In 2003, the CGIAR Secretariat asked the Standing Panel on Impact Assessment (SPIA) to initiate a series of impact assessment studies on natural resources management (NRM) research. The main objectives of this SPIA initiative were to obtain better information on the demonstrable impacts of CGIAR investments in NRM research, to identify gaps in data and methodology, and to provide avenues for better NRM impact assessment in the future. The impact brief presented here describes the major results of one of seven center NRM impact assessments emerging from this SPIA initiative: Dey M.M., Kambewa P., Prein M., Jamu D., Paraguas F.J., Pemsl D.E., and Briones R.M. Forthcoming. Development and dissemination of integrated aquaculture–agriculture technologies in Malawi. In: *The Impact of Natural Resource Management Research: Studies from the CGIAR* (Zilberman D. and Waibel H., Eds). CAB International: Wallingford, UK.

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*Nourishing the Future through Scientific Excellence*

# Development and Dissemination of Integrated Aquaculture–Agriculture Technologies in Malawi

Fish have traditionally been an important part of the diet in Malawi. But an expanding population and declining catches have cut annual per capita consumption from 14 kg in the 1970s to 4.2 kg in 2005, with a corresponding price hike. In a country where two-thirds of people consume less than the minimum daily calorie requirement[1], this pattern is part and parcel of the overall decline in food security, especially in rural communities.

From the 1970s to the mid-1990s, several donor organizations attempted to introduce aquaculture to rural farmers in Malawi as a way of increasing fish supplies while relieving the pressure on capture fisheries. But they had little success. The projects required considerable investment by farmers who could not afford it. Subsidies terminated with the projects, causing a decline in production and frequently leading to the abandonment of aquaculture. Furthermore, there was no diffusion of the technology outside project areas. Thus, in 1985 the total estimated aquaculture production in Malawi was only 173 tonnes from 170 hectares of ponds.

In response, the WorldFish Center (WorldFish), in collaboration with Malawi's Department of Fisheries, implemented a farmer participatory research (FPR) project to explore the potential for adding fish farming to established smallholdings. The approach they took, known as Research Tools for Natural Resources Management, Monitoring and Evaluation (RESTORE), combines FPR field procedures with the use of an analytical database.[2] The project emphasized the concept of integrated aquaculture–agriculture (IAA), which calls for the use of farm waste, crop byproducts, and other on-site natural resources as nutrient inputs to the fishponds. Prior to this, many farmers were unaware of the potential of recycling to increase nutrient supplies.

The FPR approach has since been adopted by national agencies, resulting in the development of IAA technologies and their dissemination to other farmers, with sizeable impacts at both household and national level.

This impact assessment study, conducted by WorldFish in 2004, rests on the hypothesis that IAA leads to increased farm productivity because it:

- Offers technologies that allow more effective use of such conventional inputs as labor, organic fertilizer, and capital
- Improves human and social capital, which in turn boosts the efficiency with which farmers use natural resources
- Increases the use of biodiversity.

In turn, the productivity increase leads to higher household incomes and higher consumption of fish, resulting in improved health.

## Impact assessment framework

To determine the factors that promote adoption and lead to higher productivity, researchers carried out a two-phase *ex post* impact assessment, using 'with' and 'without' scenarios. Phase one identified technical, socio-economic, institutional, and policy factors influencing adoption, while phase two assessed the effects of adoption on efficiency, food security, employment, and sustainability. In addition, a qualitative description of the institutional impact of the technology transfer approach was given.

The impact of IAA was assessed at household level. Data were collected in early 2004 from households at six sites representing various agroecological conditions. All sites had good water resources and were dominated by smallholdings that had the potential to increase production. At each site, 30 non-IAA 'control' households were selected in addition to 30 adopting households. Of the 360 farmers in the selected sample, 315 were available for interview. Data included socioeconomic farmer profiles, information on income sources, wealth status and the production system in 2003–2004. In addition, information on the farming environment, social and institutional factors, and household food consumption was collected.

The characteristics of IAA adopters and non-adopters are shown in Table 1. For both groups the principal water source was rain.

The survey analysis applied a comprehensive impact assessment framework. This explored adoption, land use changes, profitability, productivity, input efficiencies, income, and family health.

To describe the adoption process, a two-stage adoption model was used. The first stage captured the adoption decision and the second the intensity of adoption, measured as the level of integration of aquaculture with other farm enterprises. Land-use changes were measured using frequency statistics and profitability

**Table 1.**
**Key characteristics of IAA and non-IAA respondents**

| Variable | IAA respondents (n = 166) | Non-IAA respondents (n = 149) |
|---|---|---|
| Average age of respondents (years) | 45.4 | 39.9 |
| Average household size | 5.2 | 4.9 |
| Average number of male farmers per household | 1.1 | 1.0 |
| Average number of female farmers per household | 1.2 | 1.2 |
| Average farm size (ha) | 2.0 | 1.5 |
| Land type (%) | | |
| Homestead | 22 | 30 |
| Lowland | 37 | 28 |
| Upland | 32 | 31 |
| Wetland (*dimba*) | 10 | 10 |
| Topography (% of parcels) | | |
| Flat | 27 | 21 |
| Gentle slope | 57 | 62 |
| Other | 16 | 17 |
| Source of water (%) | | |
| Rainfall | 75 | 78 |
| Water course (natural) | 9 | 8 |
| Well | 6 | 4 |
| Other | 10 | 10 |

was compared using descriptive statistics. The Tornqvist Index was used to account for the multi-input and -output IAA system when assessing total factor productivity. Stochastic production and technical efficiency functions were estimated to determine the effect of the IAA technology on the technical efficiency of input use.

Income effects were measured by applying a two-step instrumental variable approach. Predicted probability of adoption was used as a variable to measure the effect of farm income. At household level, descriptive statistics and parametric tests were used to assess the impact of IAA adoption on food consumption and nutritional status.

The welfare effects of the project on the Malawian economy were estimated by calculating the economic surplus using a multi-commodity model. The increase in consumer and producer surplus was used as a measure of gross benefit. Accounting for the research and development (R&D) investment and taking into consideration the effect of other aquaculture projects on fish output, the internal rate of return on investment was calculated.

## Multiple benefits to food security, livelihoods and the environment

Results obtained using the adoption model showed that the decision to adopt IAA is influenced by access to extension, intensity of IAA training, land endowment, and farmer age. In contrast, the degree of aquaculture integration, which may be considered a proxy measure of the success of the participatory approach, was found to be influenced by access to irrigation, gender, educational level of the household head, and land endowment. Hence, the adoption decision is influenced by the project variables, but the level of aquaculture integration would appear to be driven by factors external to the project's approach. While the study provided a good understanding of the adoption process, no data were provided on the scale of adoption.

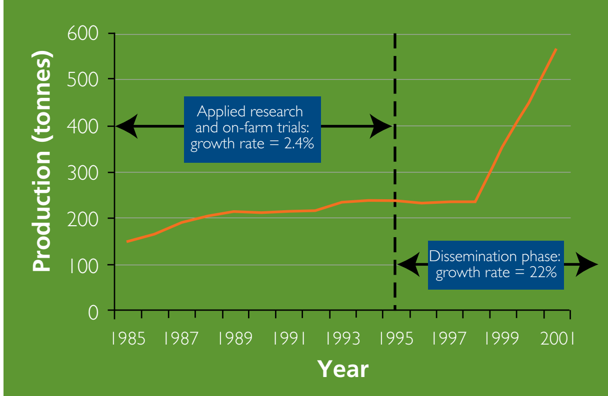
The project's impacts at farm level can be described as follows:

- The availability of pond water and nutrients allows IAA farmers to grow more crops, including higher value crops such as vegetables around their fishponds
- Total factor productivity of IAA adopters is 11 per cent greater than that of non-adopters
- Labor input of IAA adopters exceeds that of non-adopters by 25 per cent
- Average farm profits per unit area managed by IAA adopters are more than double those of non-adopters
- Net farm income of IAA adopters exceeds that of non-adopters by 60 per cent
- Fish accounts for just over 10 per cent of net farm income among IAA adopters
- A 1 per cent increase in IAA adoption increases average net farm income per hectare by 0.9 per cent
- Increasing farm size has a negative effect on net farm income per hectare, but positively influences the decision to adopt IAA
- IAA adopters make more efficient use of inputs than non-adopters
- IAA adopters consume more animal protein than non-adopters
- No significant impact of IAA adoption on the nutritional status of children below five years of age could be demonstrated. However, this may emerge over the longer term.

The project has also had a marked impact at the national level. The success of IAA as a strategy for promoting aquaculture development in Malawi is evident from the fact that, since 1986, total annual fish production from fishponds has increased from 90 tonnes to 1,000 tonnes. Much of this increase is due to IAA dissemination since 1995, with the average annual growth in production increasing to 22 per cent after 1995, from 2.4 per cent previously.

The sustainability of natural resources associated with IAA technologies was assessed by monitoring four

**Figure1. Aquaculture production (in tonnes) in Malawi during research and dissemination phases of the WorldFish IAA project**



factors on an annual basis: diversity of species and enterprises within farming systems, recycling within the system, biomass production, and profit–cost ratio. Results indicate that IAA farmers have increased enterprise diversity, recycling flows, and overall biomass production, as well as economic performance. The implication is that farmers' increased knowledge allows them to select the options that best suit their agroecological as well as their socioeconomic conditions.

The specific findings with regard to environmental impacts were:

- The adoption of IAA has increased the recycling of bio-resources in Malawi (prior to 1988 four out of five small farms were not recycling).
- IAA farms recycle four times as much material as non-IAA farms and retain more nitrogen and phosphorus, indicating a potential improvement in soil characteristics.[3]
- The increase in irrigation capacity and the complementary production of fish and vegetables can increase the overall sustainability of farming.
- IAA reduces nitrogen loss by 50 per cent and improves nitrogen use efficiency.

The social and institutional impacts of IAA were assessed through case studies conducted at five locations. The main findings were:

- Changes in human capital: farmers' knowledge is enhanced through training, and this persuades other farmers to switch to IAA
- Changes in social structures: IAA adoption strengthens institutions such as fish farmers' clubs. These exploit economies of scale to cut farmers' input costs and market their produce. The clubs are key mechanisms ensuring the sustainability of IAA adoption
- Social recognition: farmers are recognized for their leadership skills or as sources of information
- Development of cooperatives: these have been established for the marketing of both fingerlings and fish
- Policy influence: the FPR approach was incorporated into the Malawi Fisheries and Aquaculture Policy in 2000 and a Presidential Initiative on Aquaculture Development in Malawi was signed in 2006.

The cost of IAA technology development by WorldFish from 1986 to 1994 was calculated at around US$1.5 million. A further US$100,000 was added to this figure to account for the cost met by the collaborating national agricultural research system, making a total of US$1.6 million. From 1994 onwards, a constant annual cost of US$100,000 was assumed to reflect the cost of dissemination activities by the government and various nongovernment organizations (NGOs). The internal rate of return on investment in research and dissemination of IAA in Malawi is at least 12.2 per cent.

## Conclusions

The development and dissemination of IAA technologies in Malawi has improved the welfare of producers and consumers. Although the results of this impact analysis imply that it is larger farms that tend to adopt the technologies, smaller farms are also able to benefit, since IAA offers a food security safety net. Small-scale farmers tend to adopt later, taking a wait-and-see approach, then benefiting from community-based initiatives and the knowledge and training of those already established in IAA. The project has also institutionalized the RESTORE approach within the Malawi Department of Fisheries and greatly strengthened local institutions.

Through the project, WorldFish and its partners have demonstrated the viability of aquaculture not just for individual communities but also for whole countries. The experience in Malawi can serve as a model for developing and disseminating IAA technologies elsewhere. A major reason for Malawi's success has been its bottom-up approach: direct engagement with farmers, using their local resources while recognizing their constraints.

### Notes

1 Jamu D.M. and Chimatiro S. 2004. Sustainable agro-pisciculture Malawi. *Entwicklung und Ländlicher Raum*, 38(6): 27–28.
2 Lightfoot C., Bimbao M.A.P., Lopez T.S., Villaneuva F.F.D., Orencia E.L.A., Dalsgaard J.P.T., Gavanilao F.C., Prein M., and McArthur H.J. 2000. Research tool for natural resource management, monitoring and evaluation (RESTORE). Vol. 1. Field Guide. ICLARM Software Series 9 (Vol. 1); Lightfoot C., Prein M., and Lopez T. 1994. Bioresource flow modelling with farmers. *ICLEIA Newsletter* 10(3): 22–23.
3 Brummett R.E. and Noble R. 1995. Aquaculture for African smallholders. ICLARM Technical Report 46. International Center for Living Aquatic Resources Management: Manila, the Philippines, and Deutsche Gesellschaft für Technische Zusammenarbeit: Eschborn, Germany.

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