Peter Edwards writes on

Rural Aquaculture

From integrated carp polyculture to intensive monoculture in the Pearl River Delta, South China

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Dramatic changes have taken place over the last 20 years in inland Chinese aquaculture with a decline in traditional integrated Chinese carp polyculture. I was fortunate to witness the peak development of the former as a consultant for UNDP/FAO at the Integrated Fish Farming Center, Freshwater Fisheries Research Center, Wuxi, in 1981, which included field visits and interviews of farmers of the dike-pond system (DPS) in the Pearl River (Zhujiang) Delta. On a visit to southern China last November I spent a day revisiting fish farms around Quangzhou and in Shunde County (now a district), Quangdong Province and saw at first hand these remarkable changes.

Traditional dike-pond system

The integrated agriculture-aquaculture DPS system dates back to the 14th century (Lo, 1990). Wetlands in the Pearl River Delta were reclaimed by digging ponds and using the excavated soil to raise elevated dikes on which fruit and vegetables were raised, including mulberry bushes to provide leaves to feed silk worms which supported the silk industry of southern China. It was also characterized by integration with other local human activity systems besides plant crops and used inputs, both on- and off-farm, from animal husbandry, sanitation and cottage-level industries such as silk and soybean processing wastes. It used the well known Chinese practice of carp polyculture which consists of a polyculture of up to 8-9 species of fish, with various feeding and spatial niches leading to efficient utilization of nutritional and spatial niches or resources in the pond. The major species in the dike-pond system were the herbivorous grass carp, the filter feeding bighead and silver carps, the detritus feeding mud carp, and the omnivorous common and crucian carps. It reached its most complex stage of development in the 1980s during the era of collective ownership of agriculture.

Watering vegetables with fish pond water. Shunde District, 2007.

Cultivation of mulberry (foreground) adjacent to a fish pond. Le Liu People's Commine, Shunde County, 1981.

Watering vegetables with pond water, foreground, sugar cane background. Shajiao People's Commune, Shunde County, 1981.

The most comprehensive description of the system is the book by Ruddle and Zhong (1988).

Demise of the dike-pond system

As I witnessed late last year, the dike-pond system has changed beyond recognition since the Government introduced a market-driven economy in the mid 1980s. The Pearl River Delta now has the most expensive land in southern China as it has been the powerhouse of Guangdong's economic reform of the last 25 years (Jin, 2007). Guangdong Province took the lead in China in setting up special economic zones (SEZs) starting in 1979. Township enterprises are booming in the former rural area. By the early 1990s, Shunde County at the centre of the former DPS had already become one of the four richest counties in China. It is the largest productive base of electric appliances in China; it is the "capital of home appliances of the world" and it hosts annually China's International Fair of Home Appliances. The largest bicycle production base and the largest producer of microwave ovens in the world are also located in Shunde District as well as factories for manufacture of air conditioners, refrigerators, electronics, telecommunication appliances, garments and animal feed.

The cultivation of mulberry was one of the defining features of the pond-dike system but it has disappeared from most of Shunde District. Polyculture of Chinese carps has been mostly replaced by monoculture of high-value species such as eel, freshwater prawn and soft-shell turtle over the past decade (Yee, 1999). The farmer I interviewed during my recent visit, was culturing channel catfish in 100 mu (6.7 ha) area of ponds in Xin Long village in Longjiang, Shunde District. The village had 1,000 mu (67 ha) of privately owned ponds in which many species were being cultured, including tilapia. Although the fish farming village was surrounded by urban/industrial development, it was not going to be converted into factories as it was a special area for aquaculture as decided by the village fish farmers according to the farmer I interviewed.

While considerable areas of land and ponds occupied previously by dike-pond systems have been converted into urban and industrial development, there may be a larger pond area today than in the 1980s as previously reported by Yee (1999). Many farmers continue to be involved in aquaculture although mainly intensive culture of high-value species with off-farm feed within aerated ponds. There is a ready market for fish in the relatively affluent area and intensive fish culture is more profitable for farmers than the traditional DPS dominated by lower value filter feeding species. Dikes are now much narrower to maximize pond surface area as aquaculture is more profitable than dike cropping and many are in poor shape through neglect as well as erosion by aerated pond water. Crops are still being cultivated on the dikes of some ponds but are mainly integrated with aquaculture through use of the pond for watering crops. I saw no livestock in Shunde District as manuring of ponds is no longer required; today the major concern is pond eutrophication from residual fertilizer effects of uneaten fish feed and faeces rather than use of livestock and human manures to fertilize the pond as in the past.

Most fish ponds have aerators. Shunde District, 2007.

Feeding channel catfish with pellets. Shunde District, 2007.

Cultivating vegetables on a fish pond dike. Shunde District, 2007.

Nutrient relationships of the dike-pond system

A widely held misconception is that the dike-pond system was a more or less closed system in terms of nutrient flows. Ruddle and Zhong (1988) in their detailed study of the traditional dike-pond system claimed that it was a relatively closed ecological cycle "based almost entirely on the tightly managed recycling of materials" and the "bulk of the inputs have always been generated from the within the system itself". Similar claims were often repeated: "the Chinese dyke-pond system…is unique in integrating agriculture and aquaculture within a single self-contained system…requiring minimal input of energy and materials" (Zhong, 1989); "without any external input of fuel, fertilizer or feed in an ecologically-balanced system" (Chan, 1993); and, "the DPS itself supplied most of the nutrients for effective functioning of the system" (Yee, 1999).

However, it was difficult to reconcile the production and export of large amounts of nutrients in commercial crops such as fish, pigs, silk, sugar and vegetables with a "relatively closed ecological cycle" (Edwards, 1993). It was estimated that the mean yield of fish alone would require an absolute minimum of 180 kg of consumable nitrogen/ha/year, most of which could not have been regenerated within the system. Data from household surveys presented by Ruddle and Zhong (1988) showed that most of the total inputs to the fish ponds were manures, mainly pig manure but also human manure or nightsoil. With an extremely high local population density in the dike-pond area of 1,700 persons/square km and only 12% of the agricultural land under rice, a considerable amount of pig feed and human food must have been imported into the system. It was also claimed that the feed requirements of the pigs were met by a "diet of greens, particularly water hyacinth, sugar cane tops and vegetable waste". Feeding greens to pigs is a traditional Chinese practice but pigs are monogastrics and require additional, more digestible sources of feed for adequate growth. While the ponds effectively treated human and pig manure and the nutrients were recycled in the dike-pond system, it was characterized by considerable nutrient flows from outside the system rather than being a closed system.

An example for sustainable development

Another myth in view of the demise of the dike-pond system is that it provided a model for sustainable aquaculture elsewhere. According to Chan (1993), the dike-pond system "should serve as a model for economic as well as ecological development for the rest of China and many other parts of the world"; and "many countries in the region would benefit from adaptation of the Chinese DFS model" (Korn, 1996).

This page: Fish ponds are interspersed with urban and industrial developments. Shunde District, 2007.

Integrated duck-fish culture. Sanshui District, 2007.

The dike-pond system provided benefits for centuries but could not compete with industry in terms of social development or sustainability even though it may have been environmentally sustainable. There has been widespread delinking of crops and livestock from fish ponds in the major fish farming areas of China. According to Zhou En Hua, my interpreter as well as teacher in China over 25 years ago, who now runs feeding demonstrations in various provinces of the country, "it is really difficult to locate any large-scale fish farms with integrated farming practice as we saw in the early 80s in most of the aquaculture production areas of China". However, I did see large numbers of integrated duck/fish farms on the outskirts of Guangzhou, simplified two component feedlot livestock/fish systems, presumably because fish culture is still a profitable way to treat and reuse duck manure where there is high market demand for ducks as in southern China.

Towards sustainable intensive aquaculture

The intensification of inland aquaculture is causing environmental concerns in China because of pond eutrophication and the absence to date of treatment of pond effluents. A farmer of a large pellet-fed tilapia farm I visited in Hua Du District told me that his major problem is very green water from excess residual nutrients. Zhou En Hua recently told me that he never recommends monoculture in pellet-fed ponds to farmers as pond water readily becomes eutrophic which stresses the fish. He recommends an 80:20 system of stocking fish with 80% of the biomass at harvest comprising the target species, and the remaining 20% of the biomass, "service fish" such as silver carp to feed on the phytoplankton produced by fish metabolic wastes. Although silver carp has a relatively low value compared to target fish such as crucian carp and tilapia, the improvement in water quality leads to a better food conversion ratio, less disease, reduction or elimination of the need for chemicals and drugs, safer fish and therefore a higher economic return for the farmer. Thus, some of the principles of traditional Chinese aquaculture practice are being introduced to help to make pellet-fed monoculture environmentally as well as socially sustainable.

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