Climate change vulnerability and adaptation in the low-lying tropics: the case of shrimp farming in coastal Bangladesh

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Rural Bangladesh
Livelihoods of Rural People

Around 70% people live in rural Bangladesh

- Agriculture
- Aquaculture
- Fisheries
Aquaculture in Bangladesh

- Suitable for aquaculture - favorable resources, climate
- Aquaculture - fastest growing food producing sector
- An average annual growth rate: 8%
- Source of food & nutrition: 60% protein
- Income and employment opportunities for rural poor
- Fish farmers: 15 million (9.4% population)
- Prawn and shrimp farmers: 0.83 million
Fish Production in Bangladesh
Capture & Culture

Year


Fish Million t

1.78 1.89 1.99 2.1 2.21 2.32 2.44 2.56 2.7 2.89 3.06 3.26 3.41
Aquaculture Inland capture fisheries

1.86

Production (Million tons)

Bangladesh rank 5th after China, India, Vietnam & Indonesia

0.96

Bangladesh rank 3rd after China & India

0.59

Marine fisheries

55%

28%

17%

Total fish production in 2013: 3.41 million t

Sources: DOF (2014) FAO (2014)
Aquaculture in Bangladesh: Geographical Location

Freshwater aquaculture
- (1) Carp polyculture
- (2) Catfish farming
- (3) Tilapia

Coastal aquaculture
- (1) Prawn-fish/ prawn-fish-rice
- (2) Shrimp-fish/ shrimp-fish alternate rice
Coastal Aquaculture: Prawn & shrimp farming

- Prawn and shrimp farming were initiated in the 1970s and began to expand rapidly in the 1980s
- Prawn and shrimp farming are widespread in coastal Bangladesh due to favorable resources
- Export markets – EU and USA
- Export earnings – US$396 million/year
- Commercially known as “White Gold”
- Coastal aquaculture – 2nd export earner
Prawn & Shrimp Post-larvae (PL) Fishing: Capture to Culture

- Prawn and shrimp culture still dependent on wild fry
- About 400,000 coastal people involve in PL fishing
- PL fishing impacts on environment & biodiversity
- In 2000, DOF imposed ban on wild PL fishing
- Total 130 hatcheries – 60% operational – produce 10 billion PL (60% demand)
- PL fishing likely to continue
Production & Export: Prawn & Shrimp

Source: DOF (2014)
Exporting of Prawn & Shrimp: From Pond to Plate
Benefits from Coastal Aquaculture

- Socioeconomic transformation
- Income of households
- Livelihood opportunities
- Shrimp-fish-rice farming
- Prawn-fish-rice farming

- Rice
- Fish
- Prawn
- Shrimp
- Fish
- Rice

- Export earnings
- Food & nutrition

- Income of households
- Livelihood opportunities
- Socioeconomic transformation

- Benefits from Coastal Aquaculture

- Food & nutrition
- Export earnings
Coastal Aquaculture: Inter-linkages (Social-Ecological Framework)
Sustainability of Coastal Aquaculture?

Climate Change

Social aspects

Socio-economic

Socio-ecology

Sustainability

Ecological-economic

Economic aspects

Ecological aspects

Climate Change
Climate Change & Bangladesh

According to GCRI, Bangladesh rank:
- 1st in 2012
- 4th in 2013
- 5th in 2014
- 6th in 2015

Bangladesh: a nature’s laboratory on disasters
Cyclones

- Cyclone 1970: death 300,000 people
- Cyclone 1991: death 138,000 people
- November 2007: SIDR
- May 2008: cyclone Nargis
- April 2009: cyclone Bijli
- May 2009: cyclone Aila
- October 2010: cyclone Giri
- May 2013: cyclone Mahasen
- October 2013: cyclone Phailin
Sea-Level Rise

- Bangladesh is one of the largest deltas in the world, lies just less than 2 m above sea-level
- Sea-level rise in Bangladesh: 15.9–17.2 mm each year
- Global sea-level rise 2–3 mm each year
- If 1 m sea-level rise:
  - 20-27% country under water
  - 15 million people landless
  - Sundarbans mangrove forest will be lost
  - Affect coastal ecosystems and biodiversity
Salinity & Coastal Flooding

Saline water has entered 100 km towards inland 700 rivers and tributaries with 57 trans-boundary rivers
Ecological Effects on Post-larvae (PL)

Climate change

Proximate Ecological Responses (reproduction-physiological-morphological)

Performance of individual

Larvae

Growth

Recruitment

Adult

Changes in population size and structure of community

Emergent Ecological Responses

Changes:
- Species distribution
- Diversity
- Productivity

(adapted from Harley et al. 2006, Occhipinti-Ambrogi 2007)
Declining Post-larvae (PL) Fishing Rate

Year

2007
2008
2009
2010
2011

PL fishing rate (No./fisher/day)

Set bag net
Pull net
Impacts on Coastal Aquaculture

- Cyclone
- Drought
- Flood
- Salinity
- Sea-level rise
- SST
- Prawn & shrimp aquaculture
- Rainfall
- Climate change
## Vulnerability of Shrimp Farming

<table>
<thead>
<tr>
<th>Climatic variable</th>
<th>Shrimp alternate rice (n = 50)</th>
<th>Shrimp (n = 50)</th>
<th>Mean ordinal rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Kendall’s W value</td>
<td>Chi-square ($\chi^2$) value</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Coastal flooding</td>
<td>4.62</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>Cyclone</td>
<td>4.54</td>
<td>0.84</td>
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<tr>
<td>Sea-level rise</td>
<td>3.94</td>
<td>0.68</td>
<td></td>
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<tr>
<td>Salinity</td>
<td>3.80</td>
<td>0.57</td>
<td>0.56</td>
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<tr>
<td>Drought</td>
<td>3.40</td>
<td>0.97</td>
<td>P&lt;0.0001</td>
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<tr>
<td>Rainfall</td>
<td>3.18</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>Sea surface temperature</td>
<td>2.02</td>
<td>0.62</td>
<td></td>
</tr>
</tbody>
</table>

1 = not vulnerable, 2 = less vulnerable, 3 = moderate vulnerable, 4 = highly vulnerable, and 5 = extremely vulnerable
Impacts on Shrimp Farming

- Rainfall
- Flood
- Drought
- Cyclone
- Sea-level rise
- Salinity
- Sea surface temperature
- Shrimp alternate rice
- Shrimp-only

Shrimp alternate rice: Green line
Shrimp-only: Red line
Climatic variables
- Coastal flood
- Cyclone
- Sea-level rise
- Salinity
- Water temperature
- Drought
- Rainfall

Ecological effects
- Increased salinity, reduced freshwater biodiversity
- Sedimentation and erosion of farms
- Increased water pollution and turbidity
- Reduce photosynthesis and O$_2$ depletion
- Hinder ecological interactions
- Limit primary productivity
- Increased toxicity and CO$_2$ emission

Production impacts
- Affect stocking survival & growth of PL
- Reduced feeding rate by prawn & shrimp
- Failure growth and recruitment
- Outbreak of prawn & shrimp diseases
- Reduce prawn & shrimp production
- Reduced fish & rice production
Sequential Ecological Effects on Production

Climatic variables:
- Rainfall
- Flood
- Drought
- Sea-level rise
- Cyclone
- Salinity
- SST
- Water pollution
- Low light
- High CO₂
- Low pH

Effects:
- Turbidity
- Less primary productivity
- Water temperature
- Low photosynthesis
- Low O₂
- Low pH

Graph:
- Intensity
- Effect
- Climatic variables
- Time

Axes:
- PL stocking
- Survival
- Growth
- Disease
- Yield
Impacts on Socioeconomic Conditions

Climate Change

Food
- Rice and freshwater fish
- Vegetable and fruits
- Milk, meat and eggs

Rice straw
- Fodder for cattle
- Housing building
- Cooking fuel
Wider Impacts: Economy of Bangladesh

Climate change

- Tropical cyclones
- Sea-level rise & SST
- Salt water intrusion
- Rainfall
- Flood & Drought

Coastal aquaculture

- Prawn and shrimp yield
- Export earnings
- Livelihoods of poor
- Income of households
- Economic growth

Poverty and vulnerability
Coping Strategies

- Reduce food consumption
- Loans from kin
- Sell non-productive assets
- Pledge productive assets
- Sell productive assets
- Migration?
Multiple Challenges

(1) Climate Change
(2) Increasing population
(3) Reducing agriculture land
(4) Soaring demand for food production
Adaptation Strategies: Community Based adaptation (CBA)

- Community awareness and preparedness
- Construction of earthen dams, embankments
- Netting and higher dike construction around farms
- Irrigation facilities with drainage systems (microirrigation)
  - Dr Daniel Hillel awarded World Food Prize 2012
- Coastal plantation with social forestry
- Introduce salt and drought tolerant rice varieties
- Mixed culture of prawn and shrimp with brackishwater fish

Bangladesh readies flood-tolerant rice
3 varieties to prevent a million tonnes of crop loss a year
Conclusions

- Integrated Coastal Zone Management (ICZM)
  - Mangrove plantation & forestation (REDD)
  - Coastal embankments
  - Integrated management of coastal rivers and estuaries
  - Disaster management

- Research and Development (R&D)
  - Farming systems (cage culture)
  - Integrated culture systems with euryhaline species
Community-based climate change adaptation strategies for integrated prawn–fish–rice farming in Bangladesh to promote social–ecological resilience

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Abstract

Farming freshwater prawns with fish in rice fields is widespread in the coastal region of southwest Bangladesh because of favourable resources and ecological conditions. This article provides an overview of an ecosystem-based approach to integrated prawn–fish–rice farming in southwest Bangladesh. The practice of prawn and fish farming in rice fields is a form of integrated aquaculture-agriculture, which provides a wide range of social, economic and environmental benefits. Integrated prawn–fish–rice farming plays an important role in the economy of Bangladesh, earning foreign exchange and increasing food production. However, this unique farming system in coastal Bangladesh is particularly vulnerable to climate change. We suggest that community-based adaptation strategies must be developed to cope with the challenges. We propose that integrated prawn–fish–rice farming could be relocated from the coastal region to less vulnerable inland areas, but caution that this will require appropriate adaptation strategies and an enabling institutional environment.
Thank You All