

INTEGRATED FISH FARMING STRATEGIES

Ruth Garcia Gomez
FIRA Service, FAO
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Outline:

- Definition
- Historical overview
- Major Types of Integrated Aquaculture Systems:
  - Integrated Agriculture and Aquaculture
  - Integrated Irrigation and Aquaculture
  - Waste water use in fish culture, public health considerations
- Environmental considerations
- Conclusions
- FIRA Normative and Field Activities

INTEGRATED FISH FARMING STRATEGIES

URBAN APPROACH:

- The pressure put on land, water by the urbanization process puts urban and periurban food production at risk.
- Integrated fish farming strategies could be regarded as an alternative for efficient utilization of available resources, waste recycling and energy saving, and for maintaining ecological balance and circulation.

- On the other hand, the scope of urban and periurban aquaculture is limited due to:
  - water availability
  - water quality
  - multiple use of water

Definition:

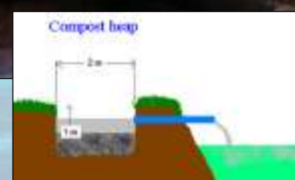
Integrated aquaculture is the **concurrent or sequential** linkage between two or more farm activities, of **which at least one is aquaculture**.

Main Objective:

Increase the productivity of water, land and associated resources while contributing to increased food fish production.

Definition:

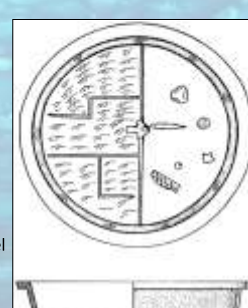
Integrated fish farming systems refer to the production, integrated management and comprehensive use of aquaculture, agriculture and livestock, with an emphasis on aquaculture.



Historical overview:

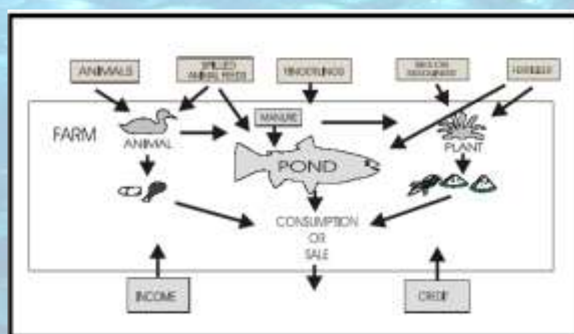
- First integrated aquaculture systems (IIA/rice-fish farming): China, 2000 years ago;
- India: about 1500 years ago;
- In the fifties of the 19th century integrated fish farming practices were transferred from China to Japan;
- Integrated aquaculture systems have been practiced in Russia since 1850 and in Madagascar since 1914.

Rice fish culture Chinese model



Integrated Agriculture and Aquaculture:

The main linkages between agro-livestock activities and fish culture involve the **direct use of crop/livestock wastes, as well as the recycling of crop or manure-based nutrients** which function as fertilizers to stimulate natural food webs.



Farm animal waste output:

	Pigs	Hens	Ducks	Cattle	Horses	Sheep
Animal weight(kg)	55	2	3	500	380	30
Kg wet waste/animal/day	8	0.7	1.0	30	24	2.1
% faeces	45	-	-	70	70	66
% urine	53	-	-	30	30	34

Composition of livestock waste used in fish culture:

	As % of	Pork Pig	Laying hens	Feedlot Beef	Sheep	Cattle
Total wet wastes (TWW)	TLW/d	5.1	6.6	4.6	3.6	9.4
Total solids (TS)	TWW TLW/d	13.5 0.69	25.3 1.68	17.2 0.7	29.7 1.07	9.3 0.89
N	TS TLW/d	5.6 0.039	5.9 0.099	7.8 0.055	4.0 0.043	4.0 0.036
P	TS TLW/d	1.1 0.007	2.0 0.034	0.5 0.035	0.6 0.007	0.5 0.004
K	TS TLW/d	1.2 0.008	1.7 0.029	1.5 0.011	2.4 0.026	1.4 0.012

Integrated Agriculture and Aquaculture:

SOME PRACTICAL EXAMPLES:

Manure to be applied before stocking:

Cow dung — **60-80Kg/100m²**
or Wet Pig manure — **20-35kg/100m²**
or Chicken/Duck manure — **10-15kg/100m²**
or Green Manure — **20-30kg/100m²**

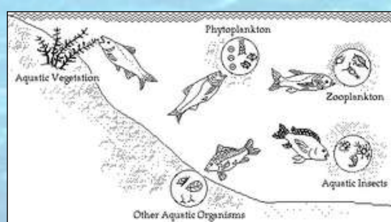
Duck/fish culture system:

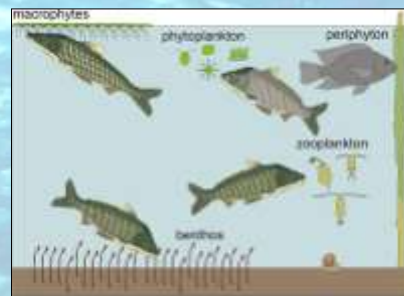
Extensive rising, in which only small amount of supplementary duck feed is provided and the number of ducks is limited by the food they can find in the pond water (150-500 ducks/ha).

Intensive raising , in which the ducks are fed at the same rates as on land and held at a much higher densities per unit of pond area (750-1300) ducks/ha).

In China, fish yields of approximately 3500 kg fish/ha/year without addition fertilization or supplementary feeding have been achieved by raising up to 1500 ducks/ha.

Integrated Agriculture and Aquaculture:





Policulture systems:

Different species/different feeding habits/several tropic niches = multitrophic approach

Integration of Irrigation and Aquaculture:

Raising fish in irrigation systems is a fundamental part of adopting a multiple use approach **to using water more efficiently.**

As water become a resource under pressure, stocking fish within the physical structures used to capture, store and transfer water increases overall benefits.

Aquaculture is a productive, non-consumptive use of water that does not compete with irrigation.

Integration of Irrigation and Aquaculture:

Inside the city and in the periphery, integration of aquaculture into irrigation systems may contribute to a more efficient use of scarce freshwater resources.

There is always a need to consider limitations and constraints:

- Water availability...aquaculture is more demanding than irrigated crops in terms of continuity of water supply.
- Water quality...loads of agrochemicals in return flows from agriculture, industry.
- Technical feasibility...effect of aquaculture structures on water conveyance in the canals.

Integration of Irrigation and Aquaculture:

Water quality standards for finfish

Water variants	Acceptable levels for fish culture	Levels in wate where fish kills have occurred
Oxygen	>6ppm, up to 100%	<3ppm, >100% sat.
Carbon dioxide	1.5 - 3.0 ppm	>15ppm
PH	6.7 - 8.6	<4-5, >9-10
Ammonia (unionised)	<0.02 ppm	>0.2- 1.0 ppm
Nitrate	<1.0 ppm	>100 ppm
Nitrite	<0.1 ppm	>2.0 ppm (fresh)
		>20 ppm (salt)
Total hardness	20 - 200 ppm	>200 ppm (CO_2 excess)
Salinity		>800 ppm (all causes)
Total suspended solids	<80 ppm	>5000-100,000 ppm
Total dissolved solids	<400 ppm	>5000-20,00 ppm
Hydrogen disulphide	<0.002 ppm	>0.5-10 ppm
Heavy metals		
Aluminium	–	>0.1-5 ppm (low pH)
Cadmium	<0.005 ppm soft water	>3 ppm
	<0.003 ppm hard water	
Copper	<0.006 ppm	>0.5 ppm
Mercury	<0.0002 ppm	>0.15 ppm
Lead	<0.02 ppm	>1-5 ppm
Zinc	<0.005 ppm	>0.5-1.0 ppm

Water variants	Acceptable levels for fish culture	Levels in wate where fish kills have occurred
Pollutants / Organochlorine pesticides		
Endrin	<0.003ppb	>0.0003-0.002 ppm
Endosulphan	<0.01 ppb	>0.01 ppm
Aldrin	<0.01 ppb	>0.013-0.06 ppm
Dieldrin	<0.005 ppb	>0.01-0.07ppm
Chlordane	<0.004 ppb	>0.02-0.08 ppm
DDT	<0.003 ppb	>0.008-0.027ppm
Organophosphate pesticides		
Diazinon	<0.002 ppb	>0.2-5.2 ppm
Malathion	<0.008 ppm	>0.1-30 ppm
Trichlorphon	<0.001 ppb	>0.8-100 ppm
Pyrethrin insecticides	<0.001ppb	>0.0006-0.001 ppm
Rotenone piscicides	0.5-4ppm (16-22°C)	
Algicides / herbicides		
Chlorine	<0.003 ppm	>0.1-4.0 ppm
Copper sulphate	<0.002 (max)	>0.14 ppm
Glyphosate (Round-up)	-	>10-130 ppm
Lime (CaO, $Ca(OH)_2$)	-	causing pH >9-10
2,4-D	<0.004	>2.0-100 ppm
Simazine	<0.01ppm	>10 ppm
Diesel oils, car oils	-	>50-100 ppm
Nicotine	-	>1 ppm
Detergents	<0.1 ppm	>4.0 ppm

Integration of Irrigation and Aquaculture:

Rice fish farming is among the most popular integrated aquaculture system.

A rice field is by design intended for rice and therefore conditions are not always optimum for fish… e.g. rice does not necessarily need standing water at all times to survive.

PARAMETER	NORMAL RANGE	
	RICE	FISH
1. Depth of Water	Minimum: saturated soils with no flooding. Ideal: Continuous flooding starting at 3 cm depth gradually increasing to max of 15 cm by 60th day. Complete draining 1 – 2 weeks before harvest (Singh et al. 1980).	0.4-1.5 m for nursery and 0.8-3.0 m for grow-out (Pillay 1990)
2. Temperature	Water and soil temperature of up 40°C and fluctuations of up to 10°C in one day apparently with no deleterious effect.	25°-35°C for warmwater species. Stable temperature preferable. Feeding may slow down at temperatures below or above normal range. Metabolic rate doubles with every 10°C rise.
3. pH of water	Neutral to alkaline.	6.5-9.0 (Boyd 1979).
4. Oxygen	Important during seedling stage for development of radicles.	Preferably at near-saturation or saturation level (5.0-7.5 ppm depending on temperature).
5. Ammonia	High levels of ammonia common immediately after fertilization.	Un-ionized ammonia highly toxic. Ionized form generally safe.
6. Transparency or Turbidity	Immaterial.	Important for growth of natural food. Very high level of suspended soil particles may impair respiration.
7. Culture Period	90-120 days for HYV; up to 160 days for traditional varieties.	120-240 days depending upon species and market requirement.

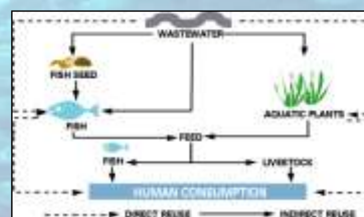
Integration of Irrigation and Aquaculture:

IIA is not limited to rice-fish culture, small storage reservoirs in irrigation schemes, as well as irrigation canals can be suitable for raising fish using cages.

Wastewater-fed Aquaculture:

The term "waste"...philosophically and practically it is better to consider wastes as "resources out of place" (Taiganides, 1978).

Wastewater-fed fish farming is based on its cost-effectiveness (and also on the interest in resource recovery from the investment in wastewater treatment e.g. through the use of effluent from waste stabilization ponds in fish ponds).



Wastewater and excreta:

- Domestic sewage without significant industrial effluents
- Excreta
  - Faeces and urine.
  - Faecal sludge, nightsoil, septage.

Public Health considerations Wastewater-fed Aquaculture:

Effluent Guidelines for Aquaculture:

Following a review of the literature on the survival of pathogens in and on fish by Strauss (1985).

- *Bacterial guideline* = 10^3 FC (faecal coliforms) per 100ml (geometric mean) for fishpond water.
  - Protect against the risk of bacterial infections.
  - Prevent invasion of fish muscle.
- *Helminth quality guideline:* absence of viable trematode eggs.
  - Prevent the transmission of trematode infections such as schistosomiasis, fasciolosis and clonorchiasis.

Public Health considerations Wastewater-fed Aquaculture:

- Minimum retention time in a **waste stabilization pond**: 8-10 days
- Maintain fish in freshwater 10-12 hours after harvest to facilitate evacuation of gut contents
- Good hygiene in fish handling and processing:
  - Fish gutting is required
  - Heat treatment,

  adequate cooking is necessary.

Waste stabilization ponds

Waste stabilization ponds are shallow man-made basins into which wastewater flows and from which, after a retention time of many days a well treated effluent is discharged.

Overhung fish pond latrine in south Vietnam

Overhung fish pond latrine in Java, Indonesia

Discharge of city wastewater and water spinach cultivation in Phnom Penh, Cambodia

Water spinach harvest from a wastewater-fed water body in Phnom Penh, Cambodia

Harvesting duckweed from a pond fertilized with polluted surface water, China

Duckweed raised on wastewater to feed fish in Khulna, Bangladesh

Wastewater-fed Aquaculture:

Water spinach harvested from a wastewater-fed water body in Phnom Penh, Cambodia

wastewater-fed fish ponds in Kolkata, India

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Environmental considerations:

Most integrated aquaculture systems use low levels of inputs and fall within the type of aquaculture called **semi-extensive/semi-intensive.**

This means less reliance on feed and fertilized inputs, lower densities of farmed organisms and, therefore, less chances of causing serious pollution and disease risks than more intensive, feedlot-type systems.

Semi-intensive systems in synergy with agriculture (crop- livestock-fish integrated farming) capitalize on in situ, vitamin and protein natural aquatic feeds, which obviate the need for expensive feed components.

Semi-intensive freshwater ponds usually have few environmental effects other than their occupation of former natural habitats.

INTEGRATED FISH FARMING STRATEGIES

Conclusions:

- Integrated fish farming offers tremendous potential for food security and poverty alleviation in urban and periurban areas.
- It is an efficient way of using the same land resource to produce both carbohydrate as well as animal protein and important micronutrients concurrently or serially.
- Optimization of available natural resources use.
- Diversification of income generating activities
- Improvement of soil fertility.
- Improved pest control with less use of chemicals (pesticides, fertilizers).
- Aquatic Biodiversity conservation and sustainable use could be enhanced.

Related Publications:

- Integrated Irrigation and Aquaculture in West Africa: Concepts, practices and potential, FAO, 2006.
- Curriculum development for Farmer Field School in Guyana and Suriname. *A field guide on Integrated Pest Management and aquaculture in rice*. FAO, 2008.
- Farm ponds for water, fish and livelihoods. FAO Diversification booklet number 13, FAO, 2009.

Related Publications:

- Integrated Agriculture and Aquaculture. FAO Fisheries Technical Paper No.407, 2001.
- Integrated livestock-fish farming systems, FAO, 2003.
- Culture of Fish in Rice Fields, FAO and World Fish Center, 2004.
- Integrated mariculture A global review. FAO Fisheries and Aquaculture Technical Paper. No. 529, 2009.

Current Field Activities:

- New TCP
  - Mali: Integration of Irrigation systems and Aquaculture.
  - Cambodia :rice-fish culture.

- Technical backstopping to:
  - TCP/MAG/3301 (Appui à l’agriculture urbaine et périurbaine pour la sécurité alimentaire et nutritionnelle des populations d’Antananarivo)
  - Europe Aid/129-753 /L/ACT/KH (Micro and small enterprise development to achieve food security, food safety and self reliance for urban poor in Phnom Penh)

Thanks!

FAO Fisheries and Aquaculture Department:
http://www.fao.org/fishery/en