Ecosystem-based Coastal Aquaculture

To support Ecosystems and Economy

ICT-CRED 4-10-2017, Dr. ir. Roel H. BOSMA

To be cited as: Bosma RH, Hakim L, Groeneveld R, 2017. Social-Cost Benefits Analysis of Mangrove Recovery and Aquaculture Improvement in Tambakbulusan, Central Java. Forthcoming

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Content

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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 regulating ecosystem processes
4. Cultural services:
   - Non-material benefits people obtain from ES through e.g. spiritual enrichment, reflection, recreation, inspiration.

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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.).

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Regulating Services

"Benefits from regulation of ecosystem processes"

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

- Village in Demak at 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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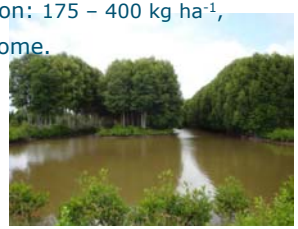
Learn from experiences - Vietnam

- 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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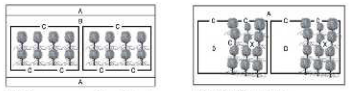
Bosma RH, Nguyen H Tin, Siahainenia AJ,Tran TP Ha & Tran Ngoc Hai, 2014. Reviews in Aquaculture 6(1)1-18

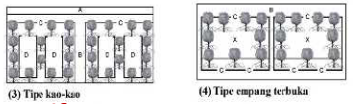
Indonesian Sylvo-Aquaculture

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

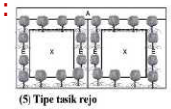
Stimulated by e.g. WWF.



✓ Limited shrimp production,
- ➢ But other products.



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



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(Puspita et al, 2005).

Sylvo-Aquaculture & ESS

- Timber & seafood,
- Habitat birds & snakes, but :
  - No inundation/drying => little diversity of mangrove.
  - Disconnected from aquatic resources, except inlet to recruit seafood seeds => no contribution to nursery.

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

⇒ their long-term effect mostly negative:

e.g. in canals roots obstruct flow => more flooding.

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

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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 sacrifice (part of) ponds to prepare water.

✓ What's the net benefit?

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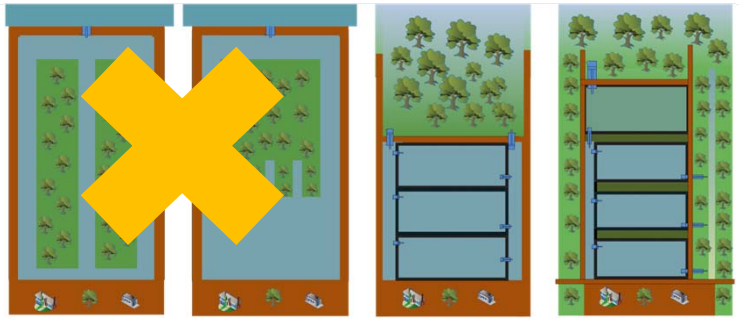
Along coast & shore: New Mangrove-Shrimp S.



- 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) for "farm" shows that:
  - Extensive shrimp: high private returns on investment, but no ESS;
  - Intensive shrimp: high yield and high risk, but ESS are lost;
  - Mixed systems has intermediate shrimp yield plus ESS:

For 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

** Bosma Roel H., Eleonora A. Tendencia and Stuart W. Bunting, 2012. Asian Fisheries Science 25, 258-269.

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.

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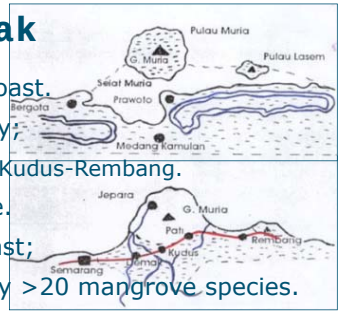
History coastal Demak



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 covered by >20 mangrove species.
1972: Tambak progressed, paddies >2km from coast.
1980: Rice irrigation scheme in Sayung, but still some narrow coastal/riverine mangrove for protection.
1986: Shrimp culture boom left a string of mangrove.
1996: Start abrasion; still sedimentation in Wulan delta

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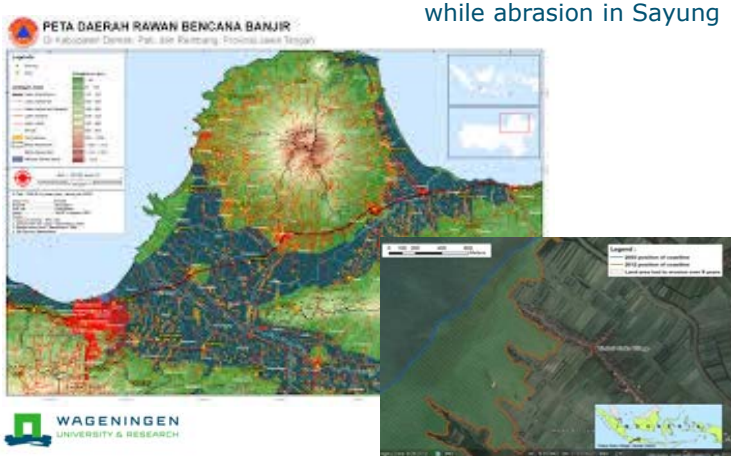
History coastal Demak

Still sedimentation out mouth of Wulan river, while abrasion in Sayung



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Land lost within 10 year by abrasion

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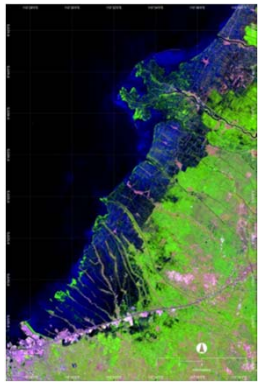
Causes for Abrasion in Demak

- Land subsidence due to groundwater use (Putranto et al; CMSE9)
  - ✓ 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 ponds in sea/estuary.
- Last & least: Climate change =>
  - ✓ Stronger storms,
  - ✓ Sea level rise.



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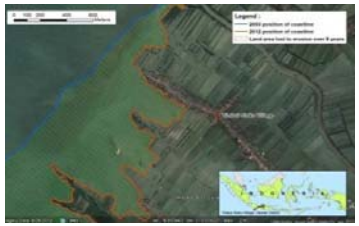
Land subsidence in Demak

Due to excessive water abstraction:

- ✓ Mainly by industry from aquifer nourished in mountains,
- ✓ Causing subsidence of 10 to 30 cm/year.
- ✓ Even poultry-broiler industry uses 5 times more fresh water than the few intensive shrimp/fish farms.
- ✓ 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 abrasion not only due to aquaculture, but how to prevent mangrove loss?



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

Ruhdi Pribadi et al (CMSE42 - 4/10)

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,
  - By building & maintaining permeable dams for 5 year;
  - Only plant mangrove when no natural recovery.
- ➢ improve aquaculture by training farmers through Coastal Field Schools, inspired on farmer field school.

What will be the benefits?

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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* => + 55 billion IDR
- *Invest 2.4 billion IDR in mangrove plus aquaculture:*
  - => + 245 billion IDR.

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BwN interventions and coastal subsidence

- Enough sediment along coast:
  - Permeable dams & mangrove catch > 10 cm / yr.
- But land inwards the subsidence continuous:
  - Small decline is good for aquaculture,
  - But all infrastructures should be higher.
  - Also industry needs to consider higher cost,
  - Even the water they pump will be come saline.
- Better prevent = make up-hill water catchments,
- Locate high water demanding industry along river.

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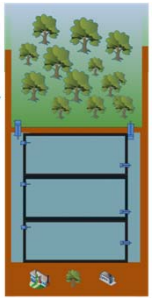
Conclusions



- Aquaculture has sustainability issues,
- Classical sylvo-aquaculture =
  - *low shrimp yield and low ESS.*
- Demak's coastal abrasion:
  - *Dominant impact from water extraction*
  - *Preventing recovery of mangrove & land.*
- **Invest in water, mangrove & aquaculture:**
  - ***recovering mangrove = climate change mitigation,***
  - ***improving aquaculture = climate change adaptation,***
- Then aquaculture can support mangrove.

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Thank you for your attention

Acknowledging:

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

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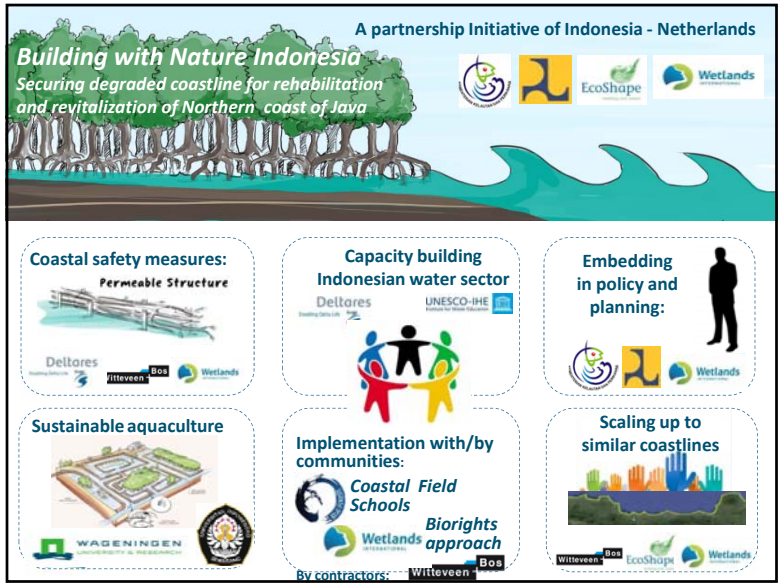
Witteveen+Bos UNESCO-IHE Institute for Water Education EcoShape Wetlands International Deltares WAGENINGEN UNIVERSITY & RESEARCH


A partnership Initiative of Indonesia - Netherlands
Building with Nature Indonesia
Securing degraded coastline for rehabilitation and revitalization of Northern coast of Java
Coastal safety measures:
Permeable Structure
Capacity building Indonesian water sector
Embedding in policy and planning:
Sustainable aquaculture
Implementation with/by communities:
Coastal Field Schools
Biorights approach
Scaling up to similar coastlines
By contractors: