Integration of Aquaculture and Agriculture: A Route To Sustainable Farming Systems

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Land degradation following slash and burn. Photos by Clive Lightfoot.

The ways farmers use their land and water cannot anymore meet human demand for food and money, let alone the need for environmental conservation. Certainly, present systems of farming will not meet projected food needs for the 21st century. Commodity yield increases through research on individual crops, including fish, will not be enough. We need more research that combines ecology and production knowledge and integrates many diverse enterprises at the farm level.

New ways of farming that regenerate environments and increase household purchasing power must be designed, tested and put into operation by large numbers of farmers. Important parts of such systems, both for environmental and economic objectives, will be biological diversification and nutrient recycling. Where there is sufficient water I believe that integration of aquaculture and forestry into agriculture-based farms provides an appropriate starting point for the design of regenerative farming systems.

Many of today's farming methods degrade the environment. Persistent poverty is forcing farmers to adopt non-sustainable systems. Slash and burn cropping which was sustainable in earlier times now contributes to the 1,571 ha of deforestation that is estimated to occur each year in Southeast Asia and 3,349 ha in Africa. One hundred and forty-two million hectares of rainfed crop land in Southern and Sudano-Sahelian Africa have become 'desertified' as a result of farming, as have an estimated 150 million ha in South Asia. Salinization of irrigated land affects 5 million ha in Southern and Sudano-Sahelian Africa and 59 million ha in South Asia.[1]

Farmers fully understand what they are doing to the environment and its consequences for future generations. Their farming practices are an indication of their despair and lack of alternatives to earn a decent living (see box on livelihood indicators). They have to use land and water resources more intensely and in the absence of alternatives exploitative techniques will prevail. This situation poses a challenge to find affordable technologies to improve soil and water resources and to enable farmers to use what they have more intensely. These concerns have been expressed by international bodies like the International Union for the Conservation of Nature and the Consultative Group on International Agricultural Research.

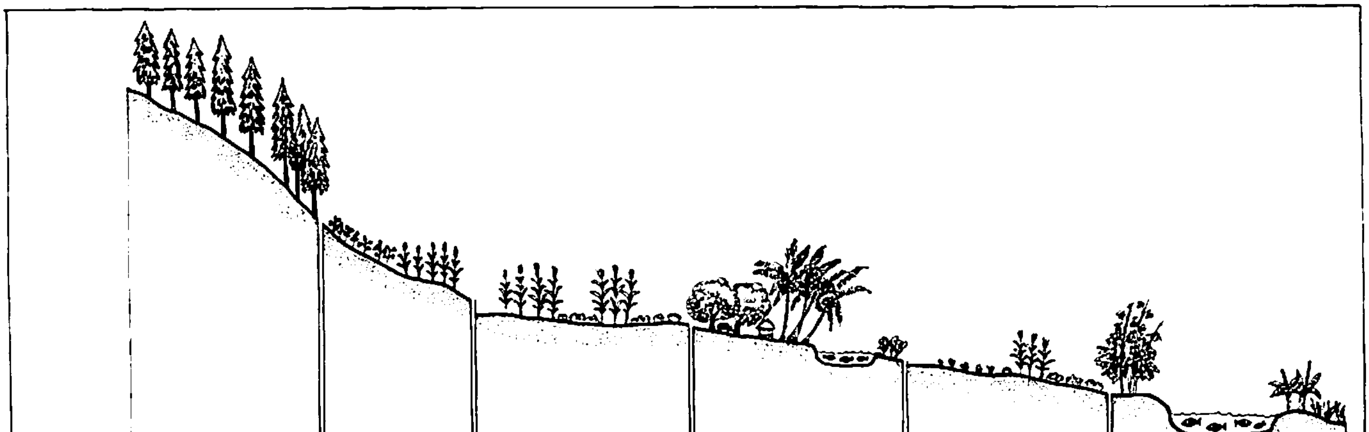
The need for new sustainable farming systems has been recognized for decades but there is a general lack of vision as to how they might be developed. One major reason for this is the "tunnel vision" of researchers locked into their narrow disciplines and sectoral issues. One authority said: "Somewhere, somehow, experienced researchers must step outside the component technology and make imaginative guesses; and development agencies must be persuaded to try those guesses in practice, even at risk of making some expensive mistakes".[2]

Such systems thinking is rare. Recent developments in Farming Systems

LIVELIHOOD INDICATORS FOR AFRICA AND ASIA

	Africa	Asia
Per cent population with not enough calories for active working life	44%	50%
Per capita GNP	US$300	US$500
Child mortality under 5 years	15 in 100	10 in 100
Child malnutrition	30%	30%
Access to potable water	<30%	<50%
Access to sanitation	<10%	<10%

Data from World Resources 1988-89. A Report by the World Resources Institute and the International Institute for Environment and Development. Basic Books, Inc., New York. 1988 p.372.



LAND TYPE	Forest land NKHALANGO	Sloping crop land NTUNDA	Corn land MUNDA	Housing area MASALA	Vegetable garden DIMBA	Wet land DAMBO
SOIL	sandy	sandy	sandy clay	sandy clay	heavy clay	heavy clay
WATER	v. deep	deep	low	low	high	high
CROPS		corn, cassava	corn, cassava, finger millet ground nuts		rice, sugarcane green-corn, kidney beans, pumpkin	grasses
TREES	pine, eucalyptus			mango, guava, coconut, papaya, eucalyptus		bamboo banana
LIVE-STOCK FISH				chicken, goats, sheep, cattle, fish		fish

Fig. 1. Agroecosystems transect, Zomba, Malaŵi.

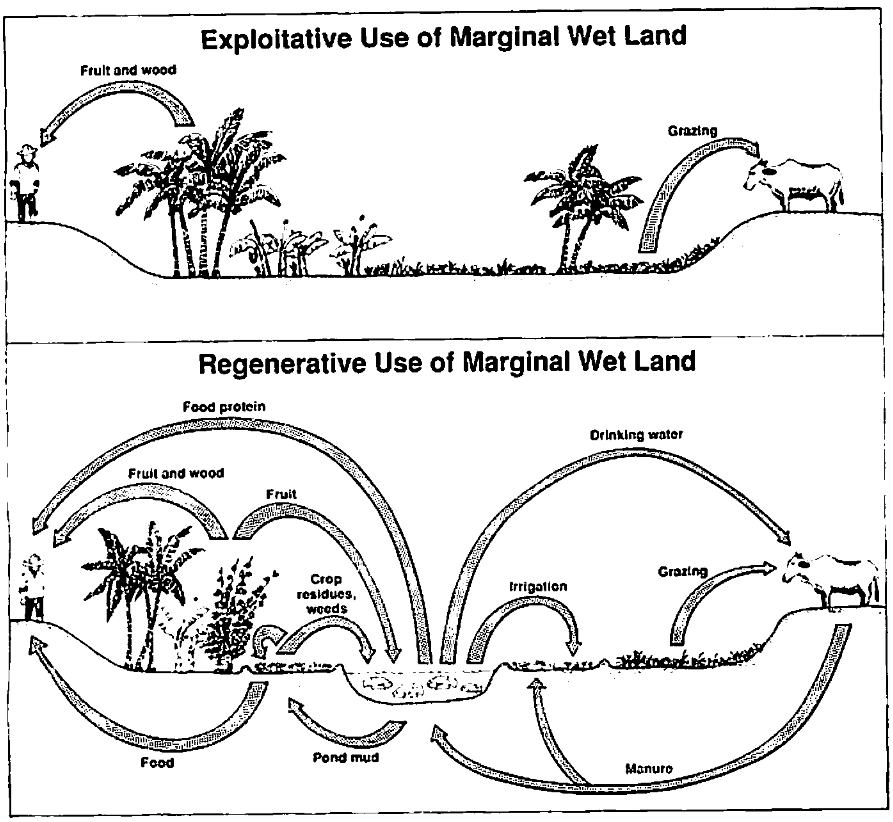
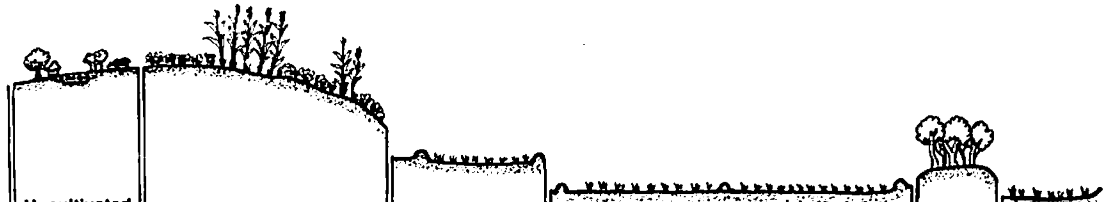


Fig. 2. Species diversification and nutrient recycling in regenerative farming systems, Malaŵi.

Research and Extension (FSRE), particularly in agroecosystems analysis, however, offer frameworks for scientists to see opportunities for intensifying resource use and regenerating diminished environments by integration of agriculture and aquaculture. Aquaculture provides a way to use agricultural waste to make marginal lands more productive. Fish convert plant and animal waste into high quality protein and enrich pond mud for use on crop land.

The value of this kind of analysis to intensify farming that actually regenerates the environment through diversification and recycling is exemplified in ICLARM's collaborative research in Malaŵi and India.

Farmers in Zomba district, Malaŵi, identify six land types from mountain to river plain. The agroecosystem analyst arranges the land types in sequence to form a 'composite' transect listing all enterprises, soils and water characteristics (Fig. 1). There are major differences between high water table floodplain types; the sandier soil, low water table flat types; and the sloping land types. Floodplain lands are further divided according to whether they are cultivated or not. Crop and livestock enterprises vary accordingly as Fig. 1



LAND TYPE	Uncultivated upland "Jhaura Bhita"	Cultivated upland "Gaura Bhita"	Midland "Dhankar"	Lowland "Chauri"	Upland "Khenhári"	Flood prone land "Dabra"
WATER TABLE	>10'	>10'	4-7'	2-3'	7-10'	<2'
SOIL	Sandy loam	Sandy loam	Loam	Silty clay loam	Sandy loam	Clay loam
CROPS		Rice, Redgram, Castor, Cucurbits, Ladies finger, Wheat, Maize, Potato, Mustard, Gram, Lentil, Pea, Beans, Linseed, Oats, Tomato, Garlic, Onion, Cabbage	Rice, Wheat, Greengram, Lentil, Maize	Rice, Wheat (late sown), Maize, Greengram		Rice
TREES	Mango, litchi, date palm, sesso, guava, papaya, citrus				Sesso	
LIVESTOCK FISH	Fish, Goat, Cattle, Poultry, Buffalo		Fodder oats, Grazing (dry season)	Grazing (dry season)	Grazing	Fish

Fig. 3. Agroecosystems transect, Dhobigama, India.

shows. Fishponds are constructed in wet lands and homestead land when a nearby stream or spring permits.

Zomba's agroecosystem transect suggests many points for joining together land and pond 'crops'. Pond mud would revitalize vegetable plots. Pond water could irrigate vegetables and water animals. Animal manure, along with crop residues, weeds, tree leaf and rotten fruit and vegetables could fertilize ponds as well as the soil. Other crop by-products like maize and rice brans could also be fed to fish. Occasionally, one finds a farmer who is exploring these connections to intensify resource use. Some have upgraded diminished wet land into orchards, fishponds, fodder and vegetable plots (Fig. 2). In essence they are intensifying the use of land and water resources in a sustainable manner through species diversification and nutrient recycling. Resource productivity increases, farmers' incomes rise, soils are improved and the water is kept clean.

Land-type transects described by farmers from Dhobigama, India, suggest several ways to link up farm and pond (Fig. 3).[3] For example, uplands are not only where people live and livestock shelter but also where fruit trees and fish are raised. All sorts of cereals, pulses and vegetables are grown on the sandy loams of the cultivated uplands, particularly where supplemental irrigation is available. With few exceptions, terraces of bunded rice cover the remaining land types. These silty loams and clay loams where the water table is not too high support many crops after rice and livestock graze them during the off-season. In the flood prone land, migratory fish are often caught.

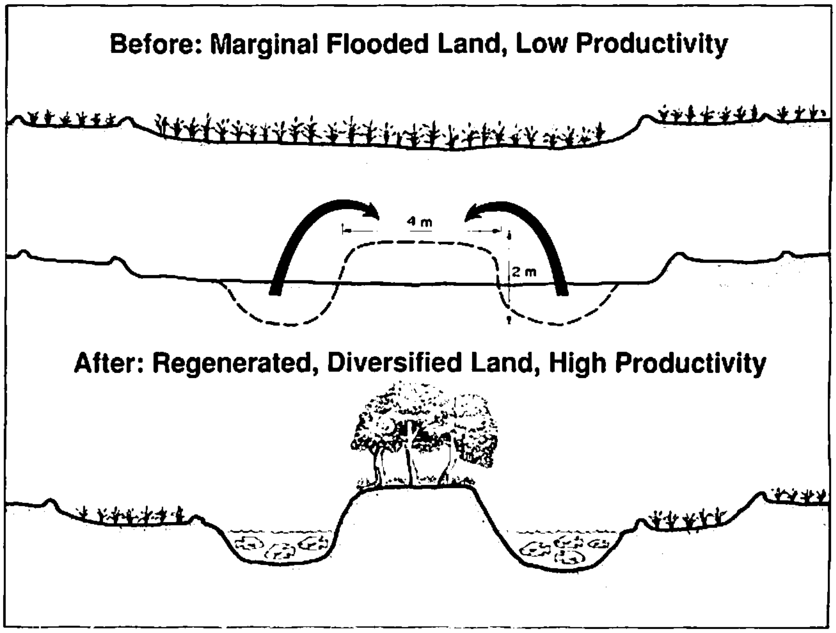


Fig. 4. Regenerative intensification of marginal flooded land in India.

Just like Malawian farmers who dig ponds in marginal wet lands we found a farmer in Dhobigama who was upgrading flood prone land. So dissatisfied with the low and risky productivity of this land was he that he modified it. The farmer dug out the flooded area and made several mounds nearly 2 m high and 4 m wide and planted fruit and sesso trees on them (Fig. 4). While the trees were still

Fishpond, orchard, vegetables and fodder from upgraded swamp land, Malawi.

Improved use of flood prone land, India.

small, undercropped vegetables provided an immediate income. In the ditches which now had more assured water the farmer was thinking of raising fish.

Such seemingly great potential for intensifying the use of marginal lands in this manner begs the question: why are FSRE and agroecosystem tools so little used?

As mentioned earlier, perhaps the first and most important reason is the institutional structure in which agricultural research and development is conducted. FSRE requires social scientists to work alongside biological scientists but these scientists are separated by the disciplinary structure of universities. Moreover, interdisciplinary teams require all members to have a working knowledge of the other disciplines but education programs rarely offer appropriate courses. Agroecosystem analysis and the new farming systems it inspires require integration of crops, livestock, fish and forestry but these commodities are separated into different departments, ministries and research institutes at national and international levels. Institutional barriers inhibit the growth of expertise, the flow of funds and the use of FSRE and agroecosystem tools.

Even the leading scientists concerned with a holistic treatment of farming systems often omit whole enterprises from their analyses. One influential group[4] promotes agroecology for sustainable development without considering the many small waterbodies that occur in tropical ecosystems. Simmonds[2] bemoans the neglect of perennials by the agronomists working in FSRE. Indeed, most studies reflect the bias of the lead discipline. Thus, fish biologists working on integrated agriculture-aquaculture systems have concerned themselves mainly with the fish, the pond and the use of agricultural residues to feed the fish.[5] We can conclude that a contributing factor to the lack of new farming systems development is the attitude of scientists.

To make degraded land productive and farmers' incomes larger, new farming systems must promote integration of crops, vegetables, trees, livestock and fish, and exploit all opportunities for nutrient recycling and other synergisms between enterprises. One component's by-products must be another's inputs. Water is a resource for plants, livestock and fish. Scientific procedures for quantifying, analyzing and experimenting with farming systems of this breadth and complexity are badly needed.

Even if new farming systems of such complexity can be synthesized they must be put into practice by farmers. Such operations must go beyond the simplistic notion that many farmers will adopt new systems from a model farm demonstration. Model integrated farms developed on research stations rarely get adopted. Few FSRE initiatives get sufficiently large numbers of adopters to show a real impact. Operational procedures for mass farmer participation in an evolutionary research process with alternative endpoints and pathways are badly needed. ICLARM would appreciate readers' ideas on the needed procedures identified in this article.

Acknowledgements

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Further Reading

[1]World Resources 1988-89. 1988. A Report by the World Resources Institute and the International Institute for Environment and Development. Basic Books, Inc., New York. 372 p.

[2]Simmonds, N.W. 1986. A short review of farming systems research in the tropics. Experimental Agriculture Vol. 22: 1-15.

[3]Lightfoot, C., N. Axinn, V.P. Singh, A. Bottrall and G. Conway. 1989. Training resource book for agroecosystem mapping. International Rice Research Institute, Los Baños, Philippines. 125 p.

[4]Dover, M. and L.M. Talbot. 1987. To feed the earth: agro-ecology for sustainable development. World Resources Institute, Washington, DC. USA. 88 p.

[5]Edwards, P., R.S.V. Pullin and J.A. Gartner. 1988. Research and education for the development of integrated crop-livestock-fish farming systems in the tropics. ICLARM Stud. Rev. 16, 53 p.

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