Fingerponds: An agrofish polyculture experiment in East Africa

Roland Bailey (King's College London), Rose Kaggwa (Makerere University, Uganda), Julius Kipkemboi (Egerton University, Kenya) and Hieromin Lamtane (Dar es Salaam University, Tanzania)

Introduction

Among ideas for the wise use of wetlands in the immediate post civil war years in Uganda, Denny & Turyatunga (1992) advocated the possibility of enhancing food production, especially during dry seasons, by excavating ponds at the landward edge of swamps. Their simple idea was that seasonally flooded by water backing up through the swamps, these hollows would retain water and trap fish migrants for later cropping during flood drydown, and the excavated topsoils would offer fertile material for vegetable growing.

Whereas agrofish polyculture systems are not new, the fingerpond concept differs in that it relies almost entirely upon natural events and has minimal interference with the integrity of the environment. The dug pond is merely a hole in the ground with nature taking care of water levels and fish stocks. Water levels remain unregulated, no commercial fish feeds are used and the well being of the fish depends on the natural productivity and food webs of the pond ecosystem, possibly enhanced by additions of manure if it is readily available. The adjacent garden is watered from the pond as required and may be fertilised with pond sediments after the fish harvest.

Thus, the fingerpond system is envisaged as a low technology tool for sustainable development with a role for increasing food security amongst riparian communities. Would it work? To test the fingerpond concept, the EU through INCO-DEV funding, agreed to support a collaborative project with three East African and three European partners and the following gives a summary account of its progress, paying particular attention to the fish!

Setting up

In Year 1, two sites were identified at swamp edges in each East African partner country. Critical factors in selection were the likelihood of a single major flood season each year and an amenable farmer or community for participation in the project. The sites in Uganda and Kenya lay within the Lake Victoria Basin and in Tanzania beside lakes in the floodplain of the lower River Rufiji.

Experimental plots at each site were prepared at the landward edge of the permanent swamp vegetation. Each comprising of a cleared area with four elongated (hence finger) ponds, 8 m x 24 m, partially extending into the swamps when local conditions allowed, and separated by three raised vegetable plots of similar dimensions. Ponds were dug to give a maximum depth of 2 m to the landward grading to 1 m at the shallow swamp-ward end. Four ponds offered the potential of testing up to three different management regimes against a control.

One early lesson to emerge relates to the major issue of site selection. Knowledge of the 'usual' seasonal hydrology at a site is vital but it cannot be guaranteed, and may be altered by an irregular flood pattern, exceptional rains or a drought. At three sites, early and prolonged flooding coupled with heavy rains, took completion of pond digging into year two. In Tanzania, ponds at one site remained under water following the initial flood whilst those at the second remained more or less dry, in both cases until year four. In the same year ponds in the Lake Victoria basin were scarcely if at all inundated as the lake fell to its lowest water level since 1961.

Underway in Uganda and Kenya

During Year 2 plots in the Victoria basin were flooded between April and June becoming disconnected or isolated during drydown between May and July. The ponds were found to contain generally turbid, nutrient poor water with low algal and zooplankton biomasses. Importantly all contained self-stocked fishes which at initial censuses, (using successive removal seining) revealed varying stocks by total numbers, 4 - 2342, and weights, 0.5 - 11.0 kg. Three species of tilapias (*Oreochromis leucostictus*, *O. niloticus* and *O. variabilis*) and two haplochromine species were most numerous. The tilapias were generally small with early evidence of precocious spawning and few individuals over 200 g weight. There were also some clariid catfish, rarely more than 200 g weight, an occasional large lungfish of 3kg or more, and quantities of small anabantids and cyprinodonts.

Tilapias were regarded as the key fish. Stomach content analyses showed that the three species consumed variable quantities of algae, detrital material, rotifers and microcrustaceans with the latter invariably the major component in fry guts. Accordingly protocols were developed for experimenting with additions of locally available manures in order to enhance growth and production of fish either directly as feed or through increasing algal and zooplankton production, the latter in part via the microbial loop.

In Year 3 the Victoria basin plots functioned well - the flood came and went, leaving water and fish in the disconnected ponds. A range of vegetables were grown and harvested from the raised gardens and trials with chicken and cattle manures in the ponds were conducted. For the pond trials and during the initial censuses at each site, attempts were made to harvest all small species, lungfish, and large clariids, and to reduce tilapia stocks to equal densities of 'fingerling' sized fish. Thereafter pond margins were regularly netted to try and reduce tilapia numbers from precocious spawning and at the same time, to remove frogs, toads and their tadpoles which compete with juvenile tilapias for food resources. At two sites clariids were retained and redistributed equally as a potential means, along with the avian kingfishers that were invariably attracted to the ponds, of naturally reducing the densities of tilapia fry.

In the manuring experiments total fish biomasses rose considerably by final harvests but with marginal increases in average fish weights. Harvests typically produced a few tilapias > 70 g, but these were greatly outnumbered by fish of 2 – 10 g, bringing into question the value of partial netting of the pond edge.

In Uganda at Gaba, treatments with chicken manure gave much larger harvests than the control, the higher figure corresponding to a yield of 2.5 t per ha. Differences between harvests at Jinja were less pronounced where security of the site was low and there was some evidence of poaching. The lowest value came from the highest applications of manure, - a level at which the diurnal cycle of dissolved oxygen began to be adversely affected. The use of cattle manure in Kenya clearly enhanced final harvests. Modest daily additions at Nyangera produced the equivalent of 1 t per ha of small tilapias and two-weekly bulk manuring at Kusa gave final harvests of about 0.4 t per ha, substantially greater than from the control. Kusa was one of the sites where clariids were retained and distributed between ponds and in all of them at harvest, there was a noticeable increase in average weights of the fish obtained.

Despite the failure of flooding in year 4, the partial filling of ponds with ground water and rain allowed some further experimentation with manuring, approaches to increasing epiphytic primary production using staked mats of cut swamp vegetation, and the culture of monosex stocks of tilapia. Preliminary analyses of the results are interesting but at the same time it is fully appreciated that these experiments conflict with the essential premise of the fingerpond concept that the system is left to nature.

Underway in Tanzania

Meanwhile year 4 was at last a success story in Tanzania. One site (Ruwe) was flooded for the first time and at dry down in June was left with viable ponds for 6-7 months. The other (Uba) was exposed for the first time in September leaving ponds with a rather tenuous disconnection from the lake for 4-5 months. Ponds at both sites contained nutrient rich water reflecting the eutrophic nature and close proximity of the floodplain lakes, and the openness of intervening swamps. Aquatic macrophytes competed with algal blooms for supremacy in the ponds - the former 'winning' at Ruwe and the latter at Uba. The raised plots at Ruwe were planted and provided good crops of maize, ochra and tomatoes.

By contrast to the Victoria basin, the Rufiji fingerponds trapped a greater variety of fishes - mostly small in size apart from some clariids and relatively large (> 160 g weight) tilapias (*Oreochromis urolepis*). During initial stocktakings at both sites the larger fish and all smaller species were generally harvested. The residue of tilapias, smaller clariids and at Ruwe, the cyprinid *Labeo congoro*, were regarded as the key fish and distributed equally between the ponds. Analysis of fish data from Rufiji is incomplete, being complicated by midterm partial harvests and poaching. At Ruwe three ponds were 'fed' with 7 kg of fermented green manure at 1 - 5 day intervals without positive results but the retention of *Labeo* was rewarded with a mean individual weight gain in excess of 600%. At the untreated Uba ponds, the overall mean total biomass achieved at final harvest, equivalent to about 1.6 t per ha, was substantially higher but some ponds here gained unknown quantities of adult spawning tilapias and other fishes from partial reconnections with the lake during the trial period.

To conclude

So far as fish are concerned, the lessons from fingerponds in East Africa were perhaps not too surprising. As anticipated, some of the fish that migrate through swamps with the flood on to seasonally flooded grasslands do find refuge or become trapped in ponds at drydown. The quality and quantity of trapped fish will differ not only between major hydrological zones but also between different localities within them. However tilapias and clariid catfish are ubiquitous and merit retention, albeit not exclusively, to provide periodic harvests of fish during the dry season. Although scarcely, if at all, evident in the Rufiji ponds, tilapias are prone to build up populations of small fish by spawning precociously, - a familiar problem in tilapia culture. As for cropping it seems that the largest individuals of any species are likely to be available as soon as possible after disconnection, and that whereas only a modest growth amongst individual tilapias may be expected, manuring could substantially increase the overall total biomass for harvest. At the same time it should be noted that just as a big fish was always welcome, large numbers of small fishes were also immediately acceptable to participating farmers.

The experiment has shown that fingerpond systems can work biologically, and pending a satisfactory cost/ benefit analysis of their potential role in rural economies, one important task remains, namely the preparation and dissemination of appropriate 'how to do it' information.

Reference

Denny, P & Turyatunga, F. (1992) Ugandan wetlands and their management. In E. Maltby et al (eds) : Conservation and Development : The Sustainable Use of Wetland Resources. IUCN, Switzerland, pp77-84.