SOCSCIENCE

Social, Economic and Policy Aspects of Fisheries

Editor: K.K. Viswanathan

Seasonality, Labor and Integration of Aquaculture into Southern African Smallhold Farming Systems

R.E. Brummett

Abstract

Fish production on Malawian smallholdings is generally limited by the quantity and quality of inputs to the pond (Brummett and Noble 1995). The timing of labor availability and other farm activities limit the amount farmers put into their ponds resulting in lower growth rates and yields. There is potential for improving production and yields through modifications of production schedules to accommodate other farming activities. Limited material and labor inputs among farming system enterprises can be better allocated by considering seasonal availability of inputs and adapting the pond and fish farming technology to the farming system.

This case from Malawi demonstrates that aquaculture technology that neglects the annual cycle of events and constraints on the farm will not be easily integrated into the farming system. Focusing on technology that maximizes fish production rather than facilitation of adoption and integration has been a feature of the majority of African smallholder agriculture/aquaculture projects. Farming Systems Research (FSR) must identify niches and opportunities for system improvement for it to be worth supporting as a development intervention.

Low Inputs, Low Yields

Figure 1 illustrates the typical slow growth of a 1:1 mixed *Tilapia rendalli* (Boulenger) and *Oreochromis shiranus* (Boulenger) population in 200 m^2 ponds at the Malawi National Aquaculture Center fed a diet based on the inputs used by 18 local smallholders in Zomba District of Southern Malawi (Brummett 1998). To improve fish growth rates and yields, smallholders are advised by aquaculture research/extension to begin feeding with an application of agricultural and household by-products totaling to about 35 kg dry matter per hectare per day (3.5 g dry matter per m^2 per day) increasing with standing stock up to a maximum of 120 kg/ha/day (Hepher and Pruginin 1981). The mismatch between the recommended feeding rate, based on increases in fish standing stock, and the amount actually used is the major reason for low growth and yields from small-holder ponds.

Over the average year, the desirable rate would result in a total input of 2,608 g dry matter/m^2 into the pond while the typical farmer only puts in 1,144 g. For the typical 200 m^2 smallholder pond, the farmer would need 522 kg of dry matter to feed properly. For the typical total pond area of 700 m^2, the farmer would need 1,826 kg of dry matter as inputs.

Table 1 shows the materials identified as possible pond inputs by Noble and Chimatiro (1991) in a survey of Malawian smallholdings. Even if the quantity of materials varies somewhat from year to year, there is clearly enough dry matter produced by the farm to feed the pond properly. However, discussions with farmers and observations of smallholder farming systems reveals that the reasons for inadequate inputs to fish ponds are more complex.

The Farming Cycle

The agricultural year begins in Malawi in September/October, prior to the onset of rains (Table 2). During this time, the family is busy burning fields to remove pests and stubble, and tilling in preparation for planting maize, the staple crop.

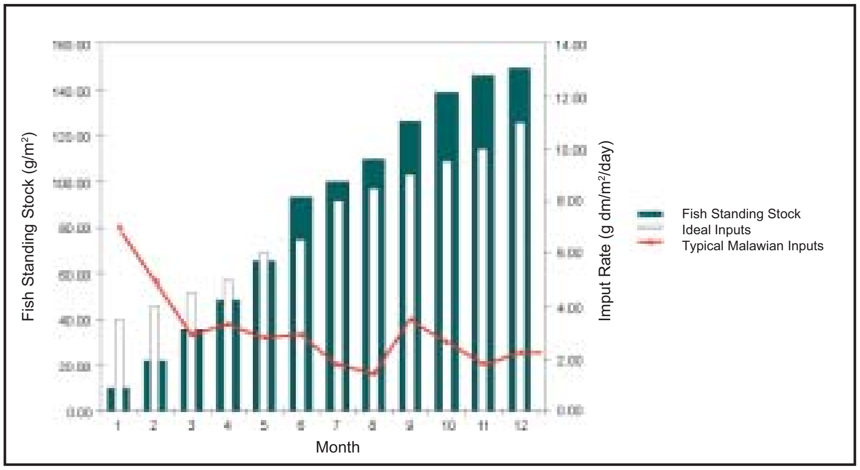


Figure 1. Typical growth of a 1:1 mixed* Tilapia rendalli *and* Oreochromis shiranus *population in 200 m*^{2} *ponds at the Malawi National Aquaculture Center fed a diet based on the inputs used by local smallholders (Brummett 1998). The standing stock is a combination of the average weights of the stocked fish plus reproduction. The ideal feeding rate for the fish population described is based on the recommendations of Hepher and Pruginin (1981). CC indicates carrying capacity of the system.

Table 1. Household and agricultural by products identified on the typical Southern Malawian smallholding of 1.57 ha by Noble and Chimatiro (1991).

Material	Quantity (kg/farm)	Approximate Dry Matter (kg)	Alternative Uses
Firewood Ash	438	438	None
Maize Bran	296	192	Emergency food, normally not used
Rice Bran	54	35	None
Rice Straw	888	275	Mulch, normally burned
Maize Stovers	2513	2262	Mulch, normally burned
Weeds	1595	494	Mulch, normally burned
Total	5784	3696	

When the rainy season begins in November/December seeds are sown and fishponds that have dried begin to fill with water. The first rains bring a flush of plant growth along roads, field margins and any other area not actively cultivated. These plants and the relatively idle labor following planting and prior to serious weeding of the maize fields, which begins in earnest in January, form the basis of the early season peak in pond inputs. Also, farmers are excited about the new crop of fish and tend to prioritize them at this time of year. However, fish standing-stock is low and cannot efficiently use the excessive inputs supplied by the typical farmer.

As the rainy season wears on, more and more green materials are available as pond inputs, but labor is busy with maize cultivation. The weeds at this time of year demand constant attention. Maize plots are often located as much as a kilometer from the pond site. Consequently, pond inputs decline, despite the availability of materials.

The rains end in March/April and the maize begins to dry in the fields. At this time, labor is more easily diverted to the fishpond, but the availability of materials is declining as weeds dry up. Input rates consequently remain at about the same level as earlier. While fish growth has been high up to this point, it now slows as the amount of materials input to the pond falls below the amount needed. In May/June the maize crop is harvested and stored, putting new demands on labor while the availability of input materials continues to decline.

July and August are the coldest months in Malawi and fish growth rates and feed requirements are low. Labor is now busy planting vegetables which do well in the cooler, dryer weather. As the need to weed the gardens increases with the growth of the vegetables and since most vegetables are grown in the same part of the farm in which ponds are constructed, there is a modest increase in pond inputs. September and October are hot and dry and inputs once again decline as vegetables, ponds and everything else dry up in expectation of the rains. Labor, as mentioned above, is busy burning and cultivating for another maize season.

In addition to the seasonal availability of inputs, availability of water and labor play important roles in constraining aquaculture adoption and production. Pond inputs are not available during the hot, dry season when fish growth would be highest. At the time when inputs are maximally available, labor is engaged with production of the staple crop. The main agricultural by-products being harvested during most of the warm rainy season are generated in maize fields that are often far removed from the fishpond. Pond productivity and input constraint data are summarized in Table 3.

It is worthwhile noting that these constraints to aquaculture are seldom identified as important when research and extension are plotting their technical aquaculture messages. Even though a small minority of Malawian farmers has access to perennial water supplies, government guidelines restrict the construction of ponds in springs and river courses where water for filling is more or less available throughout the year and filling/draining can be affected by gravity. In project planning, usually only the types of potential pond inputs available on farm are identified with little data


R.E. Brummett

A duck-fish pond being fed with grass and weeds during the dry season.

being collected on quantities and seasonal availability. Ponds built with water supply as the main site selection criterion are seldom located near the source of the by-products used to feed them. The labor and seasonality constraints faced by smallholders are in some ways actually exacerbated by the aquaculture technology promoted by research and extension personnel. The result is that production is well below potential and adoption of aquaculture by many smallholders is severely limited. As currently promulgated, pond aquaculture technology is not well adapted to the majority of Malawian smallholdings.

Integration

Its failure to make the impacts predicted for it in the 1960s has led some observers to question the feasibility of aquaculture as a tool in the development of smallholdings. This failure is not intrinsic to aquaculture. It is the result of improper integration of the pond into the farming system. As the case of Malawi illustrates, aquaculture *per se* is feasible on smallholdings. Based on the absolute quantity of possible inputs, it could even be more productive but for the competition with other activities for labor.

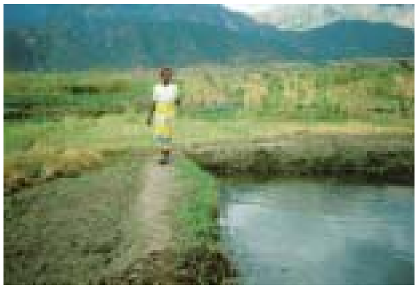
To overcome these constraints, it will be necessary to better adapt the pond and fish farming technology to the farming system. Vegetable production, for example, integrates much better than does maize production. While vegetables (most of which are introduced exotics) can be grown all year, producing them in the wet season requires the use of expensive pesticides and would compete for labor with the maize crop. The vegetables fit into the seasonal cycle by coming at a time when labor availability and the environment are most amenable; just the opposite of the situation with fish culture which wants to compete directly with maize for labor when inputs are most available, and expects highest production at temperatures which prevail when water and inputs are least available.

When a suitable niche is found, aquaculture plays an important role in the small farm's productivity and profitability (Brummett and Noble 1995; Noble 1996; Ruddle 1996). For example, rice-fish integration has grown rapidly in Southern Malawi because it takes advantage of the existing and well-understood technology associated with rice production (Chikafumbwa 1994). Deepening the rice paddies to accommodate the fish, means that two crops of rice-fish per year is now achievable where only one was possible before. Rice-fish has been successful because it easily fits both physically and seasonally into the rice farming system and the farmer can easily see its advantages. The production of imported vegetables are successful among Malawian smallholders for the same reasons.

Table 2. Farm calendar for smallholding farming systems in Southern Malawi. Adapted from Kapalamula (1993).

Month	Main Farming Activities
October	Land preparation for maize fields. Harvesting vegetable gardens. Planting rice nurseries. Tending tobacco nurseries.
November	Planting, weeding, fertilizing maize crop. Spraying, planting tobacco.
December	Weeding, fertilizing, banking maize crop. Transplanting rice. Planting yams, cassava, sweet potatoes in maize fields.
January	Weeding, banking maize and associated crops. Transplanting rice. Planting yams, cassava, sweet potatoes in maize fields.
February	Weeding, banking maize and associated crops. Harvesting, curing tobacco. Harvesting beans. Planting yams, cassava, sweet potatoes in maize fields.
March	Harvesting maize, beans, chilies. Cutting, selling sugar cane. Fertilizing, weeding rice, sweet potatoes, cassava. Harvesting, curing tobacco. Land preparation for vegetable gardens.
April	Harvesting maize, groundnuts, rice. Harvesting, curing tobacco. Growing vegetables in nurseries.
May	Harvesting maize, groundnuts, yams, cassava, sweet potatoes, sorghum. Selling sugar cane, maize, groundnuts. Harvesting, curing tobacco. Transplanting, growing vegetables.
June	Harvesting groundnuts, sugar cane, yams, cassava, sweet potatoes, sorghum. Selling maize, sweet potatoes, cassava, yams, groundnuts, tobacco. Growing vegetables.
July	Growing vegetables. Selling maize, groundnuts, tobacco, sorghum. Harvesting cassava, sweet potatoes, sugar cane, vegetables.
August	Growing vegetables. Harvesting, selling rice, sweet potatoes, cassava.
September	Land preparation for maize crop. Growing, selling vegetables. Harvesting and selling rice, sweet potatoes cassava.

Researchable Topics


R.E. Brummett

Mrs. Nancy Duwa and her integrated fishpond – vegetable garden during the early dry season, Chinseu, Western Zomba District, Southern Malawi.

R.E. Brummett

Dry season integrated fishpond – vegetable garden, Thyolo District, Southern Malawi.

As the case of Malawi demonstrates, aquaculture technology that neglects the annual cycle of events and constraints on the farm will not be easily integrated into the farming system. A primary focus on technology that maximizes fish production rather than facilitation of adoption and integration has been a feature of the majority of African smallholder agriculture/aquaculture projects. However, it is not enough to simply identify constraints. Farming Systems Research (FSR) must identify niches and opportunities for system improvement or it is not worth supporting as a development intervention.

From the annual cycle of events on the farm, the relationship between the vegetables and fish stands out. The work of Noble (1996) and Ruddle (1996) clearly establishes the close and synergistic association between these two components of the smallholder farming system. Putting further emphasis on the pond as a component of the vegetable garden might be a logical approach to improved integration of aquaculture. This would mean de-emphasizing the use of maize bran, up to now the primary ingredient in fish diets encouraged by extension for most Malawian smallholders. Maize bran is produced far from the pond at the house and its use is constrained by the need for labor to carry it to the pond, inadequate supplies (Table 1) and competition with humans in poor agricultural years. Vegetable gardening by-products, on the other hand, have no alternative uses and are generated in close proximity to the pond.

The role of the pond in emergency irrigation of vegetables is probably the main reason why smallholders tend to put their ponds near the garden. Other possible reasons are discussed by Harrison (1994). Brummett and Noble (1995) found that ponds in vegetable gardens substantially increased the productivity of both vegetables and fish because inputs to the ponds were higher and emergency irrigation enabled farmers to keep seedlings alive when rain didn't fall right on time.

Thus, to increase the adoption

Table 3. Growth rates, standing stocks and feeding rates for a 1:1 Tilapia rendalli (TR): Oreochromis shiranus (OS) polyculture. Total stocking rate is one fish of each species per m² (2 fish/m² overall). Data are based on 5 studies involving 30 farmers conducted at the Malawi National Aquaculture Center over three years. Ideal input rates are based on the recommendations of Hepher and Pruginin (1981).

	FISH GROWTH				INPUT RATES		
	Average Wt (g)		Repro-duction	Standing Stock	Ideal Inputs	Typical Inputs in Malawi	
Month	TR	OS	(g/m^2)	(kg/ha)	(g dm/ m^2/day)	(g dm/m^2/day)	Comments
1	5.3	5.1	0	104	3.50	7.04	Inefficient use of abundant inputs when fish are small.
2	10.6	11.5	0	221	4.00	5.04	
3	17.9	17.4	0	353	4.50	2.97	Inputs rates decline as labor is busy with maize.
4	23.3	24.8	0	481	5.00	3.35	
5	27.2	28.0	10	652	6.00	2.79	Fish growth high during warm months.
6	30.2	32.8	30	930	6.50	3.00	
7	35.7	39.1	35	998	8.00	1.77	Input rates decline further as grass dries.
8	42.7	46.9	40	1094	8.50	1.50	Fish growth slows at lower temperatures.
9	51.6	56.9	45	1260	9.00	3.56	Inputs increase as vegetable gardens produce wastes.
10	56.9	62.9	50	1388	9.50	2.68	Inputs again decline as dry season progresses.
11	59.9	66.2	55	1458	10.00	1.81	Rains come, increasing availability of inputs, but labor is busy with maize.
12	61.6	68.2	60	1490	11.00	2.27	
Total Inputs					2608	1144.00	

and productivity of aquaculture, extension might simply encourage the siting of "farm ponds" in the garden as a means to improve vegetable production. The use of vegetable by-products as fish feeds would probably come naturally from the location (Brummett and Noble 1995).

For smallholdings which are making the transition from a primarily subsistence to a more commercial focus, new technologies for the storage and/or processing of feed materials would be very useful. In Malawi, properly conducted fish production is more profitable than most other crops (Chimatiro and Janke 1994). The group of farmers making the transition to commercial fish production would be *de facto* those with access to more reliable water supplies. Also, cash profits would permit the direct payment of labor. If simple and economically viable technologies were available, commercial fish farmers should be willing to pay for the collection, processing and storage of materials for use in ponds when the season favors high growth rates. Being able to save materials from the time when fish standing stocks are low for use when they are high will also improve efficiency, and thus productivity and sustainability.

References

Brummett, R.E. 1998. Making experiment station results more useful to farmers. Naga, the ICLARM Quaterly 21 (2):19-24.

Brummett, R.E. and R. Noble. 1995. Aquaculture for African smallholders. ICLARM Technical Report 46. International Center for Living Aquatic Resources Management, Manila, Philippines and Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Germany, 69 pp.

Chikafumbwa, F.J. 1994. Farmer participation in technology development and transfer in Malawi: a rice-fish example, p. 30-31. ***In*** R.E. Brummett (ed.). Aquaculture Policy Options for Integrated Resource Management in subSaharan Africa. ICLARM Conf. Proc. 46. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and International Center for Living Aquatic Resources Management, Manila, Philippines (extended abstract).

Chimatiro, S.K. and A. Janke. 1994 Socioeconomic assessment of smallholder aquaculture: a case study of smallholder farmers in Mwanza and Zomba Districts, p. 10-11. ***In*** R.E. Brummett (ed.). Aquaculture Policy Options for Integrated Resource Management in subSaharan Africa. ICLARM Conf. Proc. 46. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and International Center for Living Aquatic Resources Management, Manila, Philippines (extended abstract).

Harrison, E. 1994. Digging fishponds: perspectives on motivation, p. 12-15. ***In*** R.E. Brummett (ed.). Aquaculture Policy Options for Integrated Resource Management in subSaharan Africa. ICLARM Conf. Proc. 46. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and International Center for Living Aquatic Resources Management, Manila, Philippines (extended abstract).

Hepher, B. and Y. Pruginin. 1981. Commercial fish farming. Wiley-Interscience, New York, USA, 388 pp.

Kapalamula, M. 1993. Comparative study of household economics of integrated agriculture-aquaculture farming systems in Zomba District. MSc. Thesis. Bunda College of Agriculture, University of Malawi, Zomba, 237 pp.

Dickson, M.W. and A.C. Brooks (eds.). 1997. Fish farming in Malawi: A case study of the Central and Northern Regions Fish Farming Project. Stirling Aquaculture, European Union and Malawi Fisheries Department, Lilongwe Malawi, 70 pp.

Noble, R. 1996. Wetland management in Malawi: a focal point for ecologically sound agriculture. ILEIA Newsletter 12(2): 9-11.

Noble, R.P. and S. Chimatiro. 1991. On farm biotic resources for small scale fish farming in Malawi, p. 18. ***In*** B.A. Costa-Pierce, C. Lightfoot, K. Ruddle and R.S.V. Pullin (eds) Aquaculture Research and Development in Rural Africa. ICLARM Conf. Proc. 27. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and International Center for Living Aquatic Resources Management, Manila, Philippines (abstract).

Ruddle, K. 1996. The potential role of integrated management of natural resources in improving the nutritional and economic status of resource-poor farm households in Ghana, p. 57-85. ***In*** M. Prein, J.K. Ofori and C. Lightfoot (eds). Research for the Future Development of Aquaculture in Ghana. ICLARM Conference Proceedings 42. International Center for Living Aquatic Resources Management, Manila, Philippines; Institute of Aquatic Biology, Accra, Ghana and Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Germany.

R.E. Brummett *is from ICLARM-The World Fish Center, Yaoundé, Cameroon*