Fish-rice landscapes, knowledge, and practice

Sarah Freed, Alex Stuart, Sudhir Yadav

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Overview

Outline:

- Fish-rice general typology
- Cambodia
- Myanmar
- Bangladesh

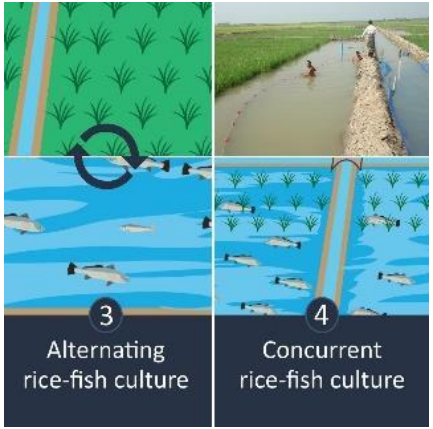
Purpose:

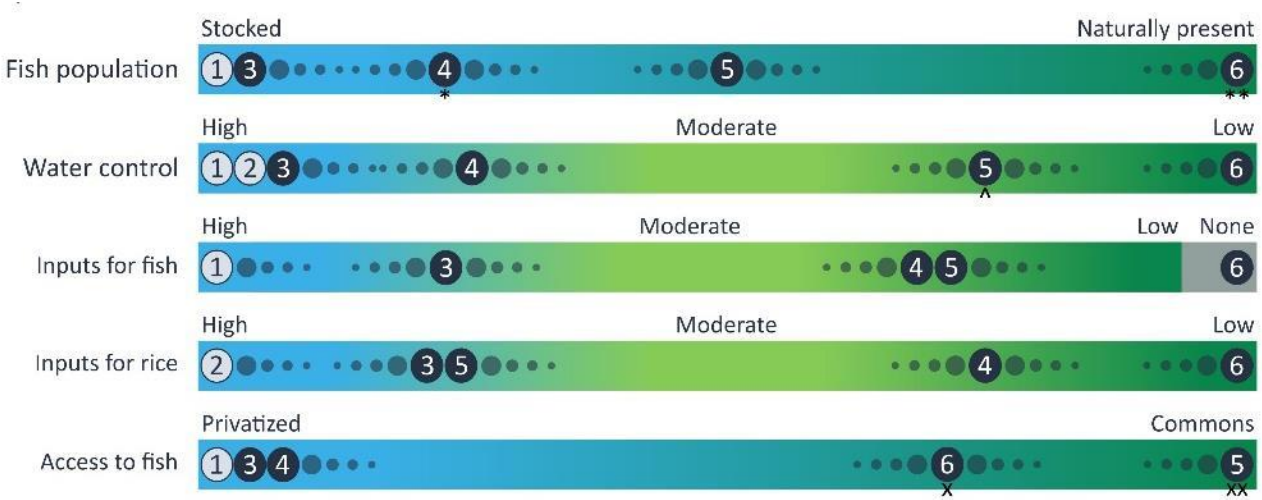
- Variety of fish-rice systems,
- Key areas of knowledge and innovation, and
- Current challenges and considerations for implementation and scaling.

Fish-rice system typology:
key attributes differentiate fish-rice systems

Typology

(Freed et al. In Review)





Fish-rice systems in practice:
different advantages, constraints, and outcomes

Bangladesh
Myanmar
Vietnam

Bangladesh
Myanmar

Bangladesh

Cambodia
Myanmar

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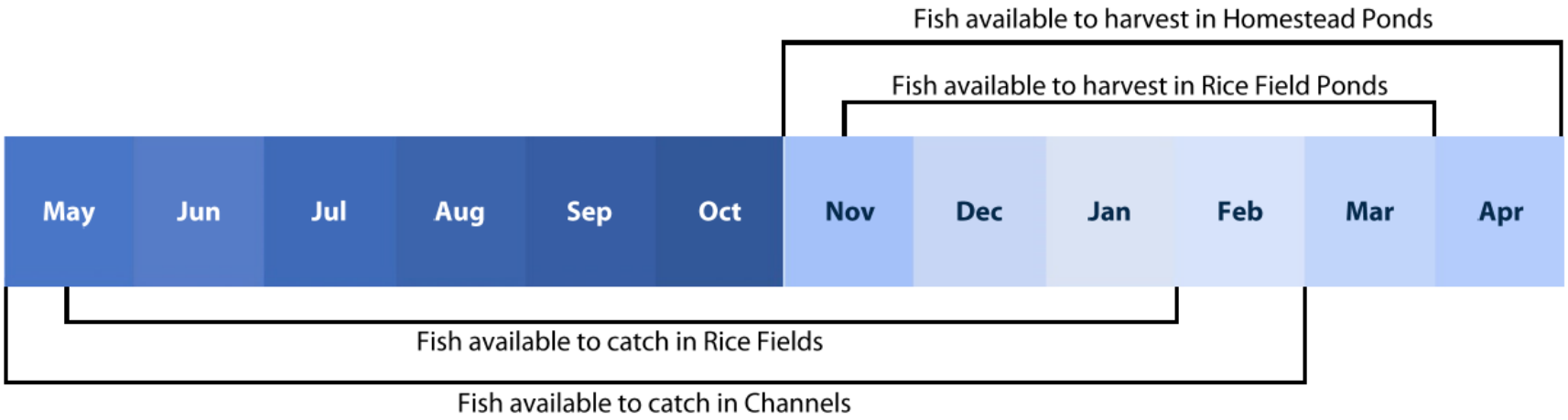
Cambodia

Cambodia: fish agri-food systems

- Range of approaches allow year-round production



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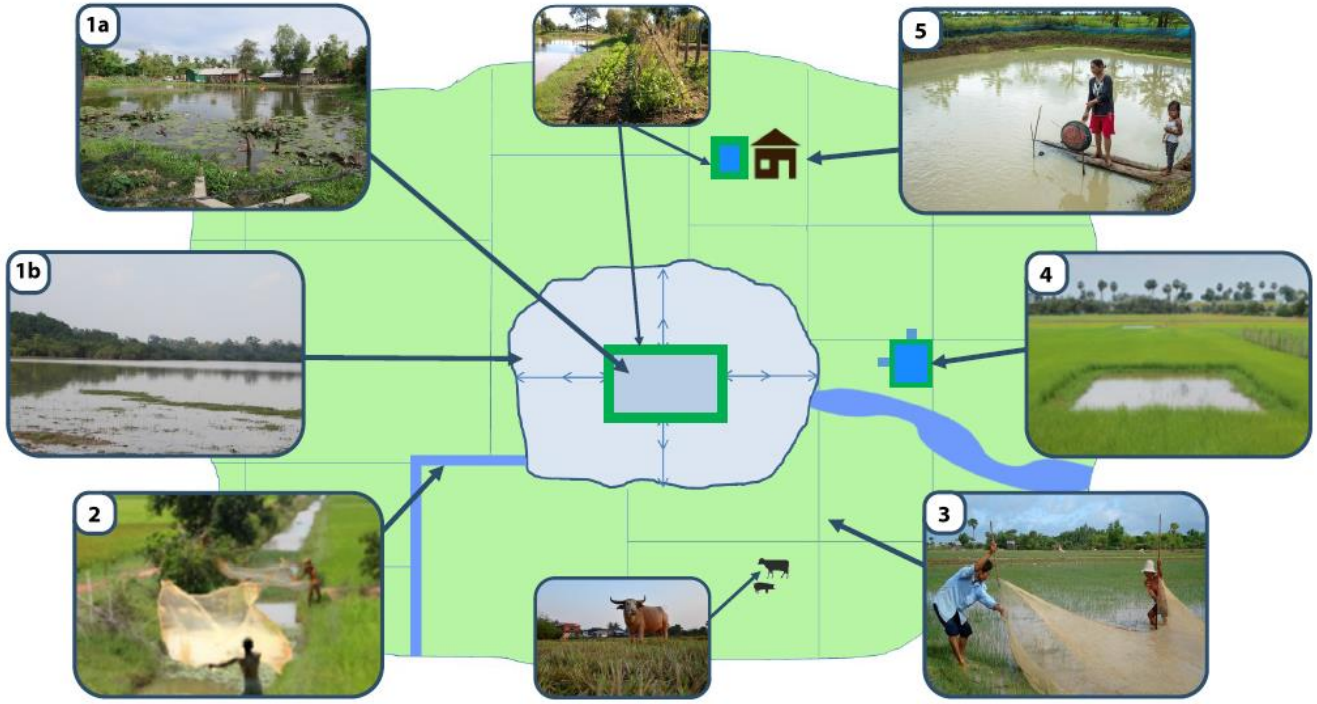
Cambodia: diverse habitats within rice landscape support rice field fisheries



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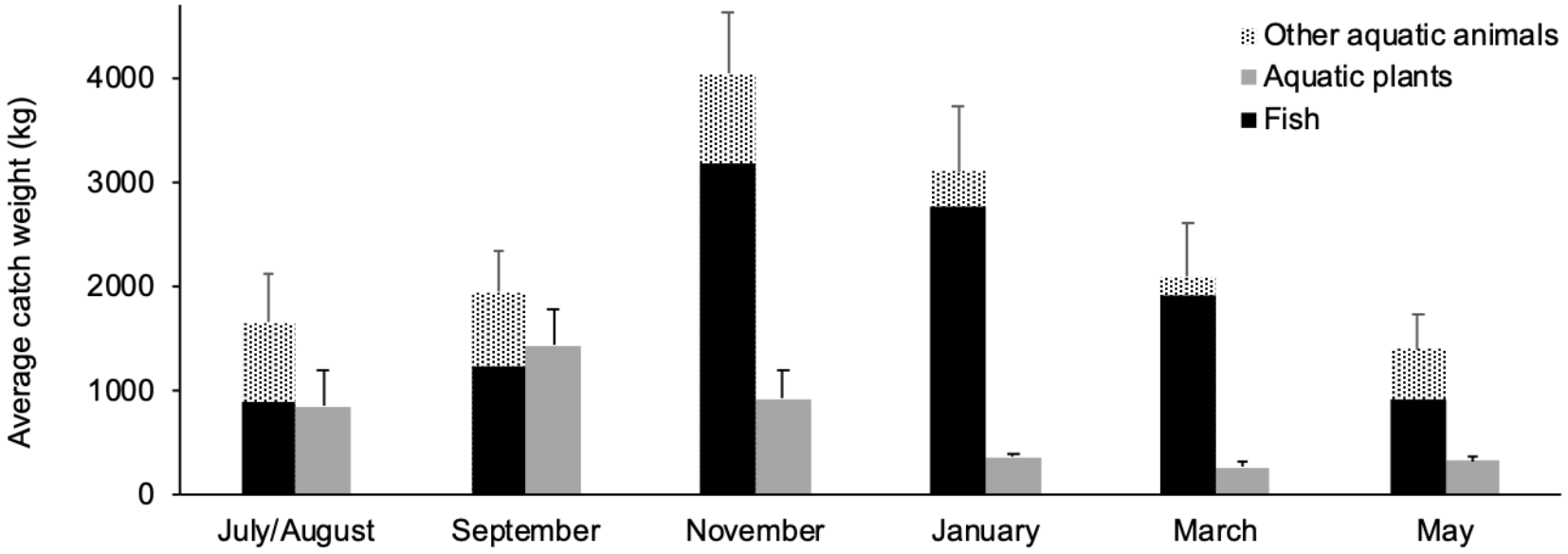
Rice field fisheries provide catch **year-round**



(Freed et al. 2020 *Fisheries Research*)

- Rice field fisheries provided **over 50% of fish** and other aquatic animals consumed
- Consumption was primary use, surplus catch was processed or sold

(Freed et al. 2020 *Fisheries Research*)

Cambodia: Challenges for fish agri-food systems

- Heterogeneous topography and water availability
- Frequent drought and fish habitat loss (flooded forests)
- Infrastructure (roads and irrigation) affect rice field fisheries and Community Fish Refuges

Ang Ta Nak CFR
April 2019

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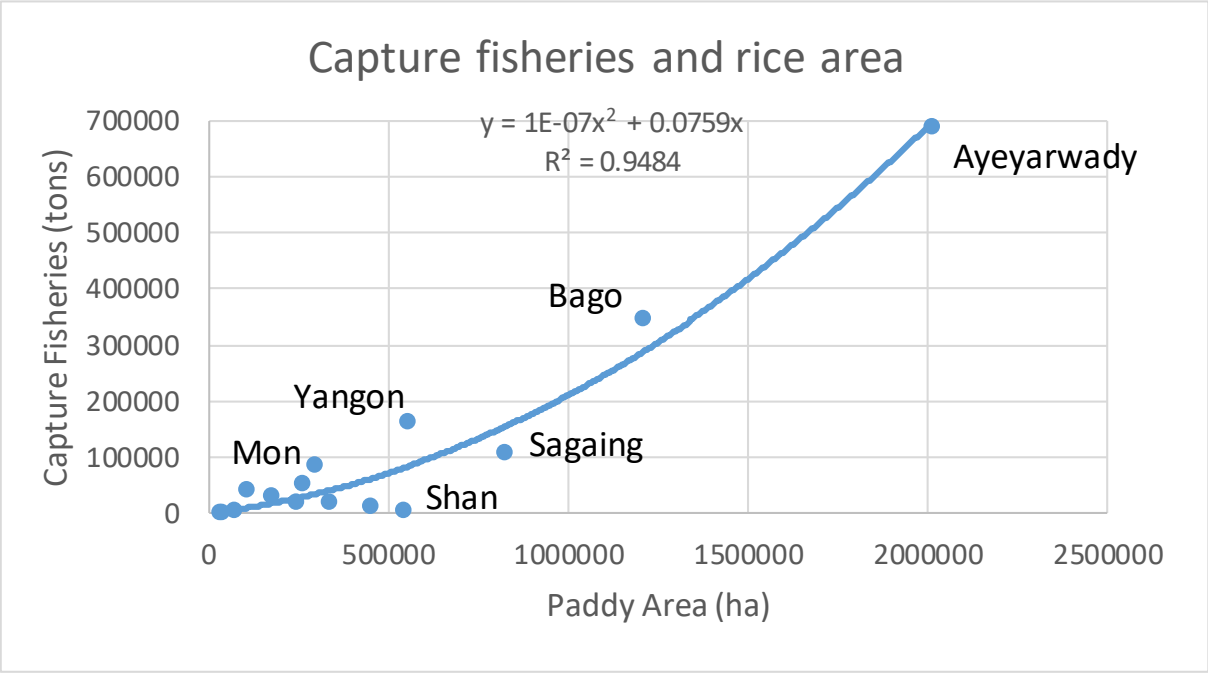
Myanmar

Myanmar: rice-fish agri-food systems

- Rice-field fisheries are common throughout Myanmar and important for food and nutrition security



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Myanmar: rice-fish agri-food systems

- **Malnutrition** is unacceptably high
- **Fish catch is in decline** due to large numbers of fishers, increasing use of agrochemicals, and electrofishing (Gregory, 2017)
- **Rice-fish co-culture** systems, such as rice-shrimp, are present in coastal zones
- Very little rice-fish co-culture occurs in inland freshwater areas due to **strict land-use** laws that were reinforced by the 2012 Farmland Act.

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Myanmar: Recent shifts in policy

- **2018**: Agricultural Development Strategy = crop diversification encouraged
- **2019**: Ayeryarwady Regional Minister granted a shift in land use regulation to allow up to 15% of the agricultural land to be used for a fish refuge

  (following the positive results generated from multi-location field trials conducted by IRRI, WorldFish and MoAli and funded by ACIAR)

- **2020**: Parliament proposed land-use reforms that will allow smallholder farmers to be able to modify up to or less than 30% of their farming land for food production purposes

➢ There is thus a **substantial opportunity to scale out such rice-fish culture** across the Ayeyarwady Delta and in other regions of Myanmar.

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Myanmar: Key challenges and research needs

- **High initial investment costs** for rice-fish co-culture (USD 1000/ha) – financial aid and innovations to reduce these costs may be necessary to enable wide scale adoption.
- **Land suitability** – continuous access to water and minimal risk of flooding
- **Research needed** in marginal areas where impact is expected to be greatest
- Research to **further optimize rice-fish co-culture**, e.g.rice-fish-vegetable-livestock; culturing fish for grow out ponds or for 2 cropping seasons
- **Decision support tools** for integrated inter-sectoral agricultural planning that serves to better understand trade-offs and development options

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Bangladesh

Bangladesh: Background

- The **coastal zone of** Bangladesh are the unique ecosystem has the potential for agriculture and aquaculture intensification
- Many Polders in coastal zone have adequate water controlling structures and canal networks
- Semi-diurnal rivers around the polders offer **huge availability of water year-round** free of cost
- Rice fields remain **flooded for 4-5 months** with water depth ranging from 10 to 100 cm
- Fish enter during high tides occurs in the peripheral rivers twice daily
  - grow naturally in the rice field
  - productivity is low, may be improved with artificial stocking

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Bangladesh: Current considerations for implementation and scaling

- About 1.2 m ha polder ecosystem having water controlling structure - offers the greatest opportunity for the rice+fish culture
- Although community the rice+fish culture is biophysically simple to implement, there are many **constraints** for its implementation:
  - **Community coordination** and lack of willingness to implement rice+fish culture for the benefit of all, including the landless residing within the watershed
  - **Profit sharing and yield distribution** among the households
  - **Socio-political conflicts**
- **Proper utilization of existing polder facilities** with appropriate fish species and feeding for rice+fish culture:
    - **Improve nutrition and income** of >1 million households
    - **Conserve indigenous fish species** through enhanced breeding

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Bangladesh: Key areas of knowledge & innovation

- We identified hydrologically bound **mini-watershed** exists in the polder ecosystems, organized and trained the community for the rice+fish culture in wet season
- Fish fingerlings were released in the **mini-watershed** two weeks after transplanting rice
- Although the rice+fish system is good for nutritional productivity and income, there was **high risks to investment and temporal variability** in performance of the system.
- Possible reasons of variable performance:
  - Fish escape
  - Social cohesion and unauthorized harvest
  - Tradeoff of maintaining water depth for controlling rodents vs growth of fish – ***need further research***
  - Fish species compatibility – ***need further research***

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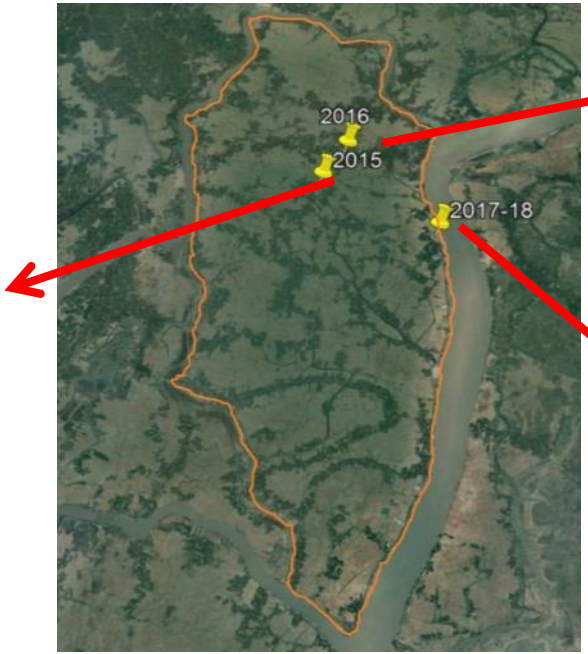
Bangladesh: Rice+Fish Watersheds in Polder



a=2015

c=2017-18

Map of polder 30 in the coastal zone of Bangladesh showing rice+fish watersheds: (a) Bhennabunia, (b) Hetalbunia and (c) Fultala.

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Bangladesh: Fish production, consumption & marketing

Year	*Fingerling stocked (kg)*	*Cost of fingerling (Tk)*	*Partial harvest (kg)*	*Consumption (kg)*	*Sell (kg)*	*Selling price (Tk)*	*Income (sale+ consumption) (Tk)*
2015	2370	311890	3165	503	2662	265087	315177
2016	620	109800	411	120	291	20370	28770
2017	655	97250	550	333	216	21330	54288
2018	492	69575	788	555	233	24463	82854

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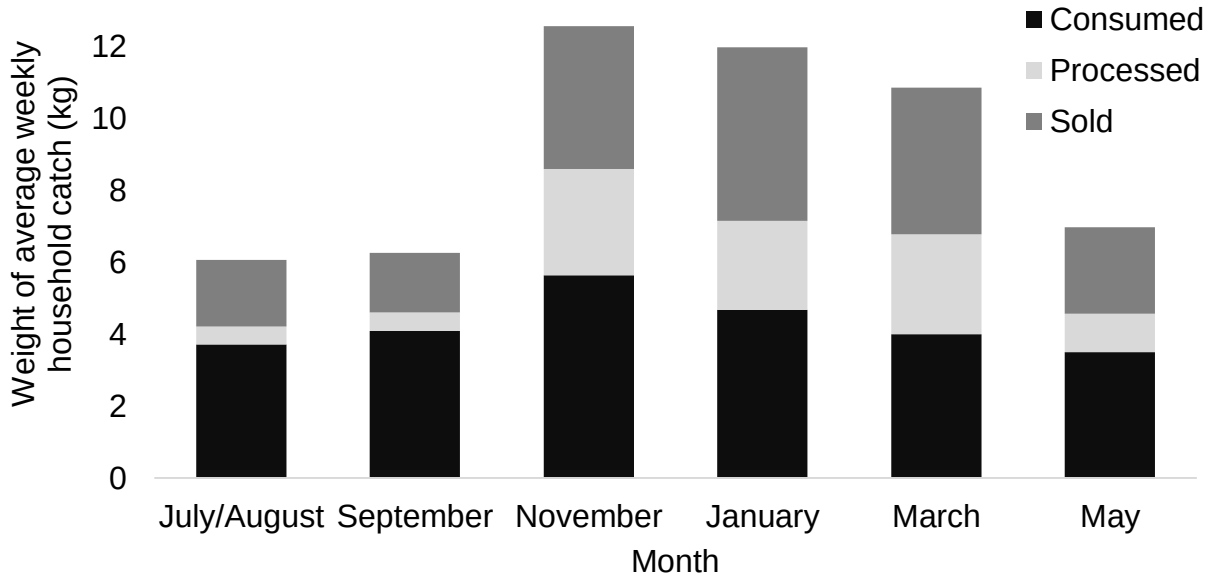
Cambodia: fish agri-food systems

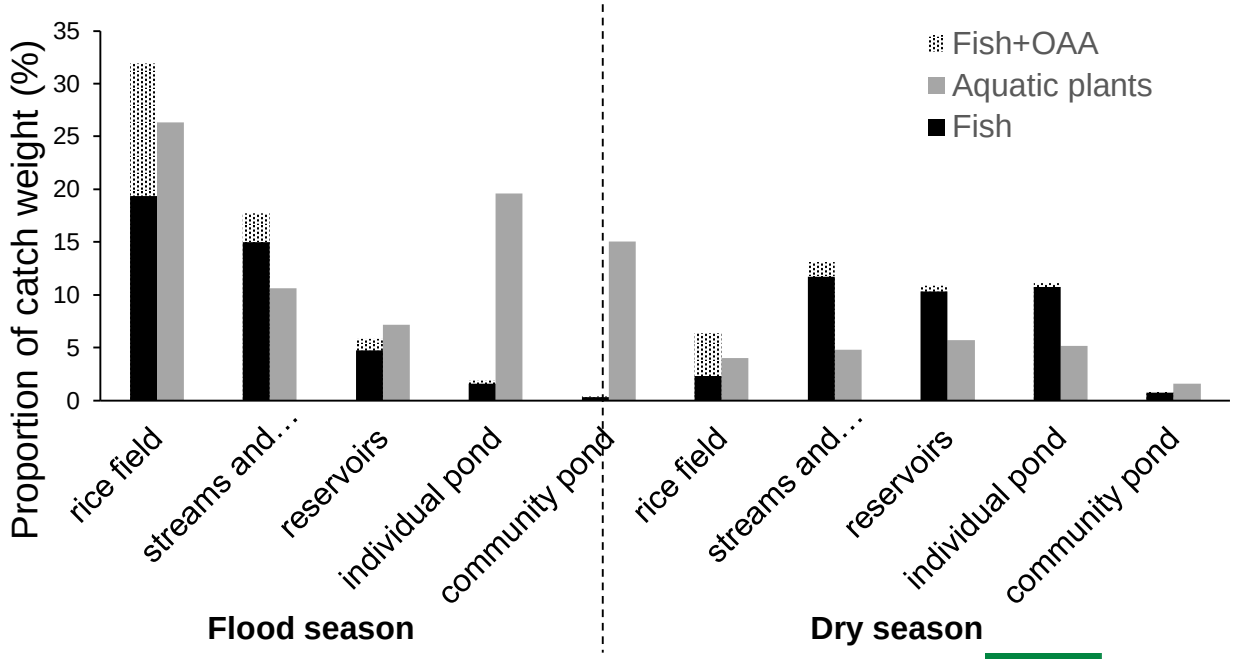
- Consumption is primary use, surplus catch is processed or sold



(Freed et al. 2020 *Fisheries Research*)

Cambodia: fish agri-food systems

- Diverse habitats within rice landscape support rice field fisheries



(Freed et al. 2020 *Fisheries Research*)

Policy environment and potential research for fish-rice in Cambodia

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Introduction

Purpose

To provide insight on the state of fish-rice knowledge and practice in Cambodia, including:

- research projects on fish-rice systems
- policies relevant to fish-rice system development
- points to consider for suitability

Outline

1. Types of ‘fish and rice’ farming tested in Cambodia
2. Existing policies and institutions
3. Fish species
4. Suitability considerations: geography, hydrology, rice farming practices, and capacity in both private and public sectors
5. Challenges and opportunities

Farming systems projects with fish and rice

- Fish nursery and fish culture (Takeo – FiA AQ Dept)
- Rice-prawn pilot (FiA - Somony)
- Fish grow-out separated from rice plots (wild and/or cultured fish) (EU-IFAD; ASA; ASPIRE; HKI)
- Fish aquaculture in rice field ponds in dry season (EU-IFAD)
- Community based fisheries and aquaculture trials (WorldFish)
- Integrated farming: Rice-fish co-culture (Danida)
- Rice field fisheries (part of the landscape, not just a project)

Policies and institutions

- **Several policies recognize value** of integrated fish and rice (most often rice field fisheries):
  - **Fisheries**: strategic planning and conservation strategy (FiA)
  - **Agriculture**: strategic development plan (2019-2023) and climate change priorities action plan (2014-2018; MAFF)
  - **Nutrition**: National Strategy for Food Security and Nutrition (CARD and TWG-SP&FSN, 2014)

Policies and institutions

- **Collaboration** to develop Rice Field Fisheries and Community Fish Refuge Management Guidelines (FiA & WorldFish)
- **Consistency needed** in other policies:

  -**Agricultural Sector Strategic Development Plan** (2019-2023):

  1. Agricultural productivity, diversification, and commercialization
  2. Sustainable management for forest and fish resources

  -Policy to **intensify rice productivity** (e.g. Rectangular Strategy)

  -**Irrigation and water management** policy and planning

Fish species

- Highly biodiverse: 150 species in rice field fisheries
- Small and large fish (nutritional diversity)
- Economically low and high value
- Opportunities for polyculture (EU-IFAD trials)
- Need to account for predatory species – time and resources required to keep them out of a culture system.

Suitability assessment

Most familiar areas for rice and fish:

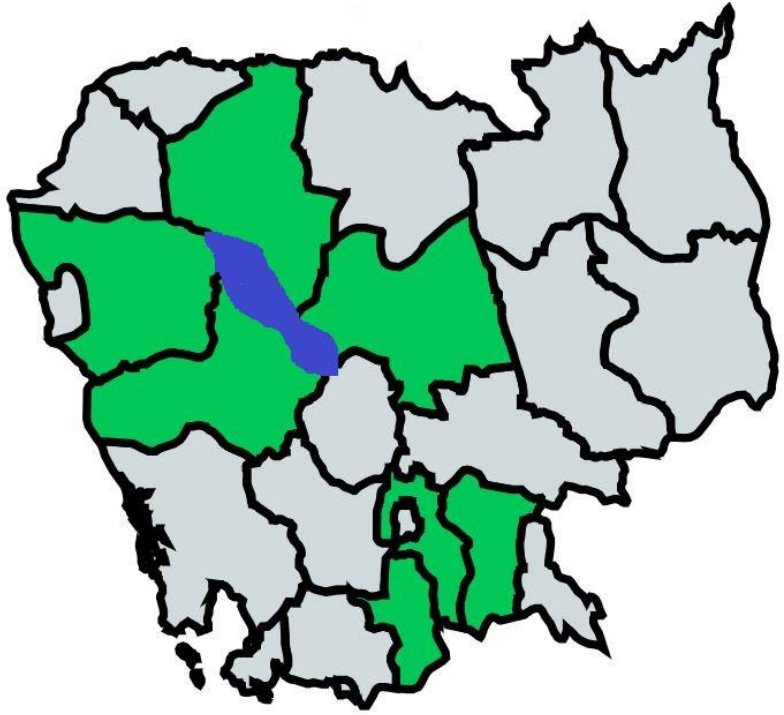
- **Tonle Sap region**

e.g. Battambang, K. Thom

- **Cambodian Mekong Delta**

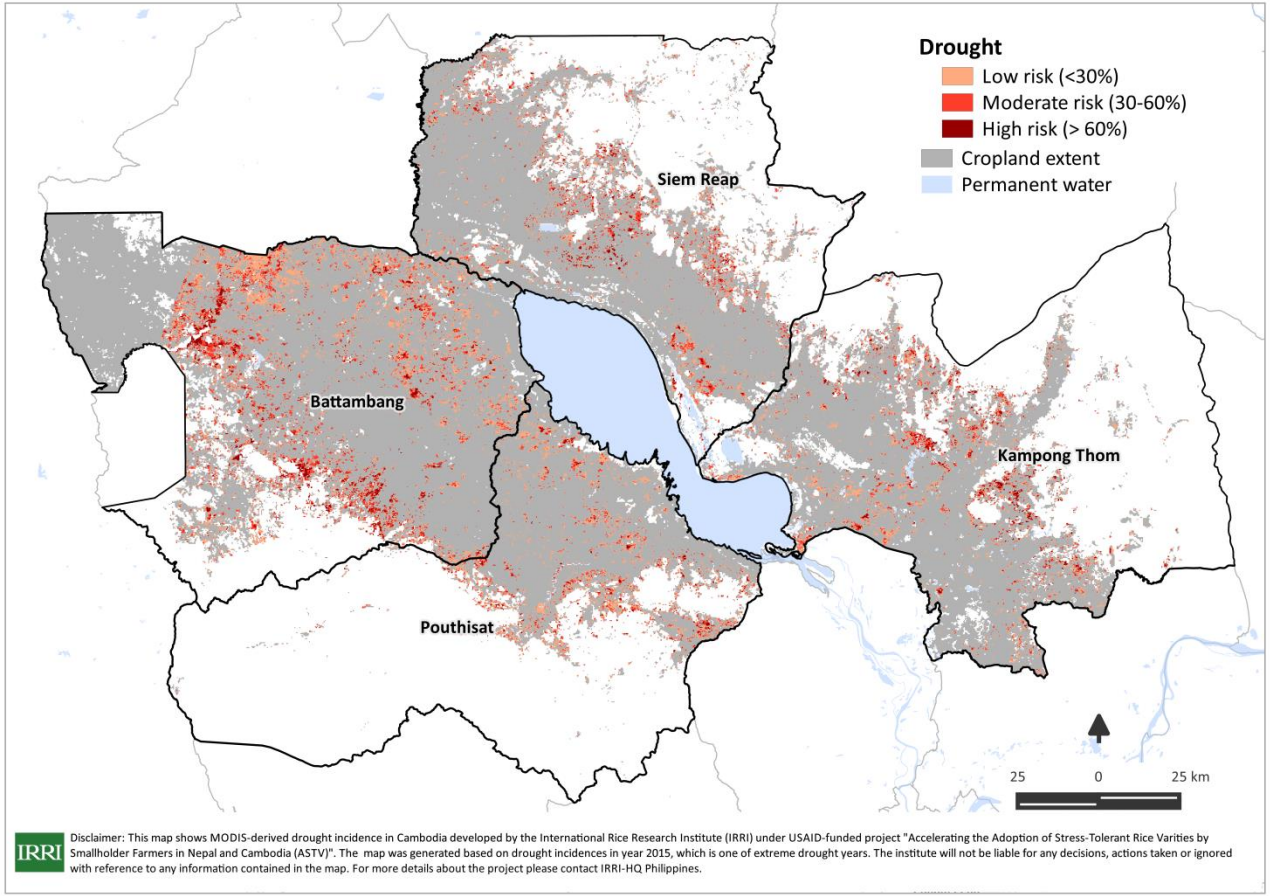
e.g. Takeo, Prey Veng, Kandal

(preks - irrigation canals)



Suitability assessment

Rice areas near lakes or rivers; still need to consider flooding or drought



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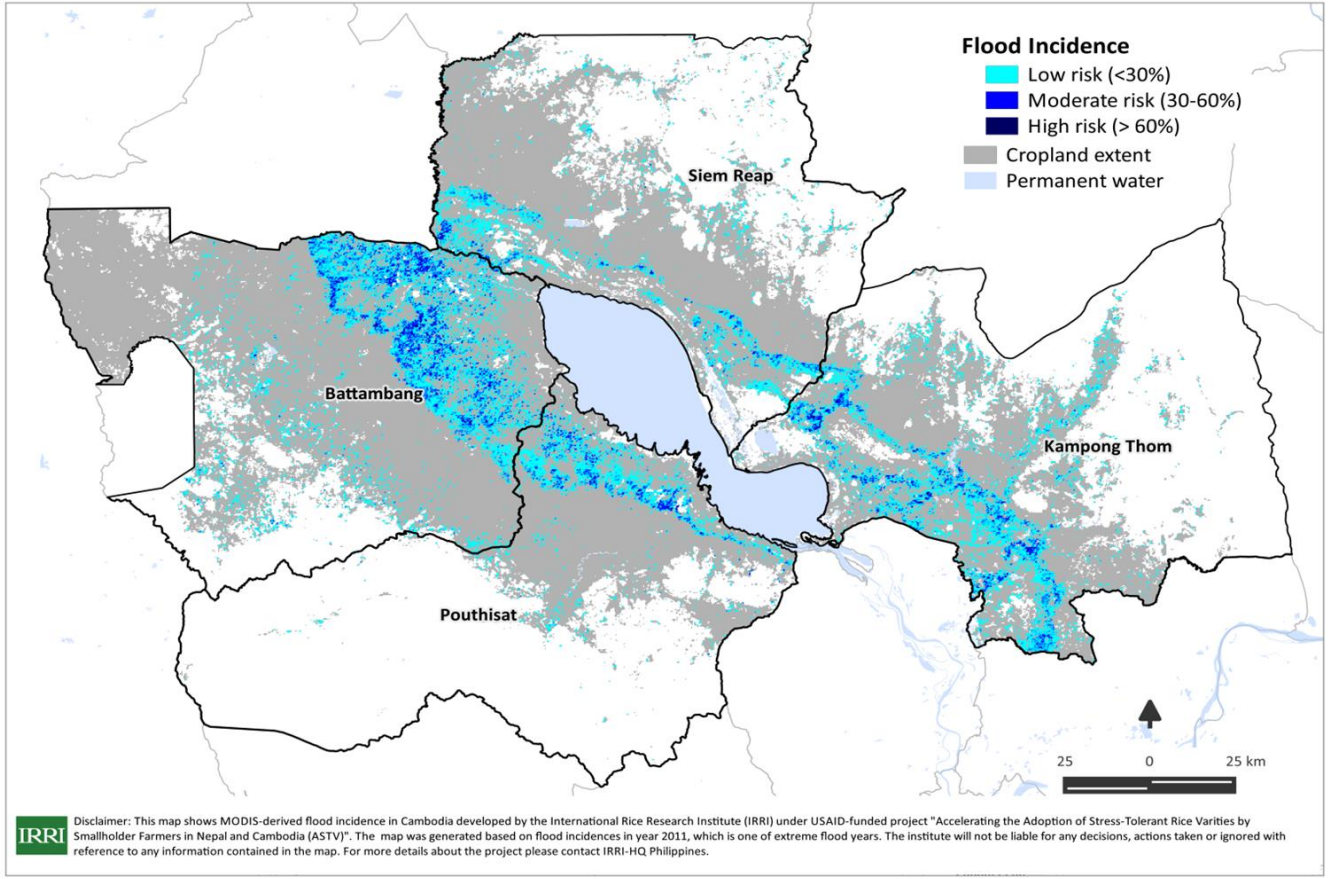
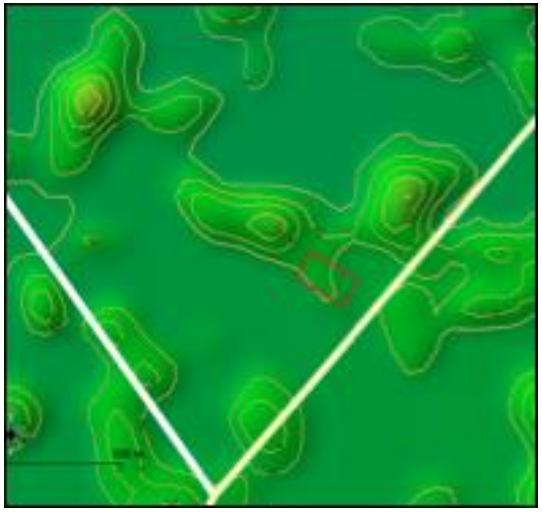


Suitability assessment

Earth observing imageries



A digital surface model (DSM) at 30 meter resolution using Shuttle Radar Terrain Mission (SRTM).

Where fish-rice systems should be located in an area requires further optimization

Analysis shows a flat topography with majority of the slope ranging between 0.01 and 0.02%: indicating the whole watershed is suitable for rice+fish system

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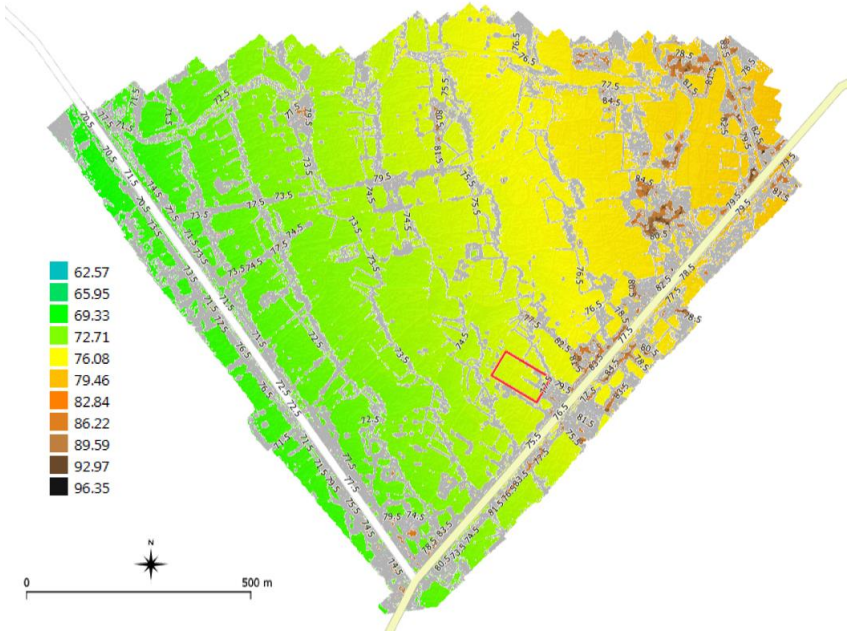
Suitability assessment

Drone imageries (with a resolution of < 1m)



Analysis suggest a gradual sloping terrain with elevation ranging from 68 to 80 meters- which indicates a trade-off with energy (pumping water) if rice+fish will be at upper toposequence

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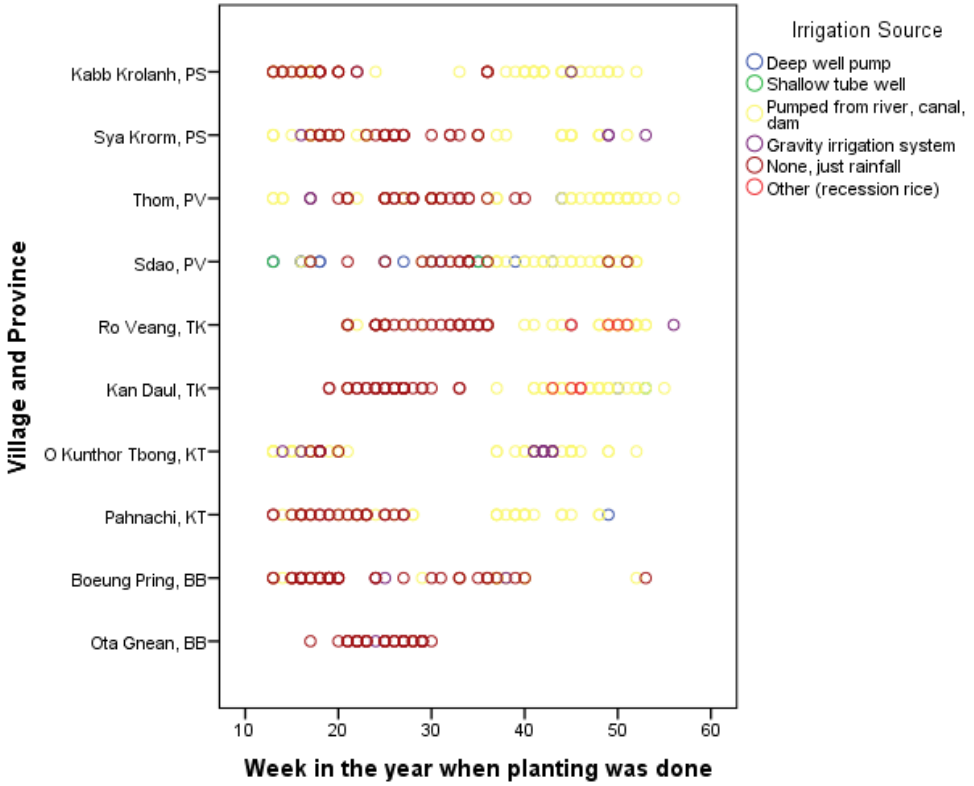
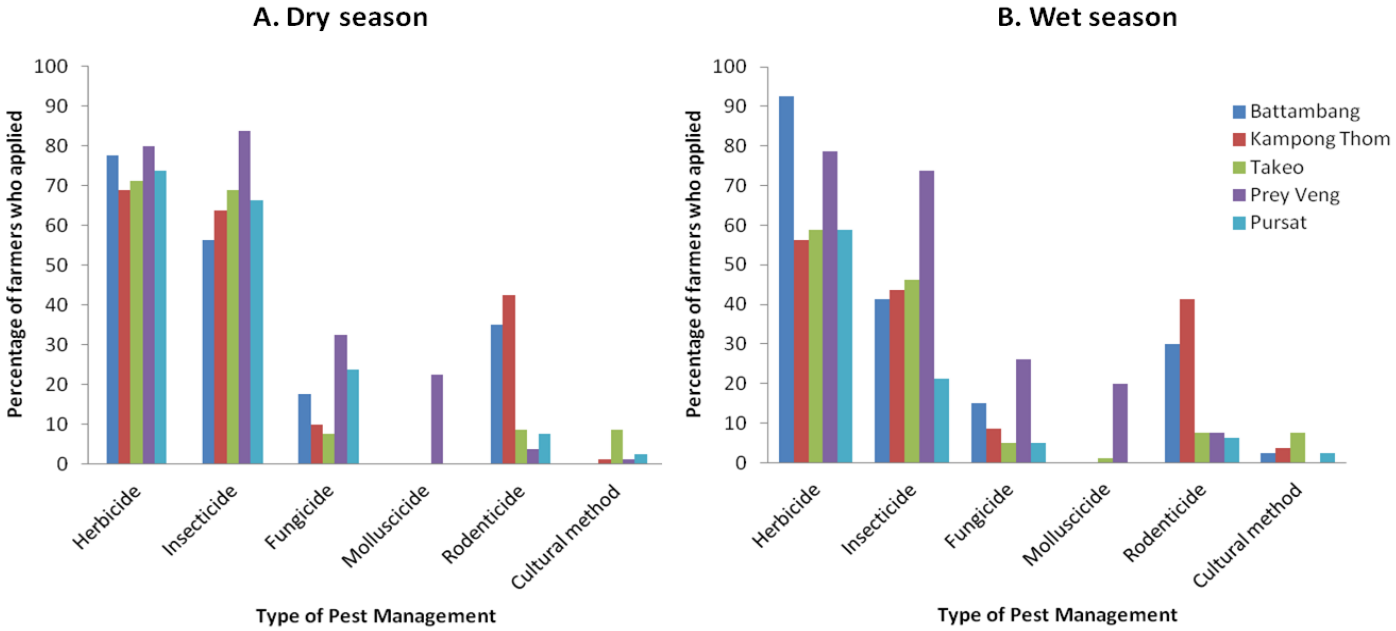
Rice production practices to consider

In villages with access to supplementary irrigation, farmers do not synchronize their planting



Rice production practices to consider

Almost all farmers apply pesticides



Percentage of farmers who implemented specific pest management strategy
A) Dry and B) Wet season 2015-16 (N=400) in five provinces of Cambodia in 2016

Rice production practices to consider

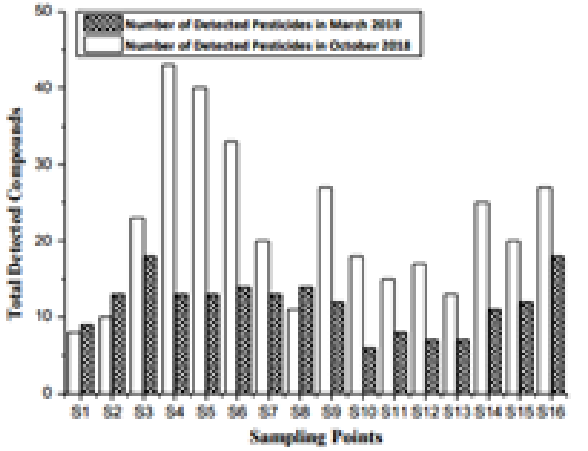
Many farmers mix pesticides in one application; They use pesticides that are toxic to fish and humans

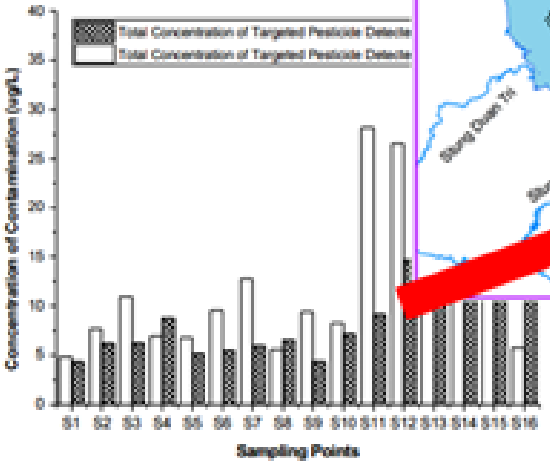
Type	Active ingredient	Type	Active ingredient
Insecticide	Thiamethoxam	Fungicide	Hexaconazole
	Imidacloprid + Chlorpyrifos		Oxytetracyline +Streptomycin
	Abamectin		Isoprothiolane
	Methyl-parathion		Propiconazole + trycozole
	Emamectin Benzoate		Isoprothiolane
	Dibromochloropropane DBCP		Difenoconazole + azozystrobin
	Buprofezin		Isoprothiolane
	Cypermethrin		Tricyclazole+ Isoprothiolane
	Pymetrozine		Propiconazole
	Phenthoate+fenobucarb		Bronopol
	Emamectin Benzoate+Permethrin	Herbicide	Chlorimuran+Metsulfuran (metsulfuron-methyl + chlorimuron ethyl)
	Phenthoate+fenobucarb		2,4-D
	Lambda-cyhalothrin		Bispyribac Sodium + Cyhalofop Butyl
	Emamectin Benzoate + Chlorfluozuron		Quinclorac+Pyrazosulfuron
	Dicrotophos		Pyrazosulfuron-ethyl
	Acephate		Chlorimuran+Metsulfuran (metsufuron-methyl + chlorimuron ethyl)
	Pymetrozine + Solvent		Butachlor
	Nitenpyram + Buprofezin		Bispyribac sodium
	Dinotefuran		Quinclorac+Fenosaprop-p-ethyl
	Permethrin		Pyribenzoxim
	Monosultap (monomehypo)		Quinclorac+pyrazosulfuron-ethyl
	Chlorantraniliprole		Fenoxaprop-P-ethyl+2,4-D
	Nitenpyram + Pymetrozine		Quinclorac
	Chlorpyrifos + alpha cypermethrin + imidacloprid	Molusticide	Metaldehyde
	Chlorantraniliprole + Fipronil	Rodenticide	Zinc phosphide
	Imidacloprid		
	Fubendiamide		
	Pymetrozine + Nitenpyram		
	Chlorantraniliprole + Thiamethoxam		

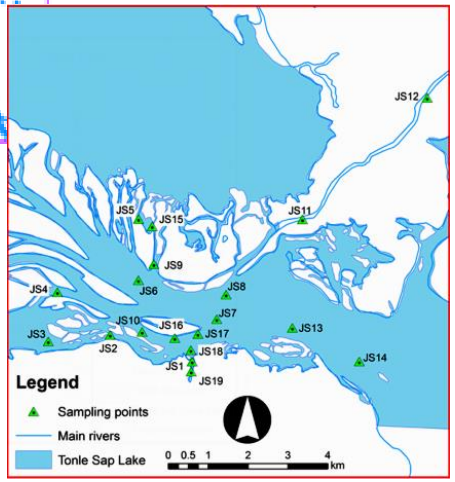
Common Pesticide Active Ingredients Used by farmers in five provinces of Cambodia in 2016

Study on pesticide contamination In Tonle Sap by JEAI

What is happening?







- More number of pesticides were detected in October
- S4 and S5 were most contaminated with pesticide residues
- High concentration of pesticide contamination were observed in S11, S12, S13, and S15

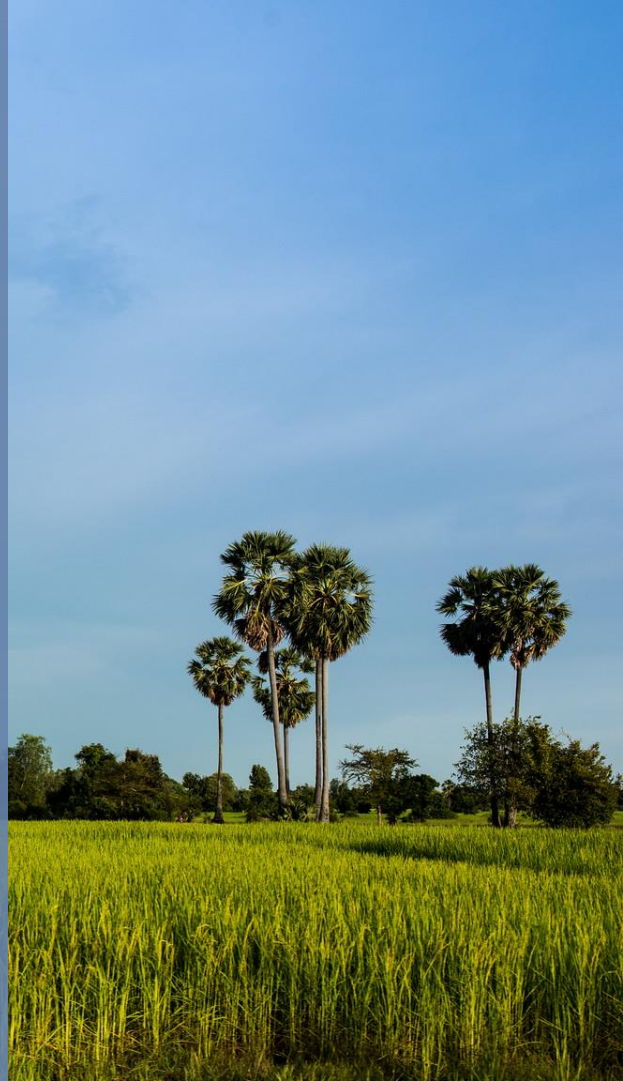
Source: Kuok et al. 2020

Capacity

- Extension services, Irrigation managers
- Smallholders (explore clusters being formed)
  - Rice farmers, vegetables/other cash crops
  - Fishers
  - Landless, former migrant workers
- Businesses
  - Fingerling producers
  - Local hatchery producer networks
  - Local market (for some species), middlemen

Additional challenges

- Risk of **fish loss** (fishing and/or predation), especially when fish are far from homestead
- How to **keep/reserve stock** for low water periods
- **Sustaining and diversifying** fish culture is a key gap
- Aquaculture products compete with **low-priced imports**
- **Perceptions** (e.g. on losing the land for making a pond, identity as rice farmer)



Opportunities

- **Different types** of rice-fish systems possible
- **Complementary** systems, requires ecologically informed design
- **Small fish** may be most feasible in terms of skill & inputs required
- **Domestication** needed to scale small fish culture
- Areas with **irrigated rice, access for water**, potential for water management in the rice areas

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Novel fish agri-food system innovations

ACIAR & CGIAR collaborations in Myanmar

Mark Dubois, Matthew McCartney & Alex Stuart

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IWMI International Water Management Institute

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The need for transformation of landscapes/food systems

EAT-Lancet Commission

Food is the **single strongest lever** to optimize both **human health** and **environmental sustainability** on Earth

Myanmar

Diet:

- 33% of HHS nationwide food insecure
- >60% of calories in Myanmar diets from rice rising to >80% in rural areas.
- Under-5 stunting 29% (2016)

Environment:

- 1990-2015: 10 million ha of forest lost (1.2% a year)
- 2000-2014: 191,122 ha mangrove lost (2.2 % per year)
- Capture fisheries declining
- Environmental and water pollution and soil erosion

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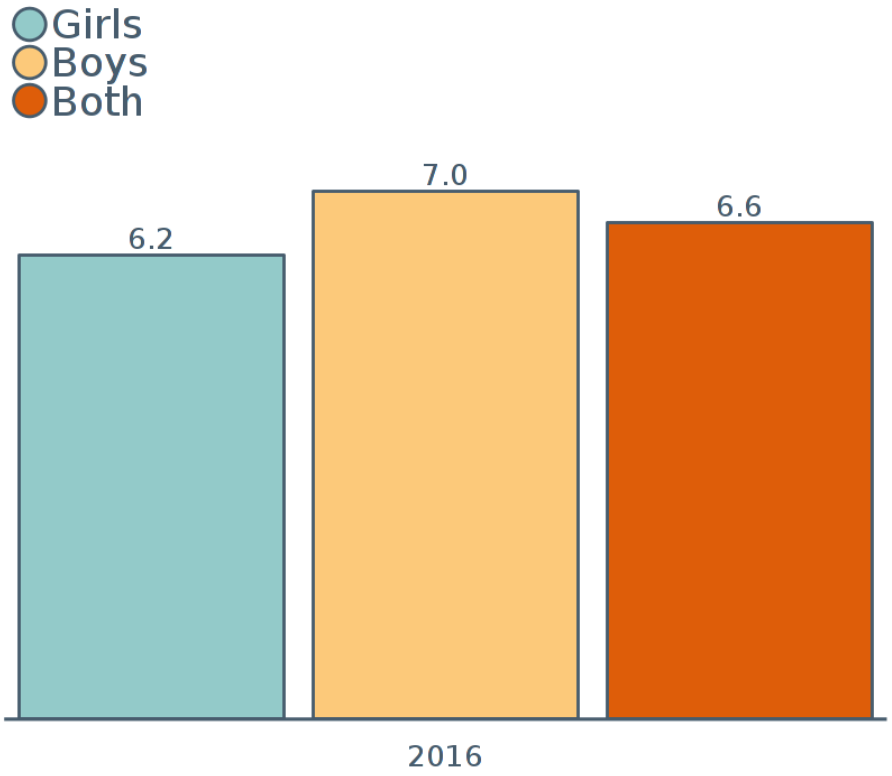
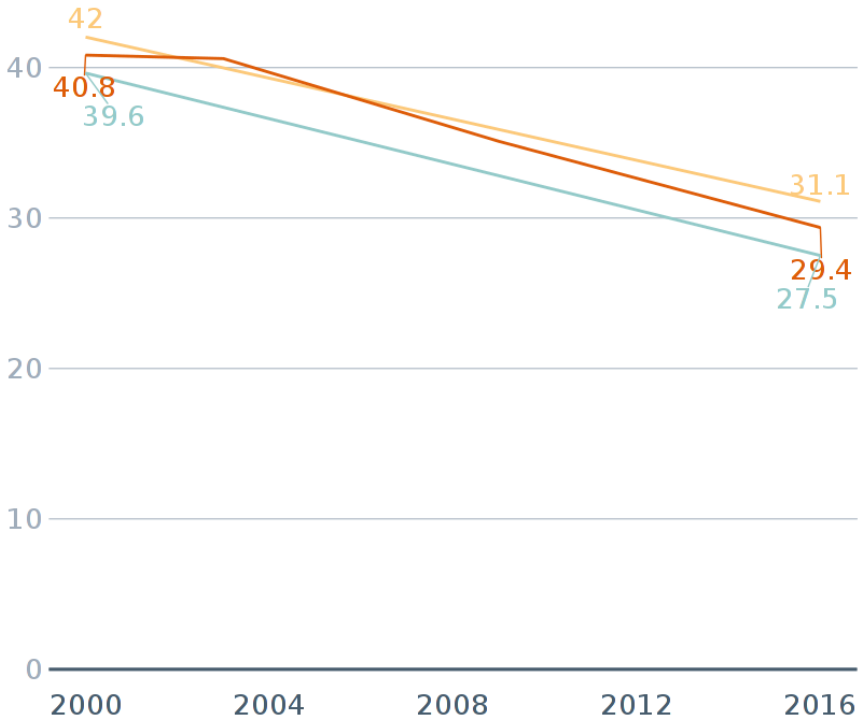
Under-5 nutrition status

Under-5 wasting by gender (%)



Under-5 stunting by gender (%)



Myanmar nutrition country profile 2018

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NRM and the Environment

"…..natural environment is the foundation upon which Myanmar's social, cultural and economic development are sustained" (MSDP, 2018)

Environmental problems that may undermine future socio-economic development include:

- Deforestation
- Mangrove loss
- Soil degradation
- Water and air pollution
- Fisheries decline
- Climate change

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Myanmar in transition

Disablers

Archaic land use policies

Limited capacity in land use planning and decision making

Low agricultural productivity

Poorly organised agricultural research and extension services

Lack of infrastructure to lift economic dev….

Enablers

Recent policy shifts such as the ADS and the MSNPAN promoting more diversified and nutritious agricultural production systems

Contribution of Research and Development initiatives in supporting the development of more sustainable and nutritious food production systems

Ongoing ACIAR research on rice-fish co-culture (experimental trial results)

From 2017-2020, field research trials were conducted in 3 districts across the Ayeyarwady Delta

Objectives of the field research trials:

1. To validate productivity of RFCS (for land use policy reform)
2. To optimize RFCS and identify best management practices (i.e to enhance RFCS)
3. To generate lessons and data for RFCS suitability mapping in the Ayeyarwady Delta

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Experimental design

Treatments:

1. Rice monoculture vs Rice-fish (Rohu + silver barb)
2. 3 nitrogen fertilizer levels (BMP*; 50% BMP; Zero N)
3. 3 rice varieties (HYV, plus 2 locally adapted)

3 replicates per site

Rice sown using a drum seeder

Minimal pesticide use (zero)

- **Fish refuge area <13% of total crop production area**

*BMP = Best management practice

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Key results over five cropping seasons

- BMP N treatment = yield is higher or similar for rice-fish compared to rice only
- For both rice and rice-fish, rice yield increased with N input
- Under BMP N, total rice production was similar between BMP rice-fish and BMP rice only even though 13% less land for rice
- Rice-fish plots had reduced pest and damage incidence

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Comparison with neighbouring rice farmers (over 5 cropping seasons)

	Rice BMP	Rice-fish BMP	Farmer practice
Rice harvest (Kg/ha)*	4358	4170	3438
Fish harvest (Kg/ha)		407	
Rice production cost (USD/ha)	449	407	316
Fish production cost (USD/ha)		329	
Rice gross income (USD/ha)	707	677	549
Fish gross income (USD/ha)		384	
Gross margin (USD/ha)	259	313	233
% difference with Rice-fish BMP	21		34

*fresh weight

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Research summary

- These results highlight the improved resource-use efficiency and potential economic benefits of adopting rice-fish co-culture in the Ayeyarwady delta without compromising rice production.

- Provided evidence-based research to support recent policy shifts regarding conversion of rice land to RFCS

- Building on this research, we then need to identify what is required and what the trade-offs are and how to mitigate these for system transformation at a landscape level

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Rice-Fish in Myanmar…What If?

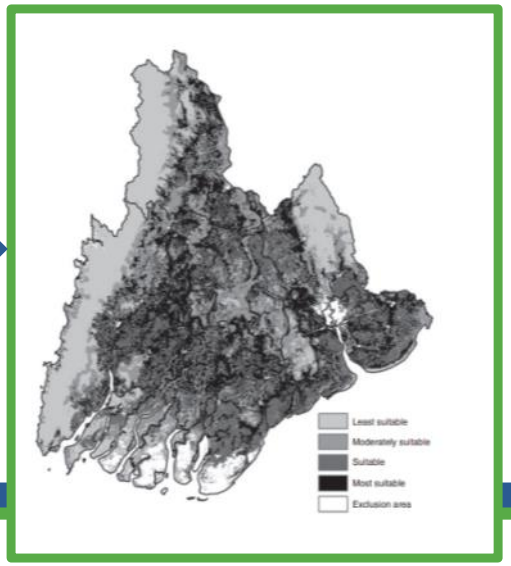
CSIRO PUBLISHING

RESEARCH FRONT

Marine and Freshwater Research
https://doi.org/10.1071/MF19182

Integrating fish into irrigation infrastructure projects in Myanmar: rice-fish what if…?

Mark J. Dubois[A,I], Michael Akester[A], Kimio Leemans[A], Shwu Jiau Teoh[B], Alex Stuart[C], Aung Myo Thant[D], Su Su San[D], Nilar Shein[E], Mansoor Leh[F], Palal Moet Moet[G] and Ando M. Radanielson[H]



15716km2 suitable land area for rice fish culture implementation.

Estimated **additional production** of **1x10(5) Mg** of edible **fish** portions.

Estimated **25% increase** in gross profit margin.

IRRI

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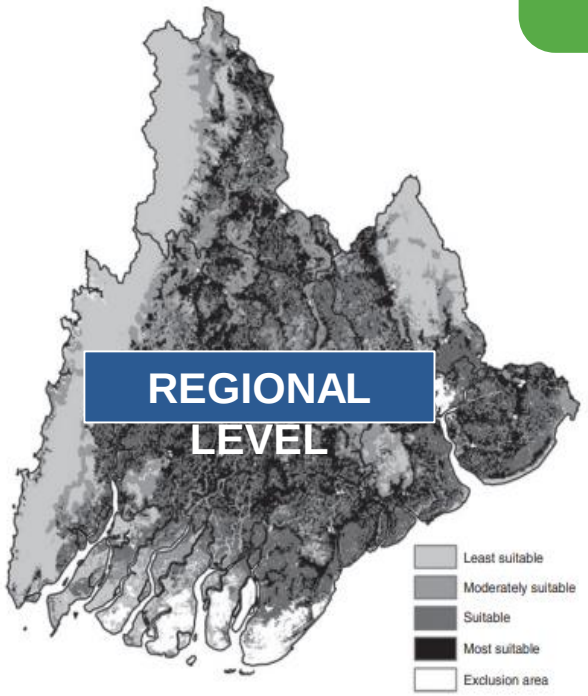
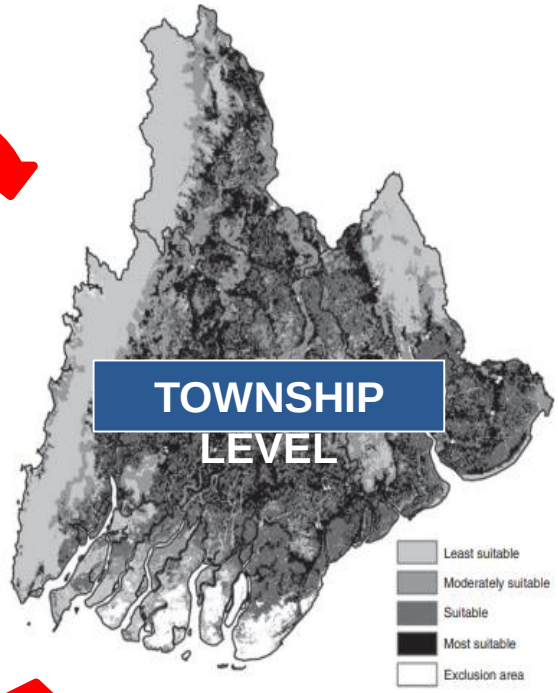
Tailoring research to local needs and aspirations

PRELIMINARY
(Phase 1 Map)



LAND USE/BIOPHYSICAL (Primary Data)

SOCIOECONOMIC (Secondary Data)



REFINED
(Phase 2 Map)

Social data layers currently being added

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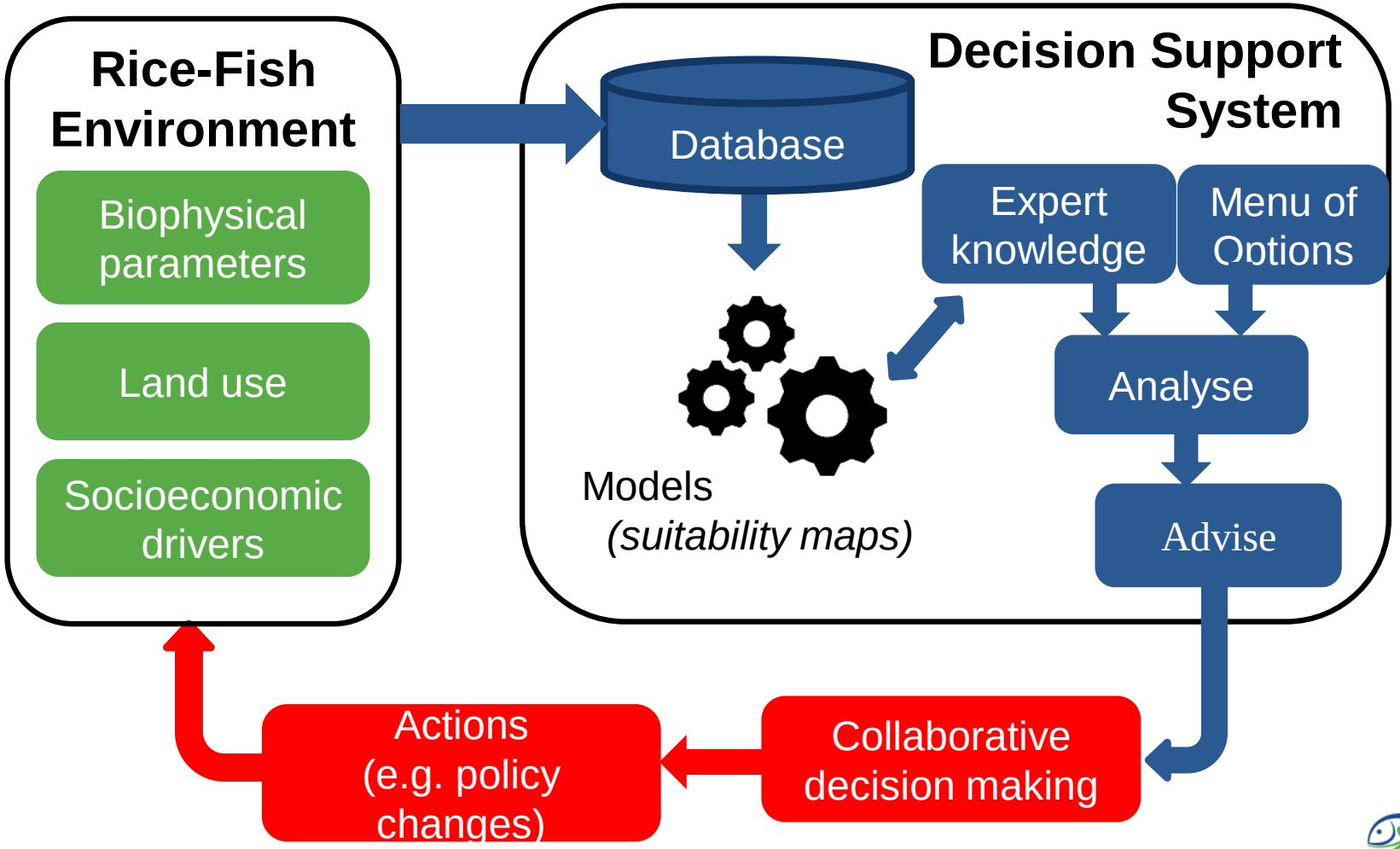
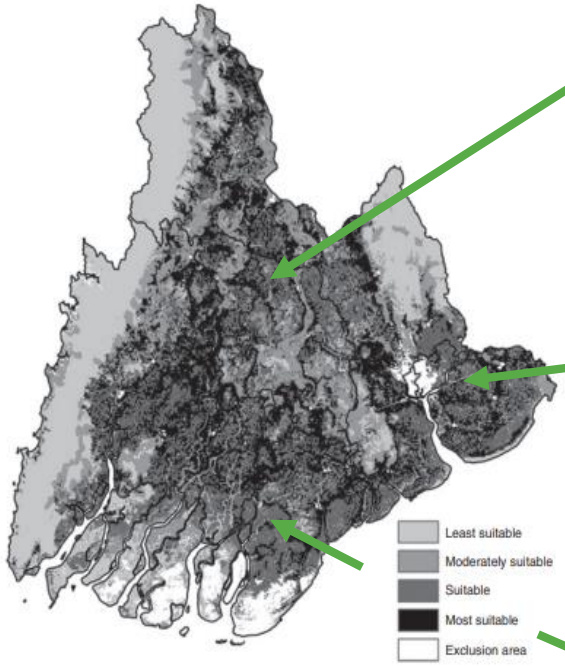
Towards integrated inter-sectoral planning



WorldFish

Land use planning and capacity develpment

LAND USE PLANNING



CAPACITY BUILDING

- Data Collection
- Database Development
- Modelling
- Map Production

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Integration of fisheries in water resources management: Fish friendly irrigation

Better integration of fisheries/aquaculture – in irrigation investments can **increase fish production, nutritional**, **livelihood** and **economic** benefits.

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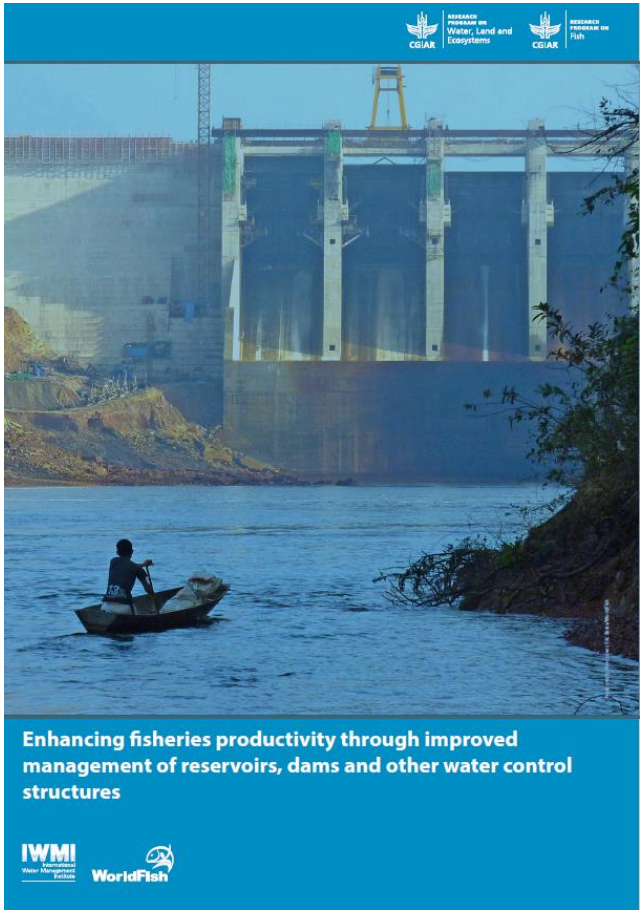
Guidelines: Integration of fisheries in Irrigation

Aim: a guide to assist the development and implementation of improved, sustainable irrigation systems.

Intended Audience: planners, managers and civil engineers responsible for the design, construction, operation and maintenance of irrigation schemes.

Co-publishing agreement with FAO, WorldFish and IWMI



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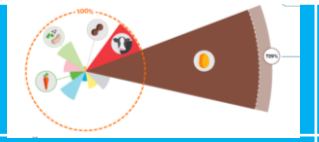
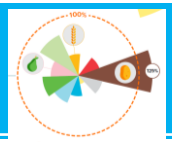
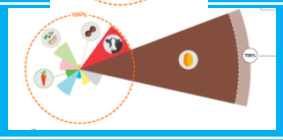
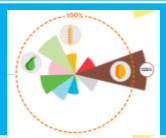
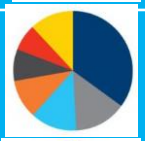
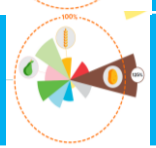
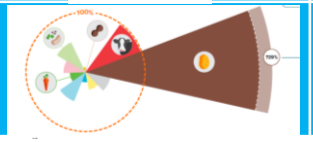
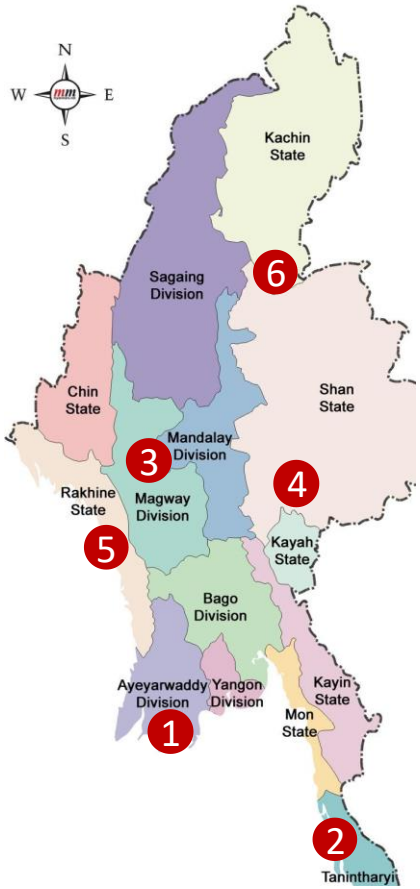
Landscape transformation

Representative Diet	Diet gap	Water footprint/GHG emissions
Ayeyarwady Delta Diet		
Southern Myanmar – Coastal Diet		
Central Dry Zone Diet		
Inlay Lake Diet		
Rakhine - coastal Diet		
Kachin/North Shan - mountain diet		



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Conclusions

Integrating fish in the landscape can increase water productivity, diversify farming systems, increase food and nutrient availability and incomes.

- Research results have contributed to reforms in land use policies.
- Evidence alone is not enough, to take it to the next level this evidence must be used.
- Importance of a programmatic vision for maximising impact and learning
- The collaboration between centers offers a model of how the 1CG approach can work in practice.

IRRI

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Thank you

Research drawn on:

- ACIAR MYFish2 project
- FAO funded FishAdapt project
- CGIAR funded gender and wetlands project

Research directly included:

- ACIAR Rice Fish project
- CGAIR Fish in multi-functional landscapes
- CGIAR Transformations in food systems
- CGIAR Flood based farming systems

m.dubois@cigar.org

Improving the sustainability of rice-shrimp farming systems in the Mekong Delta, Vietnam

SMCN/2010/083

Never Stand Still

A/Prof Jesmond Sammut, Dr Nguyen Van Sang &

OBJECTIVES

1. To better understand the key components of the sustainability of rice–shrimp farming systems;

2. To determine the sustainability of the rice–shrimp farming system by testing the identified key risk factors and system components;

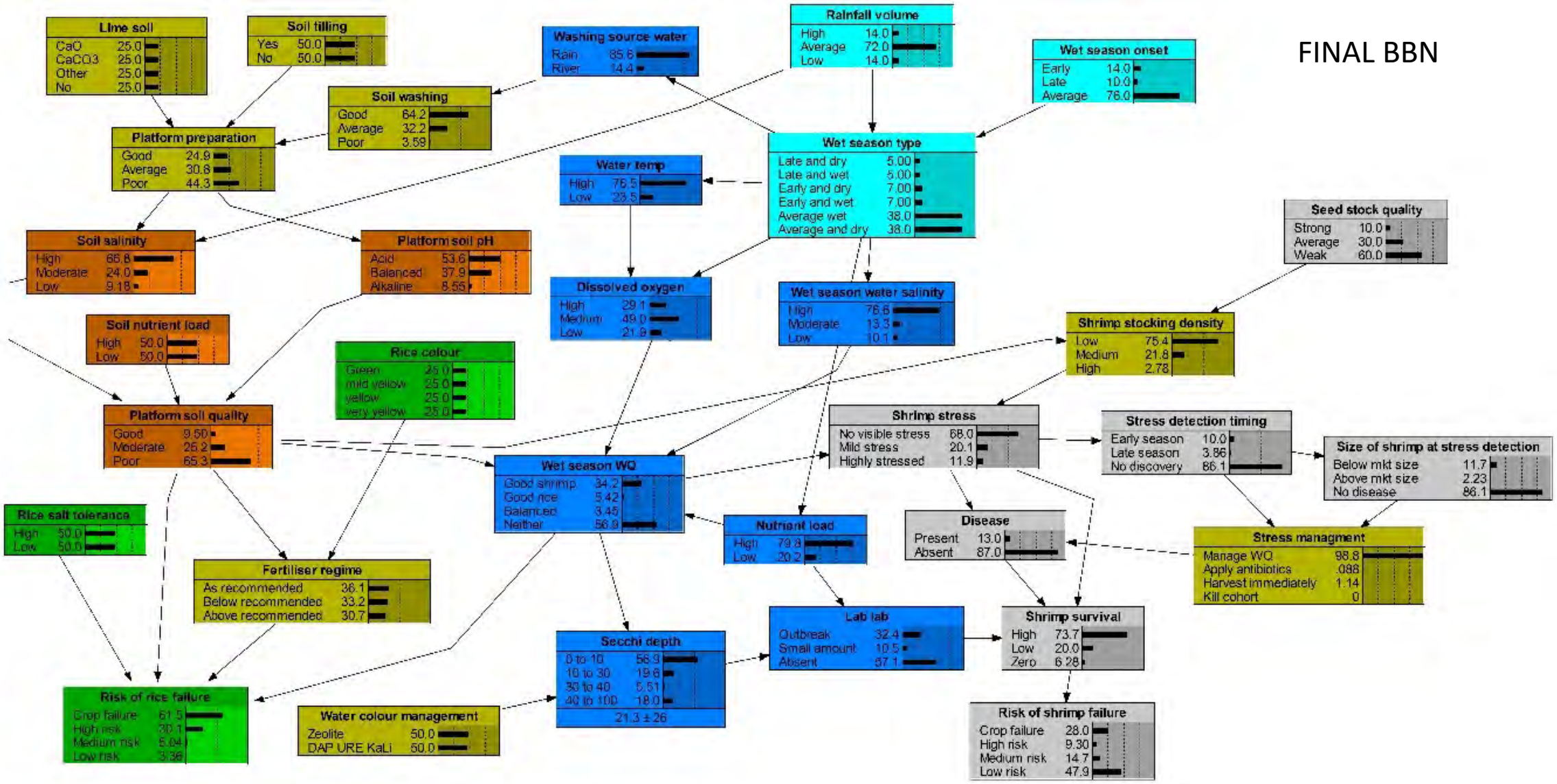
3. To determine, explain and quantify the benefits to productivity of integrating rice and shrimp farming; and

4. To identify and promote better management strategies to improve productivity and sustainability of rice–shrimp farming systems.

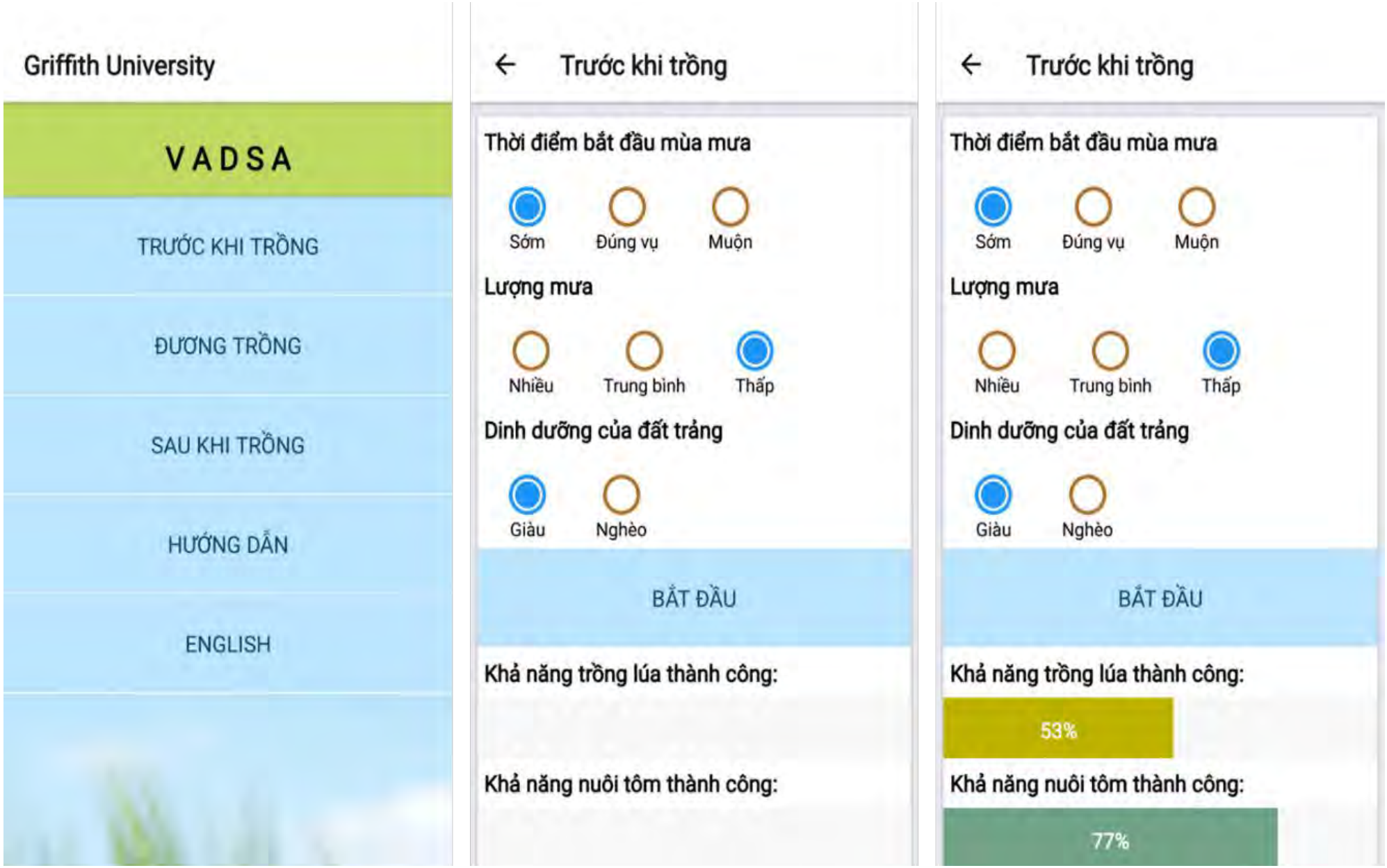
Stage 1 of Research – Evaluate System & Identify Risk Factors for Production

- Review of past studies and projects
- Various Bayesian Belief Networks (BBNs) and an Integrated BBN
  - Expert (farmers)
  - Scientific
  - Economic
- Environmental assessment
  - soil and water chemistry
  - pond processes
  - nutrient budgets and nutrient pathways
- Rice and shrimp crop evaluation – yields, quality of commodity, production efficiency, socio-economics

FINAL BBN


Lime soil
CaO 25.0
CaCO3 25.0
Other 25.0
No 25.0
Soil tilling
Yes 50.0
No 50.0
Washing source water
Rain 85.6
River 14.4
Rainfall volume
High 14.0
Average 72.0
Low 14.0
Wet season onset
Early 14.0
Late 10.0
Average 76.0
Soil washing
Good 64.2
Average 32.2
Poor 3.59
Platform preparation
Good 24.9
Average 30.8
Poor 44.3
Wet season type
Late and dry 5.00
Late and wet 5.00
Early and dry 7.00
Early and wet 7.00
Average wet 38.0
Average and dry 38.0
Water temp
High 76.5
Low 23.5
Seed stock quality
Strong 10.0
Average 30.0
Weak 60.0
Soil salinity
High 66.8
Moderate 24.0
Low 9.18
Platform soil pH
Acid 53.6
Balanced 37.9
Alkaline 8.55
Dissolved oxygen
High 29.1
Medium 49.0
Low 21.9
Wet season water salinity
High 76.6
Moderate 13.3
Low 10.1
Soil nutrient load
High 50.0
Low 50.0
Rice colour
Green 25.0
mild yellow 25.0
yellow 25.0
very yellow 25.0
Shrimp stocking density
Low 75.4
Medium 21.8
High 2.78
Platform soil quality
Good 9.50
Moderate 26.2
Poor 65.3
Shrimp stress
No visible stress 68.0
Mild stress 20.1
Highly stressed 11.9
Stress detection timing
Early season 10.0
Late season 3.86
No discovery 86.1
Size of shrimp at stress detection
Below mkt size 11.7
Above mkt size 2.23
No disease 86.1
Wet season WQ
Good shrimp 34.2
Good rice 5.42
Balanced 3.45
Neither 56.9
Rice salt tolerance
High 50.0
Low 50.0
Nutrient load
High 79.8
Low 20.2
Disease
Present 13.0
Absent 87.0
Stress managment
Manage WQ 98.8
Apply antibiotics .088
Harvest immediately 1.14
Kill cohort 0
Fertiliser regime
As recommended 36.1
Below recommended 33.2
Above recommended 30.7
Lab lab
Outbreak 32.4
Small amount 10.5
Absent 57.1
Shrimp survival
High 73.7
Low 20.0
Zero 6.28
Secchi depth
0 to 10 56.9
10 to 30 19.6
30 to 40 5.51
40 to 100 18.0
21.3 ± 26
Risk of rice failure
Crop failure 61.5
High risk 30.1
Medium risk 5.04
Low risk 3.36
Water colour management
Zeolite 50.0
DAP URE KaLi 50.0
Risk of shrimp failure
Crop failure 28.0
High risk 9.30
Medium risk 14.7
Low risk 47.9

Screenshot from the farmer BBN smartphone app



Identified risk factors

RICE

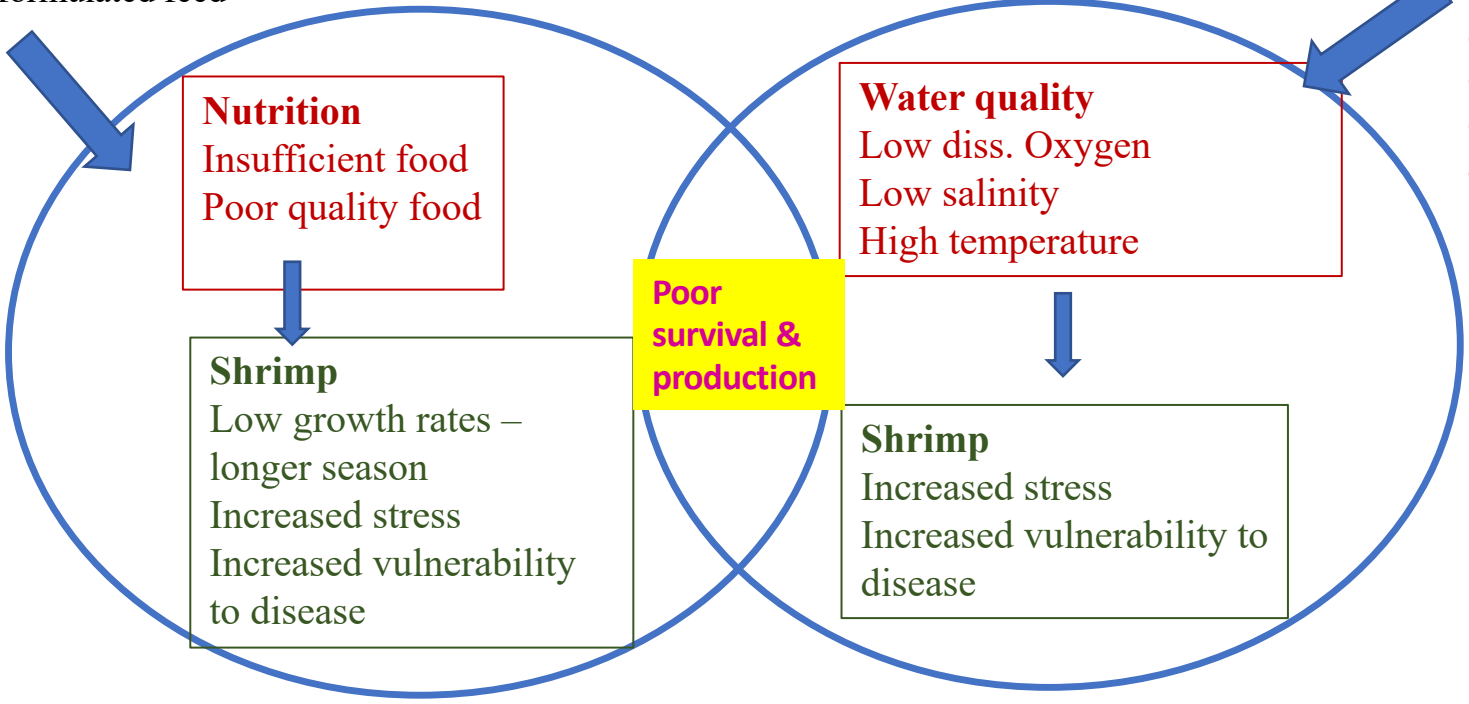
- Drought
- Elevated soil pore water salinity
- Climate variability within and across seasons
- Time of planting
- Acid sulfate soils
  - Low pH
  - Aluminium and manganese toxicity

SHRIMP

- Low dissolved oxygen
- High water temperature
- Sub-optimal salinity
- Lack of adequate feed although ditch nutrient concentrations are high
- Putative risk from acid sulfate soils and H_2S

Researchable solutions for shrimp production

Supplementary feeding – formulated feed



- Increasing aeration
- Removing sludge
- Probiotics
- Managing salinity and temperature

Stage 2 - Trials on Better Management Practices

Based on the knowledge gained from the field studies and the BBN, we tested the following better management practices:

- Rice platform preparation
  - Washing and leaching of salt and oxidation products
  - Liming
  - Tillage
  - Replacing fertiliser with shrimp farming sludge
  - Timing of planting

Rice Variety Trials – salt tolerance, production efficiency, quality

Pilot trials on shrimp

- Hapa nurseries
- Feed versus feed
- With and without rice

Rice-Fish (from work by RIA2)

- **Rice-fish:**
  - Normal conditions: in North Vietnam
  - Both normal and in flooding season: in South Vietnam
  - Species: common carp, bighead carp, silver barb, grass carp, Nile and red tilapia, clown featherback and snakehead.
  - Mekong Delta:
    - Rice cultivated area was 3.79 million hectare in 2010.
    - Approx. 2% of which was for integrated aquaculture
    - Culture species: Culture duration: 2.0-4.5 months
    - Density: one per 4 – 8 m^2
    - Yield ranges: 47.9-439.0 kg/ha
  - Total income:
    - Rice only: USD 1,000-1,200 per ha annually
    - Rice-fish: USD 3,200-4,500 per ha annually

Rice-freshwater prawn

- Total area: no exact figure, varies by year and flooding conditions
- Net used during flooding season
- Density: 12 inds/m^2
- Benefit:
  - USD 3,500-5,500 per ha per season
  - All male prawn increases yield

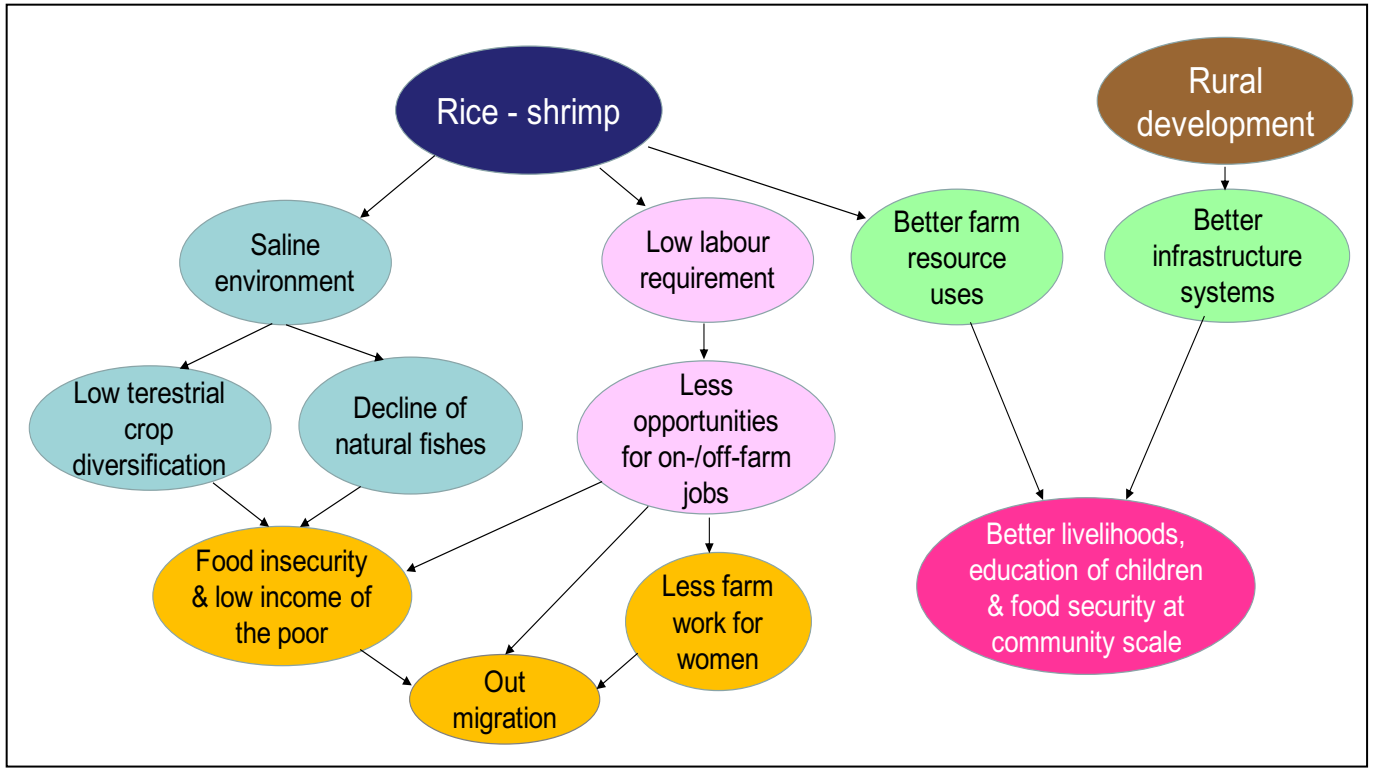
Farmer capacity building

- Lead farmers – men and women
- Farmers involved in trials
- Demonstration
- Farming clubs and associations
- Workshops
- Regular feedback sessions
- Embedded extension staff

Socio-economic studies – Sustainable Livelihoods Analysis, SWOT Analysis & Socio-ecological approaches

Barriers

- Lack of knowledge and skills
- Financial constraints
- Dealing with uncertainty
- Poor understanding of market
- Degraded soil and water
- Climate variability



Research Capacity Building

- Soil and water chemical analyses
- Bayesian Belief Networks
- Shrimp growth modeling
- Application of stable isotopes - ^{15}N-tracer pilot experiments
- Other nuclear tools – UNSW & ANSTO
- General field and laboratory
- Livelihoods analysis – UNSW and CTU
- Honours, Masters and PhD students at CTU, UNSW, CSU and Griffith

What led to success?

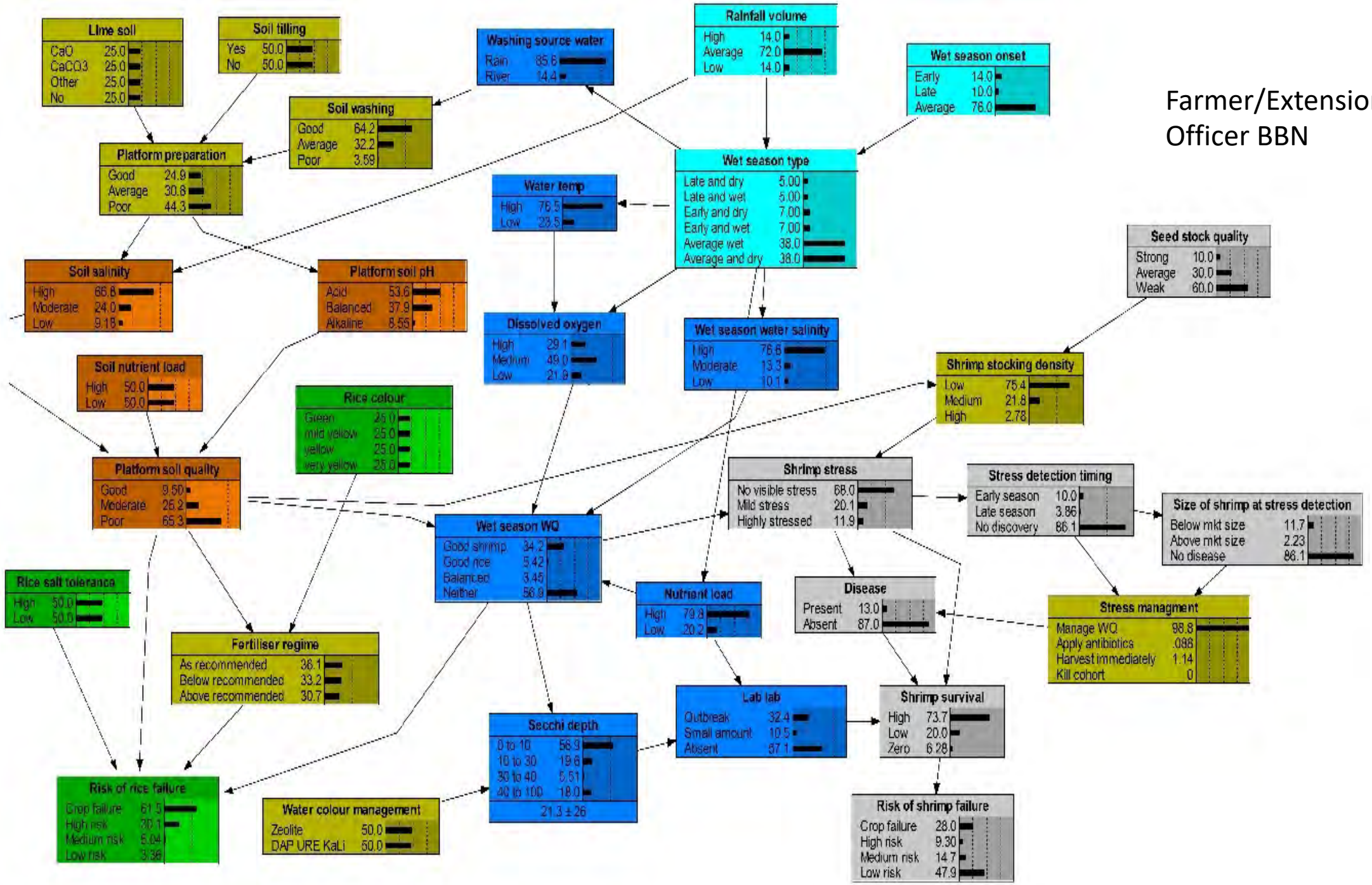
- Involving farmers and extension staff (men and women) in the research
- Research capacity building of team, farmers and extension staff
- BBN as a framework – increased efficiency and helped to focus effort and resources
- Regular feedback sessions with stakeholders
- Concept of ‘one team’
- Rigorous research: well-designed studies and multiple methods
- Peer review of the science and project reviews
- Research capacity building

Supplementary slides

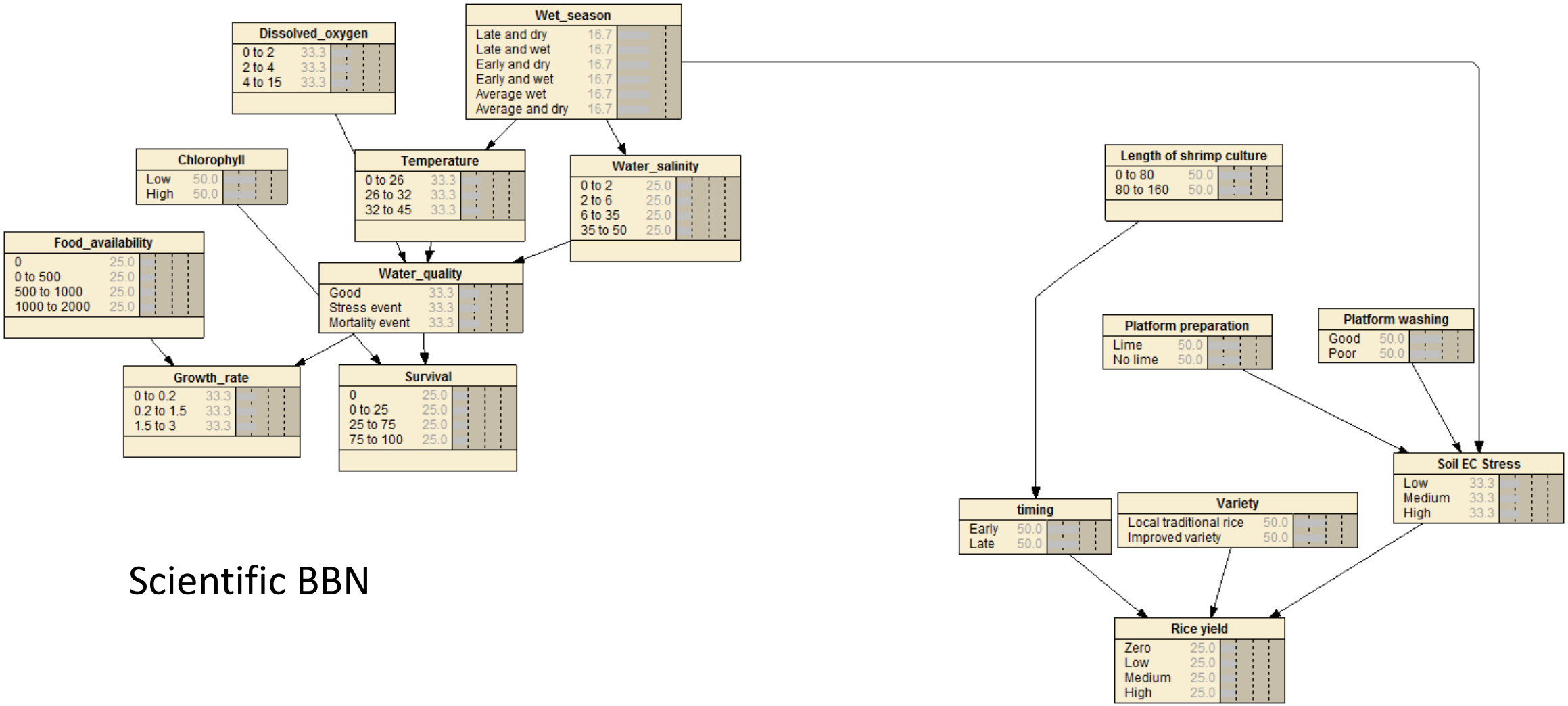
- If anybody cannot download any of the publications, please email me on j.sammut@unsw.edu.au and I will provide access to a shared dropbox folder.

Scientific publications from project

- Burford, MA; Le, HH; Nguyen, SV; Chau KM; Nguyen, KM; Faggotter, S; Stewart-Koster; Condon, J; Sammut, J. (under review). Does natural feed supply the nutritional needs of shrimp in extensive rice-shrimp ponds? – a stable isotope tracer approach. Aquaculture
- Chau KM; Condon J; Nguyen SV; Dang MD; Duong VM; Sammut J, 2018, 'Increasing rice productivity with utilisation of pond sludge fertiliser in rice/shrimp farming systems in Vietnam', in Hulugalle N; Biswas T; Greene R; Bacon P (eds.), *Proceedings of the National Soils Conference Canberra, ACT, Australia, 18-23 November 2018*, Soil Science Society of Australia Inc, Canberra, presented at National Soil Conference, Canberra, 18 November 2018 - 23 June 2020
- Duc Dien L; Huu Hiep L; Burford MA; Sammut J, 2017, 'Comparing nitrogen budgets in shrimp and rice-shrimp ponds in Vietnam', in *Proceedings of the 2016 International Nitrogen Initiative Conference, "Solutions to improve nitrogen use efficiency for the world", 4 – 8 December 2016, Melbourne, Australia*, The 7th International Nitrogen Initiative Conference (INI2016), Melbourne, pp. 1 - 4, presented at The 7th International Nitrogen Initiative Conference (INI2016), Melbourne, 04 December 2017 - 08 September 201
- Dien LD; Sang NV; Faggotter SJ; Chen C; Huang J; Teasdale PR; Sammut J; Burford MA, 2019, 'Seasonal nutrient cycling in integrated rice-shrimp ponds', *Marine Pollution Bulletin*, vol. 149, http://dx.doi.org/10.1016/j.marpolbul.2019.110647
- Dien LD; Hiep LH; Faggotter SJ; Chen C; Sammut J; Burford MA, 2019, 'Factors driving low oxygen conditions in integrated rice-shrimp ponds', *Aquaculture*, vol. 512, pp. 734315 - 734315, http://dx.doi.org/10.1016/j.aquaculture.2019.734315
- Dien LD; Hiep LH; Hao NV; Sammut J; Burford MA, 2018, 'Comparing nutrient budgets in integrated rice-shrimp ponds and shrimp grow-out ponds', *Aquaculture*, vol. 484, pp. 250 - 258, http://dx.doi.org/10.1016/j.aquaculture.2017.11.037
- Duong VM; Nguyen TQP; Nguyen SV; Chau KM; Le TQ; Condon J; Sammut J, 2018, 'Risk of sulfide formation from acid sulfate soil in rice/shrimp farming systems in Vietnam', in *Proceedings of the National Soil Science Conference, Canberra, ACT, 18 to 23 November 2018.*, Soil Science Society of Australia, Canberra, pp. 366 - 367, presented at National Soil Science Conference, Canberra, 18 November 2018 - 23 November 2018
- Leigh C; Stewart-Koster B; Sang NV; Truc LV; Hiep LH; Xoan VB; Tinh NTN; An LT; Sammut J; Burford MA, 2020, 'Rice-shrimp ecosystems in the Mekong Delta: Linking water quality, shrimp and their natural food sources', *Science of The Total Environment*, vol. 739, pp. 139931 - 139931, http://dx.doi.org/10.1016/j.scitotenv.2020.139931
- Leigh C; Hiep LH; Stewart-Koster B; Vien DM; Condon J; Sang NV; Sammut J; Burford MA, 2017, 'Concurrent rice-shrimp-crab farming systems in the Mekong Delta: Are conditions (sub) optimal for crop production and survival?', *Aquaculture Research*, vol. 48, pp. 5251 - 5262, http://dx.doi.org/10.1111/are.13338
- Stewart-Koster B; Dieu Anh N; Burford MA; Condon J; Qui NV; Hiep LH; Bay DV; Sammut J, 2017, 'Expert based model building to quantify risk factors in a combined aquaculture-agriculture system', *Agricultural Systems*, vol. 157, pp. 230 - 240, http://dx.doi.org/10.1016/j.agsy.2017.08.001



Farmer/Extension Officer BBN

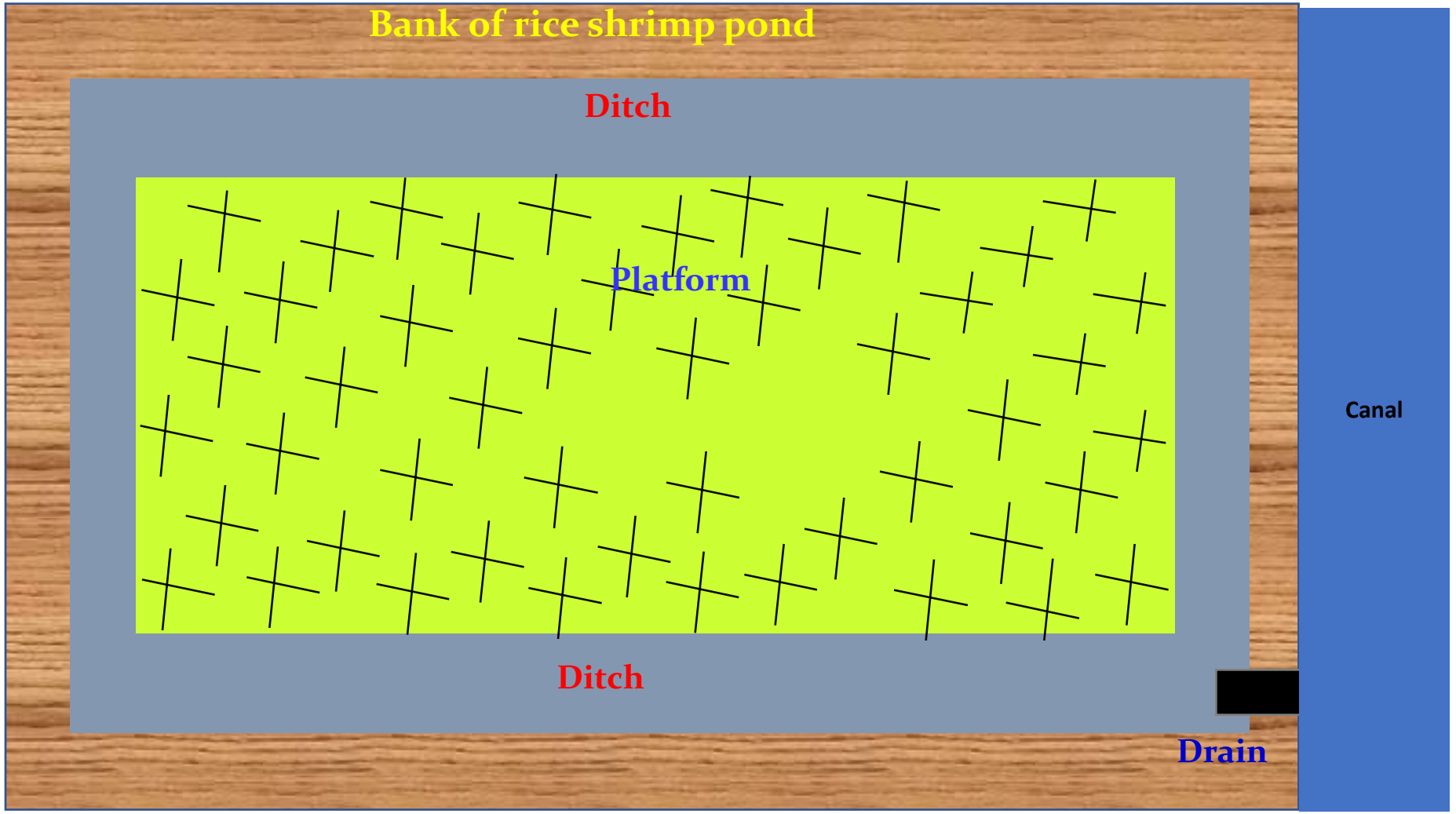


Scientific BBN

Australian Government

Australian Centre for International Agricultural Research

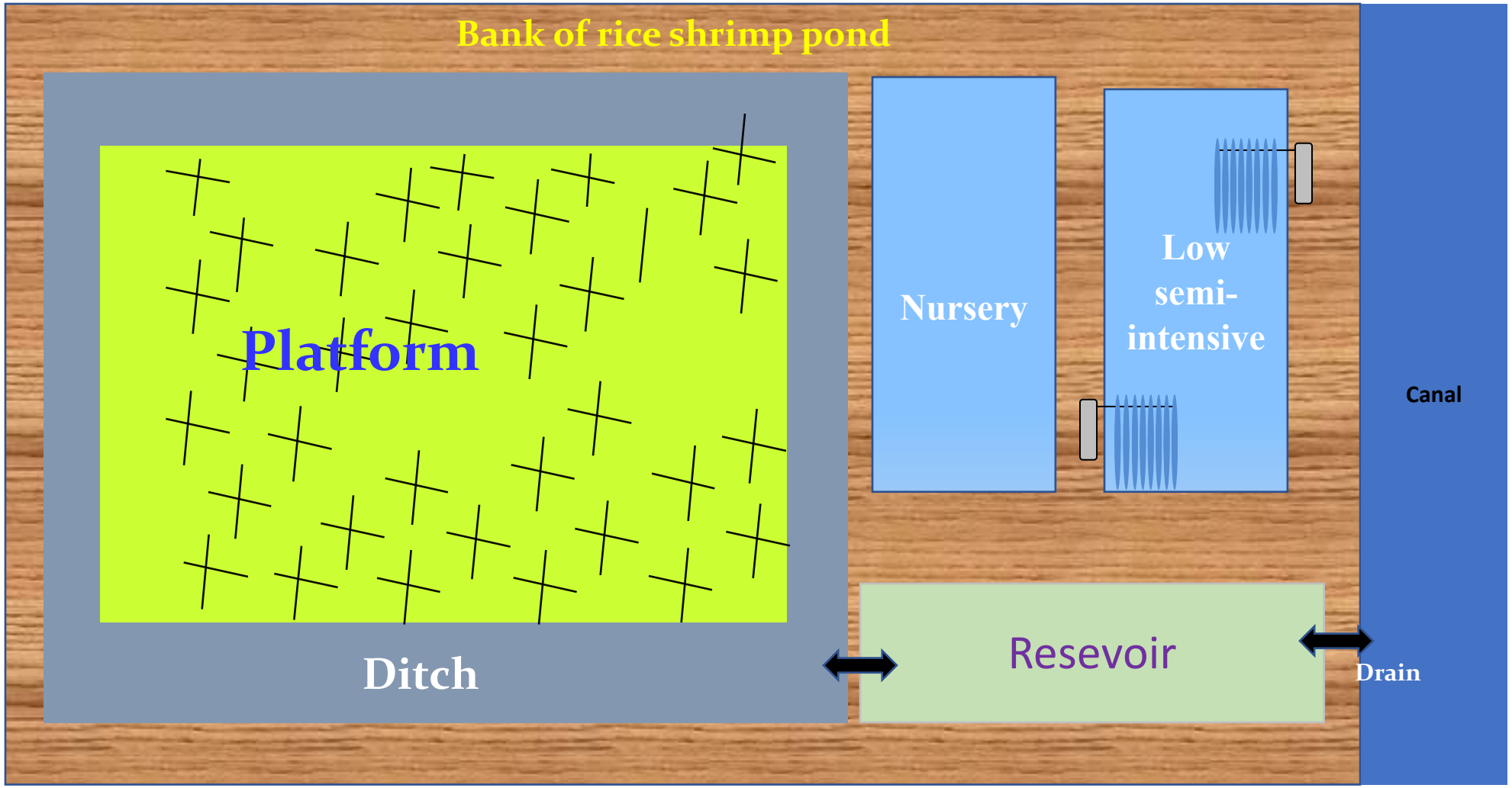
Traditional system



Australian Government

Australian Centre for International Agricultural Research

Improved system



Women’s empowerment in fish-rice value chains

Jessica Scott (Myanmar) with panelists Sarah Freed (Cambodia), Wae Win Khaing (Myanmar), Cynthia McDougall (Penang) and Suren Rajaratnam (Penang)

1st July 2020

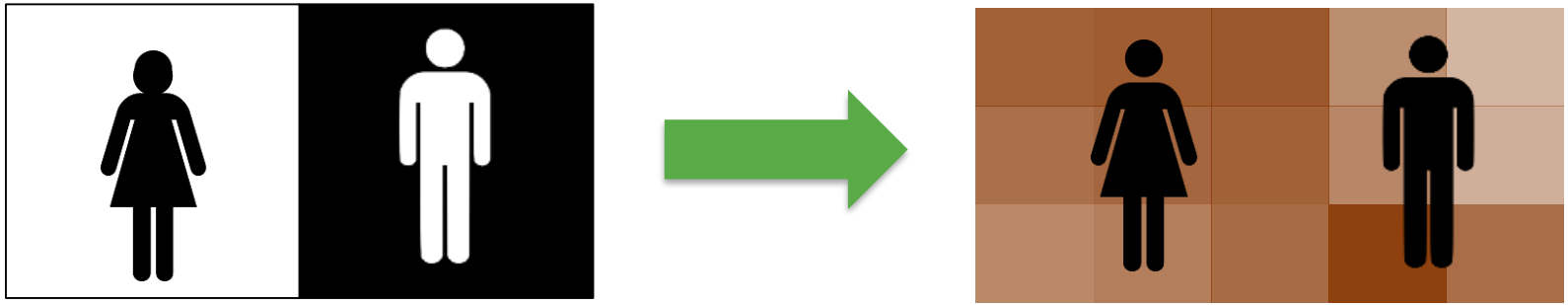
WorldFish

Outline

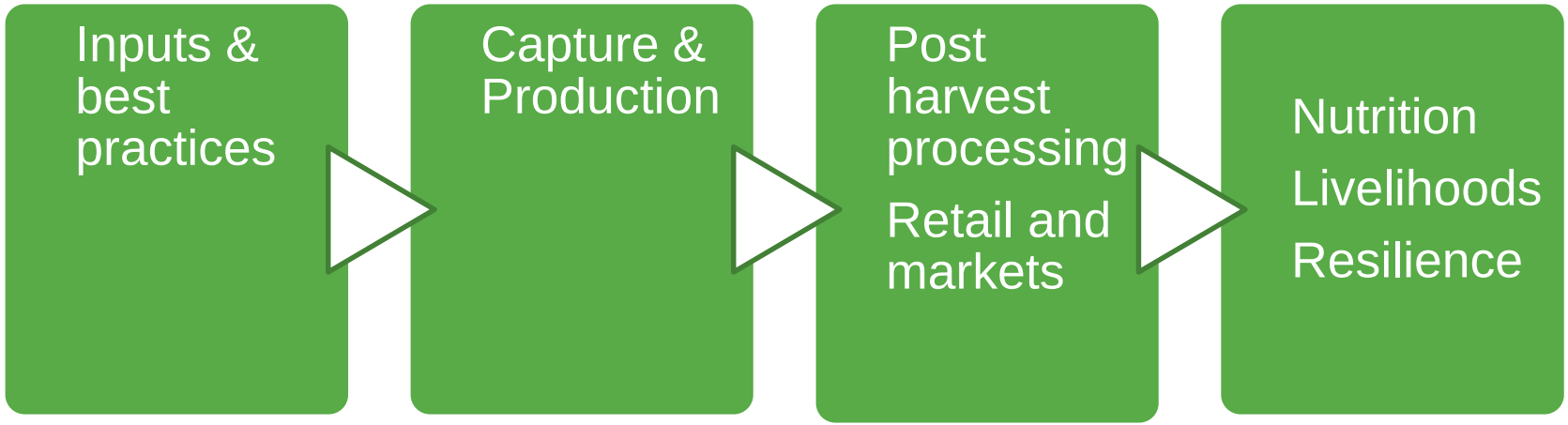
- Overview of gender in a theory of change approach
- Panel discussion
- Questions
- Resources

Intersectionality

Gender should be understood i**n relation to other intersecting social markers** such as wealth, age, ethnicity, religion, marital status, location etc.

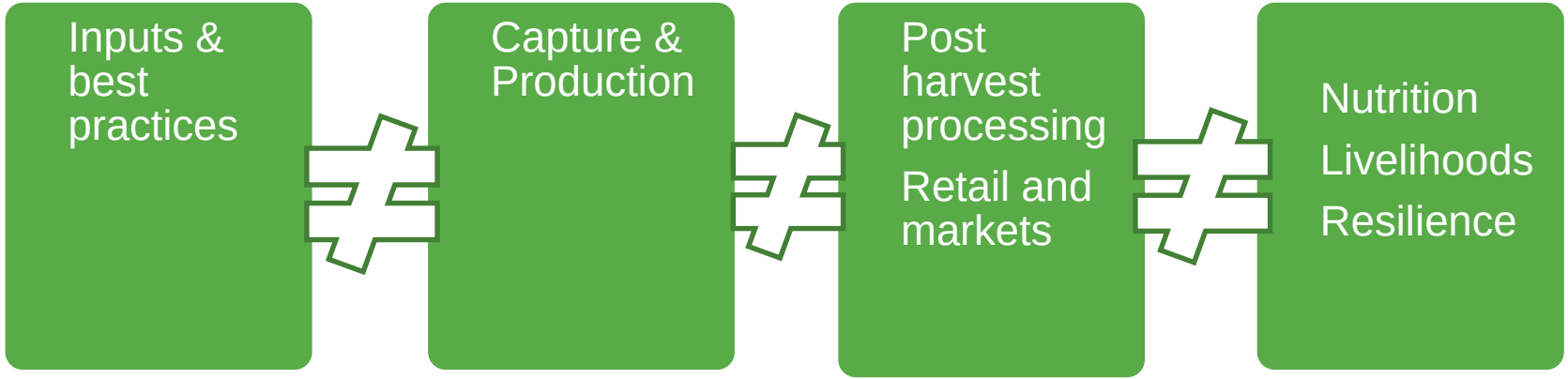


Theory of Change approach and framing for rice fish systems



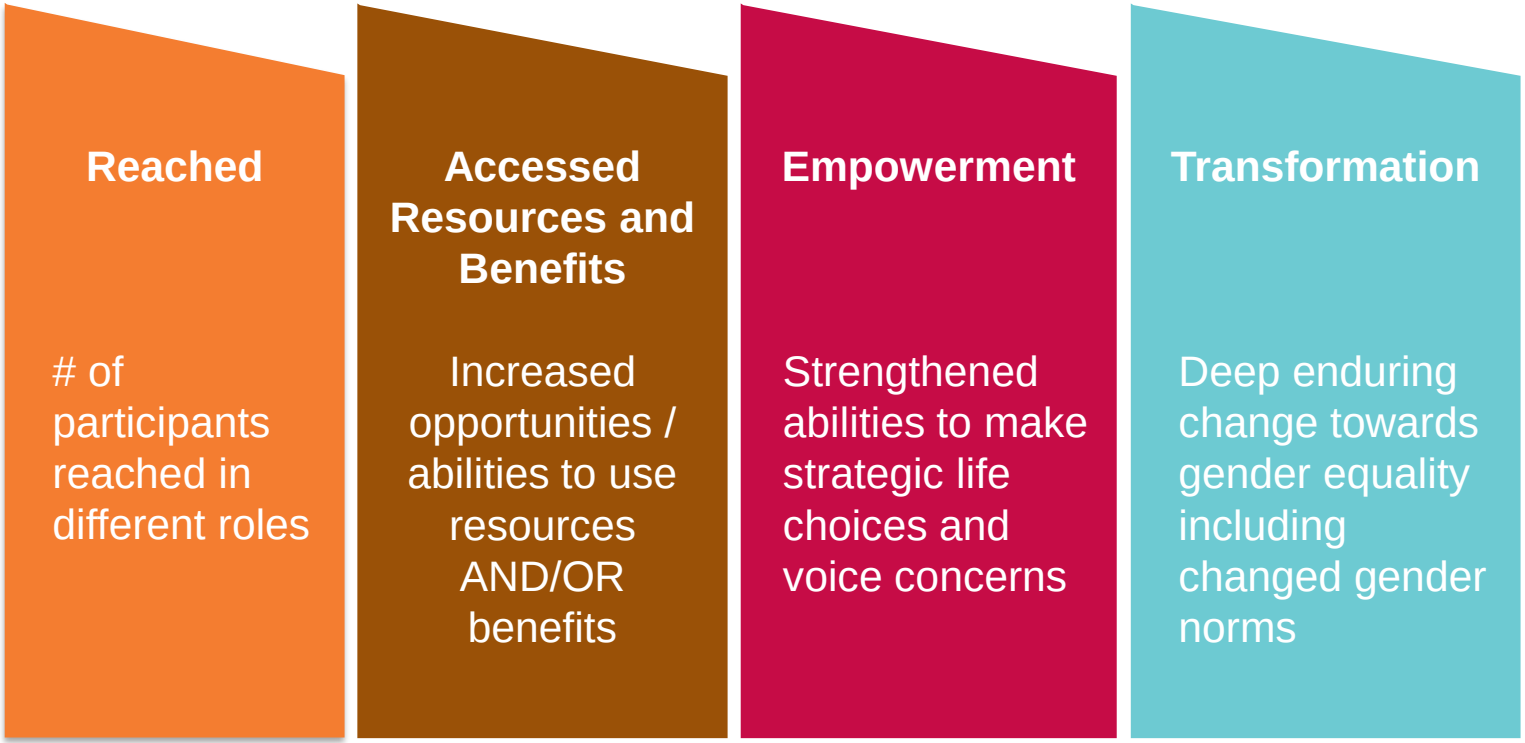
WorldFish

Will this happen on it's own?



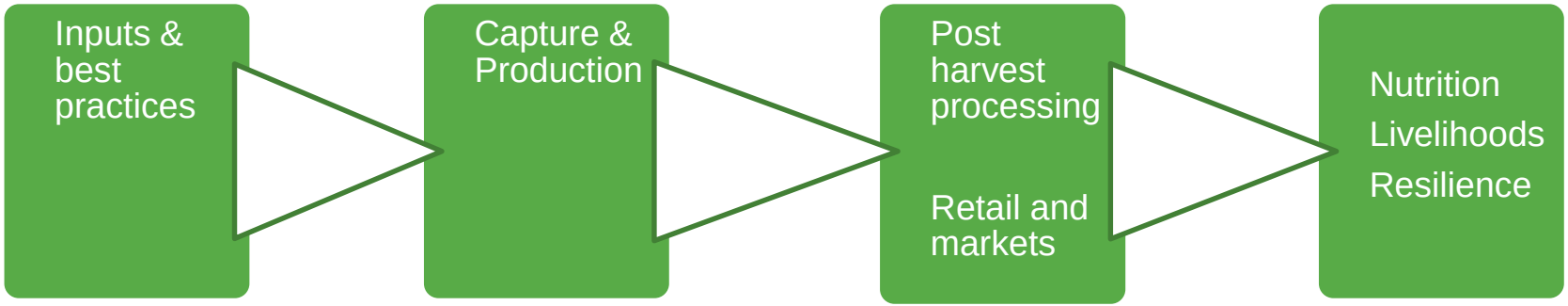
WorldFish

Gender outcomes typology



Source: FISH Gender integration guidelines (forthcoming). Adapted from Johnson et al (2018); Danielsen et al (2018 & 2019)

Gendered approach to rice fish systems



Equal access and control over productive assets

Women's empowerment
Decision making
Reduced time/labour
Increased capacities

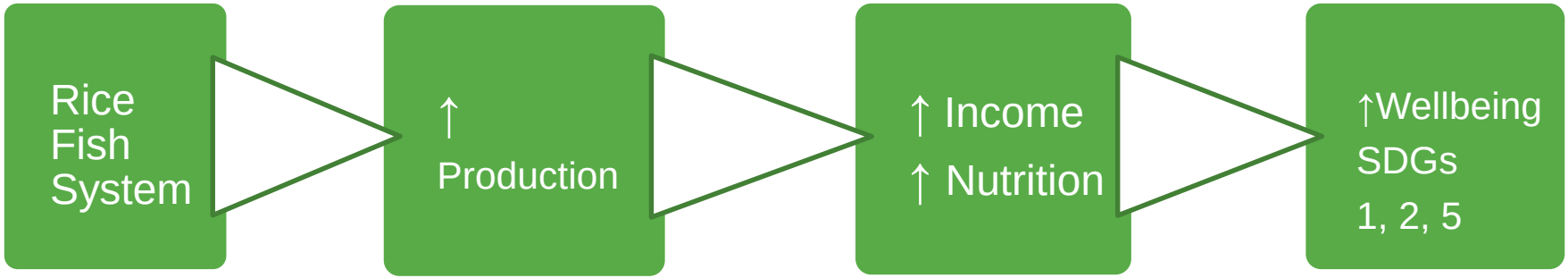
Equal control over income

WorldFish

Unpacking assumptions

- Apply a gender lens
- Within the theory of change, along the value chain
  > Food System
- Addressing women and mens roles along the VC, but importantly beyond roles (why are they there, barriers, enablers?)
- What are their aspirations?

The goal for rice fish systems



Equal access and control over productive assets

Women's empowerment

Equality

WorldFish

Panel discussion

What next?

Try out your gender lens in tomorrows ToC workshop

FISH Gender Strategy

Resources

Reach out to the global gender team

Gender Resources for Rice Fish Systems R4D

Inclusive facilitation techniques (ACIAR, FISH):

Kleiber et al. (2019). Gender-inclusive facilitation for community-based marine resource management. An addendum to “Community-based marine resource management in Solomon Islands: A facilitators guide” and other guides for CBRM. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Program Brief: FISH-2019-08.

Gender integration during COVID-19 research (FISH, ACIAR):

Safeguarding gender integration during the COVID-19 lockdown. Engendering Data Blogpost May 2020.

https://www.cgiar.org/news-events/news/safeguarding-gender-integration-in-research-during-the-covid-19-pandemic

Reducing postharvest loss (identifying processing technologies that are fit for purpose) and reducing gender barriers (ACIAR & IDRC, FISH)

Cole, S., Kaminski, A.M., McDougall, C., Kefi, A.S., Marinda, P., Maliko, M. & J. Mtonga (2020) Gender accommodative versus transformative approaches: a comparative assessment within a post-harvest fish loss reduction intervention, *Gender, Technology and Development*, DOI: 10.1080/09718524.2020.1729480 https://www.tandfonline.com/doi/full/10.1080/09718524.2020.1729480

Cole, S., McDougall, C., Kaminski, A., Kefi, A., Chilala, A., & Chisule, G. (2018). Postharvest fish losses and unequal gender relations: drivers of the social-ecological trap in the Barotse Floodplain fishery, Zambia. *Ecology and Society*, *23*(2). https://www.ecologyandsociety.org/vol23/iss2/art18/

Gender norms and their implications for inclusive livelihoods and development (ACIAR, AAS, FISH)

Locke, C., Muljono, P., McDougall, C. & Morgan, M. (2017). Innovation and gendered negotiations: Insights from six small-scale fishing communities. *Fish and Fisheries,* pp. 1-15. DOI: 10.1111/faf.12216. Link *[Includes Cambodia case]*

Lawless, S., Cohen, P., McDougall, C., Orirana, G., Siota, F., & Doyle, K. (2019). Gender norms and relations: implications for agency in coastal livelihoods. Maritime Studies, 1-12. https://link.springer.com/article/10.1007/s40152-019-00147-0

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Gender Resources for Rice Fish Systems R4D

How innovation can influence gender norms (USAID, FISH):

Aregu, L., Choudhury, A., Rajaratnam, S., van der Burg, M., & McDougall, C. (2019). Implications of agricultural innovations on gender norms: Gender approaches in aquatic agriculture in Bangladesh. In C. Sachs (Ed.), *Gender, agriculture and agrarian transformations: Changing relations in Africa, Latin America and Asia.* (pp). Link

***Example of a gender strategy for a Research for Development Project (ACIAR, FISH)*:**

Kleiber D, Cohen P, Gomese C and McDougall C. 2019. Gender-integrated research for development in Pacific coastal fisheries. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Program Brief: FISH-2019-02. https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/2826/FISH-2019-02.pdf

Studies on Women's Empowerment (showing that empowerment is not the same as engagement) (FAO, FISH):

Choudhury, A., McDougall, C., Rajaratnam, S., Park, C.M.Y. (2017). Women's empowerment in aquaculture: Two case studies from Bangladesh. Rome, Italy: Food and Agriculture Organisation of the United Nation ; Penang, Malaysia: WorldFish Link

Sari, I., McDougall, C., Rajaratnam, S., Park, C.M.Y. (2017). Women's empowerment in aquaculture: Two case studies from Indonesia. Rome, Italy: Food and Agriculture Organisation of the United Nation ; Penang, Malaysia: WorldFish Link

Gender Transformative Approach Manuals (AAS, Promundo):

Promundo-US and the CGIAR Research Program on Aquatic Agricultural Systems. (2016). Promoting Gender-Transformative Change with Men and Boys: A Manual to Spark Critical Reflection on Harmful Gender Norms with Men and Boys in Aquatic Agricultural Systems. Washington DC: Promundo-US and Penang: CGIAR Research Program on Aquatic Agricultural Systems. Link

Promundo-US, WorldFish. (2016).The SILC+GTA facilitation manual: the Savings and Internal Lending Communities plus Gender-Transformative Approach (SILC+GTA). Washington DC: Promundo-US and Penang: WorldFish.

https://www.worldfishcenter.org/content/silcgta-facilitation-manual-savings-and-internal-lending-communities-plus-gender

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Forthcoming Gender Resources of interest for this RFS investment in 2020

- **Gender Integration Guidelines** for Fisheries and Aquaculture R4D Projects
- **Conceptual Framework and Methodology for assessing Inclusion and Exclusion** in smallscale fisheries governance (can be adapted to RFS, piloted in ACIAR's Pathways Project in the Pacific)
- **Conceptual Framework and Case Study Methodology for understanding women's empowerment and pathways to empowerment** (piloted in RFS in Myanmar, qualitative focus)
- **The Pro-WEFI: M&E framework and 'before and after' tool for assessing changes in women's empowerment in development projects and action research** (available for consultation in *pre-test form in 2020*; final in 2021)
- **Conceptual Framework and Methods Package for Gender-inclusive Value Chain Analysis** for adaptation to any fish or aquatic foods value chains
- **Methods Package: Strategies for Identifying niches for women's entrepreneurship** in fish value chains
- **10 Strategies for Research Quality including Ethics** during COVID-19 social distancing

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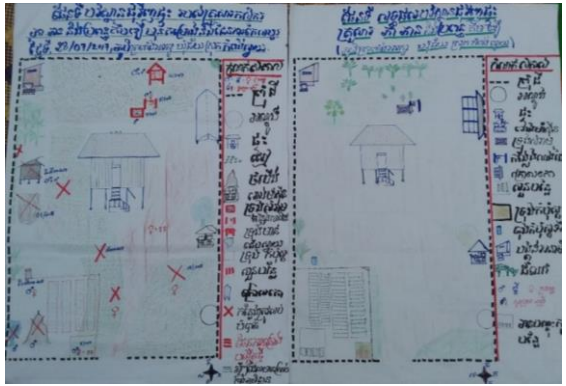
Questions or reflections?

Key interventions

1) Nutrition



2) Household visioning (roles & workloads)

3) Community leadership

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

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Household visioning

Results:

- Of the 20 households showcased in village fairs in 2019, 13 (65%) reported new income sources for the women whose tasks were now shared
    - Vegetables, fish powder, conducting trainings

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The U.S. Government's Global Hunger & Food Security Initiative

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Community leadership

Results:

- Women's membership in leadership committees more than doubled (from 29 to 65 across 40 committees)
- Qualitative differences in committee management plans
- Women committee members tend to lead community fundraising efforts (more trusted)

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Fish and Other Aquatic Foods in Food Systems for Nourishing Cambodia

Shakuntala Haraksingh Thilsted
Research Program Leader, Value Chains and Nutrition

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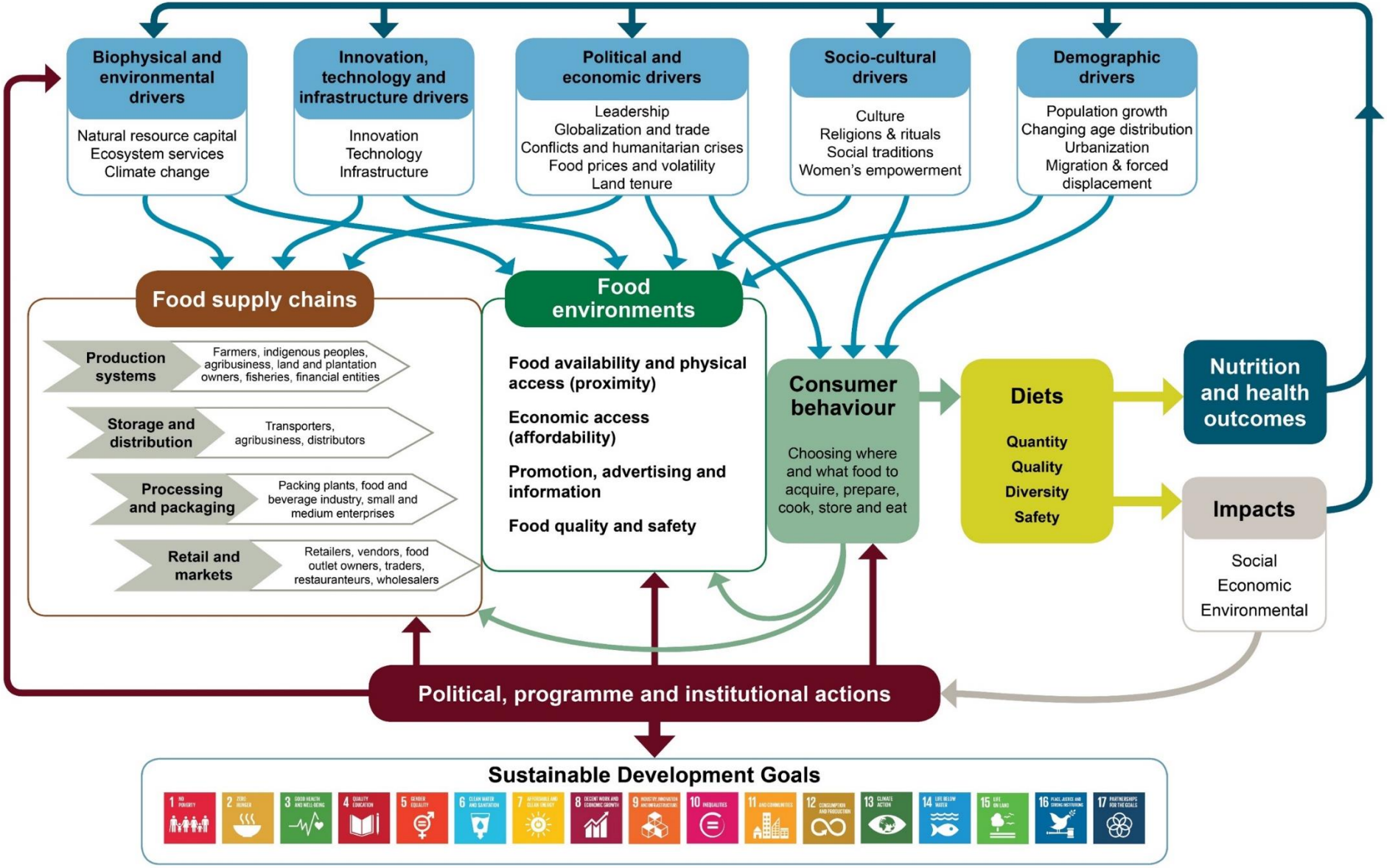
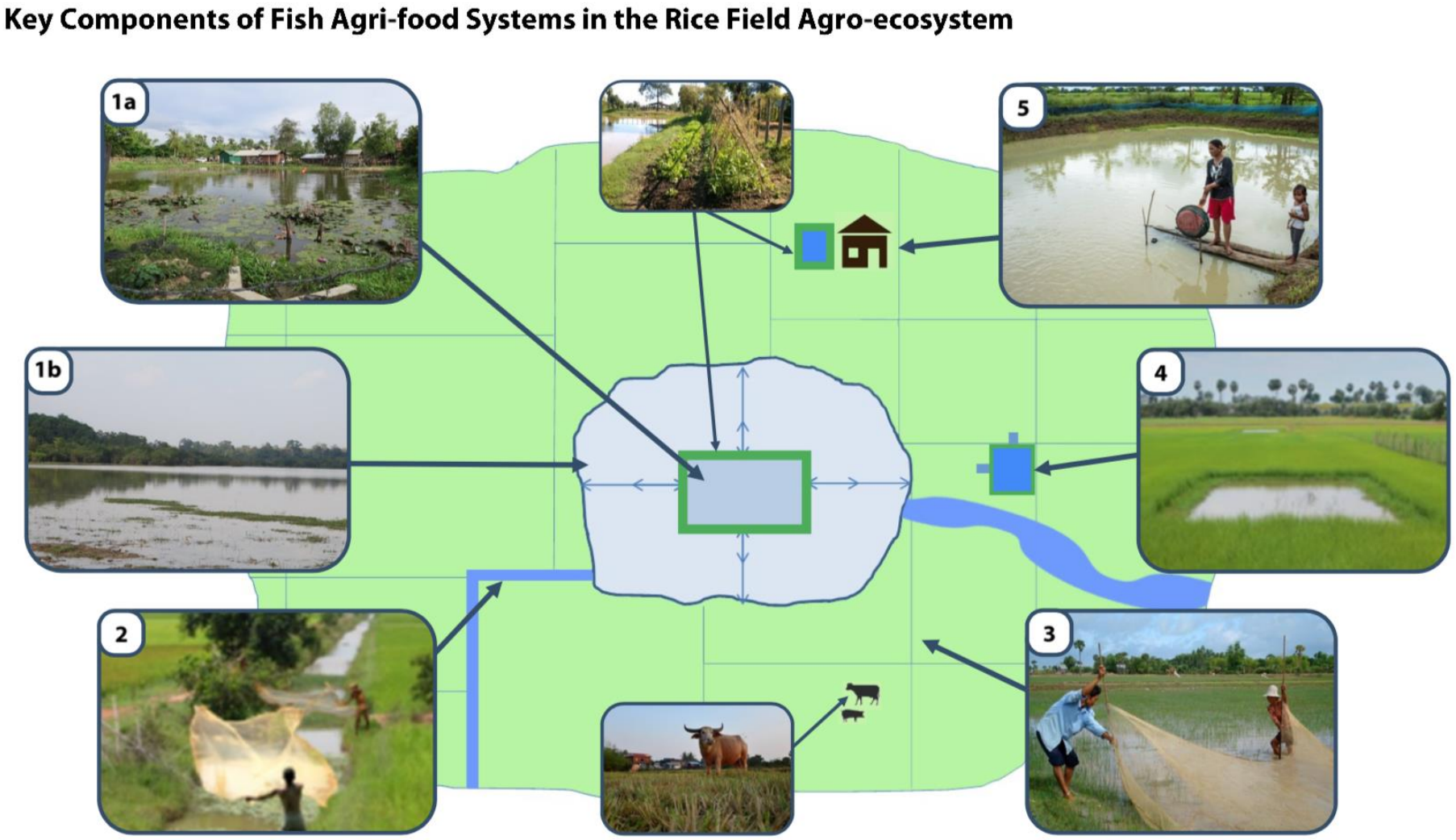
Food Systems Framework



High Level Panel of Experts (HLPE) 2017 Report no. 12 Food Systems and Nutrition
United Nations Committee on World Food Security (CFS)

Continuum of Fish - Rice - Vegetables Production Systems in Tonle Sap Floodplain

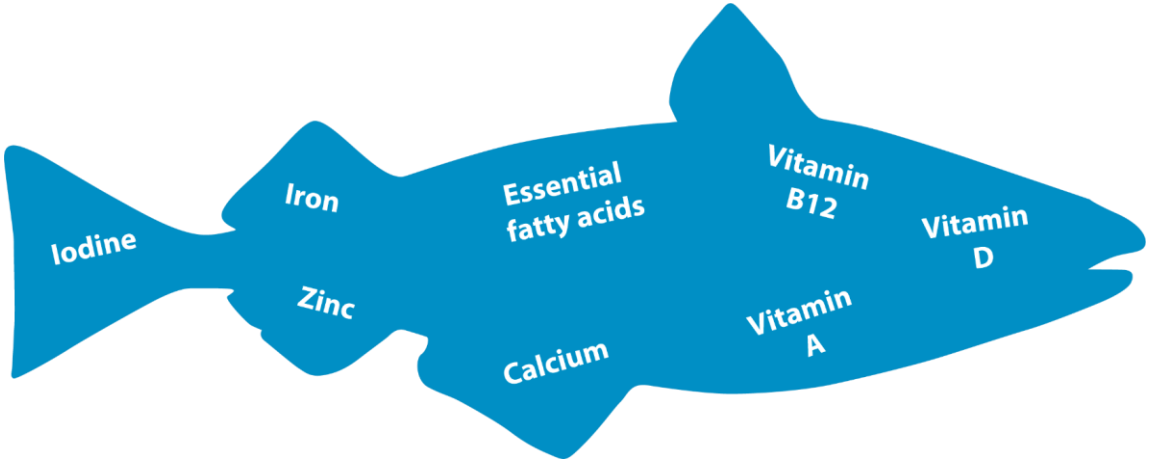


Characteristics of Fish and Other Aquatic Foods

- Bountiful
- Diverse
- Well-liked
- Seasonal
- Culturally acceptable

Fish and Other Aquatic Foods Contribute to Diverse, Nutritious and Affordable Diet

- Combat hidden hunger: micronutrient deficiencies
- Supply multiple essential micronutrients with high bioavailability



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Fish for Nourishing Cambodia

- Improves Brain Development and Cognition
- Reduces Mortality and Morbidity
- Associated with Reduced Stunting in Children
- Associated with Long-term Weight Loss in Adults

Fish consumption contributes to:

- **Better Growth and Development in Children**
- **Well-nourished and Healthy Adolescents and Adults**
- **Better School Performance**
- **Better Work Performance**
- **Inter-generational Benefits**

Why Small Fish is Unique?

- Available in local markers
- Low cost for small portions
- Small quantities can be bought
- Can be cooked in a mixed dish and therefore easy to share among all household members

- Common Food eaten with the Staple
- Adds Flavour and Taste to the Meal
- Improves Diet Diversity
- Enhances Mineral Bioavailability from Foods in the Meal
- Cooked with Vegetables, Oil and Spices, further Improving Diet Diversity, Adding Nutrients and Growth-promoting Substances

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Promoting Tasty, Nutritious Soup with Whole Small Fish

វិធីសាស្ត្រធ្វើសម្ពរប្រហើរជាមួយត្រីល្អិត

ជំហានទី១៖ ជ្រើសរើស និងលាងត្រីឲ្យបានស្អាត បន្ទាប់មកដាក់ត្រីក្នុងកញ្ជ្រែងសម្រក់ទឹកឲ្យបានស្ងួតល្អ ។

ជំហានទី២៖ ចិញ្ច្រាំត្រីល្អិតឲ្យបានម៉ត់ល្អ ។

ជំហានទី៣៖ ត្រៀមបន្លែ ស្លឹកជាសុ ខ្ចី ជីខ្សែងថ្លា ជីខ្សែងជាក់ ម៉ឺមគ្រាវ ។ល។ គ្រឿងផ្សំ និងអំបិលអ៊ីយ៉ូត ។

ជំហានទី៤៖ ដាក់ឆ្នាំងដាំទឹកឲ្យចបដាក់ប្រភេទបន្លែម៉ឺមដែល មិនងាយផុយចូលក្នុងឆ្នាំងសម្លាមុន ។

ជំហានទី៥៖ ដាក់ត្រីល្អិតចិញ្ច្រាំចូលក្នុងឆ្នាំងសម្លា មួយភ្លាម៖ ក្រោយមកទើបដាក់បន្លែងាយផុយចូល ។

ជំហានទី៦៖ ជូសសម្លដាក់ចូលចានបានរបស់កុមារ ច្រចឡើកឲ្យម៉ត់ចូលគ្នា មុនឲ្យកុមារបរិភោគ ។

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Dried Small Fish – Super Food for Nutritious Diets Year-round

- Much greater concentrations of nutrients
- Long shelf life; easy to store; overcomes seasonality
- Increases duration / frequency of consumption
- Used to make convenient (easy-to use, ready-to eat) fish-based products for first 1000 days of life

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Fish powder to be added to complementary and family foods

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Fish - Rice - Vegetable as a Nutritious Complementary Food

For initiation of complementary feeding for young childen at 6 months of age

Rice flour

Dried small fish powder

Dried vegetable (pumpkin) / fruit (banana) powder

Oil

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Effect of Small Fish Consumption on Growth in Children in Cambodia

- Randomized control studies in young children (Skau et al, 2005; Sigh et al, 2018)
- Fish powder has similar effect on growth compared to corn - soya - milk products used globally
- Higher acceptability of fish-based products

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Development and piloting of convenient, ready-to-eat, nutritious and safe fish-based products for malnourished children in Cambodia

Cambodia is the first country to replace milk powder 100% by fish powder in treatment of malnourished children.

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Challenges in Using Small Fish for Fish-based Products

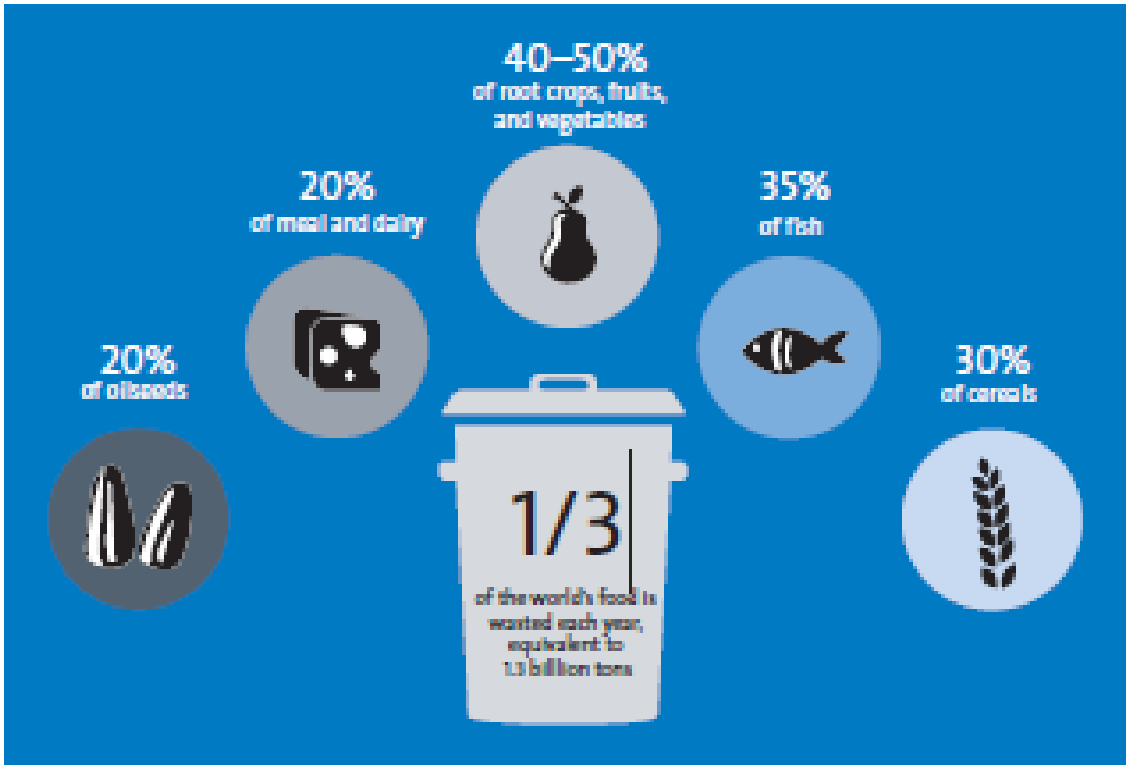
Supply

Processing

Acceptability

Reduce Loss and Waste of Fish and Other Aquatic Foods to Increase Affordable Supply

- Reduce loss and waste throughout the food chain
- Reduce non-edible parts (most micronutrient-rich)



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Improve Food Safety

Second International Conference on Nutrition (ICN2) 2014

Call for Action on Food Safety

- Pesticides used in fish during drying
- Microbes / Parasites
- Alfatoxins in rice and fish
- Arsenic, Lead, Cadium

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Use Fish and Other Aquatic Foods in School Feeding

Odisha, India

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Integrate Fish Messages in Nutrition Education

- Eating whole small fish
- Using small fish in common recipes
- Making fish powder for use in complementary feeding of young children

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Integrate Hygiene Practices and Safe Drinking Water

- Clean environment
- Washing of hands with water and soap
- Community-managed safe drinking water kiosks

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Four Action Points

- Invest in **analyses of nutrient content and food safety** of aquatic foods and make the data open access.
- Promote **increased supply of aquatic foods**, including reducing waste and loss, using a nutrition-sensitive food systems framework.
- Promote the **consumption of tasty, nutritious, safe, convenient and affordable aquatic foods** in public nutrition and health programs, throughout the life cycle, with focus on the first 1000 days of life.
- Influence global and national **policy makers for policy change and investments** so that aquatic foods can nourish nations.

Actions in Progress: Examples

- President of IFAD: at a high level side event at the 73rd United Nations General Assembly (September 2018) on the importance of prioritizing nutrition-sensitive agricultural development. To illustrate IFAD's approach he gave an example from #Bangladesh, where IFAD has been supporting the introduction of nutrient-rich indigenous small fish into fish culture systems. Over the next three years, IFAD has committed to ensure 50% of all new projects will be #nutritionsensitive.
- USAID, BMGF: Funding nutrition-sensitive interventions
- Government of Cambodia, UN Agencies: piloting fish and fish-based products in public programs
- Institute of Marine Research, Norway, Nansen Programme: analyses of nutrient content and food safety in fish species

Rice/Fish Systems

Broader goals

Improved availability of Cambodian produced fish/prawn in local and urban markets

Sustainably managed, resilient fish and rice agroecosystems contribute equitably to livelihood improvement and enhanced nutrition security for women, men, youth and children in the Cambodian Mekong Delta and Tonle Sap regions in the context of changing climate

End of project outcomes

- Water, agriculture and land management are integrated and enhance fish and rice agroecosystem functions
- Rights and access to fishery and culture systems and their benefits (use) are inclusive of landless and smallholders
- Improved resilience of production systems to emerging disruptions such as climate change and upstream water resource development
- Improved incomes for culture stakeholders through production of cultured fish/prawn
- Improved nutrition for local households, through increased household micronutrient-rich fish consumption, especially for women and young children
- Value chains for Cambodian cultured fish/prawn and MN rich fish products allow for integration and demand in local and urban markets

Intermediate outcomes

All levels of planning and management maintain/restore ecosystem functioning when implementing agricultural, natural resource, and water management activities

Effective integrated practices are continued post project and adopted at other sites

Development programs are more supportive of fish-friendly projects/systems and fund rice-fish projects

Investors such as ADB and World Bank's awareness is raised of the benefits of rice-fish projects and how irrigation can support or conflict

PNGO and GOV Train extension agents to provide ongoing guidance to producers on rice-fish systems

GOV Conducts effective integrated planning across agencies

WF, IRRI, IWMI, AUS, and GOV Participate in stakeholder platform and communicate best practices for integrated agriculture and considerations for irrigation developed to key stakeholders including **Development actors** (World Bank, ADB); Conduct regional knowledge exchange – lessons learnt from other SE Asian countries; exchange of knowledge across stakeholder groups

Producers' operations are more profitable (further income from fisheries and/or culture)

Producers as a collective/at landscape scale are using and effectively managing appropriate sustainable integrated rice and fish production practices

PNGO and GOV train and strengthen capacity for **producers** on farm-level techniques for enhanced water productivity, best management practices for integrated agriculture, and nutritional practices

WF, IRRI, IWMI, AUS, and GOV Co-design communications with stakeholders to conduct tailored communication to Commune, District, Provinces, Cantonment, and National level agencies on governance needs for integrated agriculture that also supports decentralized approach

WF, PNGO, and GOV ensure **producers** are empowered to conduct management planning and implementation for integrated production, including coordination and collective (i.e., beyond farm plot) management as appropriate; **Producers and LA** have the capacity and empowerment to organize and maintain collective approaches to production

GOV receives information on water availability and seasonal change that enables planning for adoption or expansion of interventions

Improved fish availability, value adding options, movement through the value chain, and consumption of MN-rich fish by women and children

Private sector - bridging the gap between innovation and uptake through both direct investment and awareness raising/marketing

Demand for products encourages **private sector** investment in production such as seed companies, feed companies, tech companies, traders (e.g Sustainable Rice Platform)

Producers Partner with value chain actors to market micronutrient rich fish and other fish/prawn culture products

Awareness raised through marketing and local trainings/demonstrations on nutritional value of MN rich fish and child-appropriate preparations

ACTORS
WF – WorldFish
IRRI – International Rice Research Institute
IWMI – International Water Management Institute
AUS – Australian University partner (Deakin)
GOV – Cambodia government partners (FiA, GDA/PDAFF)
PNGO – Implementing partner NGOs
Producers – farmers and fishers
LA – village, commune, and/or district level authorities

Influencing activities

1 Practices and outcomes: technical and environmental suitability, access and equity, and effective local management

- 1A. **WF, IRRI, AUS, and GOV** develop integrated practice protocol for trials (1B and 1C); provide capacity strengthening and protocol training to **PNGO and producers.**
- 1B. In areas of mid- to high-irrigation, **PNGO, GOV, and producers** trial integrated practices for rice and fish (poly) culture.
- 1C. In areas of low irrigation, where fishing in rice fields is common, **PNGO, GOV, and producers** trial integrated practices for rice, (collective) fish culture, and wild fish, including organization of collective (i.e., beyond farm plot) management.
- 1D. **WF, IRRI, AUS, and PNGO** compare trials to control sites to evaluate improvements in: production and profitability; water quality and efficiency, soil health, GHG emissions; income, food security, and food provision; benefit sharing across wealth and land ownership status; and financial investment that is empowering rather than adding debt and risk for smallholders, including equitable benefits and risk spreading through community management of production and/or value chain.
- 1E. **WF, IRRI, AUS, and GOV** develop best practice guidelines for the preferred approaches to integrated rice and fish production.

2 Landscape planning, national policy, and institutional/ministerial integration

- 2A. **IRRI and IWMI** map vegetation and hydrological situation (and changes across seasons) to inform planning and governance needs, especially water regimes affecting potential and timing for fish/prawn culture, and investigating dry season water availability and dry season rice cultivation
- 2B. **WF and IWMI** conduct modelling/ foresight studies to inform where/how such integrated practices can be scaled out

3 Value chains and nutrition

- 3A. **WF, IRRI, PNGO, and producers** Trial and develop best practices for value added/ postharvest processing, such as IRRI's solar dryer technology for collective processing
- 3B. **WF and PNGO** Support collectives to organize for processing and value chain integration to market products
- 3C. **WF** Identify traders and market integration options, facilitate connections for collectives

Foundational activities

- Consider creation of a multistakeholder platform, Or tie-in with Aquaculture Association formed by CAST (USDA)
- Networking with policy actors, project to develop coherent policies and objectives that can then be communicated to government agencies
- The various private sector investment options are investigated: Agricultural certification, insurance, micro-credit, small business networks, heritage grants, government grants
- Investigation of diverse sources of funding, including Commune Fund