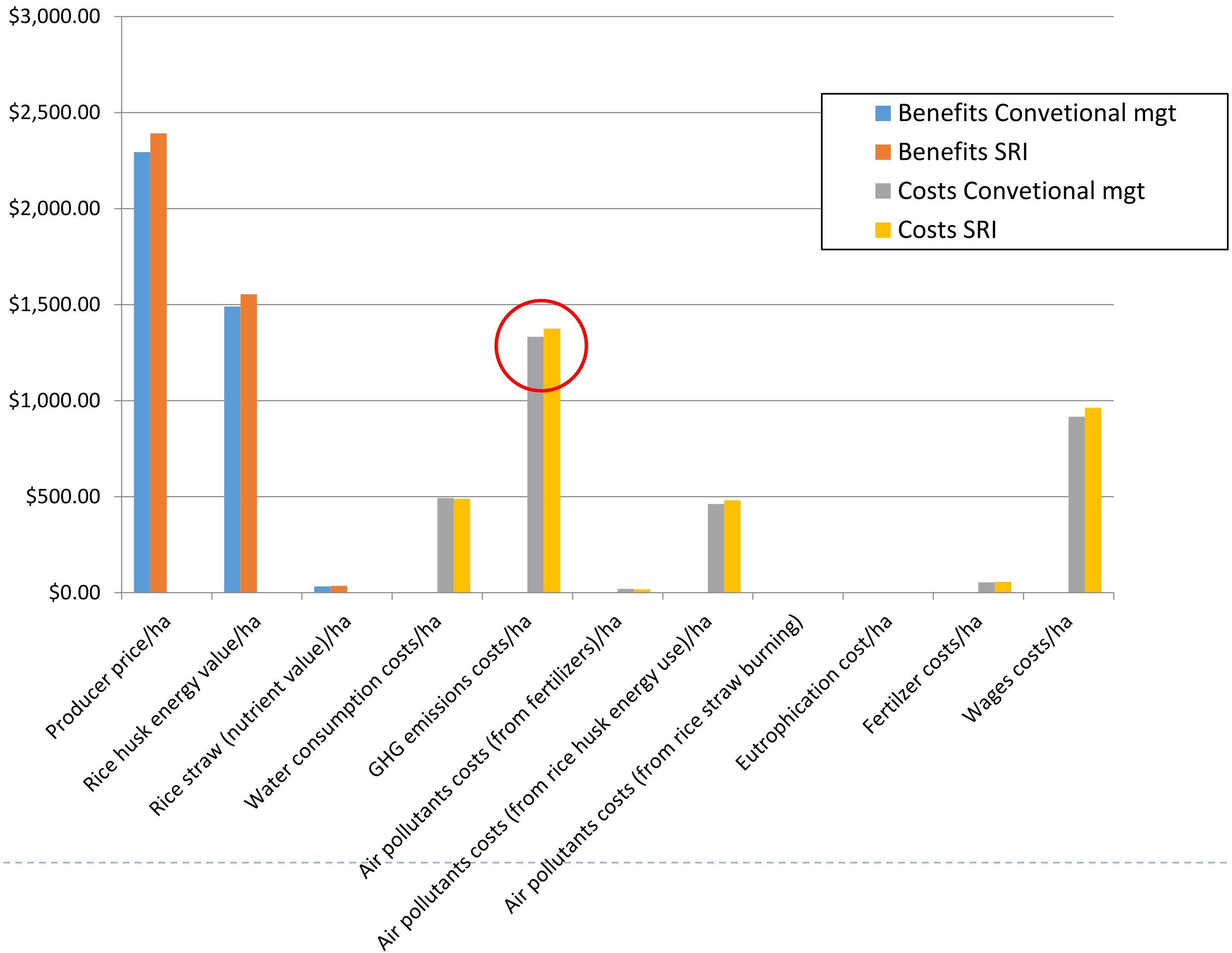
Vote-counting analysis



Water consumption vs yields – Valuation
(SRI and conventional mgt: Senegal; Philippines and Cambodia)



Costs and benefits for selected variables in Senegal for Conventional mgt. and SRI



7. Conclusions with regards to this trade-off analysis

Strength	**Weakness**
• Robust trade-off analysis due to use of primary research data • Shows opportunities and alternatives to current management practices instead of just pointing to costs of production	• Not possible to mix with global assumptions where data is missing • Based mostly on practice comparisons not on entire systems
Opportunities	**Threats**
• Solid basis for policy advise (change from practice A to practice B will decrease costs by…) • Gives the opportunity to valuate regulating ecosystem services as a positive externality – not just an avoided cost	• Lengthy and work intensive approach • Large data gaps

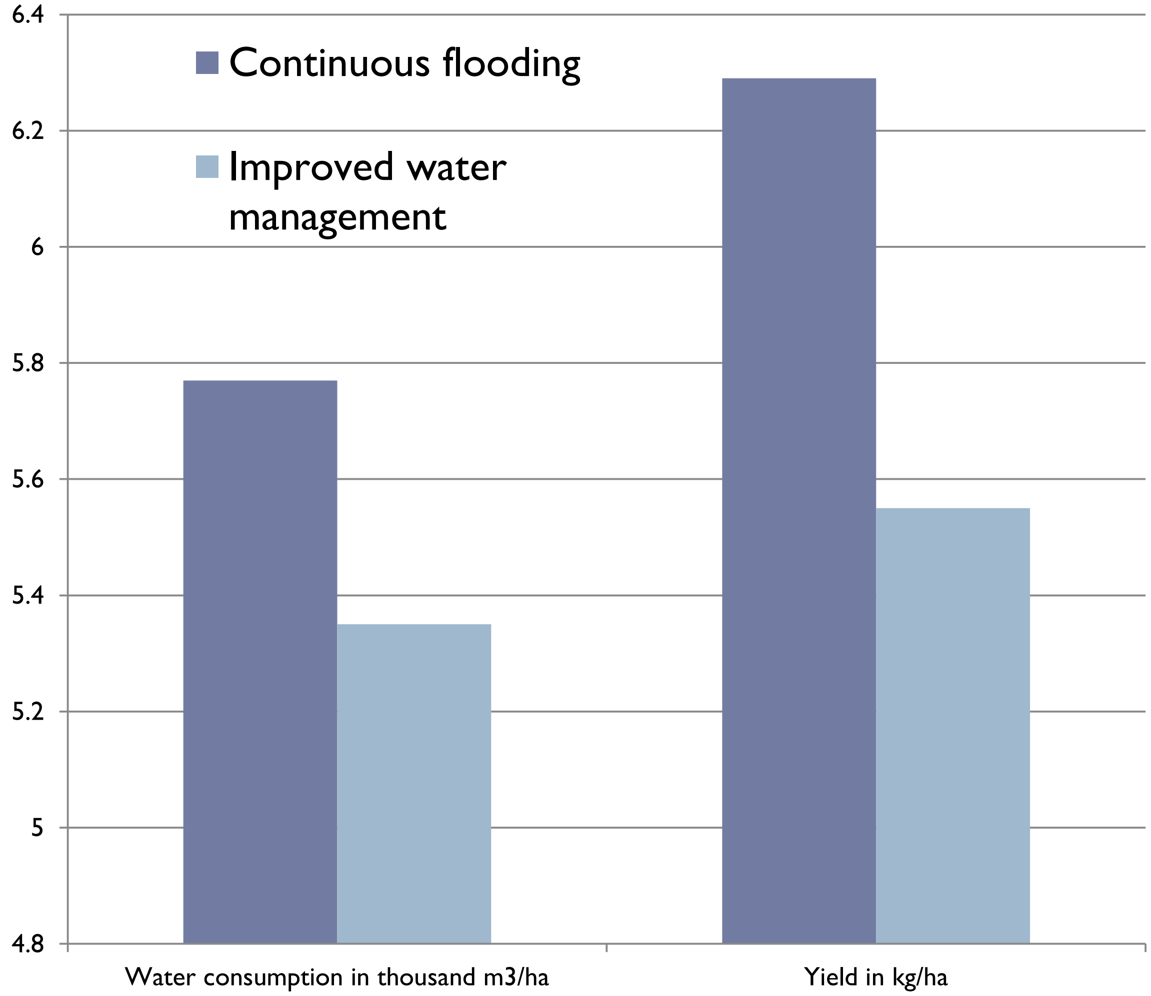
Thank you for your attention!

For more information,

please contact:

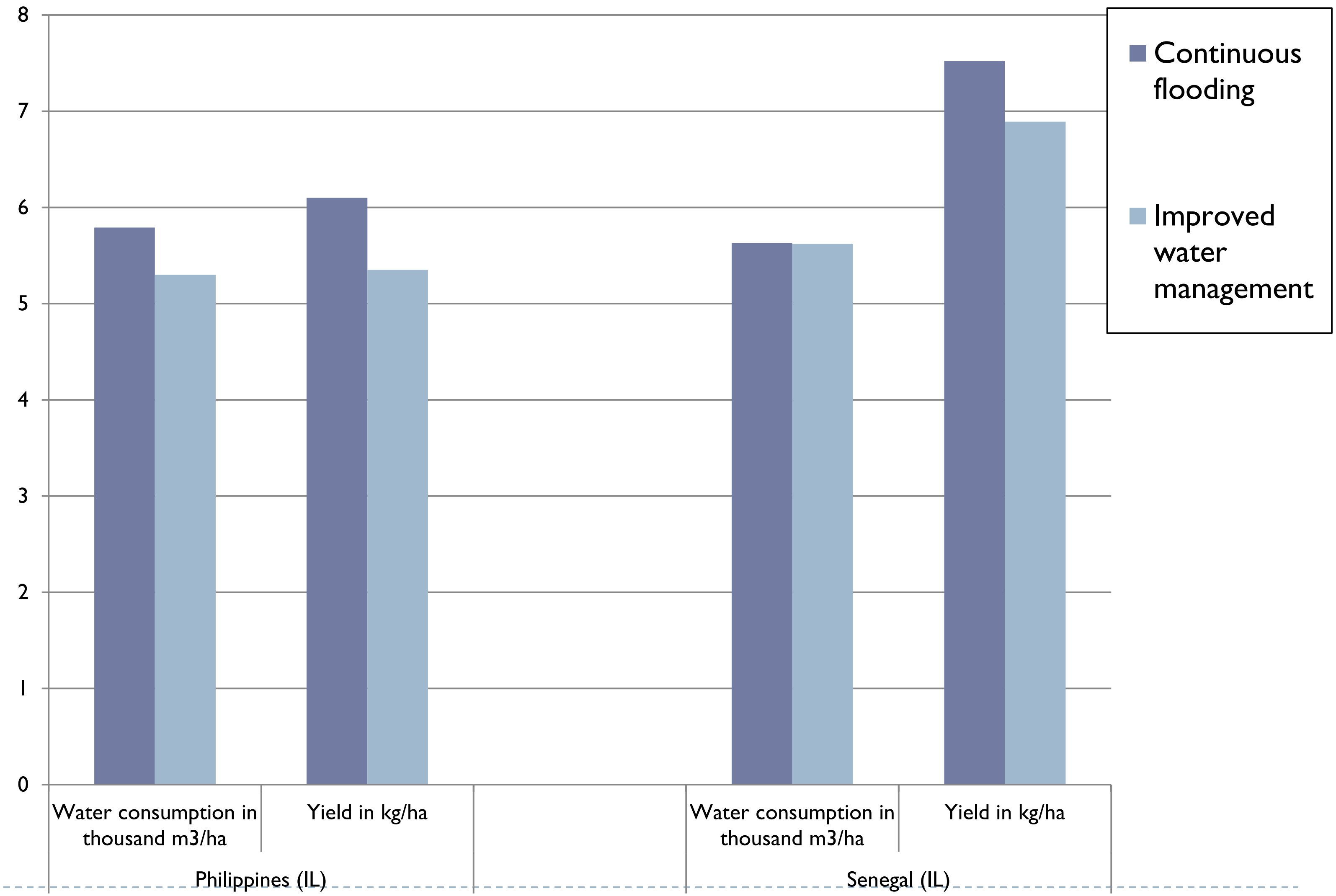
anne.bogdanski@fao.org

Water consumption vs yields - Quantification
(Improved water mgt and continuous flooding – average)



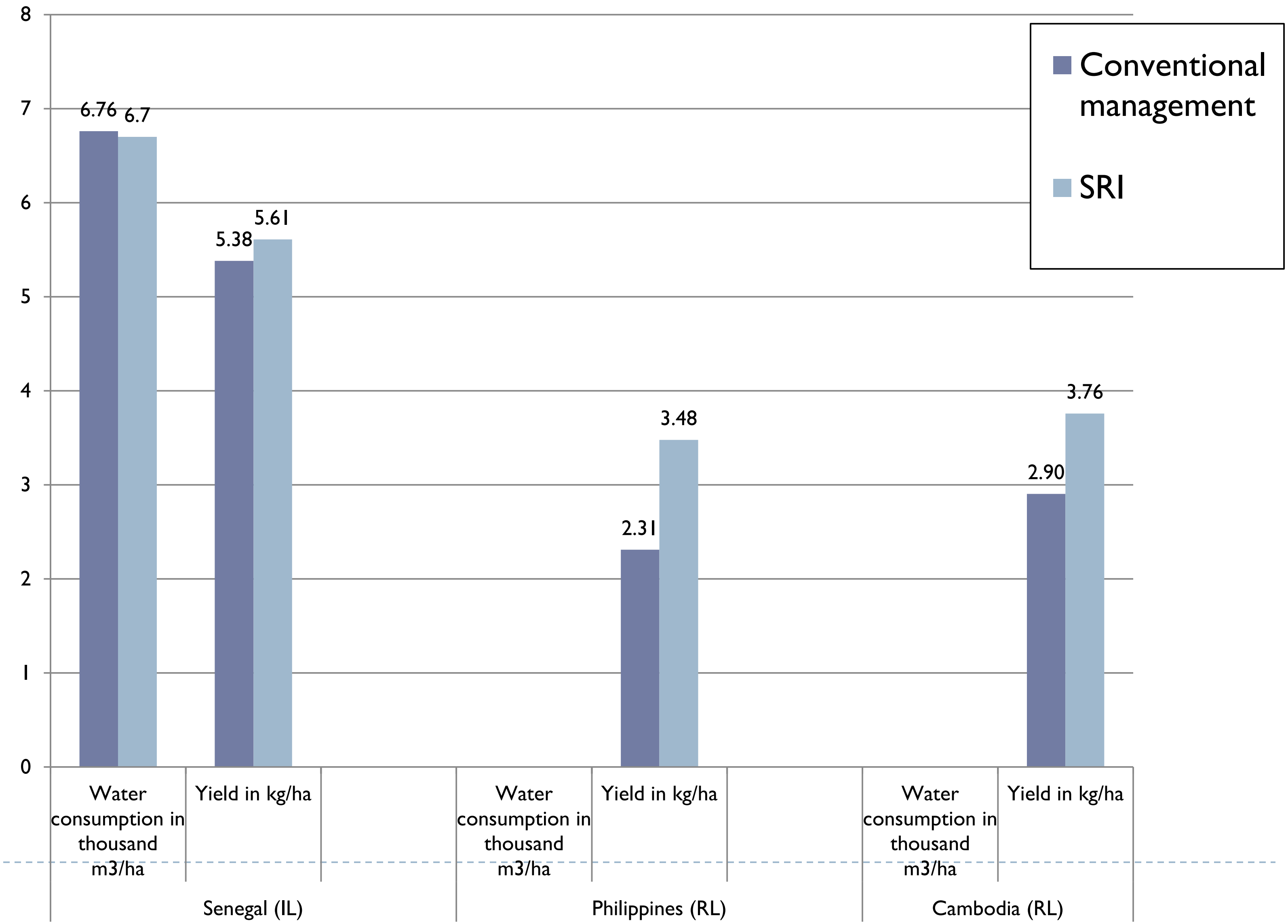
Water consumption vs yields - Quantification

(Improved water mgt and continuous flooding: Senegal and Philippines)



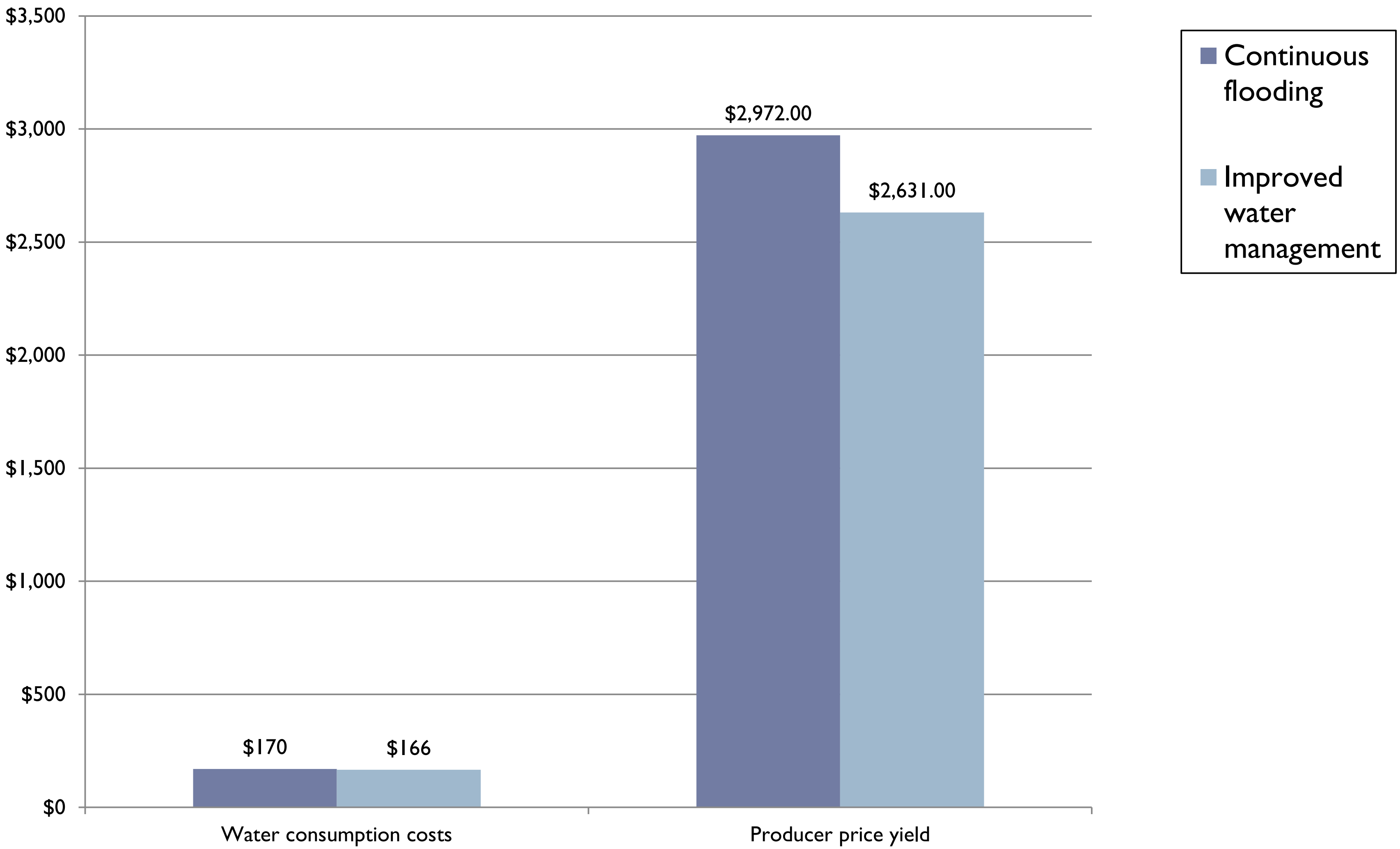
Water consumption vs yields - Quantification

(SRI and conventional mgt: Senegal; Philippines and Cambodia)



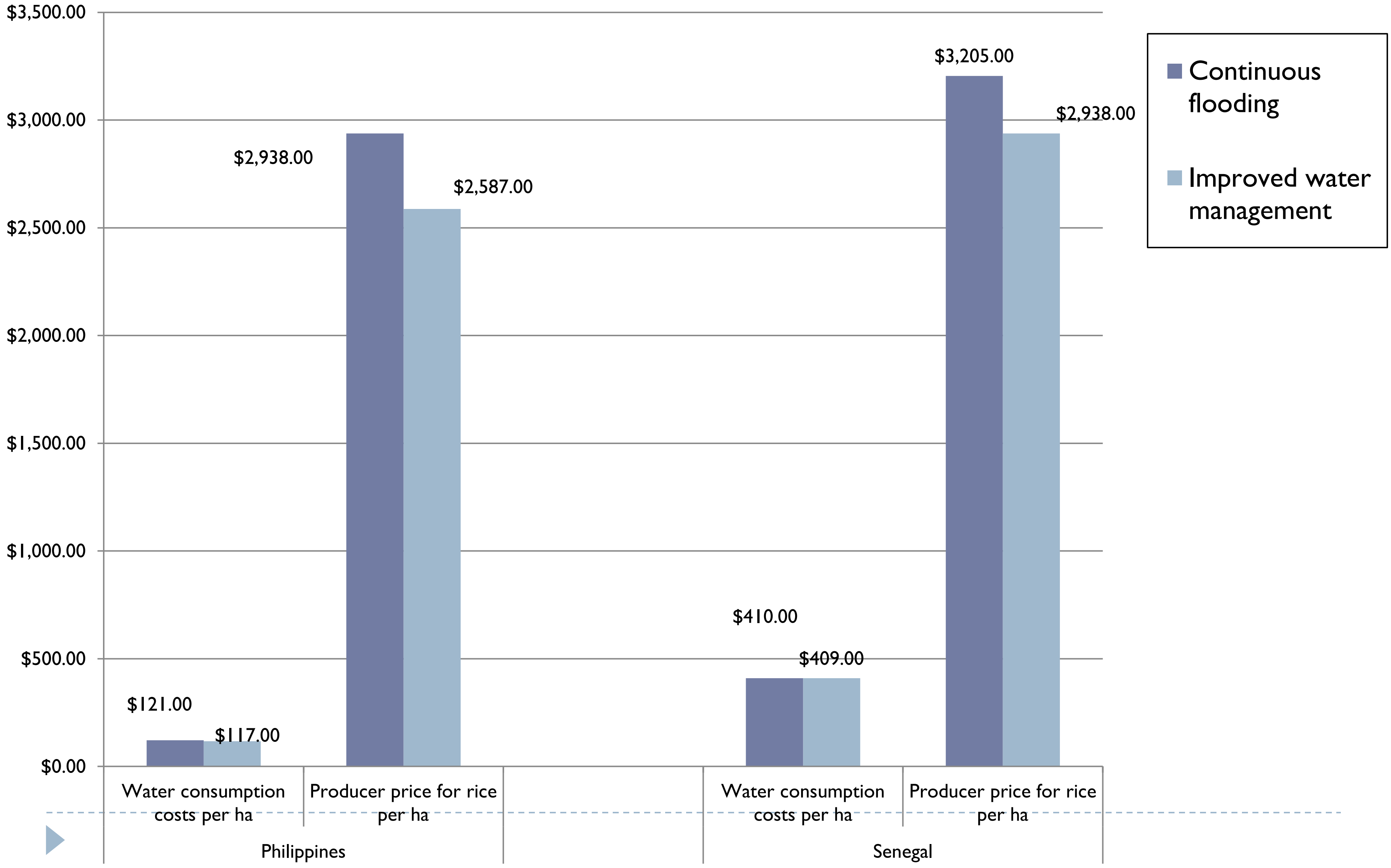
Water consumption vs yields - Valuation

(Improved water mgt and continuous flooding – average)



Water consumption vs yields – Valuation

(Improved water mgt and continuous flooding: Senegal and Philippines)



6. Results (Example 2)

- **INCREASE IN RICE YIELDS VERSUS HABITAT PROVISIONING**
  - Rice paddies are artificial wetlands that provide habitat for a wide range of organisms such as aquatic plants, fish including crabs, prawns, turtles, and mollusks and water fowl.

Picture credits: Muthmainnah

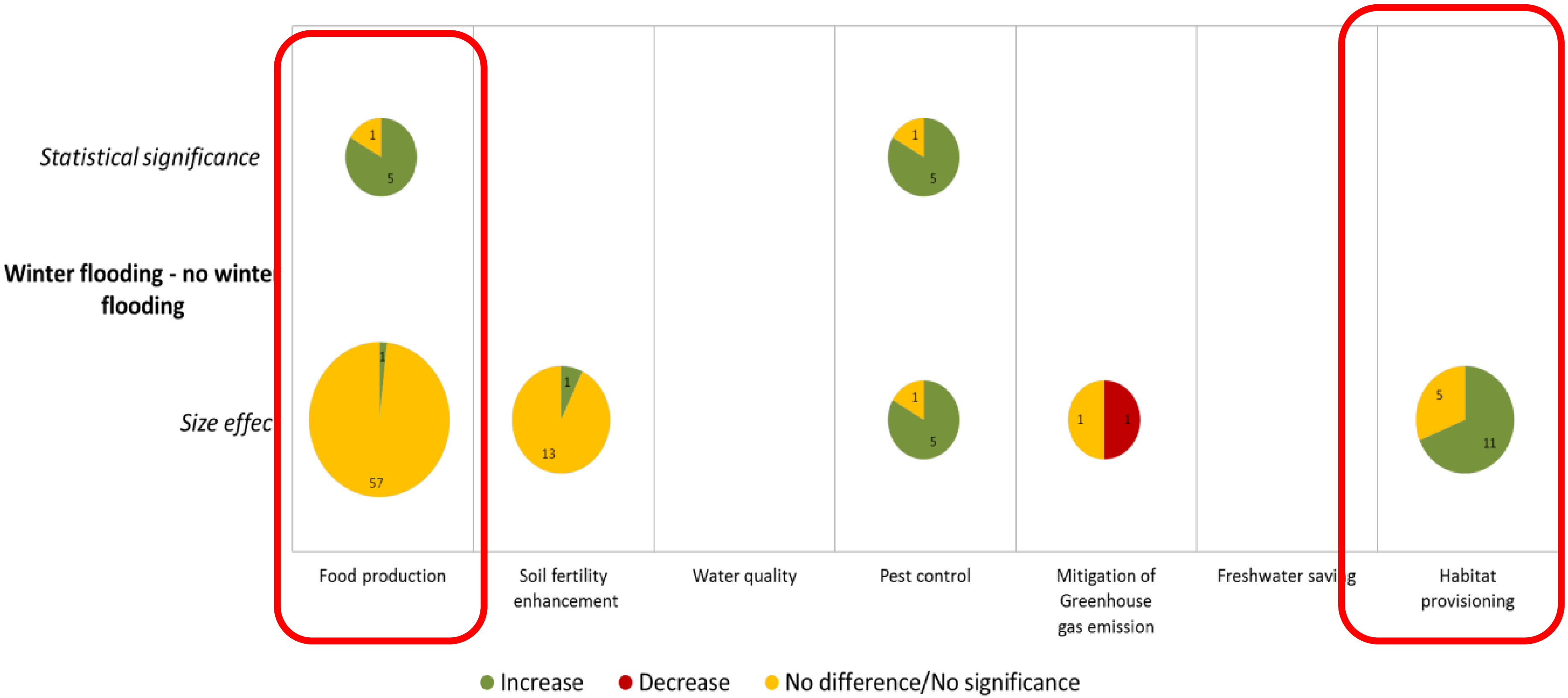
Rice yields versus habitat provisioning

- A study in 1979 recorded 589 total species of organisms in a rice field in Thailand, of which 18 were species of fish and 10 were species of reptiles and amphibians (Halwart & Gupta, 2004).

- Several benefits related to habitat provisioning
  - Food provisioning and nutrition: Fish are a primary source of protein and micronutrients for rural communities
  - Cultural services such as recreation, fishing, bird watching and hunting
  - Many regulating services such as pest control, nutrient cycling

Picture credits: Halwart

Vote counting analysis –
Rice yields versus habitat provisioning in California



Quantification of habitat provisioning and yields for winter flooding and no winter flooding in California