Seaweed farming and artisanal fisheries in an Indonesian Seagrass bed: complementary or competitive usages?

Blankenhorn, Sven & Asmus, H.

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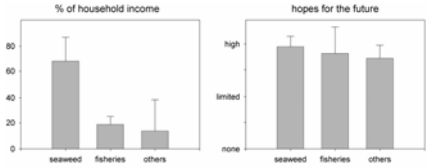
Since the 1980's, open water seaweed farming has been established many coastal communities in Indonesia . It is mostly restricted to shallow waters and their natural ecosystems, e.g. seagrass beds. They themselves are important habitats for many species of fish, shrimp and crab which are the basis for traditional fisheries. Therefore, if seaweed farming causes the seagrass ecosystem to change, its economical benefits might be outbalanced by losses in the artisanal fisheries sector. The field research for a PhD study included investigations of a) the economic importance of seaweed farming, b) the influence of seaweed farming on seagrass flora, c) the economic importance of artisanal fishery's practices and implications for management, and d) the variation in fish stock and gill net fishery in the seagrass bed of Puntondo, a small village at Laikang Bay, South Sulawesi, Indonesia.

Western part of Laikang Bay, with Puntondo on the peninsula in the centre. Note the extensive seagrass beds in shallow parts (map source: GoogleEarth)

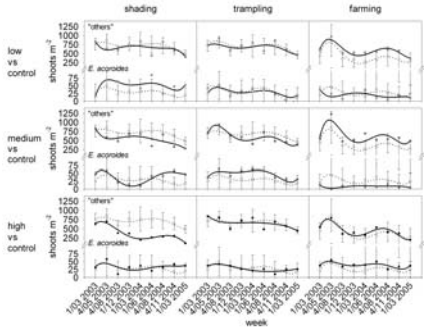
Seaweed farm at high tide. Bottles keep the cultivation lines close to the surface

Artisanal fisheries depend on healthy ecosystems

Kappaphycus alvarezii: *Freshly harvested (back) and after several days of drying*

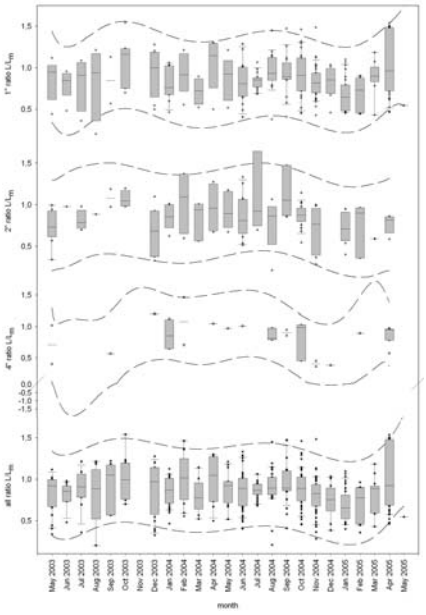


Seaweed farming contributes most to average household income. Fisheries however, is rated important by the villagers due to the daily income it creates in contrast to monthly revenues from seaweed farms. All economic activities are believed to have potential for development.



Shoot density development of Enhalus acoroides *(lower graphs) and "others"* (Cymodocea *sp. and* Thalassia hemprichii*, upper graphs) for shading and trampling on experimental plots (left and middle) and farming (right) on algae farms for different single treatment intensities. Controls with dotted, treatments with solid regression lines. Reactions varied between seagrass species. Shading with high levels reduced shoot density and biomass, trampling was only effective in combination with medium and high shading.*

Right: Evaluation of economic importance and sustainability of fisheries: high values in green, low values in red. All habitats are overfished and no method is sustainable. Nets are the most important gear , reef habitats („rock" and „coral") are the most important fishing grounds. Both are used very unsustainably. The very damaging „other methods" (e.g. spear guns, catch with bare hand) contribute very little to the local economy. P_{av}*: average length of catch in Puntondo,* L_{max}*: maximum and* L_m*: maturity length (literature data)*



Fluctuations of average L/L_m *over two years. Note non-linear scaling for 4" nets. Periodicity of catch characteristics revealed high predator densities during the night, a high percentage of mature fishes around full moon, and high abundance of immature individuals during the rainy season.*

fishing	economy: market price $\bar{x}$	economy: market price Σ	economy: economic value $\bar{x}$	economy: economic value Σ	economy: sum	sustainability: Δ fish abundance $\bar{x}$	sustainability: Δ fish abundance Σ	sustainability: ratio P_{av}/L_{max}	sustainability: ratio P_{av}/L_m	sustainability: sum	total
method											
net	0,62	1,00	1,00	1,00	3,62	-0,35	-1,00	-0,68	-0,15	-2,18	1,44
line	0,83	0,52	0,87	0,56	2,78	-0,46	-0,80	-0,50	0,17	-1,60	1,19
bagang	0,47	0,16	0,61	0,14	1,41	-0,35	-0,31	-0,73	-0,23	-1,62	-0,21
bandung	1,00	0,13	0,61	0,12	1,86	0,02	0,02	-0,58	0,00	-0,55	1,31
others	0,52	0,02	0,43	0,01	0,98	-1,00	-0,10	-1,00	-1,00	-3,10	-2,12
habitat											
rocks	0,97	1,00	1,00	1,00	3,97	-0,49	-0,71	-0,84	-0,65	-2,70	1,27
beach	0,74	0,56	0,92	0,52	2,75	-0,74	-1,00	-0,80	-0,52	-3,06	-0,31
coral	0,96	0,44	0,86	0,44	2,70	-1,00	-0,71	-0,95	-1,00	-3,66	-0,96
offshore	1,00	0,36	0,81	0,28	2,45	-0,43	-0,57	-0,55	0,47	-1,08	1,37
seagrass	0,75	0,05	0,31	0,02	1,13	-0,71	-0,09	-0,84	-0,38	-2,02	-0,89
rubble	0,38	0,04	0,16	0,02	0,60	-0,14	-0,06	-1,00	-1,03	-2,23	-1,63
mangrove	0,56	0,04	0,16	0,02	0,79	-0,14	-0,06	-0,86	-0,41	-1,47	-0,68

Potential for environmentally sustainable development of seaweed farming and fisheries

Seaweed farming is an important economical factor in Puntondo. Based on experimental data, the threshold level for a sustainable algae density was estimated to be ≈220.000 seedlings ha^{-1}. A calculation with data from seaweed farms resulted in a slightly lower level. The current farming scheme (off-bottom method, rotating farming plots, algae density approx. 110.000ha^{-1}) in the village does not directly interfere with the seagrasses below and is environmentally sustainable. However, efforts to increase production should focus on alternative farming methods and areas and on improving post-harvest processing. Catches with gill nets indicated that the seagrass bed experienced periodic migrations into it. Fisheries in the seagrass however, did not contribute significantly to the income from this sector, and the most important fish families do not directly depend on seagrass habitats. Minor changes in seagrass vegetation are therefore not expected to influence fisheries. Some fishing methods proofed to be very unsustainable and all fishing grounds were over fished. Regulation of those methods and seasonal closure of habitats seems inevitable to sustain and develop artisanal fisheries in the area.

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