Agriculture-Aquaculture interactions: Examples from Africa and Asia

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Goal

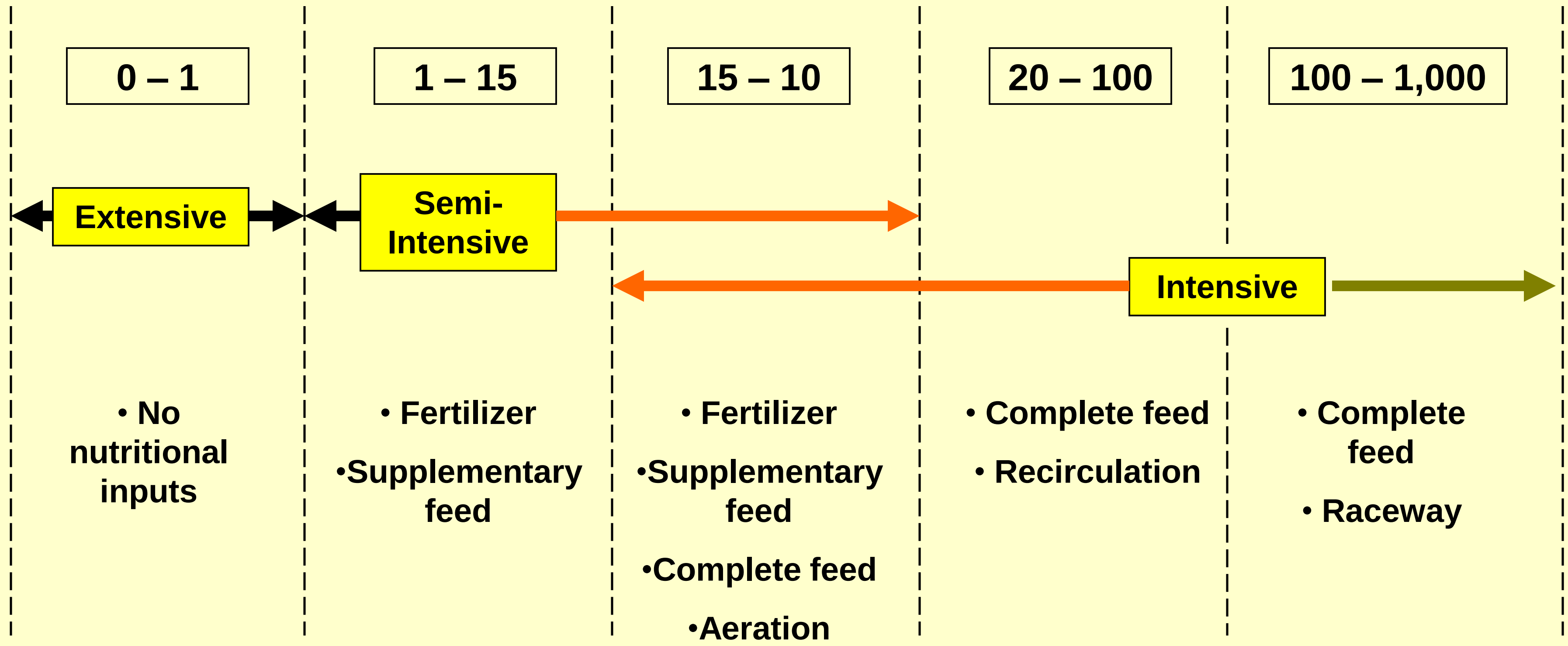
- Provide some insights from the fields (Bangladesh and Malawi) on aquaculture-agriculture intensification for future modeling efforts (BioSight)

Outline

- Introduction (Aquaculture Intensification)
- IAA in Malawi: low intensive aquaculture
- Rice (cereal/vegetable) -fish system in Bangladesh:
  - Low intensive
  - High intensive
- Some concluding remarks

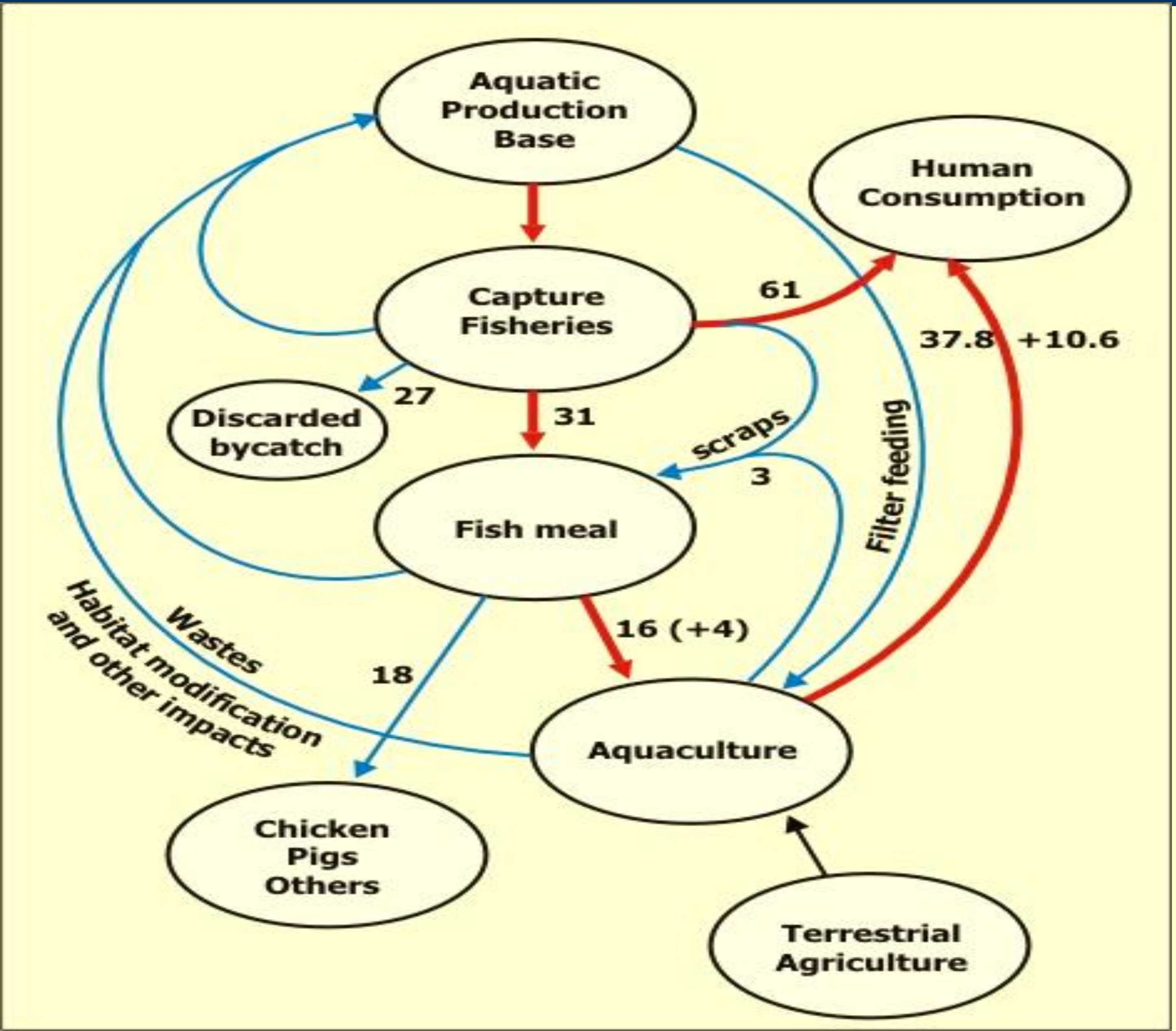
Intensification of Aquaculture Systems

Yield $(t \cdot ha^{-1} y^{-1})$



(after Edwards 1993)

Capture Fisheries & Aquaculture



Naylor et al. 2000

Integrated Aquaculture – Agriculture Technologies in Malawi

AGRICULTURAL ECONOMICS

Agricultural Economics 41 (2010) 67–79

The impact of integrated aquaculture–agriculture on small-scale farms in Southern Malawi

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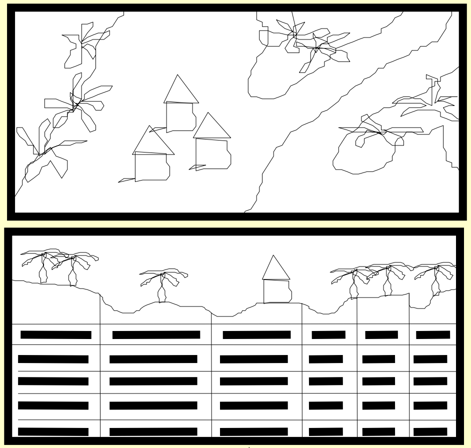
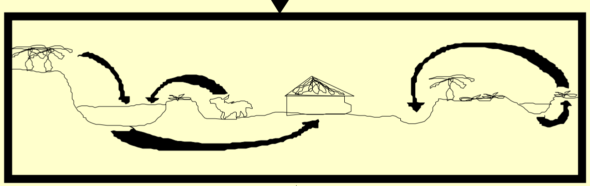
Integrated Resource Management Approach used in Malawi

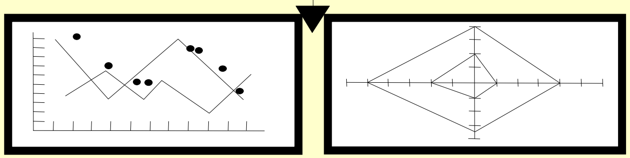
FARMER PARTICIPATORY SYSTEM TRANSFORMATION



Participatory research with farmer groups to construct farm transects and resource maps describing their natural resource systems.



Future farm bioresource flow models guide system transformation



Time-series Analysis

Comparative Analysis

Performance indicators
- diversity
- efficiency
- input-output balance
- recycling
- equity

MODELING

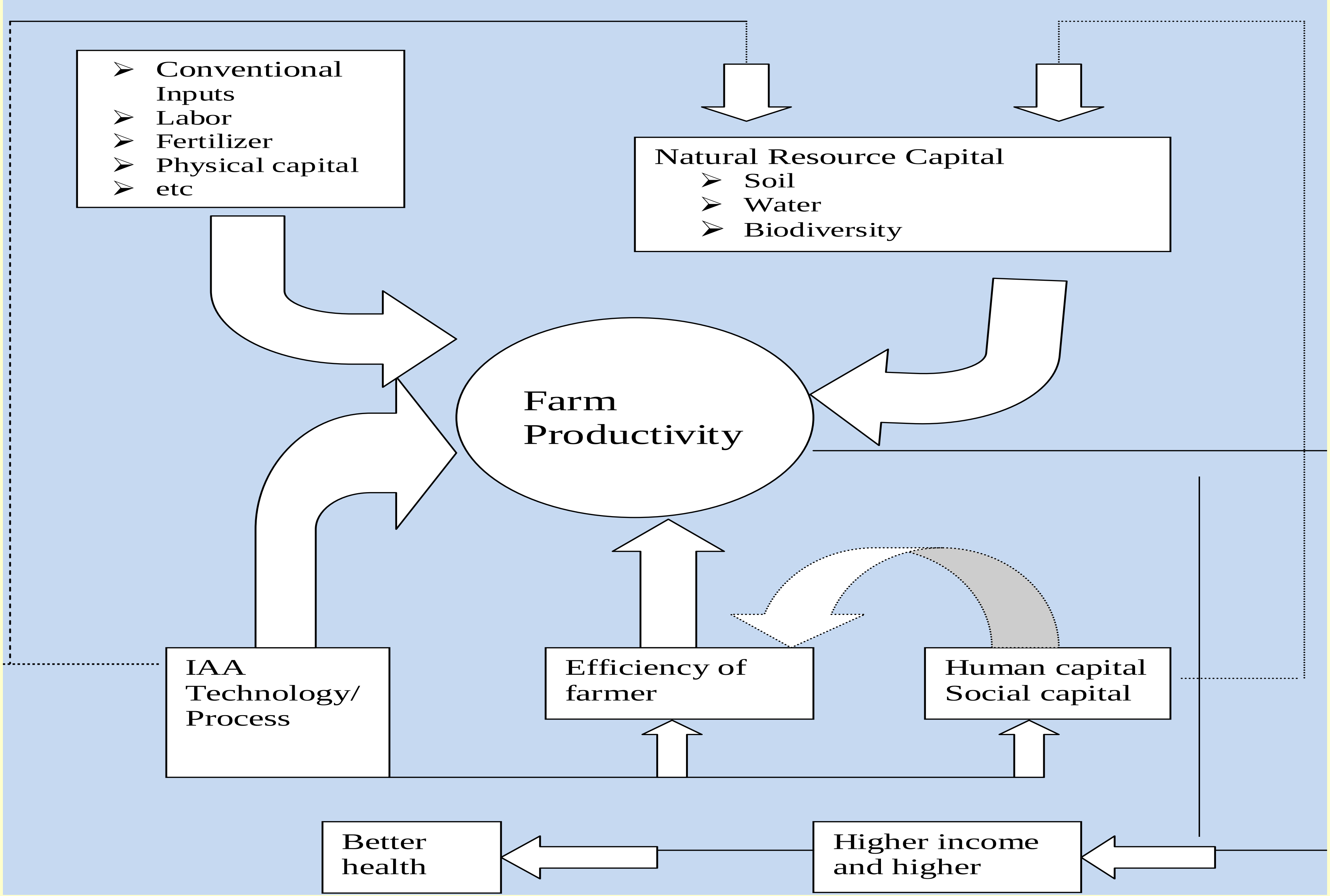
Bioeconomic programming models and multivariate analysis.

Steady state ecological models (ECOPATH) and dynamic simulation models.

NEW ENTRANTS

Household and community issues in adoption, institutional and policy factors effecting adoption.

IMPACT OF IAA: SCHEMATIC DIAGRAM



Assessment of IAA Technologies in Malawi

Methodology:

- ➢ "With and Without" and "Before and After" Scenarios

- ➢ A two-stage framework
- ✓ Identification of factors affecting adoption of IAA
  - ✓ Effect of IAA adoption on
    - efficiency
    - food security
    - employment
    - sustainability
    - etc.

Estimation of adoption function: two-stage approach

Stage 1: Full sample (adopter, non-adopter, dis-adopter)

Adoption is a function of:

- 1 = adopter
- 0 = non/dis-adopter

Agricultural and Environmental factors

- Dambo/total area,
- Access to water in potential NRT

Farm environment

- Number of agricultural enterprises
- Soil quality

Socioeconomic factors

- Income, education, land tenure
- Number of persons trained in IAA
- Extension program and credit program
- NGO present dummied (years),
- Presence of HIPC
- Distance to market
- District dummy

Institutional enabling factor

Estimation of adoption function: two-stage approach

Stage 2: Adopters only

Degree of integration is a function of:

Agricultural and Environmental factors

Dambo/total area,

Access to water in potential NRT

Farm environment

Number of agricultural enterprises

Soil quality

Socioeconomic factors

Income, education, land tenure

Number of persons trained in IAA

Extension program and credit program

NGO present dummied (years),

Presence of HIPC

Distance to market

District dummy

Institutional enabling factor

Significant 'independent' variables affecting adoption-IAA, Malawi

- Extension (+)
- Training in IAA (+)
- No of farm enterprises (+)
- Farm size
  - Positively effecting level of integration



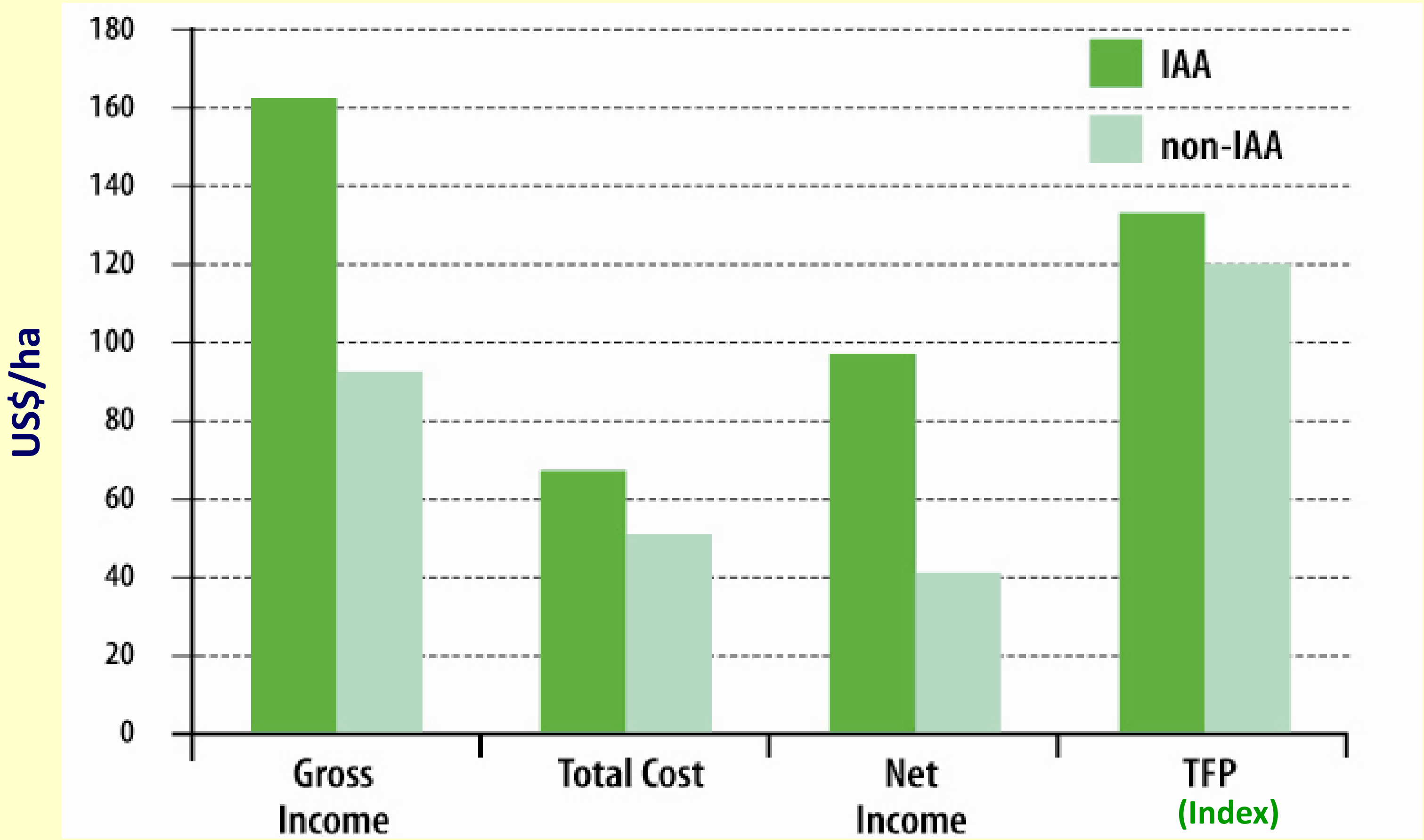
Direct effect of IAA: land-use pattern

Land type	Crop name	Area in ha: Non-IAA	Area in ha: IAA
Homestead	Maize	0.49	0.35
	Vegetables	0.20	0.60
	Other crops	0.62	0.29
Lowland	Maize	0.71	0.86
	Vegetables	1.00	0.92
Upland	Maize	0.52	1.20
	Vegetables	0.20	0.56
	Other crops	0.60	0.44
Dimba (Wetland)	Maize	0.27	0.38
	Vegetables	0.70	0.70

Impact of IAA:

Increase in farm profitability	76 %
Increase/decrease in internal input cost	32 %
Increase/decrease in external input cost	35 %
Increase/decrease in labor cost	27 %
Increase in per capita fish consumption	163 %
Increase in per capita protein expenditure	23 %

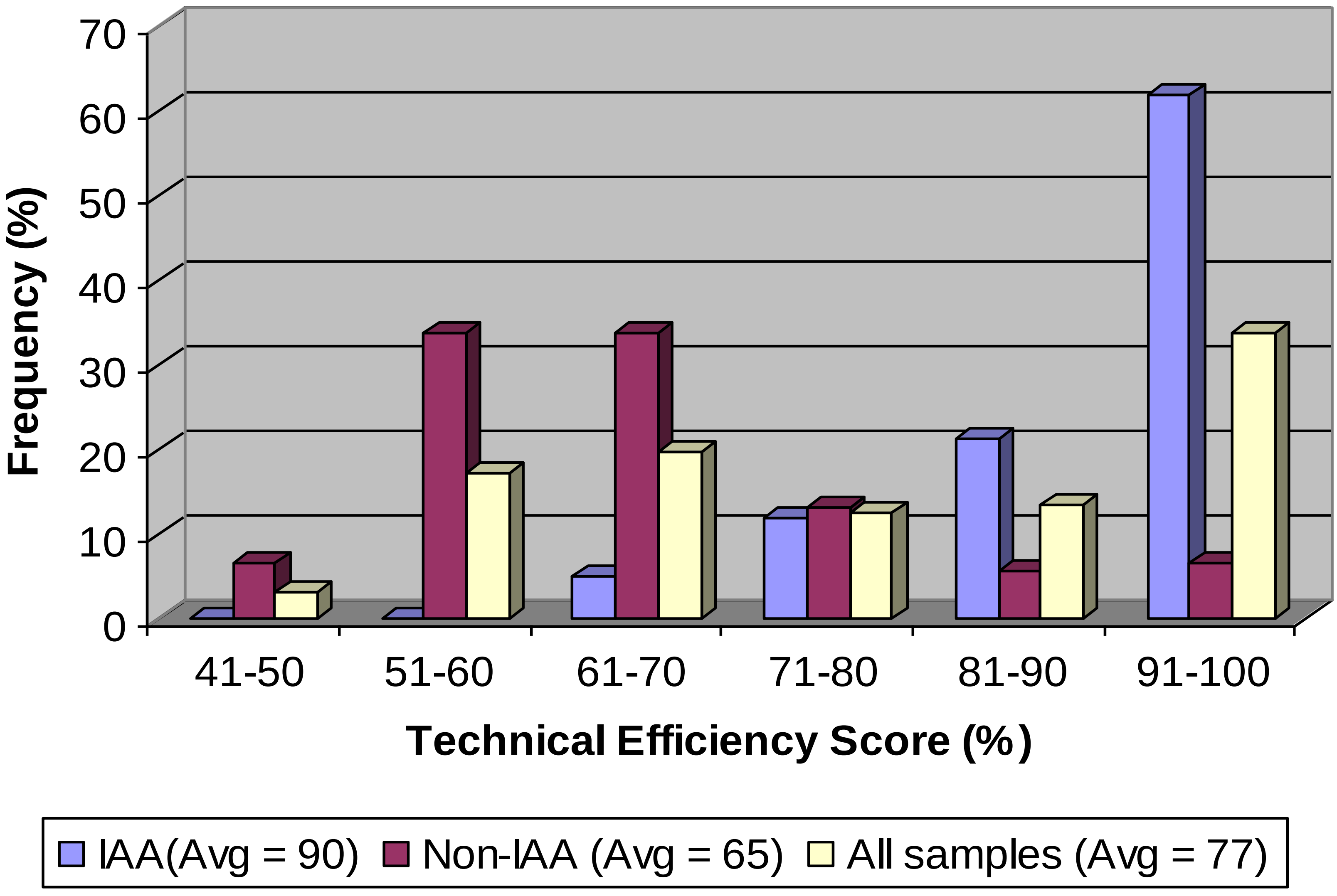
Impact on farm profitability and productivity



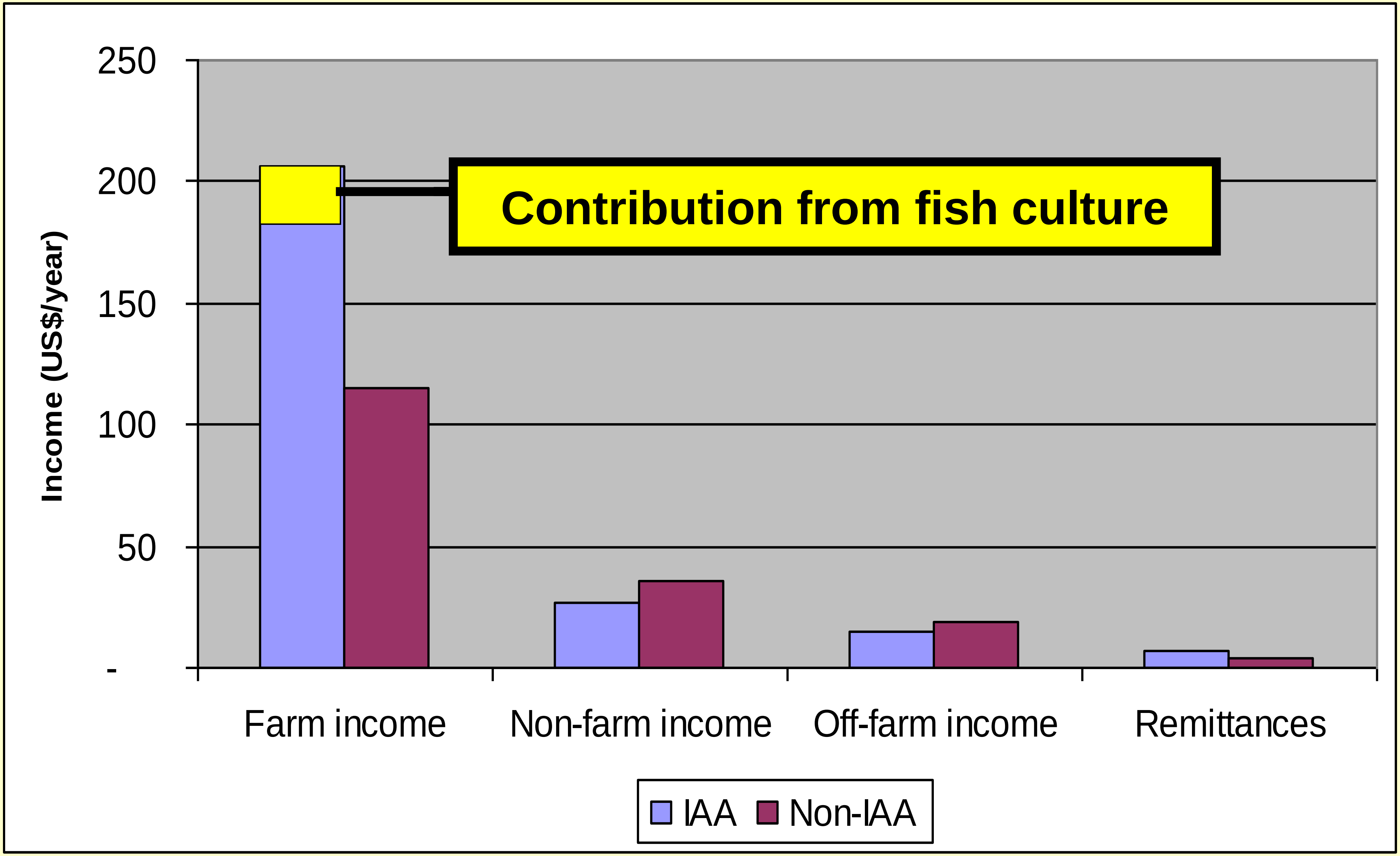
Farm profitability (US$/ha/year) and productivity.

	By household type		Impact	Level of integration	
	IAA	Non-IAA	(%)	Low	High
Gross income	163	93	76	101	205
Total cost	67	51	30	54	74
Seed	14	10	32	11	16
Fertilizer	22	16	35	18	22
Manure	3	2	38	2	5
Labor	28	22	25	23	32
Net income	96	41	134	47	131
TFP	1.33	1.20	11	1.18	**1.52**

Technical Efficiency



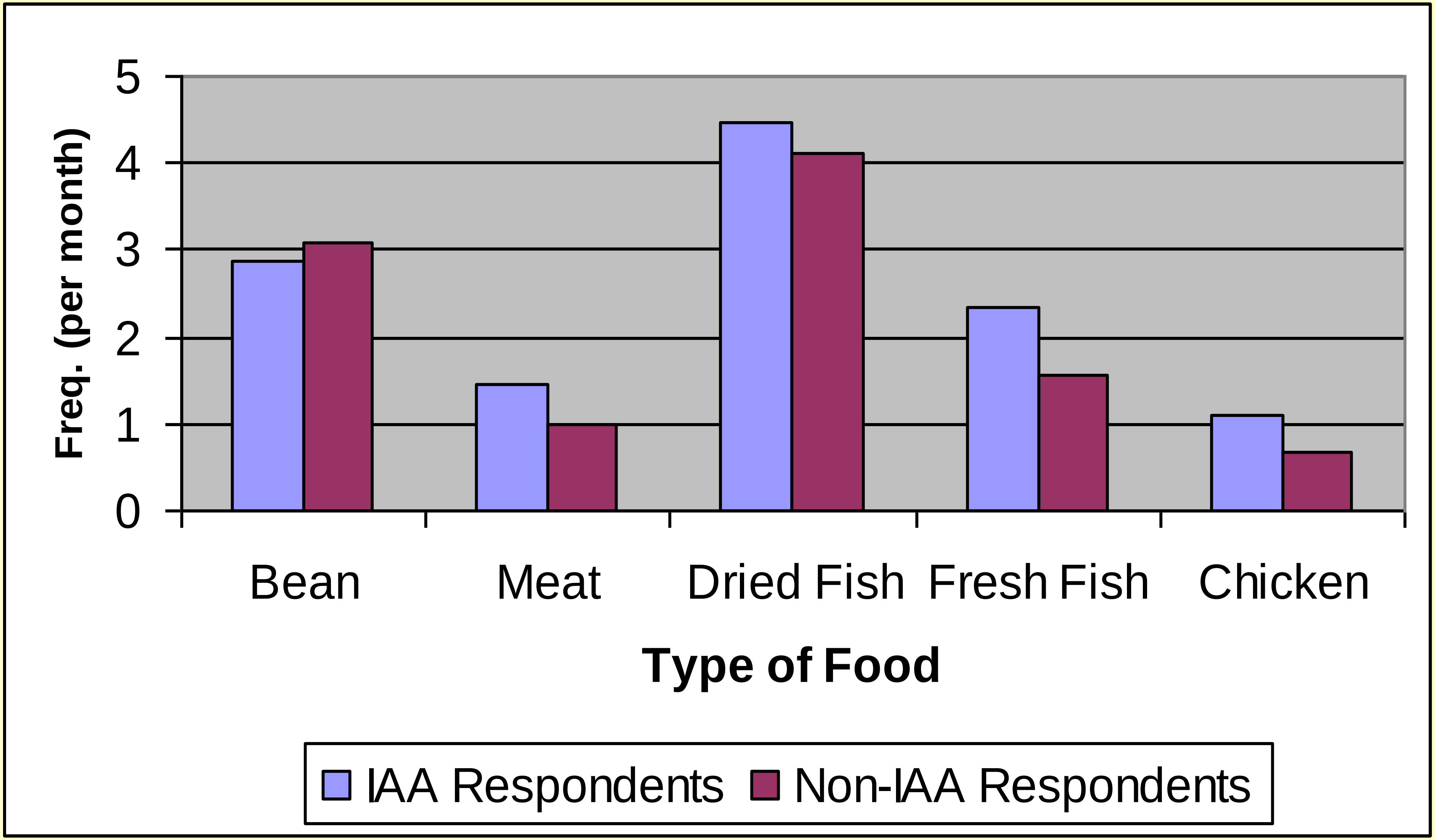
Comparison of Income by source



Monthly income and Protein consumption

	By household type	
	Non-IAA	IAA
Monthly income (Kwacha/capita)	2,100.65	2,646.49
Monthly protien expenditure	389.64	479.14
Share of different protein item to total protein expenditure (%)		
Beans	0.25	0.23
Meat	0.16	0.19
Dried fish	0.35	0.28
Fresh fish	0.09	0.18
Chicken	0.16	0.12
Montly protein consumption (kg/capita)		
Beans	0.74	0.86
Meat	0.37	0.63
Dried fish	0.63	0.59
Fresh fish	0.36	0.96
Chicken	0.34	0.33

Frequency of consumption over the last month, Malawi



Impact on poverty and household welfare

Methodology

- Economic surplus method
- Three stages approach
  - Simple fish/agriculture sector model in Malawi
  - Ex ante impact indicators
    (based on adopter and non-adopter survey)
  - Estimation of benefit to producers and consumers

Economic Surplus Analysis

	Value (US%000)	%
Producer surplus	1087	31
Consumer surplus	2396	69
Net present value of benefits	3482	
Benefit cost ratio (BCR)		1.56
IRR		15%

Impact on Sustainability

- **Data: Long term RESTORE monitoring; special on-station train**
- **Key results:**
  - **Better resilience against drought (an average IAA farmer gets 18% higher per ha farm income than a non-IAA farmer)**
  - **Better maize yield (IAA farmers: 4-6 ton/ha, best progressive non-IAA farmer gets up to 3 ton/ha)**
  - **Less N Loss (IAA-With pond sediments: 5 mg of N per m^2/day; non-IAA: 10 mg of N per m^2/day)**
  - **Better N Use efficiency (N yield per kg of N applied): IAA farmers: 0.4-0.6; non-IAA farmers: 0.2-.03**

Rice-Fish Systems in Bangladesh

Food Policy 43 (2013) 108–117

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Change and diversity in smallholder rice–fish systems: Recent evidence and policy lessons from Bangladesh

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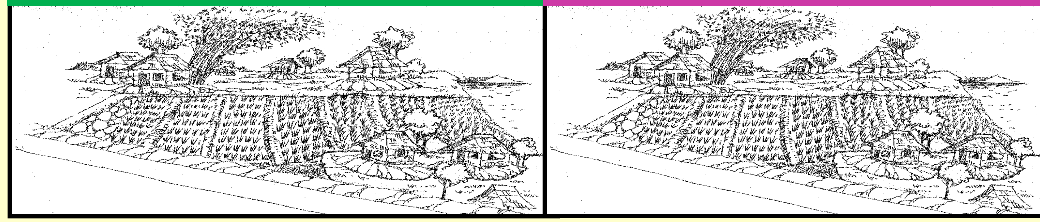
Rice-Fish Culture

- **Rice-farming combined with**
  - culture of fish, capturing wild stock or a combination of both
- **Sequential or simultaneous**
- **Two broad systems**
  - Culturing fish in rice paddies (Amon or Boro Season, food fish or fingerling)
  - Culturing fish in flood-prone areas (need community-based system)

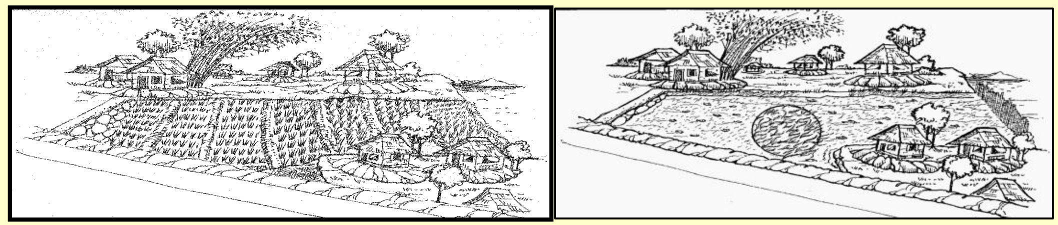
Different Types of Land-use Pattern with rice or fish

DRY SEASON | **WET SEASON**

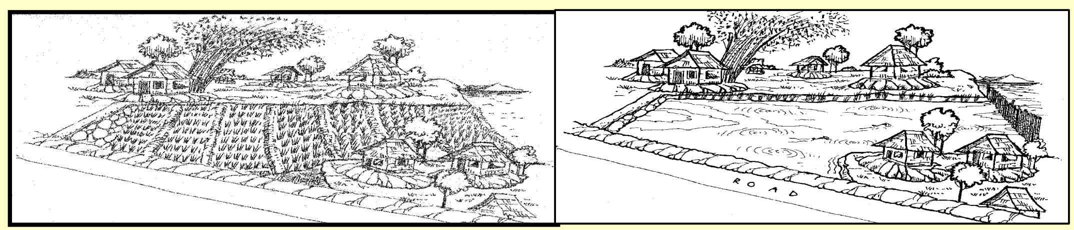
Option 1:
Boro Rice - Amon



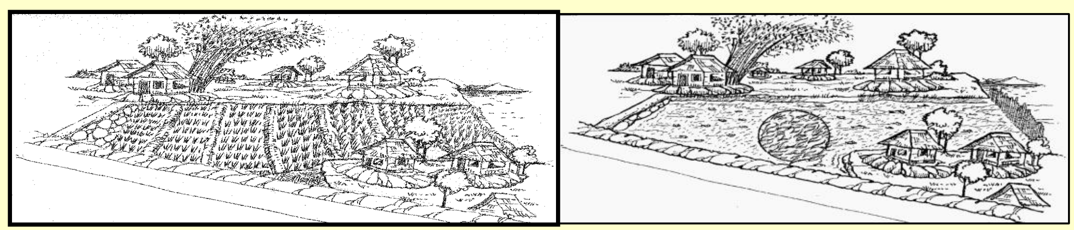
Option 2:
Boro-Amon + Fish



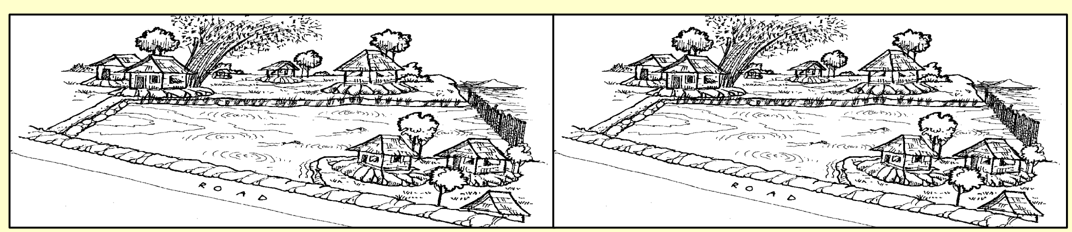
Option 3:
Boro Rice – Fish



Option 4:
Boro+Fingerlings –Fish



Option 5:
Fish



Traditional Farming System (until 1970s)

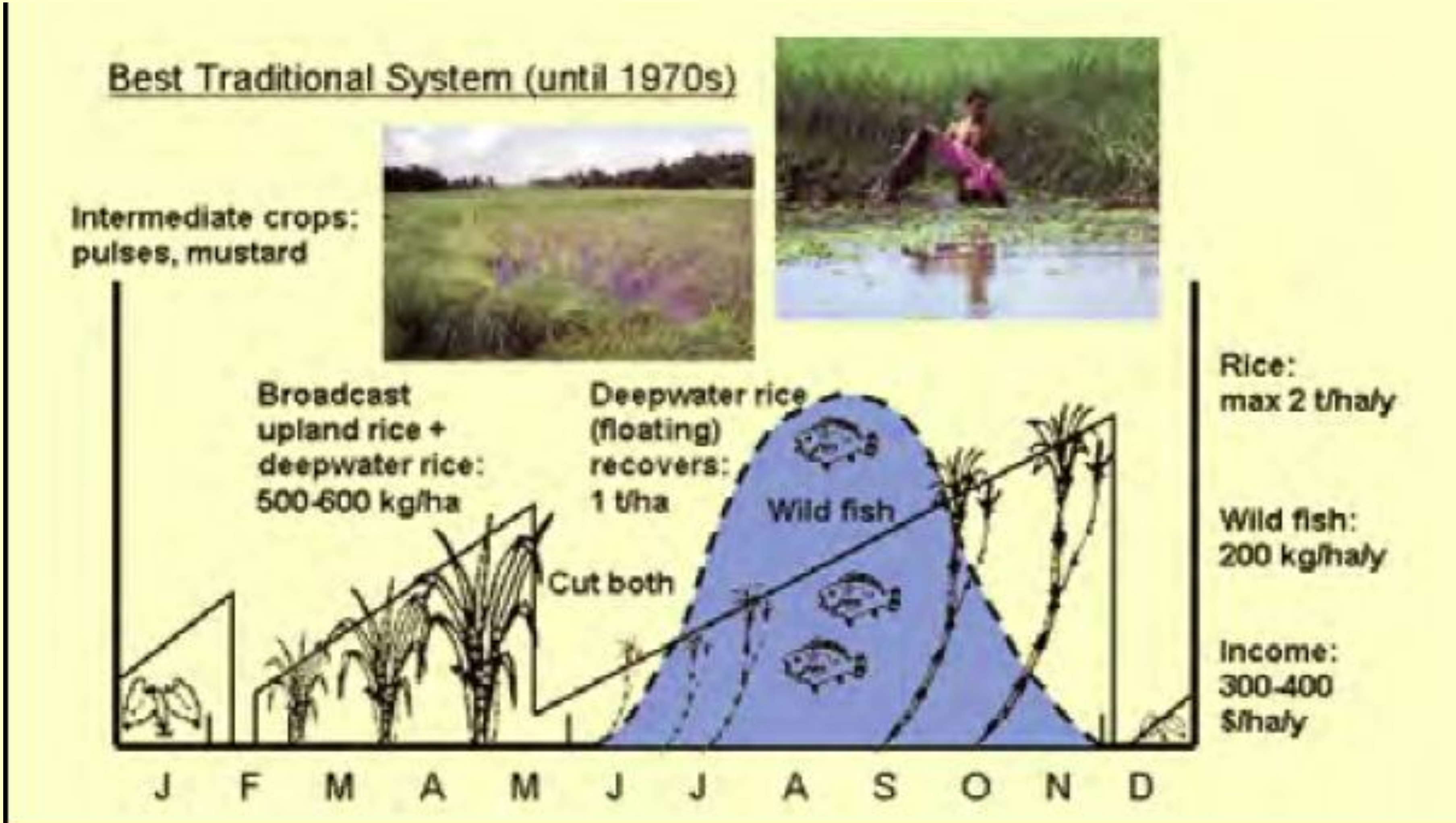


Figure I. Farming systems evolution in floodprone areas.

Source: Dey and Prein 2006

Moderately Deep Flooding Land: Rice-Deepwater Rice (1980s..)

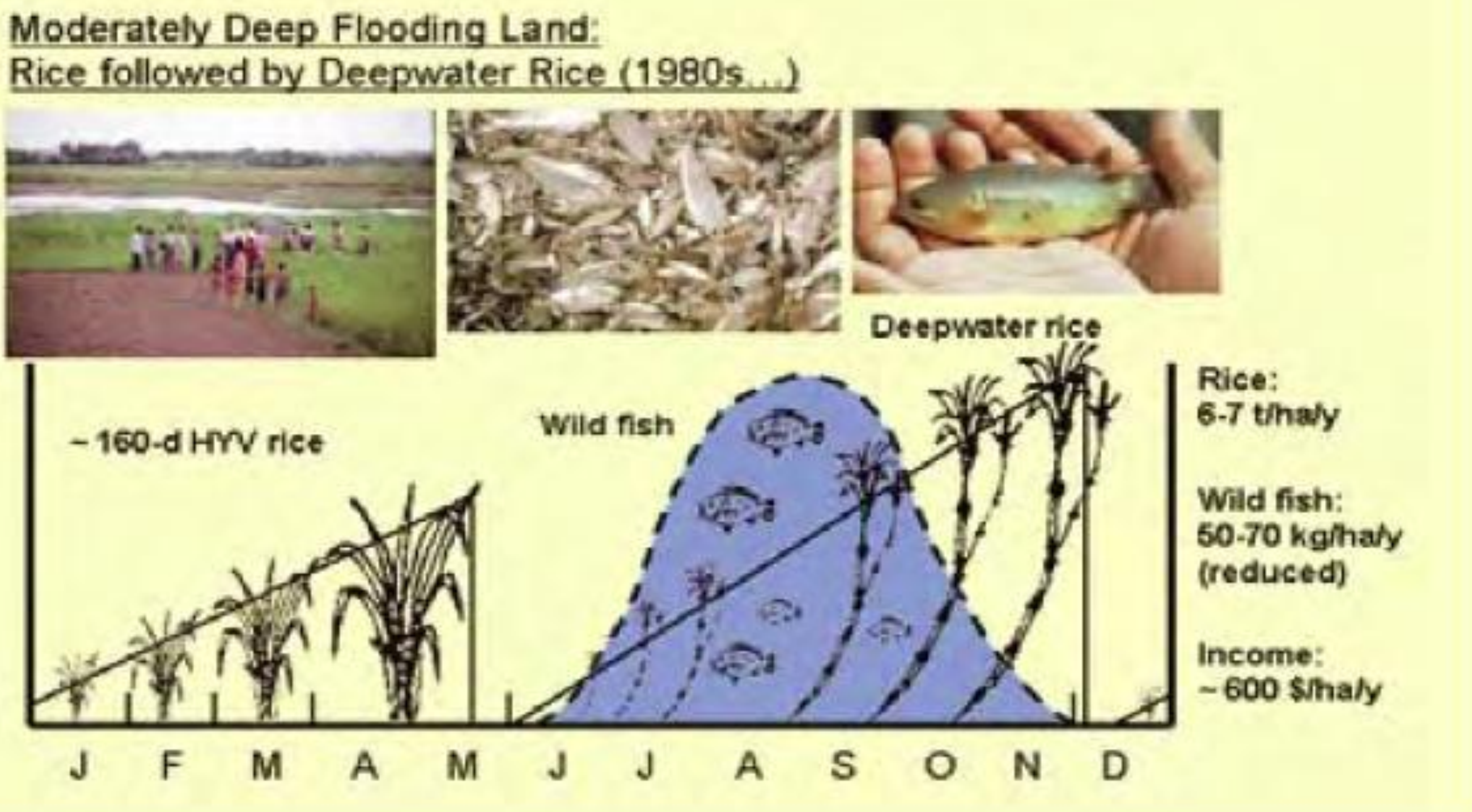


Figure 2. Farming systems evolution in floodprone areas.

Source: Dey and Prein 2006

Deep Flooding Land: HYV-Fallow (1980s-1990s)

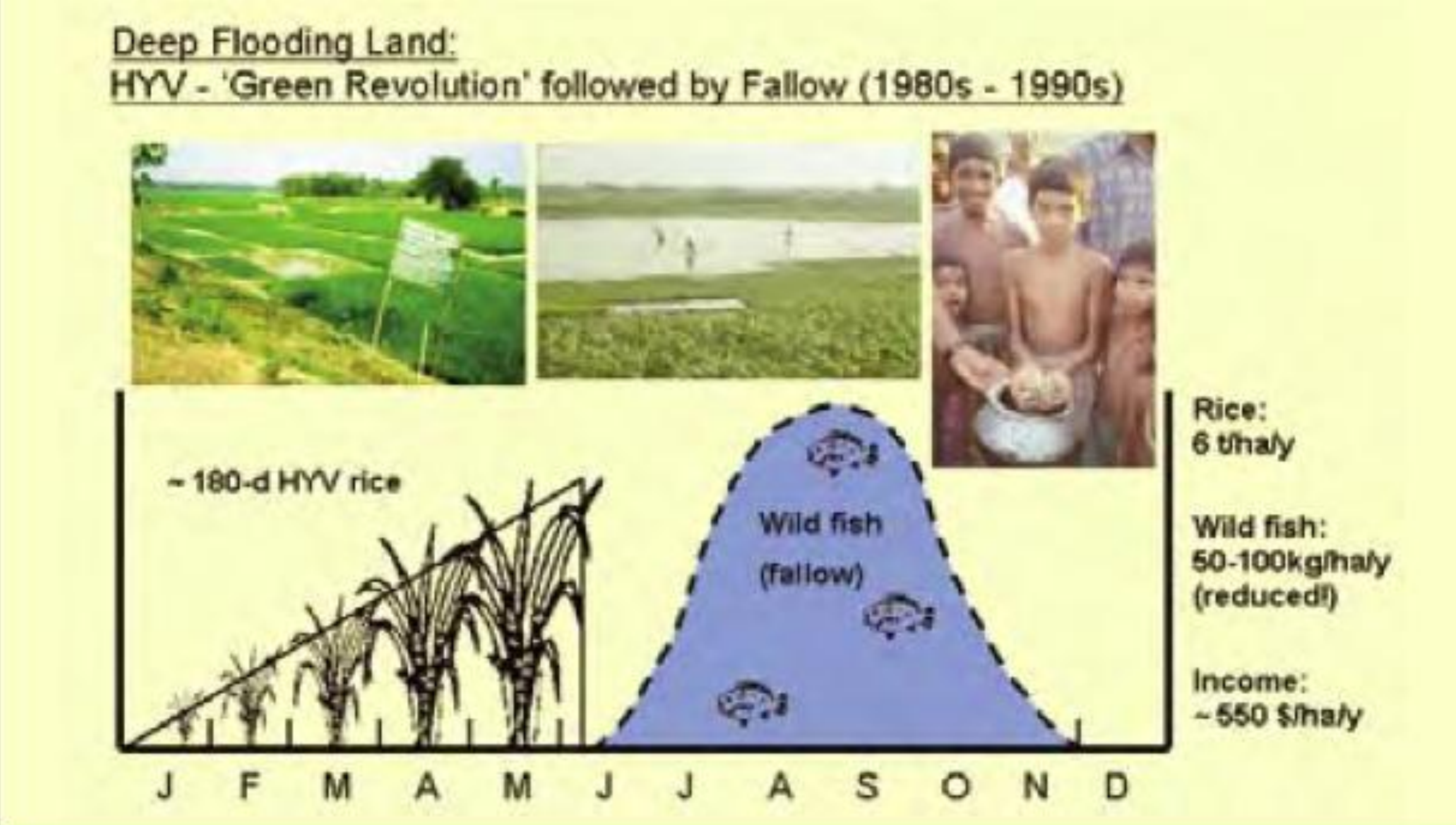


Figure 3. Farming systems evolution in floodprone areas.

Source: Dey and Prein 2006

Moderately Deep Flooding: Rice-Deepwater Rice+Fish (2000s…)

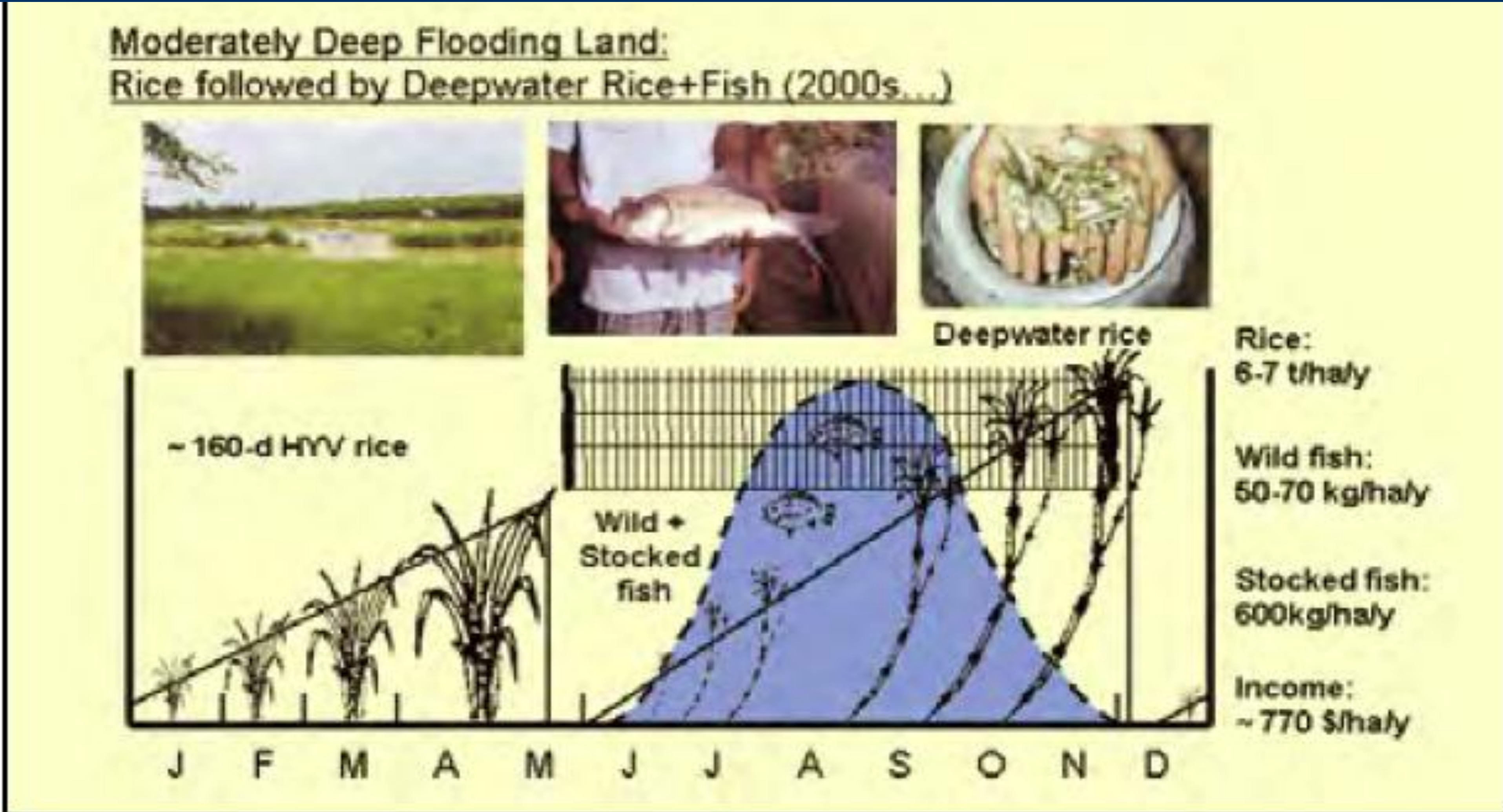


Figure 4. Farming systems evolution in floodprone areas.

Source: Dey and Prein 2006

Deep Flooding Land: Rice-Fish (2000s…)

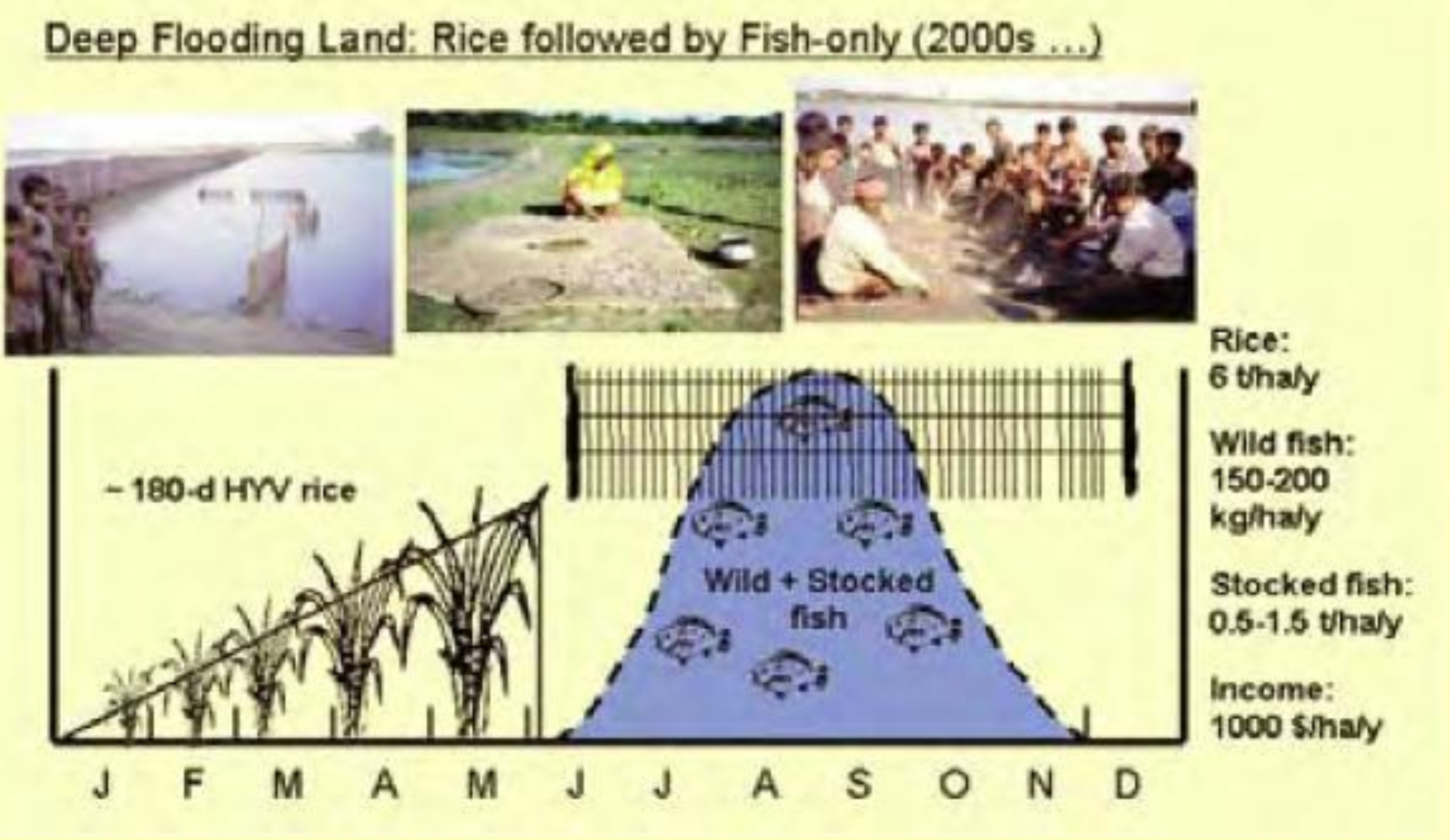


Figure 5. Farming Systems Evolution in Floodprone Areas.

Source: Dey and Prein 2006

Shallow Flooding

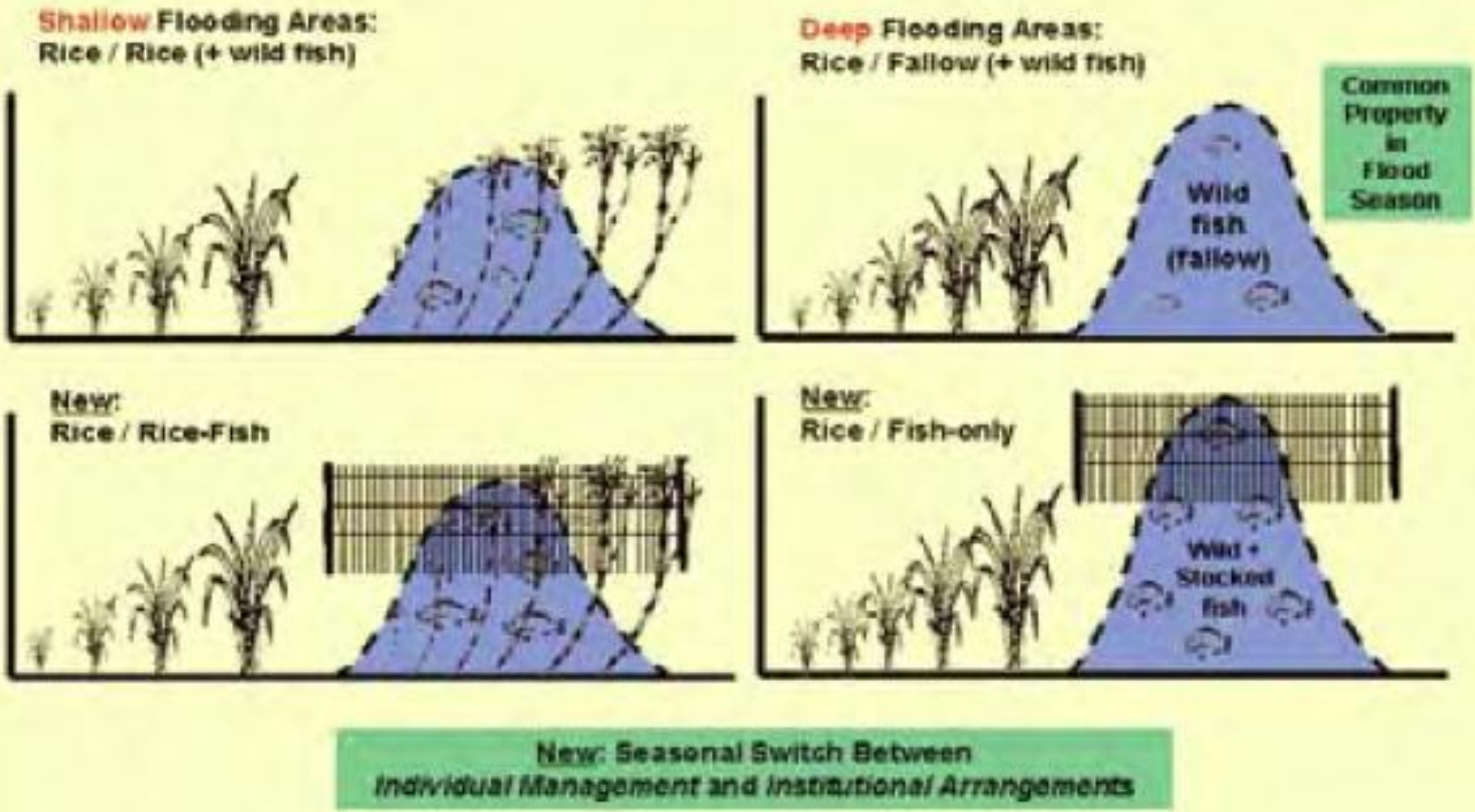


Figure 6. Farming Systems Evolution in Floodprone Areas.

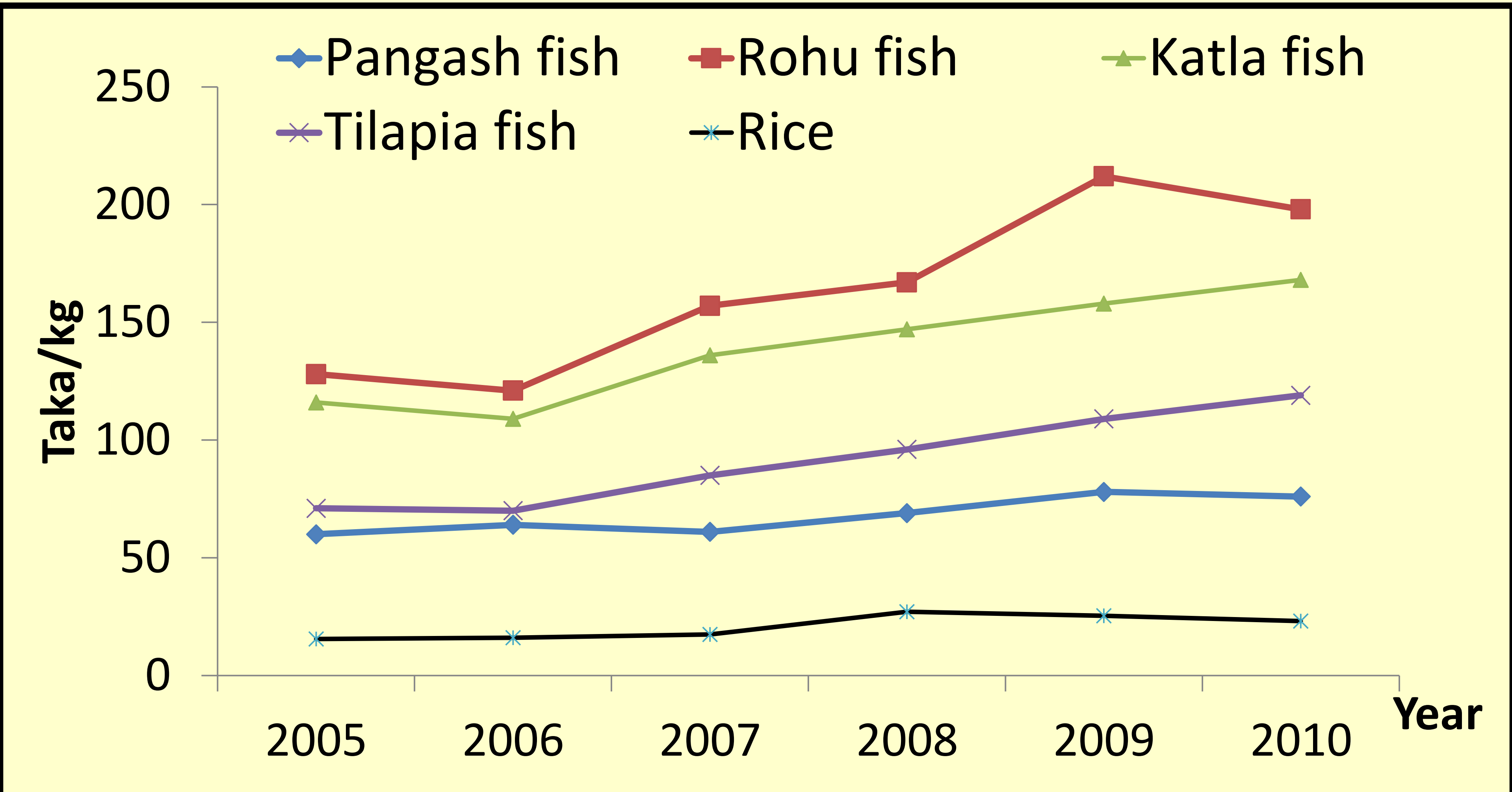
Source: Dey and Prein 2006

Changes in Land Use Pattern-Comilla, Bangladesh

Seasons	Before CBFC		After CBFC	
	Agriculture Enterprises	Area (ha)	Agriculture Enterprises	Area (ha)
Boro (1,232 ha)	Boro Rice	735	Boro Rice	735
	Jute	32	Vegetables	20
	Potato	7	Maize	50
	Vegetables	27	Water melon	180
	Maize	250	Fingerlings and Fish Culture	247
	Water melon	180		
	Spice	1		
Aman (1,232ha)	Amon Rice	382	Fish Culture	1,232
	Fallow land and fishing	950		

Demand and supply: Price of rice and fish

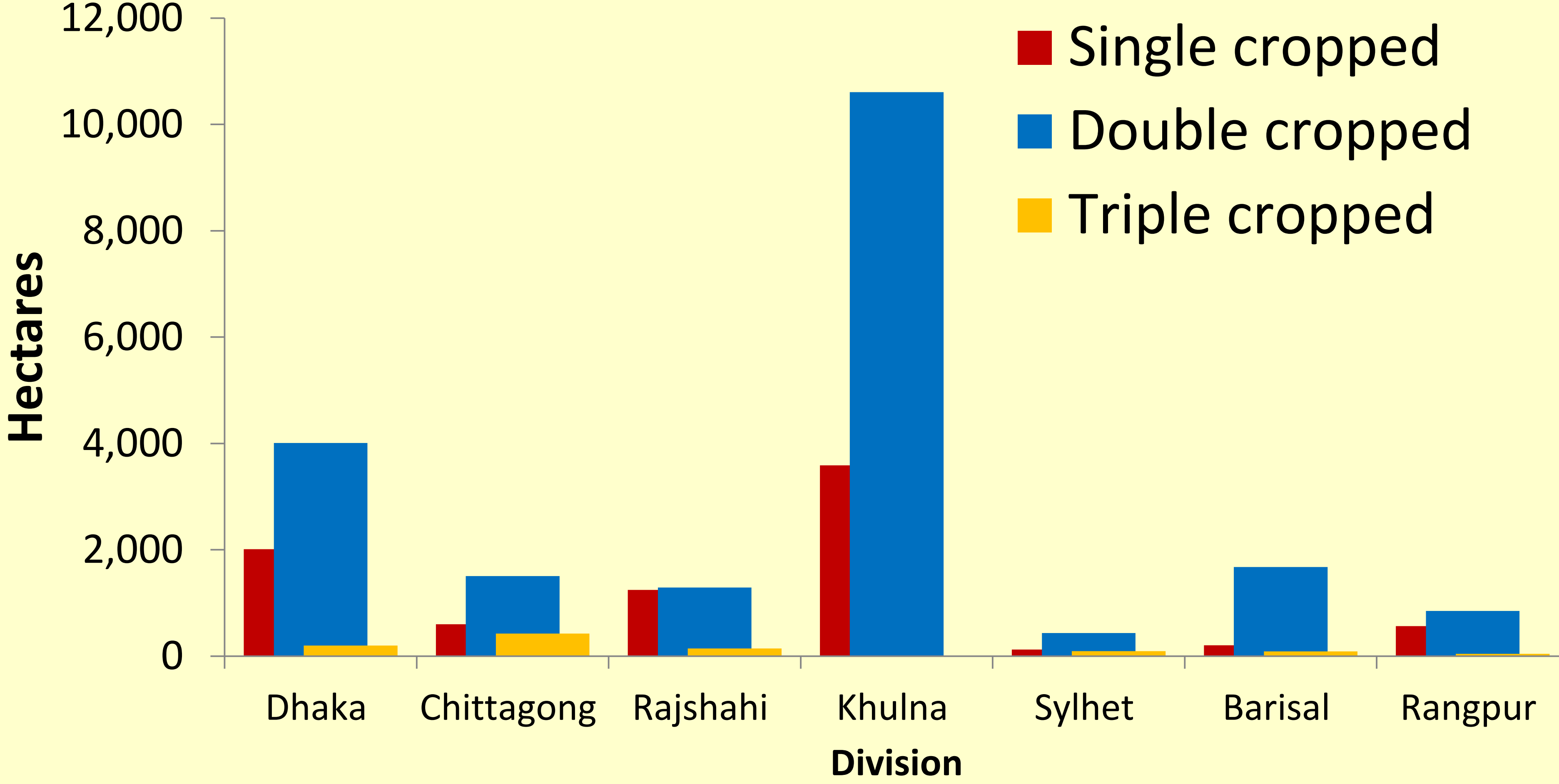
Fish and rice prices, 2005 to 2010



Source: Government of Bangladesh, various years

Supply responses to changing signals

Area converted from rice fields to fish ponds, 2006-2011



Dey et al. 2013; DoF/BAU/IFPRI Field Survey 2011

Return from pangas (catfish) based farming in Bangladesh

Commodity	Production (ton/ha)
Pangas	39.35
Carp	1.65
Tilapia	0.946
Total	**41.957**

Return from Koi (climbing perch) based farming in Bangladesh

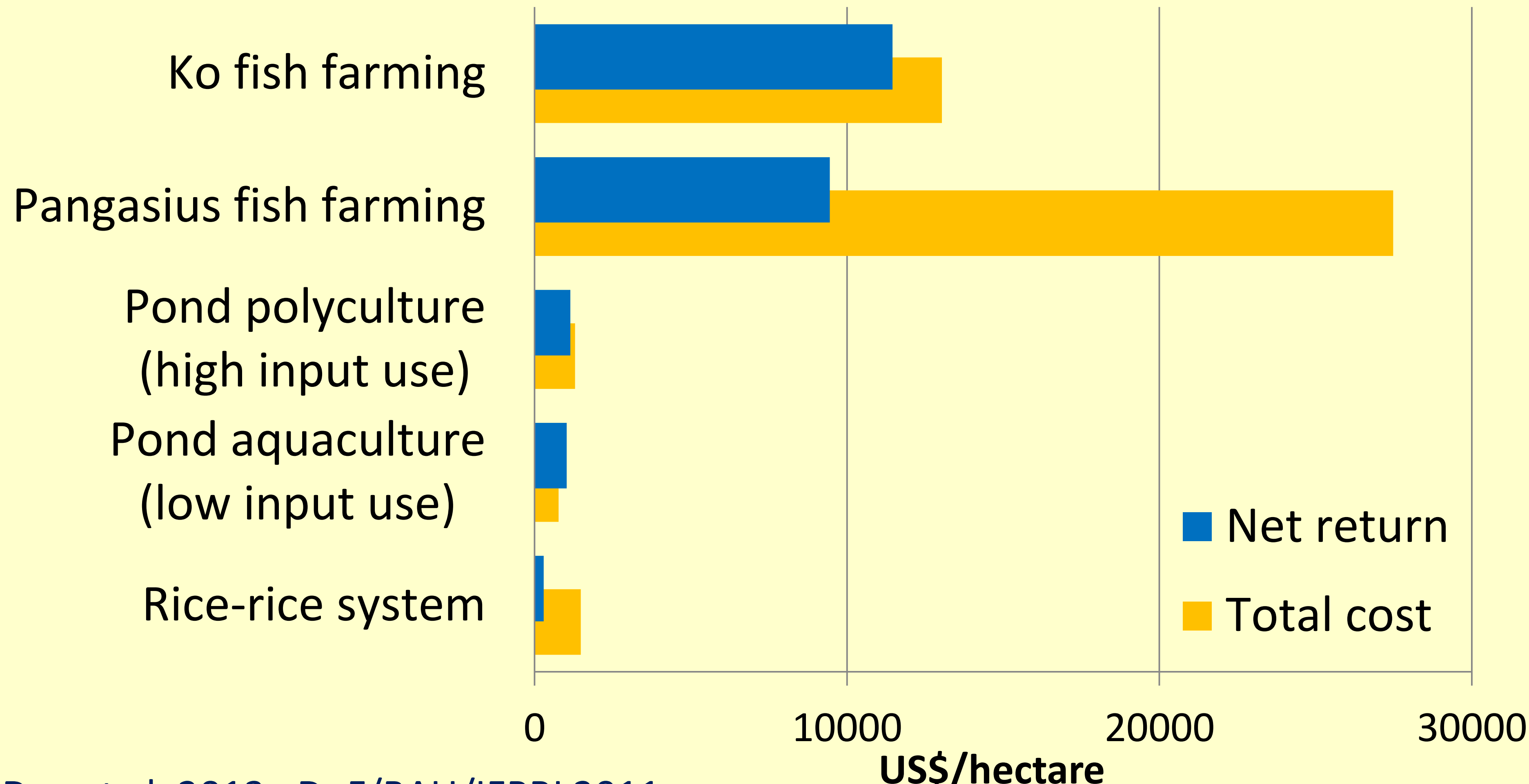
Fishpond Parameters	Unit	Std Dev
Production (Ton/ha)		
1 Crop		
• Koi	10.38	0.82
• Singh	0.11	0.12
2 Crop (yearly)		
• Koi	17.50	4.33
• Singh	0.378	0.02

Return from community based fish farming in floodplain in Bangladesh

Items	Per hectare		
	Quantity (kg)	Ave price (Tk/kg)	Gross Return (Tk)
Stocked fish	4299	76.46	333240
Non-Stocked fish	68	73.72	4965
Total	4367	77.45	338205

Costs and returns to permanent fish culturing

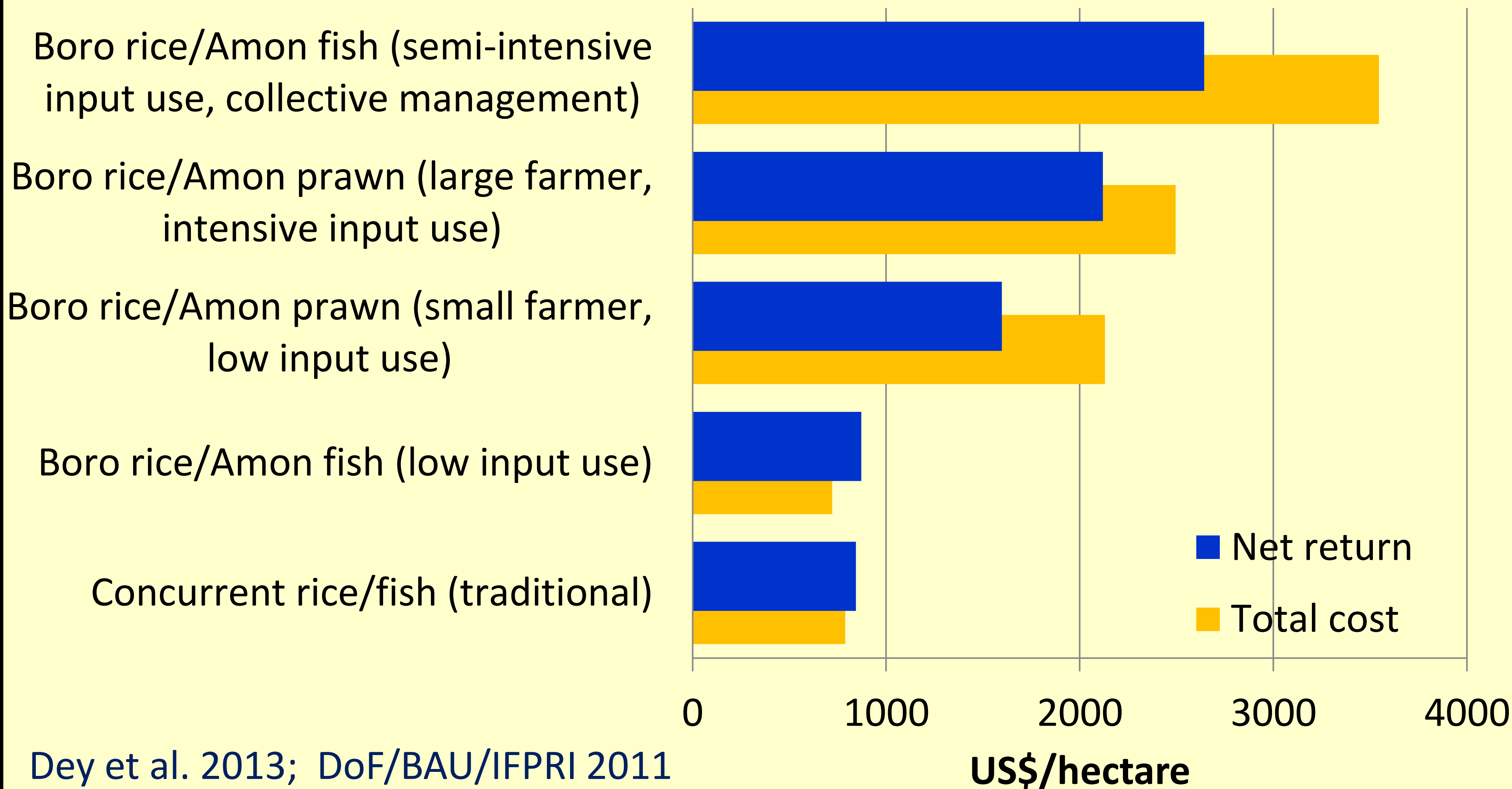
Cost and return of double-cropped rice cultivation and permanent fish culturing in in freshwater areas



Dey et al, 2013; DoF/BAU/IFPRI 2011

Costs & returns to alternating & concurrent fish culturing

Cost and return of alternating and concurrent fish culturing in freshwater areas



Dey et al. 2013; DoF/BAU/IFPRI 2011

Community–based Fish Culture: Social and Biodiversity Issues

Community based Rice-fish Culture : Biodiversity Issue

Stock	Production (%)	Species
Stocked Fish	98.44	Rui, Catla, Mrigal, Grass carp, Silver carp, Bighead carp, Common carp, Calbasu, Thai Sarpunti, Pangas, Tilapia, Bata, Cross rui, Chitol
Non-stocked Fish	1.56	Vetki, Shol, Air, Singh, Taki, Boal, Puti, Mola, Foli, Chingri, Koi, Baim, Baila Kataira, Magur, Pabda

Community based Rice-fish Culture in Bangladesh: Source of Working Capital

Source	Amount (Tk.)	%
Share sale	1,960,852	19.43
Bank loan	3,293,710	32.63
Profit from previous years production	1,994,886	19.76
Feed seller	2,844,168	28.18
Total	10,093,616	100.00

Beneficiaries involved in community-based fish culture,

averages of 30 community-based operations, Comilla

Name of beneficiaries	No.	Percent	Role*
Land owner	164	57	3
Fisherman	29	10	2
Landless	37	13	2 &5
Local unemployed people	25	8	3 &4
Local Elites/Businessman	33	12	3
Total	288	100	

***Role in Project Management**

1. Guarding;
2. Harvesting;
3. Over all observation
4. Fingerling supply;
5. Labour activities
6. Others

Distribution of shares by beneficiary groups involved in community-based fish culture,
average of 30 community-based operations, Comilla

Shares owner	Number of shares	%
NGO	84	4.3
Land owners	1,525	78.09
Elites/businessmen	131	6.71
Fisher/landless members of community	134	6.86
Freedom fighter /members of management committee	79	4.04
Total	1,953	100

Dey et al. 2013

Labor utilization of different rice- and fish-based farming systems

Farming system (dry season-rainy season)	Person days/ha			Cost of labor (USD)
	Dry season	Rainy season	Total	
Rice-rice system	140	100	240	688
Pangasius fish farming, year long			824	2,038
Climbing perch fish farming, year long			734	1,908
Boro rice-fish farming (low input use)	98	36	134	321
Boro rice-fish farming (semi-intensive input use, collective management)	128	234	352	574

Dey et al. 2013

Some concluding thoughts

(implication for future modeling)

- Complex and dynamic farming systems (beyond cropping system)
- Crop and non-crop intensification
- Degree of intensification
  - Could be non-linear
  - Might have differential effect at different levels of intensification
- Objective function of SI (growth, equity,…)

Thank you
for your attention