Ecosystem-based Coastal Aquaculture

To support Ecosystems and Economy

15/9 & 3/10 2017, Dr. ir. Roel H. BOSMA

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Content

- Aquaculture, sustainability & Ecosystem services
  - Sustainability issues of Aquaculture
  - Categories & value of EcoSystems Services (ESS)
- Mixed Mangrove Aquaculture systems.
- Social Cost Benefit Analysis of Aquaculture & ESS.
- Intermezzo: Demak.
- Social Cost Benefit Analysis of mangrove recovery.
- Conclusion

Sustainability Issues of Aquaculture

- ✓ **Land use**
- ✓ **Water use and pollution**
- ✓ **Escapes and genetic contamination**
- ✓ **Residues of metals, pesticides & antibiotics**
- ✓ Use of wild fish for seed
- ✓ Energy use and Greenhouse gas emissions
- ✓ Feed use
- ✓ Human nutrition (long-chain omega-3 fatty acids)
- ✓ Affordability.

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- List from: Waite *et al*. 2014.

Pond aquaculture uses Ecosystem

Ecosystem =

Living processes of NR-Flora-Fauna in a specific area.

- Spatially limited, but interconnected

  in both space & time through:

  - Air,
  - Land,
  - Water,
  - Fauna,
  - Flora.

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Ecosystems & Human

- Ecosystems provide services to human society.

  = **Ecosystem services** =

  Benefit/value people obtain from ecosystems.

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Categories of Ecosystem Services

Four categories of Ecosystem Services and definitions:

1. Supporting services:
   - Necessary for producing all other ESS.
2. Provision services:
   - Products obtained from ecosystems.
3. Regulating services:
   - Benefits obtained from the regulation of ecosystem processes
4. Cultural services:
   - Non-material benefits people obtain from ES through e.g. spiritual enrichment, reflection, recreation, inspiration.

Provisioning Services

- Food (incl. seafood & game), crops, wild foods & spices:
  - Habitat for flora & fauna
- Raw materials (e.g. lumber, bio-fuels, fodder & fertilizer)
- Genetic and medical resources
- Water
- Energy (hydropower, fossil fuels)
- Biogenic minerals: minerals created by living organisms, such as diatoms or bacteria.

- Ornamental resources:
  (e.g. for handicraft, clothing & decoration, pets, orchids, aquarium fish, and souvenirs like furs, feathers, butterflies, shells, etc.).

Regulating Services

"Benefits from regulation of ecosystem processes"

- Coastal protection
- Carbon sequestration
  - Among highest of all forests (Murdiyarso et al 2015)
- Climate regulation
- Purification of water & air
- Waste decomposition & detoxification
- Pest & disease control/regulation.

- Village in Demak during high tide.

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Comparing Shrimp and Mangrove

- Shrimp farm earns 1,000 to 40,000 USD $ha^{-1}\ yr^{-1}$

- **T**otal **E**conomic **V**alue of *1 ha* Mangrove*:
  - Provision: 44 – 8,300 $
  - Habitat: 27 – 68,800 $
  - Regulating: 1,900 – **135,400** $
  - Cultural: 10 – 2,900 $

E.g. South Minahasa: 36,0000 USD **

- But NR we have and just need to maintain, in shrimp we invest capital.

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* Russi *et al.* 2013; **Mankay *et al.* 2012

≠ Shrimp Farming in Mangrove Climax

Philippines

compared to

Indonesia

In latter,
most Ecosystem Services
of Mangrove are Lost

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Learn from experiences - Vietnam

- Mekong delta, along coast:
  - 300 m highly protected mangrove
  - 300 m mangrove-shrimp farms (sylvo-aquaculture).
- Mangrove-shrimp aquaculture.
  - 40 to 70% mangrove on farm, mostly on platforms;
  - (Semi-)extensive shrimp production: 175 – 400 kg ha^{-1},
    - ❖ and other products double income.
  - Good livelihoods if >= 6 ha.
- But, high land-use/kg shrimp.:
  - Due to restrictions on use of shrimp culture technologies.

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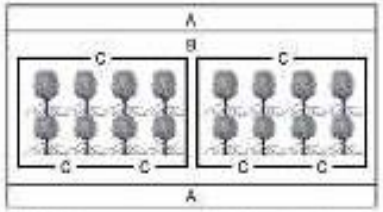
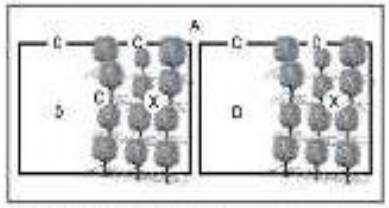
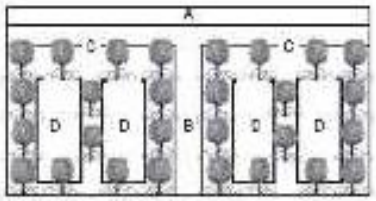
Indonesian Sylvo-Aquaculture

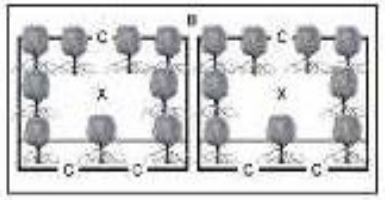
1. Traditional Empang
   - ➢ Mangrove on central platform.
2. Komplagan
   - ➢ Mangrove on one side.
3. Mangrove along/on dikes:

   Stimulated by e.g. WWF.


(1) Tipe empang parit tradisional

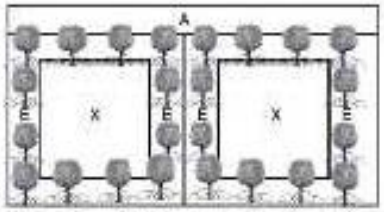

(2) Tipe komplangan


(3) Tipe kao-kao


(4) Tipe empang terbuka

✓ Limited shrimp production,
   - ➢ But other products.

✓ 1 & 3 Risky and difficult to intensify:
   - ➢ Due to a.o. low water,
   - ➢ decomposing leaves
   - ➢ Mangrove roots.


(5) Tipe tasik rejo

(Puspita et al, 2005).

Sylvo-Aquaculture & ESS

- Timber & seafood,
- Habitat birds & snakes, but :
  - No inundation/drying of mangrove.
  - Disconnected from aquatic resources, except inlet to recruit seafood seeds.

Thus, mangroves planted in ponds, on dikes and along canals look nice, but:

⇒ their long-term effect is mostly negative, and

⇒ have low significance for ecosystem services such as habitat, regulating, supporting and cultural.

Robust shrimp production systems in PH

- ✓ Mangrove outside the farm => healthy water.
- ✓ Green-Water from filter-pond with tilapia.
- ✓ Some have seabass to eliminate disease agents.
- ✓ Shrimp ponds with bio-flocs.

- ❖ But sacrificing (part of) pond to prepare water.
  - ✓ What's the net benefit?

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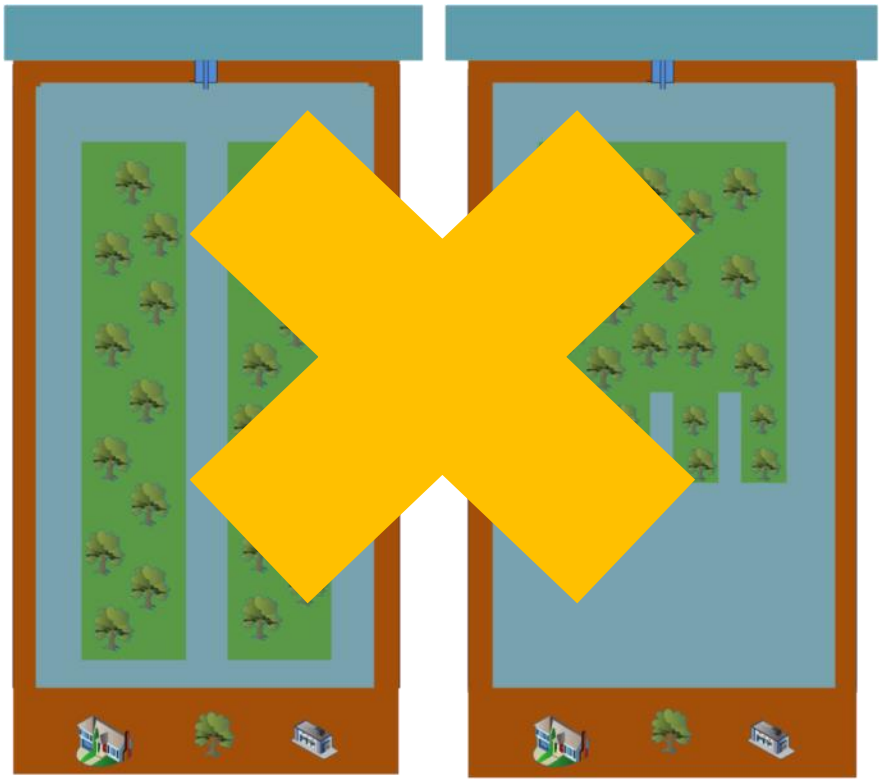
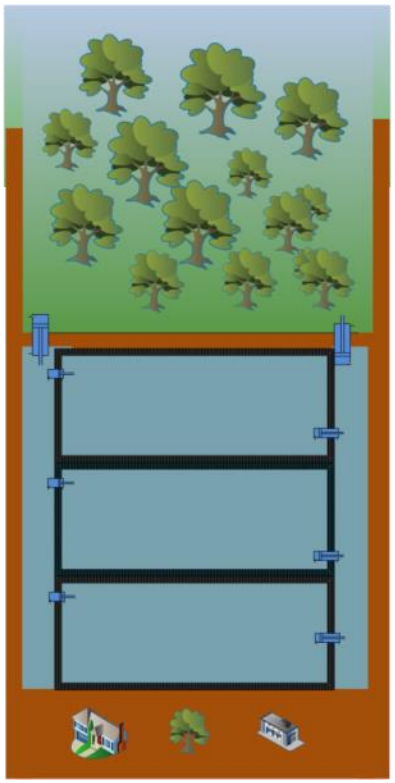
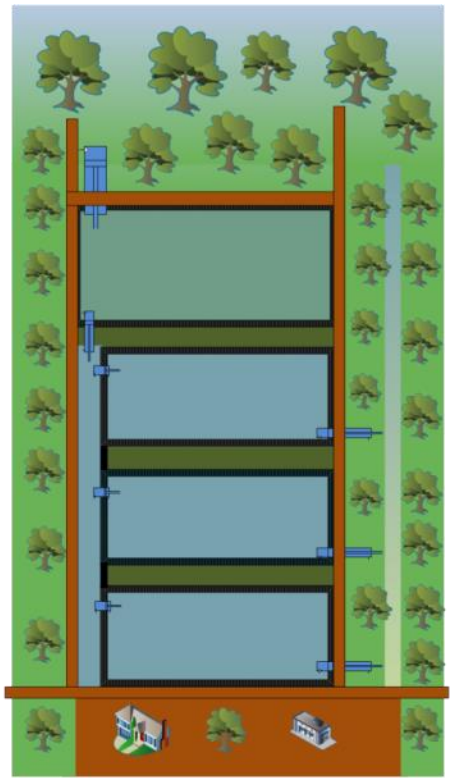
Along coast & shore: New Mangrove-Shrimp S.







- Two mixed existing systems in Vietnam (pond 30-50%):
  - **Very little contribution to ecosystem services.**

- Ecologically integrated systems (pond <50%) where mangrove:
  - Traps sediment & protects.
  - Nursery for fish.
- More intensive aquaculture.

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Total Economic Value (TEV) of 12 ha

- Cost-Benefit Analysis (CBA) shows that:
  - Extensive Shrimp: high private returns, but ESS lost.
  - Balance of total shrimp harvest and ESS from 12 ha:

Amounts in 1,000 USD	Exten-sive	7ha Mangrove + Intensive	Inten-sive
Ratio shrimp yield	1	20	90
Farm revenues /year	11	50	300
TEV Ecosystem Services/year	0	250*	0
Value shrimp + ESS / year	**11**	**300**	**300**

- **Including ESS, TEV Mangrove-shrimp = TEV Intensive.**
- **One trade-off: less shrimp** for market, processing, export.
- **But more catch from fishing**: Thus also political choice.

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* Data Minahassa

Value of Ecosystems Services

The economic value of ESS is used for advice and decision-making on:

- Land-use planning and
- Value compensation measures in case of loss of nature due to human activities, such as, infrastructures, industry, habitation ...

- Talking about loss: the case of
  Demak's coast, northern Java, Indonesia.

History of Demak's coast

Above 800 AD

Below 1990

Until 1700, ships crossed the estuary south of Muria from Semarang to Demak and further to the sea again (along the red-line)

Part of Demak regency, and in particular Sayung district, was created within 1000 year by sediments from land and sea.

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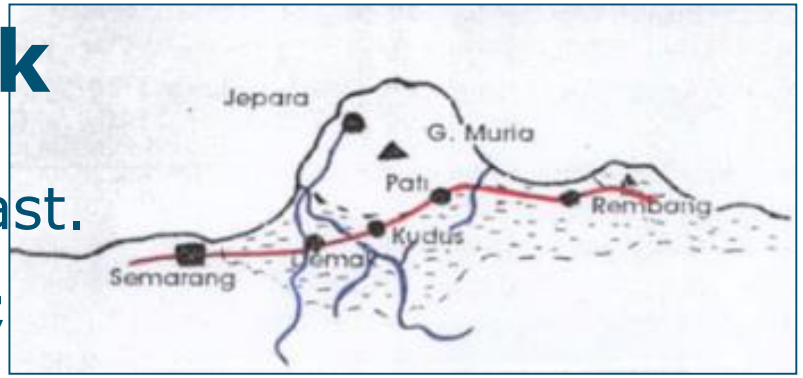
History coastal Demak



8th century: Muria, 30 km from coast.

17th c.: strait = mangrove estuary;

Navigable Semarang-Demak-Kudus-Rembang.

1892: 70% covered by mangrove.

1942: Paddies to 500 m from coast;

10% of tidal flat cove

1972: Tambak progressed, p

1980: Rice irrigation scheme

narrow coastal/riverine

1986: Shrimp culture boom

1996: Start abrasion; still se

(cc

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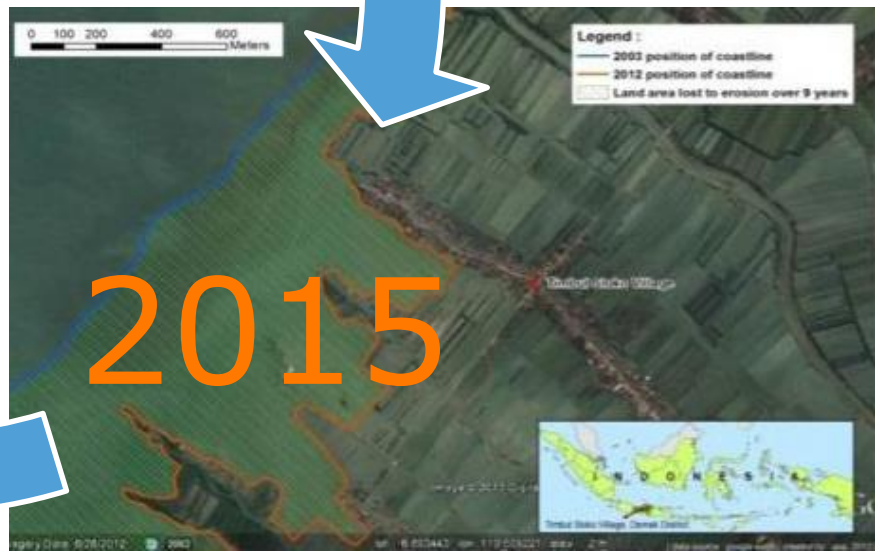
And lost within 10 year by abrasion



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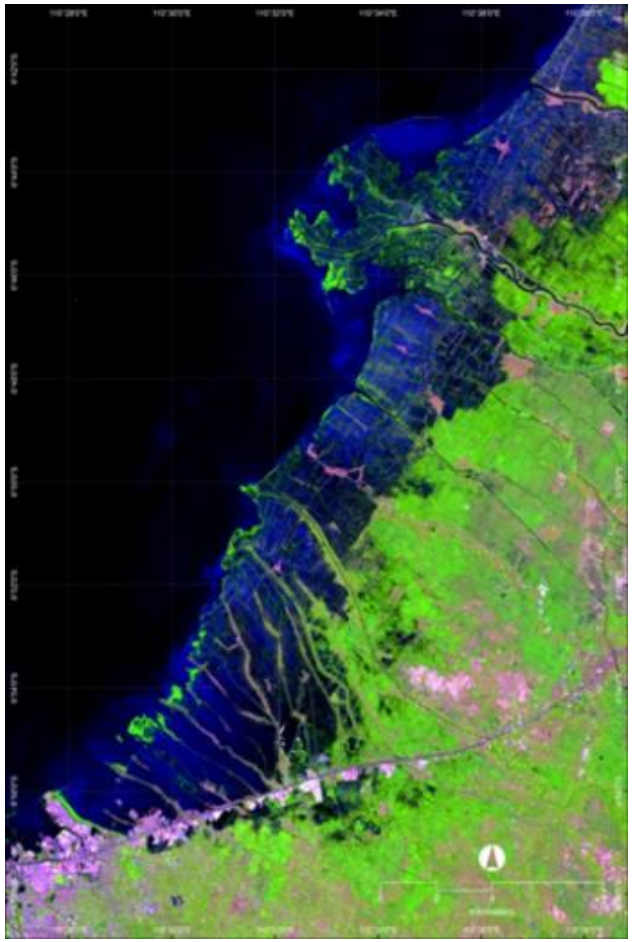
Causes for Abrasion in Demak

- Land subsidence due to groundwater abstraction:
  - ✓ Aquaculture mostly extensive with low yields,
  - ✓ Using no fresh water.
- Loss of mangrove by clearing =>
  - ✓ No sedimentation,
  - ✓ But abrasion.
- Destruction of coast
  - ✓ Mining of sand,
  - ✓ Building tambak in sea/estuary.
- Last & least: Climate change
  - ✓ Stronger storms,
  - ✓ Sea level rise.



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Land subsidence in Demak

Due to excessive water abstraction:

- ✓ mainly by industry from aquifer nourished in mountains,
- ✓ Causing subsidence of 20 to 30 cm/year.
- ✓ Four villages evacuated.
- ✓ State accepts because assumed industrial benefits,
- ✓ Without counting cost of land loss and future cost of keeping industrial zone above sea level.

Thus:

here not due to aquaculture,

but, what if benefits higher?

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In Demak, *Building with Nature* (BwN) aims to show that permeable dams recover of habitat for mangroves.

While hard structures worsen abrasion.

But motivation of ... to maintain mangrove?

Local government might not protect, and

Farmers might clear mangrove again for shrimp.

BwN proposes 3 interventions at village level:

- protect the residual mangrove,
- give up ponds along sea & rivers for mangrove habitat,
- improve aquaculture by training farmers through Coastal Field Schools, inspired on farmer field school.

What will be the benefits?

Estimated benefits of BwN interventions

Social CBA for one village Tambakbulusan (750 ha):

- investments and profits including those for fisheries,
- cost of destroyed houses and ponds, and of
- forgone benefits due to new mangrove forest and loss of land.

- Baseline: abrasion as villages that disappeared within 25 years.
- *No-intervention* scenario would cost 40 billion IDR,
  = negative contribution to GDP.
- Invest 1.2 billion IDR to:
  - *recover mangrove-only* => + 106 billion IDR
  - *improve aquaculture-only* => + 14 million IDR
- Invest 2.4 billion IDR in mangrove plus aquaculture:
  - => + *204 billion IDR.*

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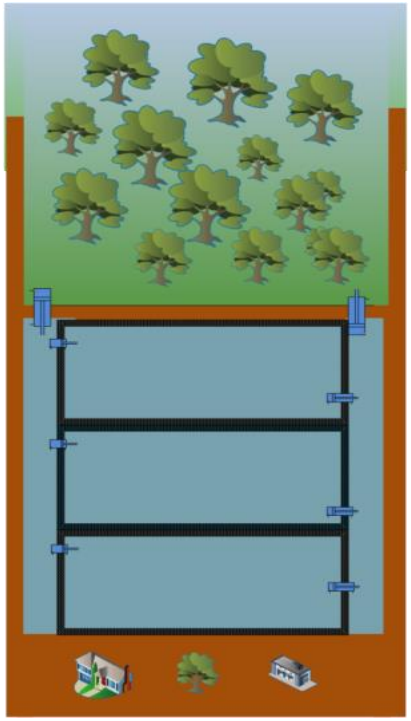
Conclusions



- Aquaculture has sustainability issues,
- Classical sylvo-aquaculture =
  - low shrimp yield and low ESS.
- Demak's coast: dominant human impact.
- Invest simultaneously in mangrove & aquaculture:
  - *recovering mangrove = climate change mitigation,*
  - *improving aquaculture = climate change adaptation,*
- Then aquaculture can support mangrove.

Thank you for your attention

Acknowledging:

- EU-Mangrove project,
- WUR-INREF RESCOPAR
- UNDIP – FPIK-Aquaculture,
- ***Building with Nature*** – Indonesia
- Bleu Forest Indonesia

DEPARTEMEN PEKERJAAN UMUM

EcoShape

Wetlands INTERNATIONAL

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Witteveen+Bos

UNESCO-IHE Institute for Water Education

Deltares Enabling Delta Life

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Building with Nature Indonesia

Securing degraded coastline for rehabilitation and revitalization of Northern coast of Java

A partnership Initiative of Indonesia - Netherlands

Coastal safety measures:

Deltares Enabling Delta Life

Witteveen + Bos

Wetlands International

Capacity building Indonesian water sector

Deltares Enabling Delta Life

UNESCO-IHE Institute for Water Education

Embedding in policy and planning:

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Sustainable aquaculture

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Implementation with/by communities:

Coastal Field Schools

Biorights approach

Wetlands International

By contractors: Witteveen + Bos

Scaling up to similar coastlines

Witteveen + Bos

EcoShape building with nature

Wetlands International