Third-World Aquaculture and the Environment

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The future well-being of the third world's burgeoning population will depend upon a much wiser balance between exploitation and conservation of natural resources than has been achieved to date. Food production and the livelihood of food producers and workers in associated industries must come from appropriate *sustainable* systems that avoid environmental harm. 'Environment' is defined here very broadly: human ecology in relation to living and nonliving natural resources.

Food production invariably has environmental effects: occupation and fragmentation of former natural habitats; reduction of the abundance and diversity of wildlife and changes in soil, water and landscape quality. Such effects are contributing to and will continue to be major factors in global climatic changes. Agriculture will remain the mainstay of most third-world economies for the foreseeable future and will cause much environmental change. Therefore a *balanced view* is essential in assessing the environmental aspects of third-world aquaculture development: a view that is realistic in relation to human needs and also fair in comparison with that applied to agriculture.

Aquaculture is relatively new and strange for many organizations concerned with third-world development and may be misconceived from impressions and advice gleaned mainly from the intensive commercial aquaculture systems typical of the 'North'. Most agriculturists are unaware of the merits of aquatic food production, particularly its high efficiency and scope for integration with third-world agriculture.

The Special Nature of Aquaculture

Aquaculture is not easy, especially where it has no continuous tradition. It has a far weaker technological base than agriculture. Moreover, the aquatic medium is in direct and intimate contact with the metabolic processes of fish and its composition/quality are crucial factors in fish health and culture performance.

The aquatic medium is shared by many users and supports diverse fauna and flora. As aquaculturists develop better domesticated breeds, international demand for these will increase. This means increased transfers of exotic breeds, as has been of immense benefit for crop and livestock farming. However, cultured aquatic organisms often escape and form feral populations which may: 1. displace or interbreed with wild stocks, thereby threatening natural genetic resources; 2. disrupt natural habitats by causing proliferation or clearance of vegetation or increasing turbidity (benthic foraging); and 3. introduce aquatic pathogens, predators and pests inadvertently. Here again a *balanced view* is essential, weighing the benefits of using exotic breeds against possible environmental consequences. Development projects often use exotic breeds without

Typical Southeast Asian rice-based farming systems. Aquaculture, well-integrated with such systems, has little or no adverse environmental impact.

Photos by Roger S.V. Pullin

Mangroves being cleared to make a coastal shrimp pond. The loss of the environmental benefits of mangrove ecosystems is rarely considered by those joining the current boom in shrimp culture.

careful appraisal of the possible consequences. Such 'experiments' (usually bilateral) may have multilateral consequences: loss or damage to habitats and genetic resources of global importance. It is encouraging that Codes of Practice to avoid this have recently been developed, but aquaculture development still lags behind agriculture in recognition of the risks of transfers and international adoption of safeguards.

Third-World Aquaculture Systems and Environmental Considerations

The environmental impact of different aquaculture systems and the associated benefits for producers are summarized in the box.

Extensive Aquaculture

Seaweed culture may occupy formerly pristine coral reef or other nearshore ecosystems and can be economically risky. Culture of most bivalves risks spoilage of produce by red tides, fecal contamination and industrial pollution. More attention must be given to bivalve farm siting, pollution control and quality control of produce, ideally incorporating depuration.

The disadvantages of extensive fishponds are related to the loss of valuable natural ecosystems (especially mangroves) for their construction and their low yields, against a background of high population growth and multiple use requirements.

Extensive pen and cage culture is very difficult to manage for equitable distribution of benefits. Pens and cages may exclude fishermen from previously open waters and restrict navigation, causing serious conflicts. Moreover, they consume large quantities of wood, usually bamboo which rots after about two years. This demand can have positive effects (additional income, employment, stopping erosion) but may also bring localized deforestation.

Semi-intensive Aquaculture

This includes most systems of current and future importance in developing countries. The inputs (fish feeds and fertilizers) available to farmers include: vegetation, fresh or composted; human and livestock excreta; chemical fertilizers (N-P-K formulations or urea, which is increasingly affordable by small-scale farmers); cereal brans and oil cakes.

Third-world semi-intensive aquaculture is not typical 'Northern' style feedlot technology. This is important as it is the high throughput of the feedstuffs necessary for intensive feedlot systems that create environmental pollution. Semi-intensive systems in synergy with agriculture (crop-livestock-fish integrated farming) capitalize on *in situ*, vitamin and protein rich *natural* aquatic feeds, which obviate the need for expensive feed components.

Semi-intensive freshwater ponds have no serious environmental effects other than their occupation of former natural habitats. In the tropics, where there is fast turnover of organic waste loading, their effluents and excavated muds usually enhance the productivity of adjacent waters and lands. They are multipurpose water stores, rather than competitors for scarce land and water, especially in rainfed areas. Special care is needed, however, where pond and dike construction may disturb acid sulfate subsoils and where water table changes may uplift subsurface salts. Moreover, saltwater intrusion from coastal ponds may poison soils and freshwater aquifers.

Freshwater ponds may assist the spread of waterborne diseases. Ponds may harbor the intermediate hosts of helminth parasites, such as *Schistosoma* and *Opisthorchis* and mosquito larvae. These problems can be minimized in well-managed, weed-free, well-stocked ponds. In African ponds used for water supply, Guinea worm can be controlled by boiling or filtering water. However, fish farm workers risk bilharzia infection in infected areas and waterborne microbial diseases (viral, leptospiral, bacterial and fungal).

Integrated agriculture-aquaculture generally has no special health risks significantly greater than agriculture. There has been some debate on zoonoses in livestock-fish systems, including possible virological risks from pig-poultry-fish culture. However, these are rare possibilities. Most pathogens and parasites that contaminate fish produce from livestock excreta-fed ponds are eliminated by the pond environment, as in sewage oxidation ponds. Problems of pesticide accumulation in ricefield fish are diminishing through integrated pest management programs that use natural substances and predators. Moreover, the most successful rice-fish systems are nursery systems supplying fingerlings for further growout in ponds and cages. The risk of accumulation of heavy metals from livestock feeds in pond sediments and fish is slight and applies more to intensive systems. The same probably applies to pathways for aflatoxins, but this has been little studied.

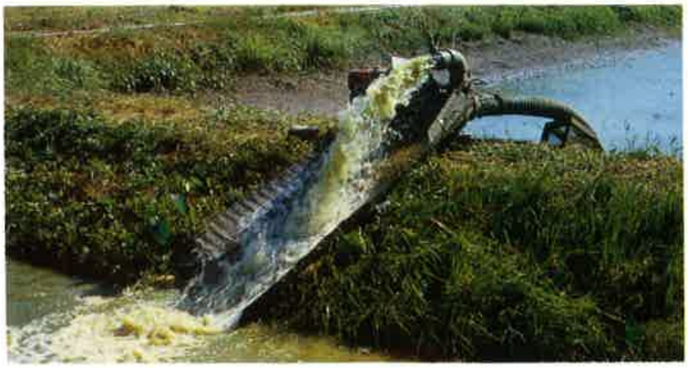
Sewage fish culture is controversial because of assumed health risks to farm workers and fish consumers. However, the risks may be insignificant, provided that postharvest handling is hygienic and produce is well-cooked. In China, large quantities of fish and vegetables are raised on human excreta. A recent study[a] at the Asian Institute of Technology, Bangkok, in which septage (slurry from

[a]Edwards P., C. Polprasert and K.L. Wee. 1987. Resource recovery and health aspects of sanitation. AIT Research Report No. 205. 324 p. Environmental Sanitation Information Center, Asian Institute of Technology, P.O. Box 2754, Bangkok, Thailand.

Third-World Aquaculture Systems: Environmental Impact and Benefits for Producers

Extensive systems are defined as having no feed or fertilizer inputs; semi-intensive systems as having some feed and/or fertilizer inputs; and intensive systems as being mainly reliant on external feed inputs. The possible consequences of exotic breed transfers apply to all systems listed here (see text).

System	Environmental Impact	Benefits
EXTENSIVE		
1. Seaweed culture	May occupy formerly pristine reefs; rough weather losses; market competition; conflicts/failures, social disruption.	Income; employment; foreign exchange
2. Coastal bivalve culture (mussels, oysters, clams, cockles)	Public health risks and consumer resistance (microbial diseases, red tides, industrial industrial pollution); rough weather losses; seed shortages; market competition especially for export produce; failures, social disruption.	Income; employment; foreign exchange; directly improved nutrition
3. Coastal fishponds (mullets, milkfish, shrimps, tilapias)	Destruction of ecosystems, especially mangroves; increasingly non-competitive with more intensive systems; nonsustainable with high population growth; conflicts/failures, social disruption.	Income, employment, foreign exchange (shrimps); directly improved nutrition
4. Pen and cage culture in eutrophic waters and/or rich benthos (carps, catfish, milkfish tilapias)	Exclusion of traditional fishermen; navigational hazards; conflicts, social disruption; management difficulties; wood consumption.	Income; employment; directly improved nutrition
SEMI-INTENSIVE		
1. Fresh- and brackishwater ponds (shrimps and prawns, carps, catfish, milkfish, mullets, tilapias)	Freshwater: health risks to farm workers from waterbone diseases. Brackishwater: salinization/acidification of soils/aquifers. Both: market competition, especially for export produce; feed and fertilizer availability/prices; conflicts/failures, social disruption.	Income; employment; foreign exchange (shrimps and prawns); directly improved nutrition
2. Integrated agriculture-aquaculture (rice-fish; livestock/poultry-fish; vegetables - fish and all combinations of these)	As freshwater above, plus possible consumer resistance to excreta-fed produce; competition from other users of inputs such as livestock excreta and cereal brans; toxic substances in livestock feeds (e.g., heavy metals) may accumulate in pond sediments and fish; pesticides may accumulate in fish.	Income; employment; directly improved nutrition; synergistic interactions between crop, livestock, vegetable and fish components; recycles on-farm residues and other cheap resources.
3. Sewage-fish culture (waste treatment ponds; latrine wastes and septage used as pond inputs; fish cages in wastewater channels)	Possible health risks to farm workers, fish processors and consumers; consumer resistance to produce.	Income; employment; directly improved nutrition; turns waste disposal liabilities into productive assets
4. Cage and pen culture, especially in eutrophic waters or on rich benthos (carps, catfish, milkfish, tilapias)	As extensive cage and pen systems above.	Income; employment; directly improved nutrition
INTENSIVE		
1. Freshwater, brackishwater and marine ponds (shrimps; fish, especially carnivores - catfish, snakeheads, groupers, seabass, etc.	Effluents/drainage high in BOD and suspended solids; market competition, especially for export product; conflicts/failures, social disruption.	Income; employment; foreign exchange
2. Freshwater, brackishwater and marine cage and pen culture (finfish, especially carnivores - groupers, seabass, etc. - but also some omnivores such as common carp)	Accumulation of anoxic sediments below cages due to fecal and waste feed build-up; market competition, especially for export produce; conflicts/failures, social disruption; consumption of wood and other materials.	Income; foreign exchange (high priced carnivores); a little employment
3. Other - raceways, silos, tanks, etc.	Effluents/drainage high in BOD and suspended solids; many location-specific problems	Income; foreign exchange; a little employment



Two effluents from tropical fish ponds at harvest time. ***(Left)*** **Green water from a semi-intensive manured tilapia/carp polyculture pond goes out to surrounding watercourses and ricelands;** ***(Right)*** **Black anoxic water from an intensive snakehead (*Channa striata*) farm.**

Environmental impact of aquatic exotic species: they always escape. ***(Left)*** **Water hyacinth, a worldwide nuisance in the tropics and subtropics, approaching a barrier designed to protect fish pens and cages from being smothered by it (Laguna de Bay, Philippines);** ***(Right)*** **Nile tilapia (*Oreochromis niloticus*), an escapee from aquaculture in the rivers of Northern Luzon, Philippines. *O. niloticus*, has not been charged with adverse environmental impact in Asia, as has the original tilapia that was spread far and wide (*O. mosssambicus*); but in Africa, tilapia transfers (including those of *O. niloticus*) threaten the future availability of wild genetic resources.**

septic tanks) was used to grow fish biomass for predatory fish (inserting a trophic step between inputs and final produce) concluded that both the predatory fish and the biomass fish were safe for human consumption. Excreta reuse through aquaculture may be a less environmentally harmful disposal method than other options. It should also be more feasible in developing countries where sewage wastes and wastewater are less mixed with detergents, heavy metals and other chemicals than in industrialized countries, though this is a worldwide constraint.

Semi-intensive cage and pen culture is unlikely to cause serious pollution problems as those associated with more intensive systems (see *Intensive Aquaculture* below). However, their economic attractiveness may start 'goldrushes': proliferation to such an extent that natural feeding becomes virtually exhausted; reliance on feed inputs increases and the systems become more intensive. As the carrying capacity of the water is approached or exceeded, the chances of fish kills from low dissolved oxygen greatly increase.

Intensive Aquaculture

Intensive aquaculture has been very successful in developed countries (e.g., catfish and salmonid culture), much less so in developing countries apart from exceptions such as catfish and snakehead culture in Thailand. It is highly capital-intensive and usually beyond the reach of the most numerous and needy developing-country target group, the small-scale farmers, whose produce feeds rural and urban populations.

Intensive aquaculture carries much greater risks of serious aquatic disease outbreaks than extensive or semi-intensive aquaculture. Intensive farms may act as reservoirs of infection threatening other farmed and wild populations. Intensive systems have greater needs for water treatment chemicals and drugs for disease prophylaxis and treatment. Misuse of these could have serious consequences: e.g. pollution of adjacent waters and development of resistant strains of human pathogens. The evolution of chloramphenicol-resistant bacteria through its use in fish culture would be a catastrophe with respect to typhoid treatment. Intensive hatcheries are heavy users of antibiotics and disinfectants and their operators need to be aware of the dangers of release of such chemicals to the natural environment including the possibilities of producing drug-resistant pathogens.

Pollution by intensive aquaculture is well-known. Fish fecal wastes and uneaten food in effluents and in settlement from cages have high BODs and contain large quantities of particulate matter. These can cause water quality deterioration and the buildup of anoxic sediments. Therefore careful site selection and strict management are essential. Stringent standards for effluents and environmental protection have been established in some countries. ●