FARMER-PARTICIPATORY RESEARCH APPROACHES TOWARDS AGRICULTURE-AQUACULTURE INTEGRATION FOR SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES[1]

by

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1 Introduction

Recycling of a farm's biological resources, wastes and by-products can husband natural resources and improve productivity and incomes. It is well known that soil fertility is improved when organic matter is returned to the soil. Farmers estimate that compost materials can replace basal applications of the elements nitrogen, phosphorous and potassium to reduce fertiliser costs by up to 50 %. Recycling is a bigger part of the farm economy than has often been appreciated. Indeed, when recycling flows are given cash values, the gross incomes of farmers increase dramatically; for example the value of all recycled materials can be up to 40 % of gross farm income. High value flows are exemplified by the use of rice grain to feed chickens, or snails to feed chickens, ducks and fish. High volume but lower value flows are exemplified by those for rice straw, which is utilised both as livestock feed and compost material, and napier grass which is used as feed for cows, water buffalo and goats. The water buffalo, like most livestock, contribute to recycling by eating grass and crop residues and producing manure (organic fertiliser) for the crops. Moreover, the water buffalo is used as a draft animal and also produces milk and meat. Ducks produce eggs, meat and droppings. And fish convert crop, livestock and household wastes into high quality

1 This report is a synthesis of recent research and was made possible by the contributions of ICLARM's staff and their partners in national institutions. Readers are referred to the papers by LIGHTFOOT et al. (1993a; 1993b; 1994) on which this presentation is based and which list collaborating partners. This is ICLARM Contribution No. 1272.

protein and nutrient rich pond mud. Pond mud is so rich that it can replace fertilizer completely in small vegetable gardens.

Taken together, the direct and indirect effects of recycling can have significant impacts on the ecological sustainablity of the entire farming system. Indirect effects include the integration of new enterprises that promote recycling as well as the rehabilitation of natural resources that either result from recycling or are necessary to enterprise integration. This paper illustrates ICLARM's experience with the introduction of aquaculture into smallholder farming systems and its role in catalysing new resource flows and recycling of farm resources in these systems.

2 The Role of Aquaculture in Mixed Farming Systems

Integrated farming systems, with aquaculture as a major or minor component of crop- and livestock-based farms, differ greatly from extensive or intensive fish farms that are stand-alone enterprises. Stand-alone fish farms can be risky ventures, especially for resource-poor farmers in developing countries, because of their environmental effects, e.g. pollution, and economic factors such as the price volatility of some aquatic produce, especially exports. Such ventures have resulted in environmental and financial disasters in Africa and Asia (CROSS 1991; MCCLELLAN 1991; POLK 1991). Despite some individual success stories, intensive aquaculture has done little to reduce poverty and malnutrition overall.

3 Sustaining Small-scale Mixed Farming Systems

ICLARM's view is that the horizon for research in aquaculture must go beyond fish production and cash income to evaluating the social, cultural and ecological services that pond water and pond biota, including farmed fish, can provide in an integrated farm that has aquaculture even as a minor enterprise. In some circumstances, improved aquaculture and water management may serve as the key to the sustainability of the entire farm (LIGHTFOOT 1990; LIGHTFOOT, PULLIN 1991). ICLARM scientists have proposed the term Integrated Resources Management (IRM) to describe the approach (LIGHTFOOT et al. 1993a; LIGHTFOOT, PULLIN 1995).

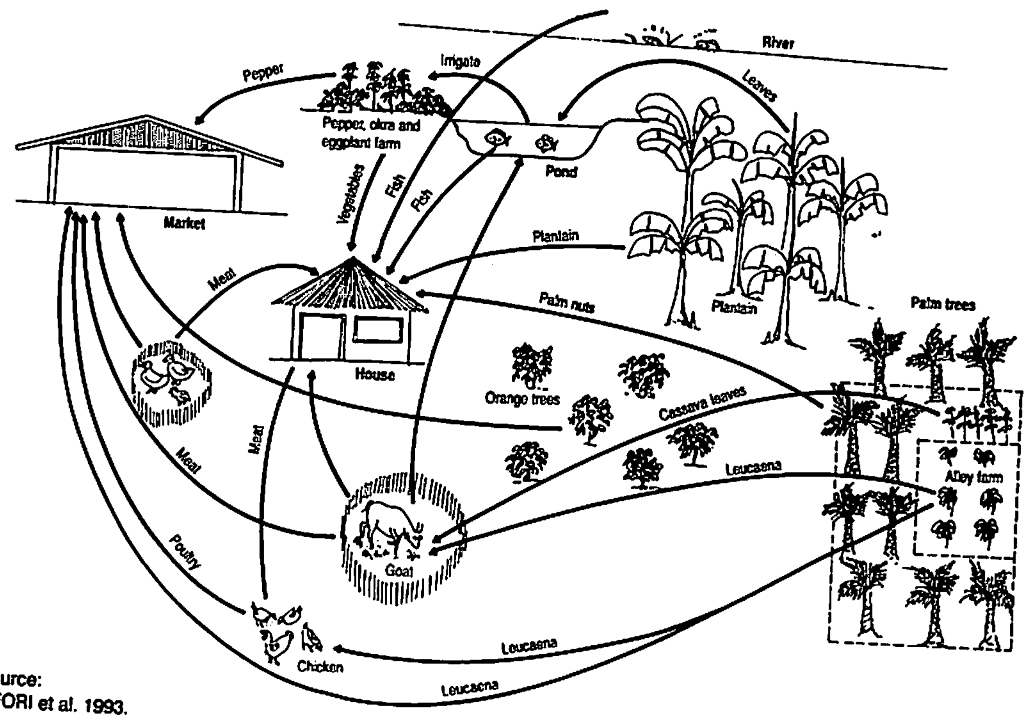
4 The Integrated Resources Management Approach

The IRM approach integrates the management of new enterprises, particularly aquaculture, with those of the existing farming systems and with their respective natural resource systems so that opportunities for rehabilitation and synergism can be exploited. The utilisation of the economic, social, nutritional and ecological services offered by managed water resources and fish is seen as a basis for sustainable farming systems. Thus, households are encouraged to see farm enterprises (particularly aquaculture) as mechanisms to improve natural resources management and overall farm system performance. The approach involves interdisciplinary research in close partnership with the targetted resource-poor farmers. Indeed, the use of indigenous categories of natural resource systems as entry points for research builds a common foundation for farmers and researchers.

Natural resources management and rehabilitation, and farmer-participatory skill-building, have shaped ICLARM's research agenda in an attempt to find procedures that will be used by farmers to help them make their own decisions and conduct their own experiments on how to integrate aquaculture and use their resources in a more sustainable way (LIGHTFOOT et al. 1993b). The Participatory Research Appraisal method that has been developed uses household groups to identify and map indigenous categories of natural resource systems. Village transects are used to summarise this information in a format easily appreciated by community members, extensionists and researchers alike. These diagrams serve as foci for the additional detailed development of the bioresources within individual farms. A detailed description of this method has already been published (LIGHTFOOT et al. 1994; OFORI et al. 1993; LIGHTFOOT, TUAN 1990) and described in a training booklet and video (LIGHTFOOT et al. 1991).

The BioResource Flow Diagram (BRFD; cf. figure 1) is a picture of the natural resource types, drawn as topographical cross-sections of land and water resources. The enterprises conducted on them are drawn as icons and the farm generated by-products and wastes that flow from one enterprise to another are drawn as arrows. Manure to crops, rice bran to pigs, and tree leaves to goats are typical examples of bioresource flows. Recycling does not include product (e.g. grain) flows to market or to household consumption except where household wastes, i.e. kitchen waste, cooking ash and night soil are recycled. Similarly, external inputs to fields like inorganic fertiliser are not included because they do not depict recycling.

Figure 1: Farmer's Drawing Envisaging the Future on his Farm, with More Enterprises and Links Among Them



Source:
OFORI et al. 1993.

Bioresource flows can be expressed in several "currencies", like biomass, nitrogen, energy and cash. We have found biomass to be the most useful when discussing recycling with farmers.

The strength of the models is that they help people learn about recycling. They do, however, have weaknesses. During discussions, farmers often ask how they should split up their meagre supplies of manure among enterprises. Modelling with BRFDs cannot provide a complete answer. Farmers can be helped visiting other farmers' plots or experiment station plots. It is, however, very difficult to generate the conversion coefficients for many wastes, particularly manures and composts, because they are so variable. This difficulty is increased by problems in trying to evaluate bioresources that do not have a market value. Simply using costs of labour involved in making the transfers, or using equivalent costs of chemical fertilisers, underestimates the true value of these materials.

Projections of the management strategies before and after integration convey clear pictures of the impact of new technology adoption and integration. They help farmers and others appreciate the importance of shifting the boundaries and focus from the individual enterprise to the entire natural resource system used, as well as the benefits to be realised from managing resources in a complementary and integrated manner that makes efficient use of available biological materials. ICLARM projects in countries in Africa and Asia have employed these techniques (ICLARM 1992) and the impact of this work on farm households, farm ecology and the environment is illustrated here through examples from Ghana, Malawi and the Philippines.

5 The Impact of the Approach

5.1 Ghana

Over the last two years - in cooperation with the Institute of Aquatic Biology and a local non-governmental organisation (NGO), the Ghana Rural Reconstruction Movement - a group of farmers in the Mampong Valley, Eastern Region, Ghana, drew bioresource flow models of future integrated farming systems. Their plans to rehabilitate water resources for dry season vegetable gardening and aquaculture are now being realised

(OFORI et al. 1993; PREIN et al. 1996b; PULLIN, PREIN 1995; PREIN et al. 1996a; PREIN et al. 1996c).

Bioeconomic models were constructed to assess the potential impact of integration on the nutrition of households. The model used a rural household of five persons to compute the annual demand for the main nutritional components. The annual nutritional supply to such a household was calculated for a holding size of one hectare of which 60 % was cultivated and the remainder under fallow. Crop yields were based on data from the Ministry of Agriculture. Nutritional inputs to the diet from staples, vegetables and condiments, freshwater and marine fish and meat were considered using data from various sources (RUDDLE 1996). Integration added the outputs of a fishpond of 100 m^2 and a vegetable plot of 400 m^2. The models suggest that integration can improve household nutrition as well as cash income (RUDDLE, PREIN 1994). The most significant nutritional impact from integration was the boost in protein intake from around 60 % of recommended levels to over 120 % and increases in the availability of vitamin A (66 %) and vitamin C from the additional vegetables.

5.2 Malawi

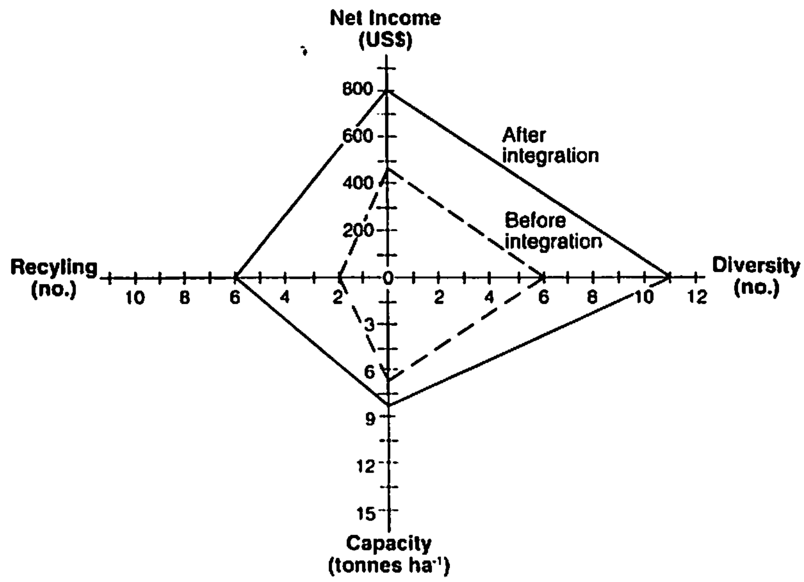
In Malawi there were both tangible product and organisational benefits from the approach which resulted in the stabilisation of household incomes. Initial results from five farms in 1992, part of a group of some 30 farms new to integrated farming, indicate that adoption has had significant and diverse impacts on farm management and the performance of farming systems (LIGHTFOOT, NOBLE 1993; BRUMMETT 1994; BRUMMETT, NOBLE 1995). Ponds served as a focal point for direct or indirect links between resource systems. Households used the ponds as water catchment for domestic use and watering livestock. Ponds placed adjacent to vegetable gardens provide water for irrigating these gardens and earnings increased from US$ 82 to US$ 112 a year. Ponds were utilised as a processing unit for converting low quality crop residues such as maize bran and green leaf waste into fertile mud for transfer to gardens, which reduced fertiliser use and brought marginal land into productive use. The ponds resulted in a ready supply of fish for household consumption so that families rarely had to buy fish. The average value of the fish harvest was US$ 22 for a single harvest, and US$ 45 for two harvests. Conversion to the use of ponds provided food and income (the average income from integrated rice-fish farming was US$ 76/year). Rice was able to be grown by some households for the first time and rice-fish pond integration provided two crops of rice per year. The average annual income after integration was US$ 235. The contribution from rice and fish pond alone to gross farm incomes varied from 10 to 62 % in 1992, a year that saw a nationwide drought and a currency devaluation of 20 %. The fact that these households managed to stabilise if not slightly increase food and cash in a year of drought and devaluation is a remarkable feat in itself.

5.3 Philippines

In order to assess the impacts of changes in natural resource management, data were collected via direct monitoring and from recall from seven households in Niugan, Cavite Province, Philippines in cooperation with the International Institute of Rural Reconstruction (LIGHTFOOT et al. 1993b; BIMBAO et al. 1995). These data were in turn used to calculate four simple indicators of sustainability for each farm: economic efficiency (net income in US$), resource system capacity (biomass output in tonnes per ha), species diversity (number of cultured and utilised species) and bioresource recycling (number of bioresource flows). For example, on analysis, a farm was characterised as having six enterprises and two resource flows. Upon integration, these increased to eleven enterprises and six flows. The newly introduced fish pond opened opportunities for the culture of fish and water spinach using on-farm inputs. Existing by-products were subsequently used to a greater extent. These low-value flows led to the production of high-value products. Diversification and integration brought about an increase in net income from US$ 350 to US$ 750 and biomass production from 7 to 8 tonnes per hectare.

By plotting the indicators graphically in a time series, new information was revealed on the direction of evolution of the farming systems over time. The positive or negative impacts of management changes and the adoption of technologies can be gauged in relation to performance of the system. The individual indicators fluctuated within years due to seasonal differences and climatic change. The general trends, however, showed a gradual and steady improvement in overall farm performance with the advent and integration of aquaculture. Greater water availability allows for its improved use, not only for fish and aquatic plants but also for rice and vegetables. Enterprises and natural resource systems thus support each other through improved management and use of the water and bioresources leading to a simultaneous increase in all indicators. To compare the situation "before" and "after" integration, data from individual time points from the time series graphs were taken and plotted in kite diagrams (figure 2). These provide at-a-glance information on changes in performance with time: the larger the kite the better the performance (BIMBAO et al. 1995).

Figure 2: Farming Systems Performance Indicator Kites for a Philippine Farm Before and After Integration



Source:
LIGHTFOOT et al. 1993a.

6 Future Requirements

These initial results suggest that the IRM approach is promising. Small but growing numbers of farmers are beginning to adopt IRM resulting in the rehabilitation of aquatic resource systems to benefit many enterprises. Clearly, some farming systems can be transformed rapidly - the monitoring of sustainability indicators shows this - but are these indicators the right ones or the only ones? The counts of flows and species should be designed to take account of quantity as well. Importantly, more direct determinants of the quality of natural resource systems need to be found. For instance, farmers in Vietnam have reported that fish in ricefields enable them to reduce fertiliser inputs by 28 % (LIGHTFOOT, TUAN 1990). Similarly, farmers in the Philippines report that fish saved US$ 12 per hectare on herbicides and US$ 13 per hectare on pesticides (FERMIN 1992). However, whereas cash substitutions for inorganic fertiliser and chemical sprays can be calculated, values for natural resource system rehabilitation, species diversity and bioresource flows are much harder to determine. Further, indicators for equity, particularly gender equity, and ecosystem attributes such as resilience and maturity are also needed. The use of ecological modelling tools like ECOPATH (DALSGAARD et al. 1995; DALSGAARD 1995; DALSGAARD, OFICIAL 1995; CHRISTENSEN, PAULY 1992) may contribute to the development of these more sophisticated descriptors of farming systems.

Given the benefits that can be achieved by recycling, far fewer farmers adopt this approach than could. Farmers give a wide range of reasons why they or their neighbours do not recycle:

- cultural taboos;
- it is not regarded as modern or progressive farming;
- competition between domestic uses for manure, such as for fertiliser or fuel;
- lack of access and tenure preventing nutrients being brought into the recycling option e.g. not being able to grow fodder trees or graze animals on the "commons".

However, perhaps the most common reason given for not recycling materials like manure is that buying inputs is quicker than recycling, which is time-consuming and labour-demanding. Simply, the returns are either too uncertain or too modest.

Enterprises that can turn low quality plant residues and by-products into feeds and fertilisers for other enterprises are vital. Fertilisers will still be needed, but to supplement organic materials rather than replace them. In some cases this will not be enough to provide satisfactory returns to the high labour inputs required. As long as chemical fertiliser is cheap and organically grown food is not subsidised, it makes little economic sense to recycle. Perhaps the most important challenge facing those concerned with the ecological sustainability of agriculture is the development of supportive agricultural policies. Policy instruments that promote and guide the evolution of IRM systems need to be formulated. Approaches that assist the resource-poor, particularly women, are in turn bound to equity issues both within a household and in the community at large. Successful exploitation of underutilized natural resource systems are bound to attract more users than they can carry. Avoiding these problems in integrated farming will require the wholehearted participation of the community in IRM.

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