ENERGY INTENSITY IN TROPICAL AQUACULTURE

Evaluation of Pangasius, Milkfish and Oyster farming using Life Cycle Assessment methodology

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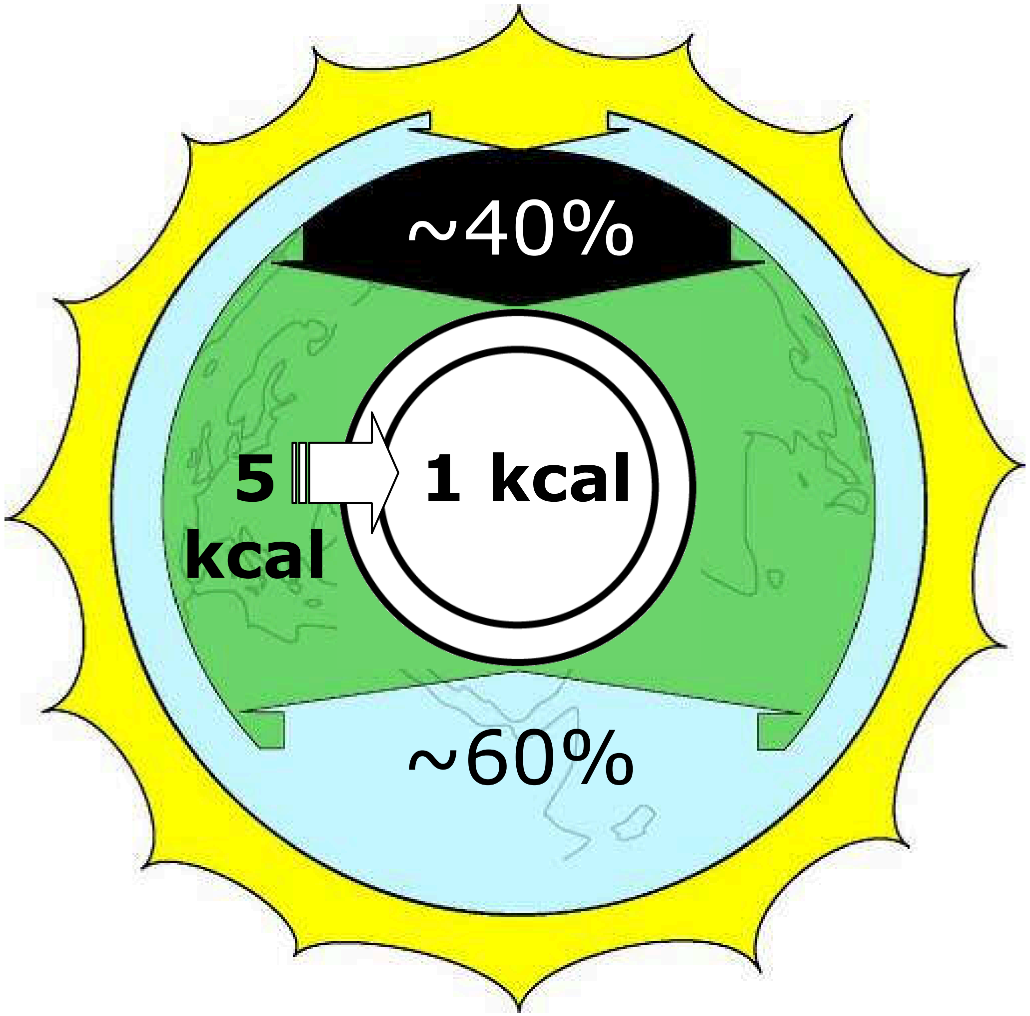
Energy intensity in food production



- 60 percent of all biomass production is utilized by man.
- This does, however, only cover ~60 percent of our energy need, the rest is derived from non-renewable sources
- The food sector accounts for 20-25 percent of the total energy consumption
- An average of 5 kcal goes into each kcal consumed

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Food at plate	MJ kg^{-1}
Beef	70
Pork	40
Chicken	35
Herring	22
Eggs	18
Bread	8.9
Soya beans	7.9
Rice	6.1
Tomatoes	5.4
Potatoes	4.6
Apples	3.5
Whole wheat	2.9
Carrots	2.7

- Sources of protein are generally more energy intensive to produce

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Introduction

- MSc, Spring 2009
- Representative farms
  - **Milkfish (*Chanos chanos*), Philippines**
  - **Pangasius catfish (*Pangasius hypophtalmus*), Vietnam**
  - **Oysters (*Crassostrea belcheri*), Thailand**
- Life Cycle Assessment approach
- Energy use as an indicator for greenhouse gas emissions, resource depletion and partial sustainability

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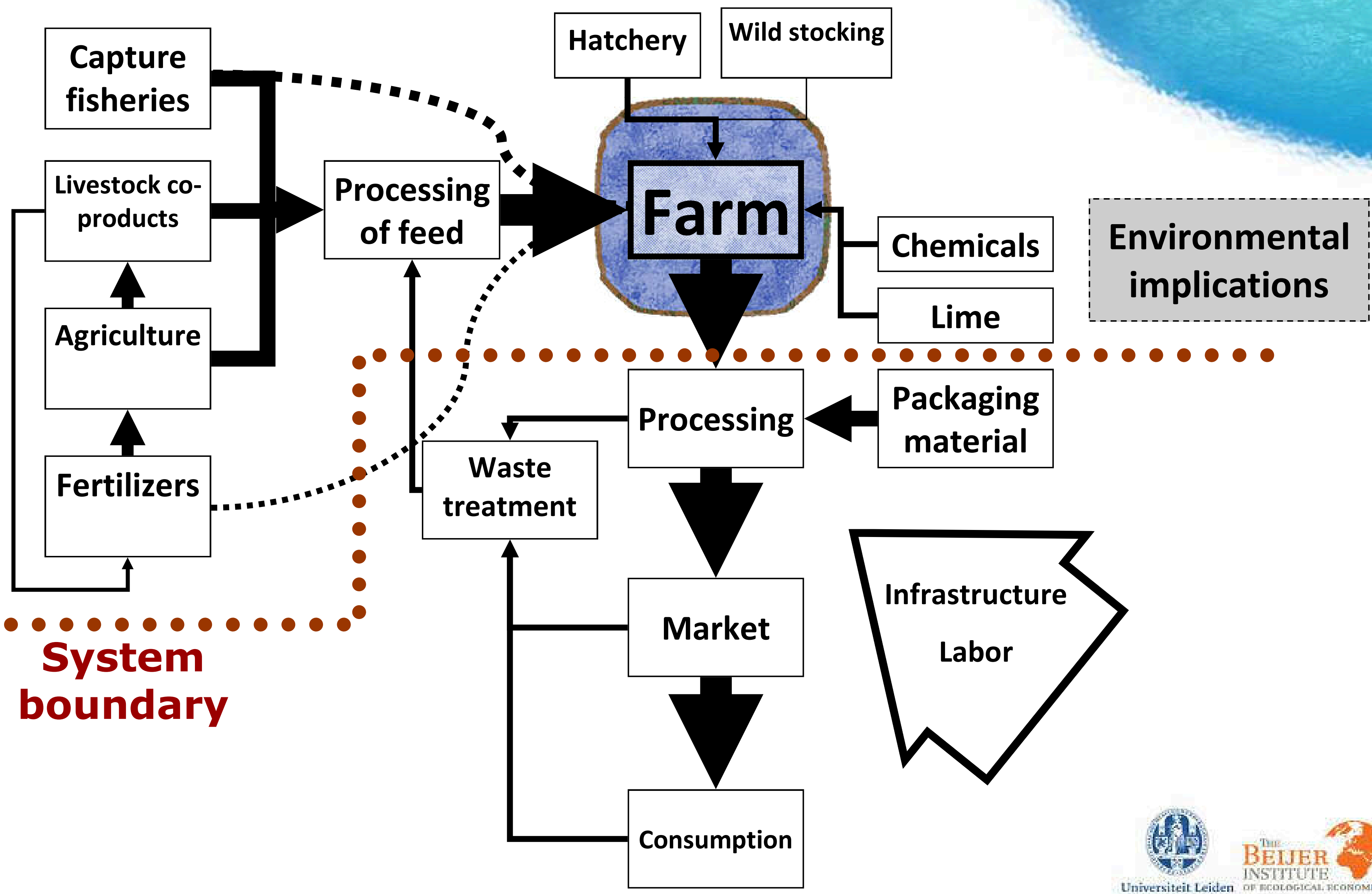
Life Cycle Assessment in aquculture

- ISO standard
- Goal and Scope
- Functional unit
- System boundary

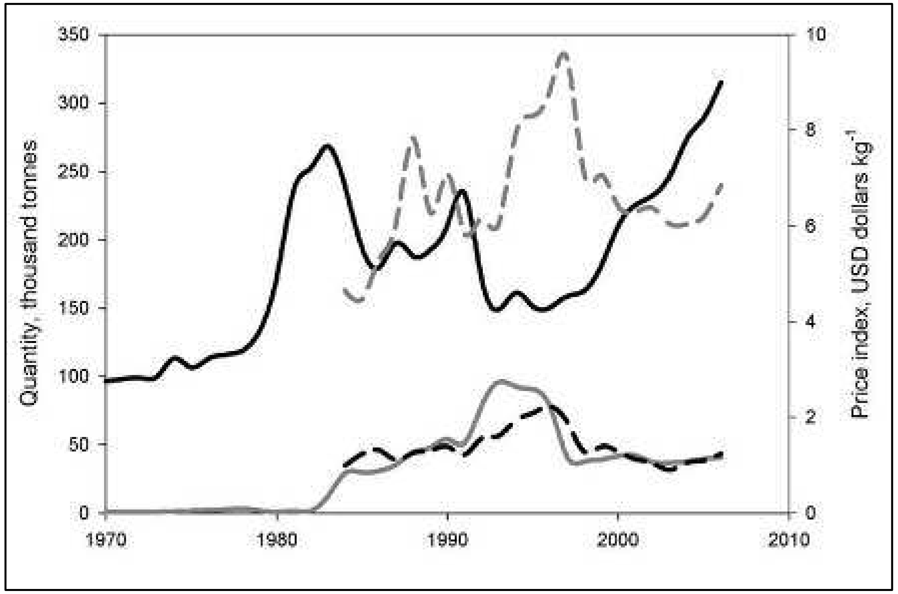
Species	Reference	Functional unit	System boundary	Allocation factor	Cumulative energy demand	Fossil fuel use	Biotic resource use	Abiotic depletion potential	Water dependence	Surface use	Global warming potential	Ozone depletion potential	Acidification	Eutrophication	Photochemical oxidant formation	Freshwater aquatic ecotoxicity	Marine aquatic ecotoxicity	Terrestrial ecotoxicity	Human toxicity	Respiratory impacts from inorganics	Cancinogens
Blue mussels	Iribarren et al. 2010	1 kg of dry edible mussel flesh	Post consumption waste	System expansion	✖			✖			✖		✖	✖	✖	✖	✖	✖	✖		
Shrimps	Mungkung 2005	1.8 kg block of frozen shrimp	Post consumption waste	Monetary				✖			✖	✖	✖	✖	✖				✖		
Rainbow trout, sea-bass and turbot	Aubin et al. 2009	1 tonne wet weight	Farmgate	Monetary	✖		✖		✖		✖		✖	✖							
Salmon, different farming methods	Ayer & Tyedmers 2009	1 tonne wet weight	Farmgate	Gross nutritional energy content	✖			✖			✖	✖	✖	✖			✖		✖		
Arctic char	Ayer & Tyedmers 2009	1 tonne wet weight	Farmgate	Gross nutritional energy content	✖			✖			✖	✖	✖	✖			✖		✖		
Atlantic salmon, different feeds	Pelletier & Tyedmers 2007	1 tonne wet weight	Farmgate	Gross nutritional energy content	✖		✖				✖		✖	✖			✖				
Trout, flow through/recirculating system	d'Orbcastel *et al.* 2009	1 tonne wet weight	Farmgate	Monetary	✖		✖		✖	✖	✖		✖	✖							
Trout	Papatryphon *et al.* 2003	1 tonne wet weight	Farmgate	Monetary	✖		✖				✖		✖	✖							
Atlantic salmon	Ellingsen and Aanondsen 2006	200 gram fillet	Processed fillets	Mass/Monetary		✖					✖	✖	✖	✖			✖			✖	✖
Atlantic salmon	Pelletier *et al.* 2009	1 tonne wet weight	Farmgate	Gross nutritional energy content	✖		✖				✖		✖	✖							

Energy consuming steps in aquaculture

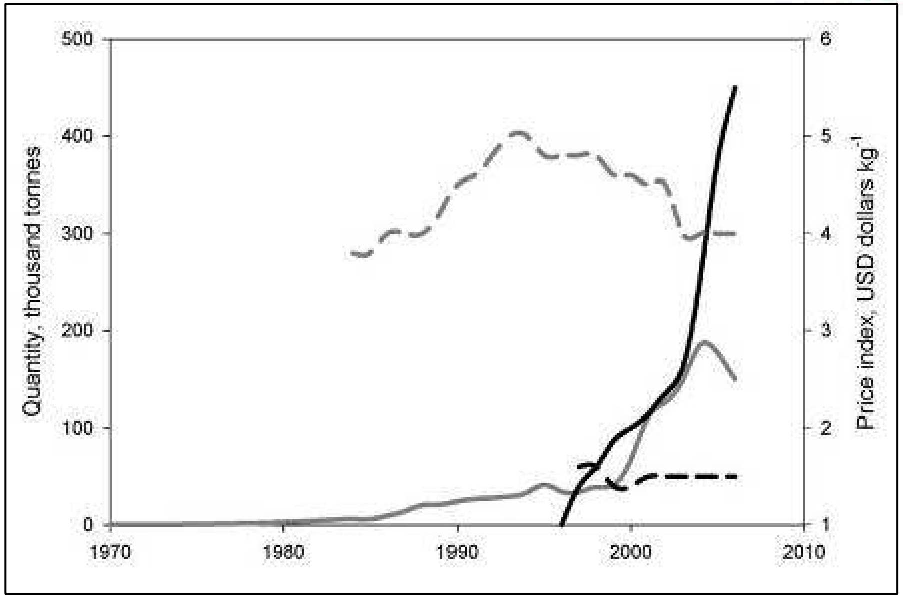


Production Trends

Milkfish, Philippines



Pangasius, Vietnam



Quantities (solid lines) and value (dashed line) for
Milkfish/Pangasius catfish (black lines) and
P. monodon (gray lines)

Source: FAO 2006

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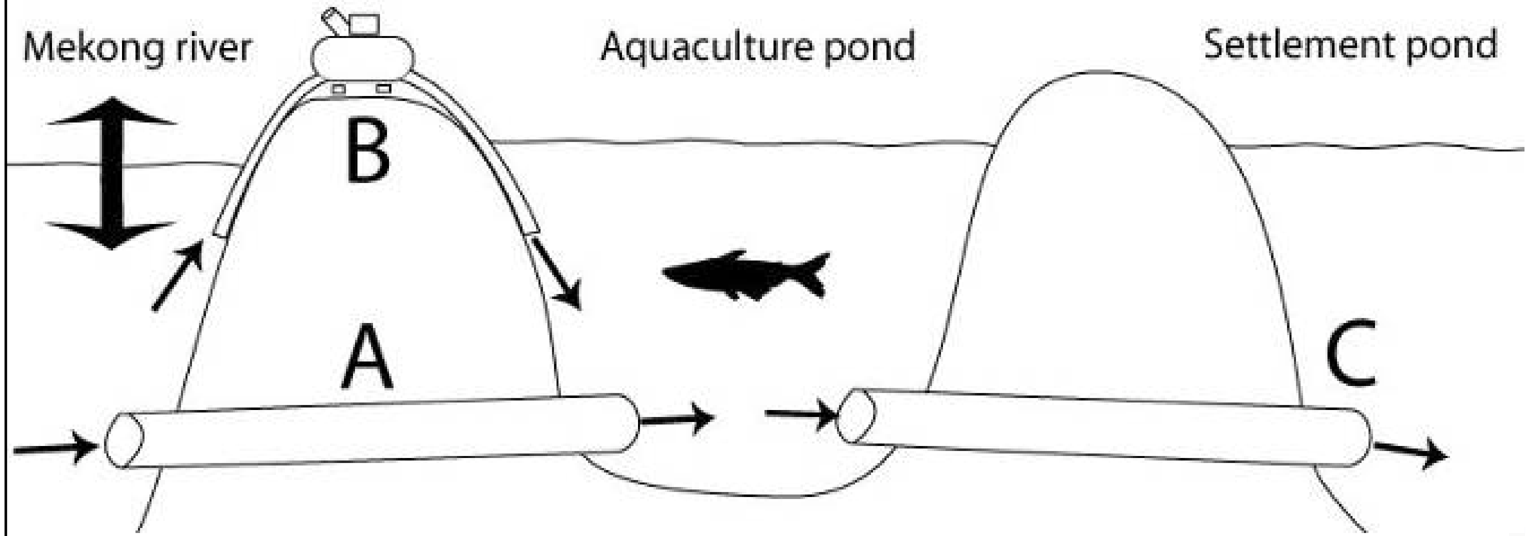
Oyster farming practices

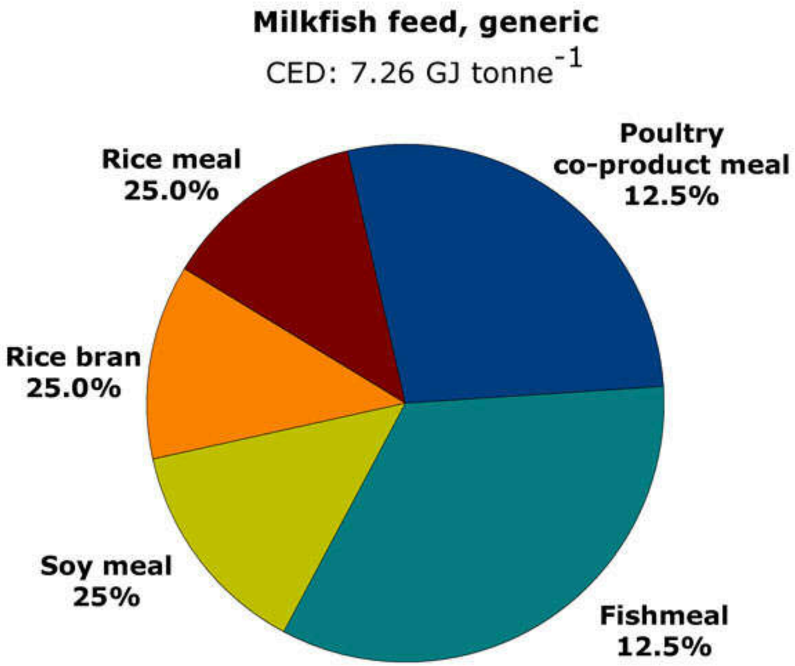
Infrastructure not included except for concrete cylinders used in oyster farming

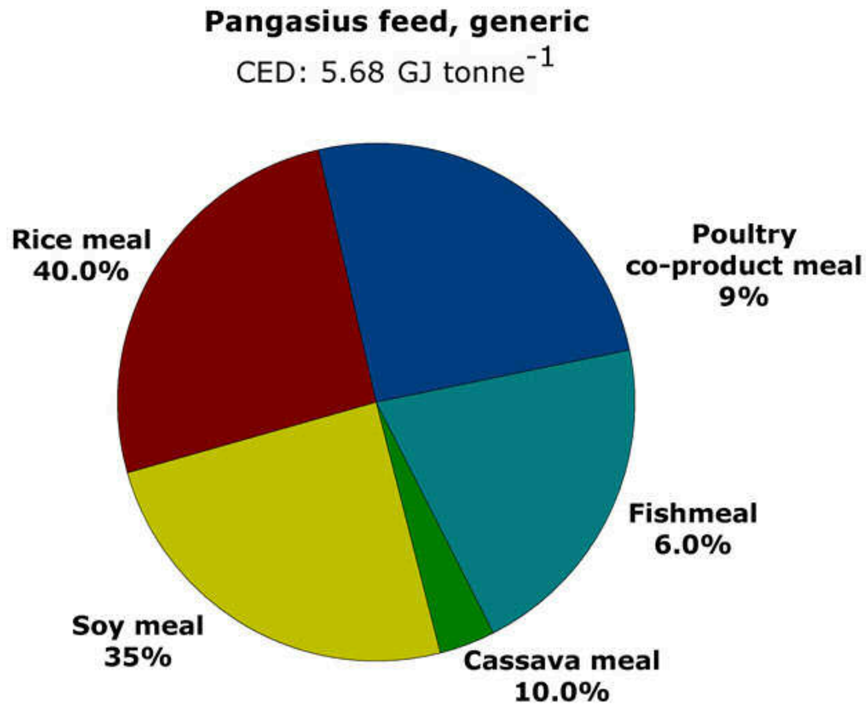
Pangasius farming practices

Water exchange differed between the two pangasius farms with one farm exchanging water through tidal movement (A) while the other used pumps to exchange water (B). Some farms grew duck weed in their settlement ponds (C).



Cumulative Energy Demand for Feed





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Results

	Milkfish extensive	Milkfish semi-intensive	Milkfish intensive	Catfish, intensive	Catfish, intensive
Location	Ramon, Philippines	Rectem, Philippines	Carcar, Philippines	Ngo Thanh Khoanh, Vietnam	Trung Thien Vietnam
System	Pond	Pond	**Cage**	Pond	Pond
Stocking density, m^{-2}	0.3	1	160	30	30
FCR	0.5	1.8	1.9	**2.0**	1.6
Main power source	Diesel	**Used cooking oil**	None	Diesel	Diesel
Annual production, tonnes	37.5	85	450	600	2000
Size of fish at harvest	300 g	300-500 g	250-300 g	1000 g	1000 g
Water supply	Tidal fed	Tidal fed	Tidal fed	Tidal fed	**Pumped**

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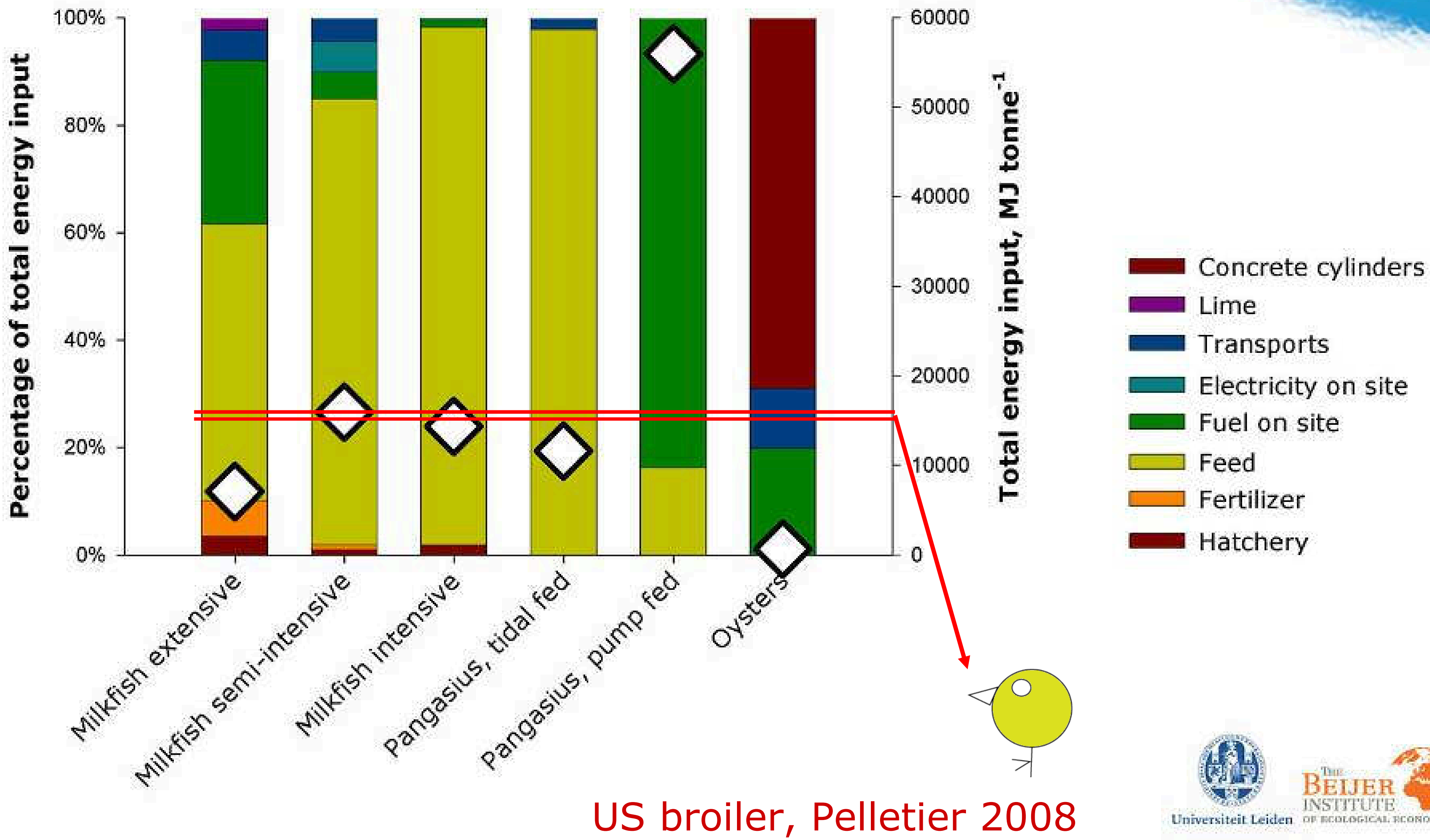
Results

Bars indicate the different inputs to the total energy demand, diamonds represent the total cumulative energy



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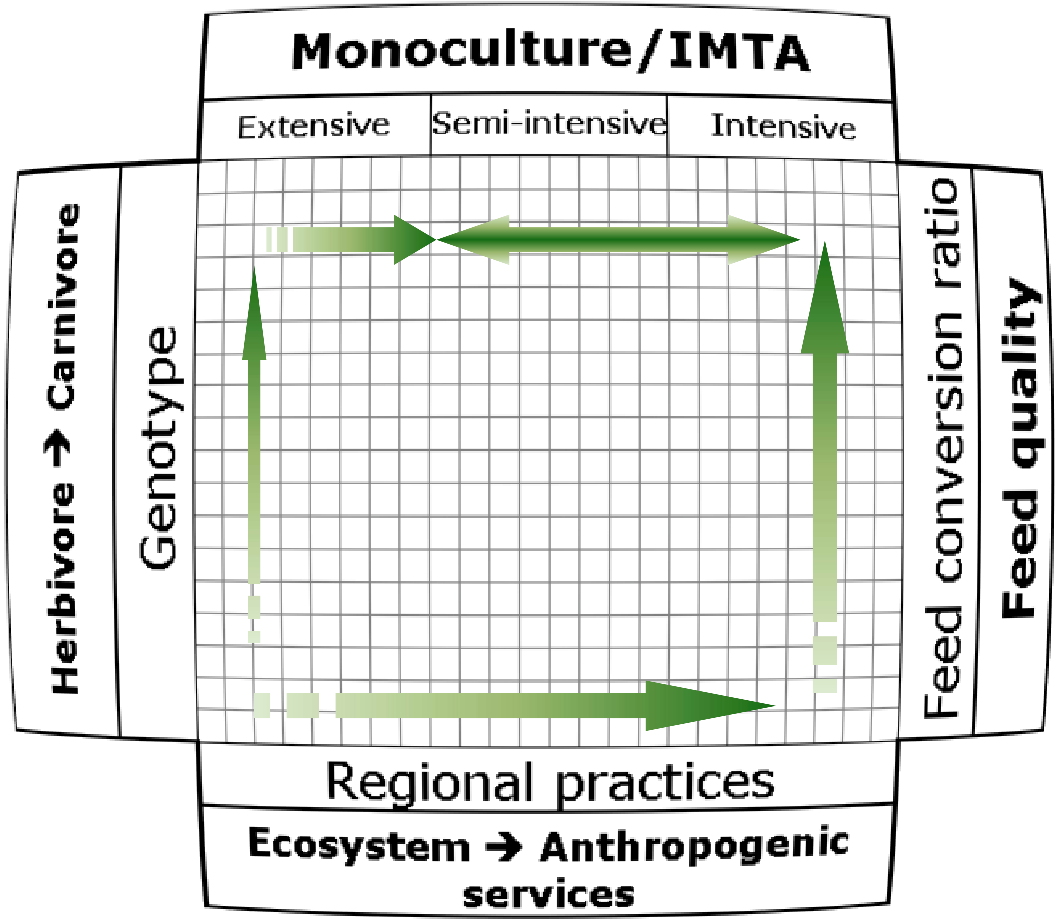
Discussion

Drivers for energy intensity in aquaculture



Factors determining the energy use in aquaculture. Feed quality and quantity are the main drivers for cumulative energy demand. Only in highly mechanized systems do farm site activities have a significant impact on the total energy use. Intensity had surprisingly little influence on the total energy demand for milkfish.

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Conclusions

- Farming intensity has little influence on the energy performance of the system compared to other factors
- Feed production is the major energy consuming practice in most aquaculture production systems
- Energy use for farm site activities can be substantial in farms where ecosystem services, to a large extent, have been replaced by anthropogenic processes
- To avoid certain environmental impacts, more consideration of different site characteristics should be considered when planning farming sites instead of implementing artificial services
- Certain environmental concerns such as the use of antibiotics, social factors, wild fish stock status are still not covered by LCA methodology

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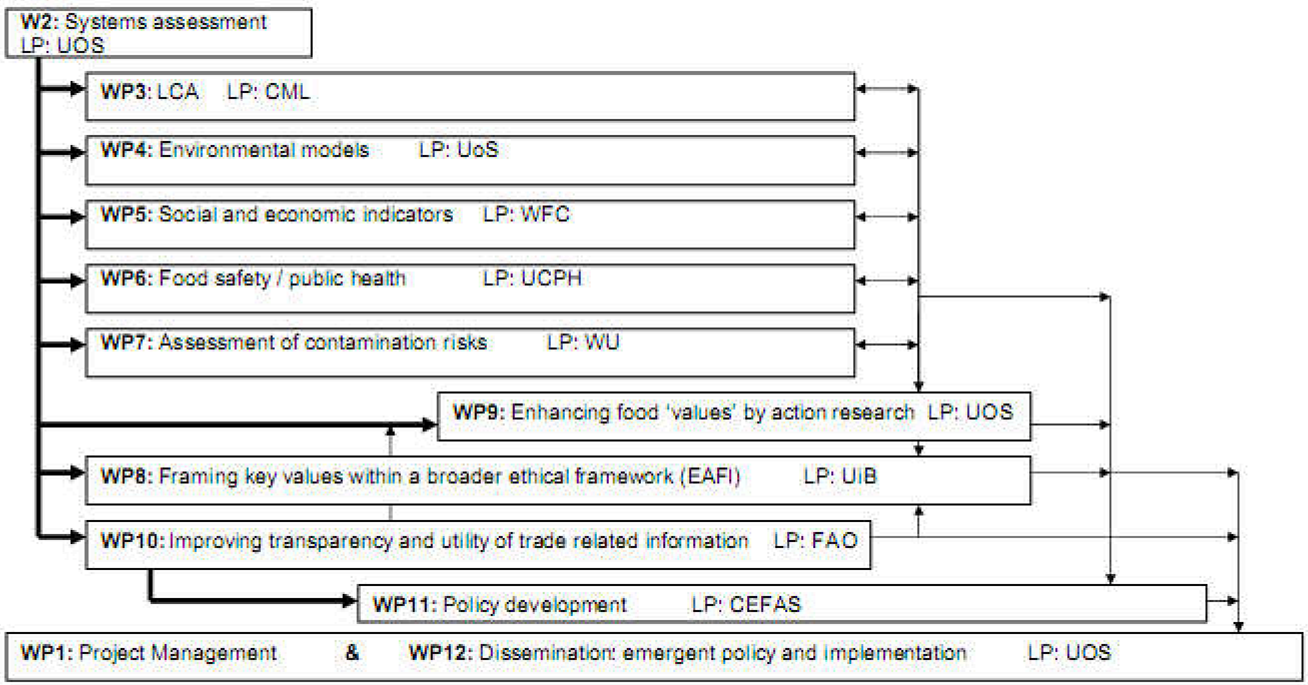
SEAT, EU FP7, www.seatglobal.eu

Country/Species	Tilapia	Pangasius Catfish	Peneid Shrimp	Macrobrachium Prawns
China	√√	√	√	?
Vietnam	√	√√	√√	(√)
Thailand	√	√	√√	√
Bangladesh	(√)	√	√√	√√
Europe	(√)	(o)	(o)	(o)

Notes: √√ - Major export industry; √ - Significant domestic industry; (√) – Limited local production/consumption; (o) - consumption only



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Questions

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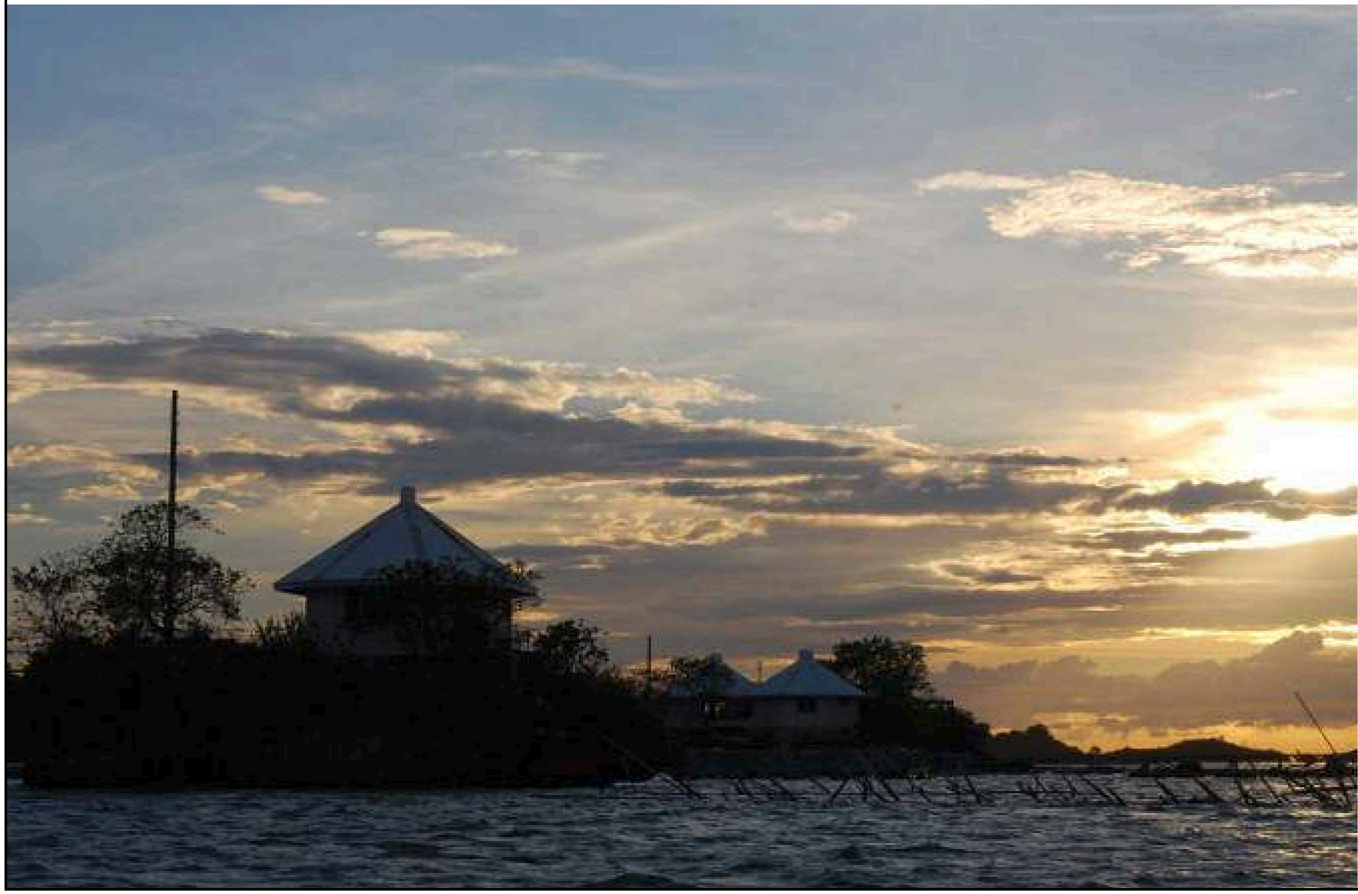

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