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Local fish farming practices and a typology of farms based on organic matter intake management

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Fish farming plays an important role in Thai Binh province. Through the use of subsidies, the political authorities there encourage the conversion of low-yield paddy fields into fish farm ponds. Furthermore, thanks to integrated agriculture, fish farming allows regulation and absorption of most animal faeces, especially pig excreta produced on farms. The various kinds of farms have been characterized. Their evolution in the coming years in relation to livestock effluents use allows a diagnosis regarding their absorption capacity of part of the animal faeces that will be produced once the pig breeding intensification project planned by 2010 is established.

Introduction

Originally, water holes were dug to use the earth for building houses and making gardens. Water collected in water holes was used for domestic needs and for producing plants used for feeding the pigs. Most faeces (pig and other) were used on crops, particularly on rice. Currently, as fish farming grows in importance, these water holes converted into ponds have made fish farming possible; animal excreta are therefore increasingly put into ponds rather than onto crops.

Fish farming plays a vital role in the absorption of livestock effluents. The study presented here is founded on an analysis of production systems that consisted of: i) collecting all the information relating to current practices (zootechnical procedures; pond fertilization; fish feeding) and of constraints encountered by producers (sanitary and socio-economic techniques) through a bibliographical study and field surveys; and ii) building up a typology in relation to the potential use of animal effluents in fish feed.

The surveys (E1) took place from 26 April to 10 June 2005 in Vu Thu, Quynh Phu and Thai Thuy districts (Table 1), a more precise monograph was produced in Thuy Ninh commune of Thai Thuy district (1): 47 questionnaires (2) were used to carry out the typology. Two farmers were not included in the analysis, of whom one had stopped fish farming after the installation of a biogas digester and the other had not yet started his first cycle. These surveys were completed and extended to Dông Hung district (E2) by the use of 149 supplementary questionnaires (1), which made it possible to confirm the results and to validate the typology.

Table 1: *Distribution of surveys by districts and communes*

Vũ Thư	***E1***	***E2***	***Quỳnh Phụ***	***E1***	***E2***	***Thái Thụy***	***E1***	***E2***	***Đông Hung***	***E2***
Vũ Tiến	*5*	*10*	*An Mỹ*	*6*	*13*	*Thụy Ninh*	*51*		*Đông Cường*	*7*
Vũ Đoài	*4*	*9*	*Quỳnh Bảo*	*5*	*6*	*Vũ Hoài*		*1*	*Phong Châu*	*8*
Duy Nhất	*5*	*8*	*An Tràng*	*4*	*10*	*Thụy Hồng*		*1*	*Đông Kinh*	*14*
Việt Hùng	*4*	*15*	*Quỳnh Hải*	*4*	*16*	*Thụy Trình*	*1*	*4*	*Hồng Châu*	*11*
Việt Thuận		*2*				*Thụy Quỳnh*	*4*	*11*	*Đông Động*	*10*
						Thái Hưng		*2*		
						Thái Hồng		*1*		
Total	*18*	*44*	*Total*	*26*	*45*	*Total*	*55*	*20*	*Total*	*40*

Main characteristics of fish farming

Public policy with regard to fish farming

The State encourages the development of fish farming, particularly in Thai Binh province. In all the communes visited during the surveys, it transpired that currently in the province, a local policy adopted from 1999 until 2010 aims to group livestock farms and fish farm ponds together in specialized areas far from dwellings. It aims to increase the export volume of fish farm products at the national level. Vietnam hopes to reach 2 million metric tons of fish farm produce exported by 2010, or 2 billion Euros.

The various aims of this provincial project are to improve the current state of more than 6,600 ha of ponds and to convert low-yield paddy fields into a system of rice-fish production or into freshwater ponds. The State, through the intermediary of the communes and districts, subsidizes works up to a maximum cost of 7,000,000 VND/ha of converted paddy fields. Between 2001 and 2004, the total area of converted paddy fields reached 1,907 ha (from a potential estimated to be 7,000 ha), broken down as 40% ponds and 60% rice-fish farming.

Fish farming integrated into the farm's production system

Fish farming is carried out in ponds that are closely integrated into the energy and nutrition vectors of other forms of production on the farm. The production system in integrated fish farming ponds is controlled by two sources of energy: the sun though the phytoplankton and organic intakes through heterotrophic bacteria. The key to capturing the various sources of energy is mixed fish farming (3). Different species use different layers of the pond thanks to a wide range of behaviours and diets. Fish farming is linked to various livestock and crop systems present on the farm. 87% of farms surveyed at least raise pigs and may also keep poultry and/or cattle (Figure 1). 80% of farms grow rice (Figure 2). More than half of them alternate rice with one or several dry crops (maize, soya, groundnuts, etc.).

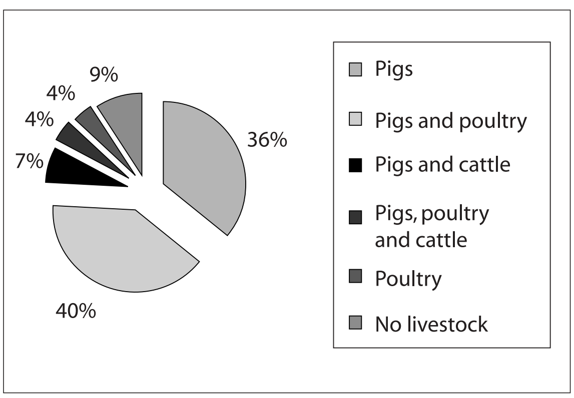

Figure 1: *The various kinds of animal husbandry*

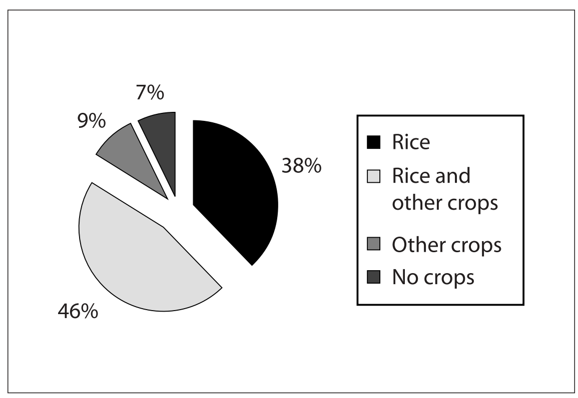

Figure 2: *The various crops*

The rice - fish system
Traditional rice-fish farming consists of growing rice and raising fish in the same place at the same time. The changes that have come about in rice growing, such as the introduction of short-cycle varieties of rice, tend to modify this system in favour of abandoning one of the associated activities or practising them alternately over time.

In Thai Binh province, there are fewer and fewer fish farmers who practise rice-fish farming since the establishment of the programme of conversion of low-yield paddy fields into ponds. For the Thai Binh provincial authorities, rice-fish farming is considered a transitional stage from the conversion of low-yield paddy fields into fish farm ponds (4). Among the farmers surveyed, only 6% of them practised rice-fish farming.

The ducks - fish system
The buildings that house ducks are constructed over or beside fish farm ponds and the animals therefore have easy access to the water. They feed on snails and small fish living in the water and also receive supplementary feed. The remains of the ducks' feed and their faeces fall into the pond and there become a source of food for the fish and organic fertilization for the pond. On average a duck excretes 30kg of faeces per year. The duck density is between 200 to 300 animals per hectare, or 7 to 10 ducks per sao (5). An almost identical system to the ducks – fish one is the chickens – fish system. The faeces are collected for spreading on ponds when the buildings where the chickens live are built next to ponds. But there are also cases where the buildings are on stilts with open grating above the pond, when the faeces fall directly into it.

In Thai Binh province, 28% of farmers interviewed practise the integrated fish - ducks system and 19% practise the integrated fish - chickens system. 8% of farmers practise the two systems simultaneously.

The pigs - fish system
Pigs are raised in buildings on the edge of the pond and excreta go directly into it along with cleaning water. Sometimes, the faeces are scraped for spreading on crops and in this case, only the cleaning waters containing the remains of urine are poured into the pond. If pigs are raised in buildings far from the pond, the slurry is collected for spreading over the water with or without having been turned into compost. The animal stock required to fertilize a pond is about 60 pigs per ha of pond or 2 per sao (6). The pigs - fish combination is the one that gives the highest yields of fish. In Thai Binh, nearly all the farmers interviewed practised this system of integration.

The VAC system, a conceptualization of traditional systems
The integration of vegetable cash crops, livestock farming and fish farm ponds is called the "VAC system". In Vietnamese, VAC is the abbreviation for "Vườn Ao Chuồng" (see Chapter 2). The VAC movement began in the 1980s; its aim was to increase and to stabilize the nutritional quality of the rural poor. Thanks to the adoption of this system, the food quality of these people has been significantly improved (7). In Thai Binh province, most farms encountered do not refer explicitly to this system, which can be considered as an optimization of traditional integration systems.

A fresh source of income for farmers

Often having been practised for less than 10 years by older and more educated farmers, the development of fish farming seems in part to be the result of government promotional activity. Most farmers (2/3) in Thai Binh province state that they became involved in fish farming to increase their income (Figure 3). Feeding the family with fish is not given as a reason. This is in line with the provincial project of converting low-yield paddy fields into ponds.

The capacity of fish farming to provide a good monetary return in exchange for work done constitutes a popular reason (more than 20% of farmers) while that of using effluents does not (fewer than 10% of farmers).

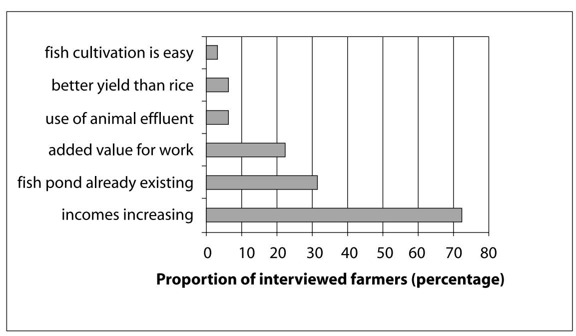

Figure 3: *Reasons that encourage farmers to begin farming fish*

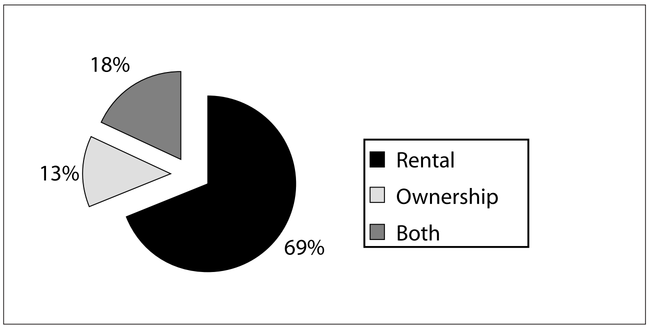

Figure 4: *Mode of pond use*

Table 2: *Mode of pond use in Thuy Ninh commune*

Farms	***Large***	***Medium***	***Small***
Number	*14*	*22*	*15*
In m² of ponds	*> 2160*	*1080 - 2160*	*< 1080*
Average surface area of ponds (m²)	*3754 ± 1780*	*1418 ± 255*	*527 ± 171*
- Owned (%)	*21*	*73*	*74*
- Rented (%)	*43*	*23*	*27*
- Mixed (%)	*36*	*5*	*0*

Most fish farmers surveyed rent all the ponds they use. The others own them or use a mixture of owned and rented ponds. However the large proportion of rented ponds is linked to an overrepresentation of large farms in the sample. The size of farms (Table 2) has an influence over how ponds are put to profitable use.

There are two kinds of rental: from a neighbouring owner of a pond, or from the commune. In the second case, the price of rental is fixed by the State. However, if the pond is derived from the conversion of a rented paddy field, the price is fixed by the State in kg of rice per sao and varies with the market price of rice.

Among all fish farmers met with, half of them have already attended courses concerning freshwater fish farming. However, in answer to the question “how did you learn to farm fish?” 68% of them replied: “by myself”, very often meaning working with family members since childhood and only 19% replied spontaneously “with the help of courses”.

Box 1: Fish farming training courses in Thai Binh

Half of fish farmers surveyed have already followed courses concerning freshwater fish farming. Those who take part in courses are chosen by the head of the commune, the selection criterion being the size of ponds. It is those fish farmers with the largest ponds who take part in courses. The courses are given by an official from the centre for the encouragement of development of fish farming and the course content addresses: i) the characterization of the various traditional species; ii) farming techniques; iii) precautions against diseases, and iv) the most common diseases. Courses are adapted to the regions in which they are given.

Major constraints concerning pond water management

Filling and emptying ponds

Thai Binh is located in an area of the Red River Delta; the terrain is therefore relatively flat. Slopes are less than 1% and altitude varies between 1 and 2 m above sea level (8). Given the gentle slope and the depth of ponds (Table 3), no natural run-off is possible. Renewal of water is not always possible either, many fish farmers questioned state that they cannot change the water in their ponds because they are not linked to the hydraulic system (Table 4). Ponds are therefore usually topped up with water or/and emptied with the help of pumps, or manually in the case of smaller ponds.

Finally, 40% of fish farmers questioned explain that flooding is a serious problem for them because the sides of their ponds being too low, when the water rises, the fish escape from the ponds. In particular, two years ago, a flood caused heavy losses for farmers with sometimes the complete disappearance of all their fish. One possible solution considered by most fish farmers is to raise the sides of their ponds by building brick walls all around the edge. This solution represents a significant extra expense.

Table 3: *Depth and source of water on farms in Thuy Ninh commune*

Farms	***Large***	***Medium***	***Small***
Average depth (meter)	*1.4±0.3*	*1.2±0.4*	*1.2±0.3*
- Rains (%)	*0*	*4*	*33*
- Canals (hydraulic system) (%)	*7*	*18*	*40*
- Rivers (%)	*93*	*68*	*27*

Table 4: *Renewal of water of farms in Thuy Ninh commune*

Farms		***Large***	***Medium***	***Small***
Yes (%)		*100*	*86*	*47*
No (%)		*0*	*14*	*53*
Average quantity of water renewed (%)		*41±28*	*37±16*	*25±20*
Frequency	*Every week (%)*	*79*	*64*	*56*
	Monthly (%)	*7*	*18*	*22*
	Rare (%)	*14*	*18*	*22*

Alkaline reserves and pH

Land located along the banks of the Red River or its tributary, the Trà Lý, are flooded yearly or occasionally. Here soil is alluvial with a low pH, about 6, (9) which is the sign of a lack of alkaline reserves. An environment deficient in carbonates reacts poorly to fertilization. The lack of carbonates is therefore a limiting factor in the increase of pond productivity; this is why the area's fish farmers are advised to lime their ponds yearly.

Box 2: Spreading lime has various aims in fish farming

1. *Optimizing the use of fertilizers by maintaining a pH of the mud of between 6 and 7 and an overall alkalinity of the water of about 20 mg/L of CaCO3*
2. *Compensating the acidifying effect de some fertilizers (urea, in particular)*
3. *Improving the decomposition of OM*
4. *Sterilizing the pond during the drying-out period, eliminating parasites and pathogens (10).*

All fish farmers interviewed spread lime in their ponds after a drying-out period of a few days; the lime is spread on the bottom of dried-out ponds. In addition, 30% of fish farmers throw some onto the surface of their ponds during the farming cycle. When the lime is spread during the farming cycle, it is often mixed with pig slurry to form pellets that are then thrown onto the surface of the pond. The fish farmers interviewed who lime during the cycle do it every month (60% of cases). The average quantity spread by the fish farmers of Thai Binh province on their ponds over one year is about 60 kg/sao (or 1.7 t/ha), which corresponds to the recommended quantities (10).However, the quantity spread varies enormously from one farm to another.

Water temperature

In the hot season, the conditions are favourable to fish farming and to the rapid decomposition of organic matter. The only data contained concerning the characteristics of fresh water in the ponds of Thai Binh province are shown in Table 5. The measures were made in Duyen Hai commune in Hung Hà district. They were carried out from June to November during the hot and humid season. During the cold season, it is recommended to reduce intake of organic matter in ponds when the water temperature goes below 18 or 20°C because at this temperature, the micro-organisms of the pond are less active for decomposition. At the beginning and end of the cold period, pathologies appear due to the rapid temperature change, which in turn increases the mortality rate among the fish. This stressful situation is aggravated by the deterioration in water quality during the dry season. One of the main constraints of fish farming in Thai Binh province is therefore the occurrence of a dry/cold season.

Table 5: *Characteristics of fresh water in the ponds of Thai Binh (11)*

Temperature	*25 to 3°C*
pH	*6.94 to 7.14*
Dissolved oxygen	*2.58 to 3.94 mg/l*
Dissolved C02	*< 4 mg/l*
Dissolved nitrogen	*0.25 to 0.29 mg/l*
Dissolved phosphorous	*0.31 mg/l*

Table 6: *Risks of fish mortality in Thuy Ninh commune*

Farms	***Large***	***Medium***	***Small***
Diseases			
- *Yes (%)*	*57*	*55*	*73*
- *No (%)*	*43*	*45*	*27*
Predators			
- *Yes (%)*	*71*	*68*	*40*
- *No (%)*	*29*	*32*	*60*
Measures			
- *Yes (%)*	*100*	*82*	*87*
- *No (%)*	*0*	*18*	*13*

Excess organic matter and pesticides
The main source of pollution perceived by fish farmers is the excess of organic matter combined with the lack of water during the dry season leading to a deoxygenizing of the aquatic environment causing the death of fish. Another kind of pollution has been reported by some fish farmers: it is due to pesticides that are discharged into paddy fields and work their way into adjacent ponds also causing fish to die. In order to avoid such problems, fish farmers close the stopcocks that link the ponds to the paddy fields during periods of crop treatment.

A mixed farming based on raising carp

Omnipresence of "traditional" species
According to the Fish Farming Department of Thai Binh province (2004), the traditional species farmed in the province are the Grass Carp (*Ctenopharyngodon idella*), the Common Carp (*Cyprinus carpio*), the Silver Carp (*Hypophthalmichthys molitrix*), the Bighead Carp (*Aristichthys nobilis*), the Indian Rohu and Mrigal Carps (*Labeo rohita and Cirrhinus cirrhosus*).

More recently farmed species include the Tilapia (*Oreochromis niloticus and Oreochromis mossambicus*), the Pirapitinga (*Piaractus brachypomus*), the Clarias Catfish (*Clarias macrocephalus*) and the Black Grass Carp (*Mylopharyngodon piceus*). During the surveys, all fish farmers interviewed stated that they farmed a mixture of grass carp, common carp, silver carp and Indian carp. This situation is widespread except in the cases of some farms with a surplus of organic matter who raise Clarias, a species capable of living in complete anoxia. Mixed farming enjoys the undeniable advantage that species use different trophic environments in the pond, as Figure 5 shows. Some farms also raise tilapia (13% of farms), pirapitinga (6% of farms) and, more unusually, catfish (2%) and black grass carp (4%). As for Indian carp and tilapia, most fish farmers make no distinction between, in the first case, rohu and mrigal and, in the second case, O. niloticus and O. mossambicus. The recently farmed species are part of a government encouragement programme (Fish Farming Department of Thai Binh province, 2004) but they are not yet very widespread. For species such as catfish, fish farmers who raise them receive subsidies from the commune in which their farm is located.

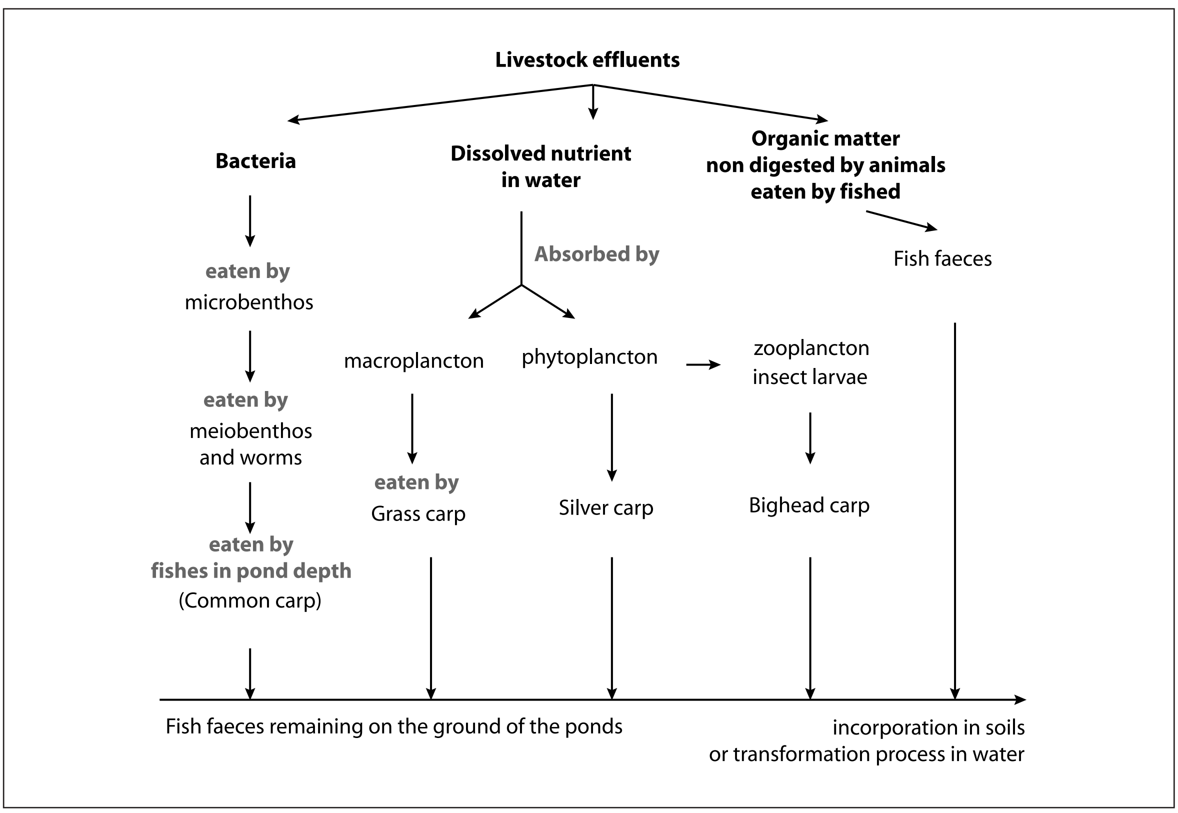

Figure 5: *Diagram representing the use of livestock effluents in ponds (6)*

The grass carp

(introduced from China in 1958, first laid eggs in 1964)

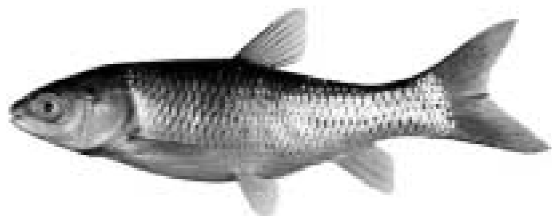

Figure 6: *Grass carp (12)*

- *Scientific name:* Ctenopharyngodon idella
- *French name:* Carpe herbivore
- *Vietnamese name:* Cá trắm cỏ

Habits: lives near the surface or at medium depth, likes clean water, can stand cold water and can survive in brackish water.
Food: eats plants directly (except bitter-tasting plants) and meal.
Growth rate: rapid, can be as much as 0.7 to 1 kg in 1 year.
Reproduction: by artificial methods, reproduction capability is high.

The common carp

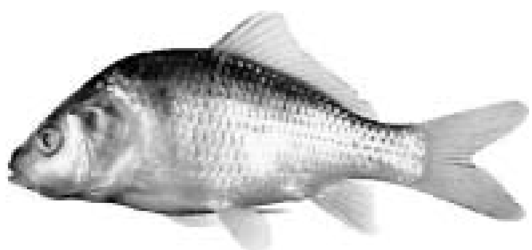

Figure 7: *Common carp (13)*

- *Scientific name:* Cyprinus carpio
- *French name:* Carpe commune
- *Vietnamese name:* Cá chép

Habits: lives on pond bottoms, can stand the cold and a low level of oxygen.
Food: eats small animals (worms, larvae and insects), OM, tree leaves and meals.
Growth rate: 0.5 to 1kg in 1 year.
Reproduction: reproduction capability is high and the common carp can reproduce in a natural environment.

The silver carp

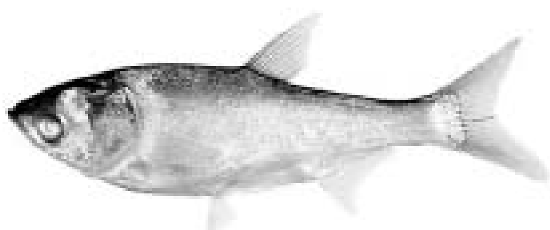

Figure 8: *Silver carp (14)*

- *Scientific name:* Hypophthalmichthys molitrix
- *French name:* Carpe argentée
- *Vietnamese name:* Cá mè trắng

Habits: lives near the surface of the water or at medium depth, likes water rich in phytoplankton and zooplankton.
Food: eats plankton, mostly phytoplankton (60 to 70%), and meals.
Growth rate: rapid: 0.5 to 0.8 kg in 1 year.
Reproduction: by artificial methods, reproduction capability is high.

The bighead carp

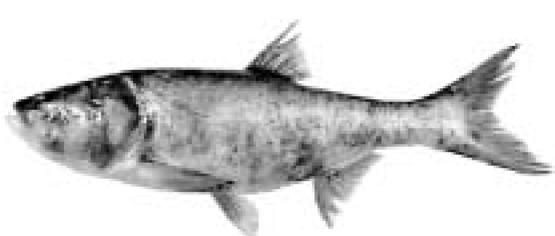

Figure 9: *Bighead carp (15)*

- *Scientific name:* Aristichthys nobilis
- *French name:* Carpe à grosse tête
- *Vietnamese name:* Cá mè hoa

Habits: lives near the surface of the water or at medium depth.
Food: feeds on plankton, mostly zooplankton.
Growth rate: rapid: 1 to 2.0 kg in 1 year.
Reproduction: by artificial methods, reproduction capability is high.

The Indian carp

(2 species have been introduced from India: Rohu (1982) and Mrigal (1984)).

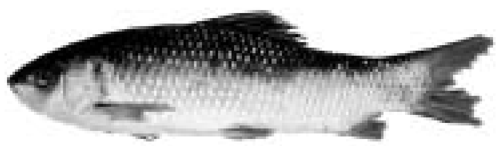

Figure 10: *Rohu (16)*

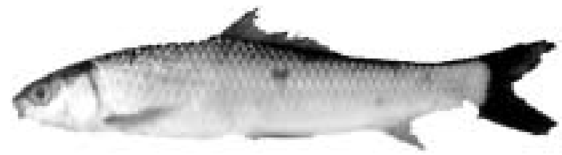

Figure 11: *Mrigal (17)*

- *Scientific name:* Labeo rohita
- *French name:* Rohu
- *Vietnamese name:* Cá trôi ta

- *Scientific name:* Cirrhinus cirrhosus
- *French name:* Mrigal
- *Vietnamese name:* Cá trôi mrigal

Habits: live at medium depth or at the bottom of ponds, like sandy-muddy pond floors, rich in zooplankton.
Food: OM, aquatic plants, green fertilizers and meals.
Reproduction: by artificial methods, reproduction capability is high.

The tilapia

(African species)

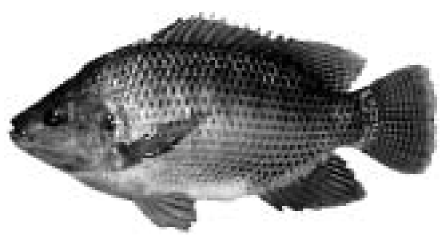

Figure 12: *Nile tilapia (18)*

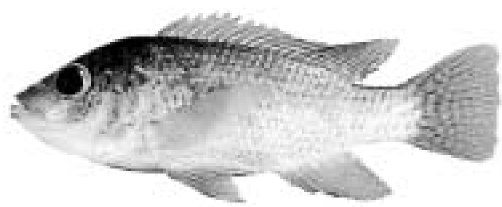

Figure 13: *Mozambique tilapia (19)*

- *Scientific name:* Oreochromis niloticus
- *French name:* Tilapia du Nil
- *Vietnamese name:* Cá rô phi rằn

O. niloticus: bigger, higher growth rate 0.3 to 1 kg in 1 year, natural reproduction 5 to 6 times a year.

- *Scientific name:* Oreochromis mossambicus
- *French name:* Tilapia du Mossambique
- *Vietnamese name:* Cá rô phi đen

O. mossambicus: smaller, lower growth rate 0.1 to 0.2 kg in 1 year, natural reproduction 10 to 11 times a year.

Habits: live at medium depth or at the bottom of ponds, cannot stand temperatures below 10°C (at less than 10°C, they feed less and can die), also live in brackish water, like pond floors with a mixture of sand and mud, rich in zooplankton. Currently, only single-sex tilapias are farmed to increase production, preventing reproduction and controlling density, allowing a greater capacity for growth.

Piaractus brachypomus

(Amazonian species introduced from China in 1997)

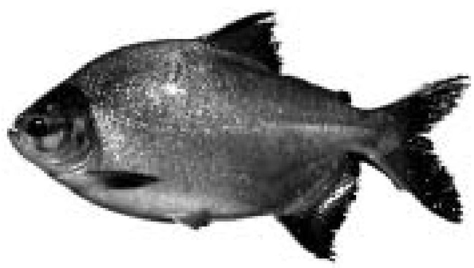

Figure 14: *Pirapitinga (20)*

- *Scientific name:* Piaractus brachypomus
- *French name:* Pirapitinga
- *Vietnamese name:* Cá chim trắng

Habits: lives at medium depth or at the bottom of ponds, cannot stand low temperatures (at less than 10°C, it feeds less and can die), can stand salinity from 0.5 to 1%, likes acid environments.
Food: omnivorous species, eats worms, small shrimps, small fish, shellfish, small snails, etc., green fertilizers, plants, meals and industrial feed.
Growth rate: rapid: 0.5 to 2 kg in 1 year.
Reproduction: artificial, reproduction capability is high.

The Clarias catfish

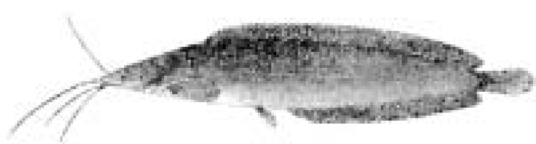

Figure 15: *Clarias catfish (FAO)*

- *Scientific name:* Clarias macrocephalus
- *French name:* Poisson-chat
- *Vietnamese name:* Cá trê

Habits: lives at the bottom of ponds, can stand salt-water and a low level of oxygen.
Food: omnivorous, eats aquatic plants, meals, OM, green fertilizer and by-products from pig slaughter-houses, shrimps, worms, crabs and small fish, etc.
Growth rate: rapid: 0.5 to 1 kg in 1 year.
Reproduction: artificial.

A great diversity in pond stock levels

Even though all fish farmers raise the same species in their ponds, the proportions for each of these species are not the same from one farm to another. There is a main species, namely the one in greatest numbers compared to the others. Each main species is suited to the conditions of specific ponds. For example, it is advised to use Indian carp as the main species in ponds where the bottom is a mixture of mud and sand, rich in nutritious particles. Density is from 2 to 2.5 fish/m2. The proportion of fish is 50% Indian carp, 10% tilapia, 20% silver carp, 5% common carp, 10% grass carp and 5% pirapitinga.

The young fish are usually produced on specialized farms. In general, farmers buy young fish or fingerlings to carry out pre-fattening or fattening (similar to pig farms). Buying of eggs occurs more rarely (only for carp, in particular Indian carp).

The initial densities of fish are extremely variable from one farm to another. They vary between 47 and 1,170 fish/sao, or 0.13 to 3.2 fish/m^2. The maximum rate seems high for the kind of fish farming in the region. Three-quarters of fish farmers interviewed have an initial density of fish that matches extensive or semi-intensive systems.

Stocking with fish is done once a year in the months from February to April in the dry season. Harvesting takes place all year round but the biggest occasions are before the Têt festival (October to December) and at the beginning of the year (January to February) when demand is strong and the sale price is higher.

Table 7: *Various levels of intensification of fish farming systems (10)*

Density of fish at time of stocking	***< 1/m²*** *(< 360/sao)*	***1 to 5/m²*** *(360 to 2,100/sao)*		***5 to 10/m²*** *(2,100 to 3,600/sao)*
Yield (t/ha/year)	*0-1*	*1-5*	*5-15*	*15-50*
Input	*None*	*Macrophytes, manures*	*Manure and simple feed*	*Mixed feed*
Daily rate of water renewal (%)		*< 5 Compensation of losses*	*5 to 10*	*10 to 30 Aeration Recirculation of water*
Level of intensification	***Extensive***	***Semi-intensive***	***Semi-intensive***	***Intensive***

A political will to develop tilapia fish farming

The Fish Farming Department of Thai Binh province has established a tilapia farming development project for the years 2004 to 2010. It takes place within the overall fish farming development project alluded to earlier. The authorities anticipate reaching fish farming production levels of 28 to 29,000 metric tons in 2005 (21). In 2004, it was already 29,215 metric tons, so the target has been easily reached. Tilapias Oreochromis mossambicus and Oreochromis niloticus were introduced to Vietnam in 1950 and 1973 respectively. Since 1996, the farming technique of single-sex tilapia is implemented and the fish are farmed at densities of about 6 fish per m² and fed with granulated mixed feed. Expected annual yields are of 20 to 25 metric tons per hectare and the final weight is 500 to 600 g/fish. Given the farming constraints discussed earlier, this target seems very ambitious. The budget allotted to this project by the State is of something over 16 or 17 billion VND, or less than one billion Euros (21). However, this programme remains at the pilot stage because at the time when all the surveys were carried out, tilapias were still being raised in extensive or semi-intensive mixed farming.

Diet and trophic intakes

In Thai Binh province, fish receive a diet based on herbs and trees (in very great quantities) for grass carp, and rice bran. Other elements are sometimes added such as maize flour, rice flour or waste from other production sources on the farm: making rice alcohol or rice noodles. Fish farming is also characterized by the profitable use made of by-products from agricultural activities (crops and livestock). The by-products are spread onto ponds in order to stimulate the trophic chain and thus increase the quantity of natural foodstuffs available for the fish. Among the substances used are: crop waste, household waste, poultry droppings (chickens and ducks), cattle, buffalo and human faeces, but especially very large quantities of pig excreta owing to the strong development of pig farming in Thai Binh province.

Quantities of effluents spread onto ponds

On 77% of fish farms that use organic fertilization, livestock effluents are spread directly without liquid/solid separation or processing. Before being used, pig slurry is sometimes mixed with urea and/or with quicklime (5% of cases). On 13% of farms, liquids are separated from solids by scraping and only cleaning water goes into the pond. This is only the case for pig, cattle, buffalo and human faeces. On 8% of farms, faeces are used after storage but without processing. This is often the case for poultry droppings; they are kept in the livestock buildings and are collected to be spread once there are no more animals in the building. Only 8% of farms make compost to spread onto ponds. But in general, it is impossible to speak of real compost because very often the farmer simply adds rice husks or other plant waste without regularly turning the mixture to ensure that decomposition takes place correctly. Farmers often combine various modes of using excreta depending on which animals they come from.

Box 3: the opinion of fish farmers on pig effluents

"The use of fresh solid faeces, according to fish farmers, has several advantages: the solid form makes it possible to localize the intake to a specific part of the pond; the solid form is better suited for consumption by small fish, more sensitive to forms of ammoniac particularly present in urine; finally, the solid form is easier to transport. In addition, according to most fish farmers, fresh slurry is the most efficient. The quality would be even better with industrial pig feed: according to some people interviewed, there would remain 30% of unabsorbed substances. The development of fish fed on fresh slurry is more rapid than that of fish fed on processed slurry. Fresh slurry is good for fish and above all is enjoyed by all kinds of fish. Finally, fresh slurry does not contain rice husks, which may "pollute" the pond. The inconveniencies of this product are as follows: if too much fresh slurry is poured into a pond this can cause pollution leading to the death of fish. Fresh slurry may also spread diseases to fish. Finally, the transport of fresh slurry in barrels is long and difficult."

Chemical fertilization at odds with recommendations

The only chemical fertilizers used by fish farmers questioned in Thai Binh province are superphosphate and urea. 27% of farms use superphosphate and 26% of them use urea. Urea and superphosphate are mixed with water and spread on the surface of ponds. They are also sometimes mixed directly with pig slurry to form pellets that are then thrown into ponds. Spreading is carried out once a month or even once every 3 months. It is recommended to spread every 7 to 10 days 2.2 to 3.6 kg/sao of superphosphate (or 60 to 100 kg/ha) and 1.1 to 1.8 kg/sao of urea (or 30 to 50 kg/ha) (4). However, these recommendations were not followed in any of the farms surveyed. Indeed, the dosages of fertilizers spread are very variable (some spread twice the amount spread by others).

Table 8: *Pond fertilization practices (Ninh commune)*

Farms	*Large*	*Medium*	*Small*
Organic			
- *Yes (%)*	*93*	*100*	*74*
- *No (%)*	*7*	*0*	*26*
Chemical			
- *Yes (%)*	*29*	*23*	*0*
- *No (%)*	*71*	*78*	*100*
Techniques (%)			
- *Dissolved in water*	*44*	*95*	*80*
- *Dry*	*56*	*0*	*20*
- *Mixed*	*0*	*5*	*0*
Previous treatment			
- *Composting (%)*	*36*	*35*	*55*
- *Biogas (%)*	*36*	*12*	*18*
- *No (%)*	*28*	*53*	*27*

Very variable total intakes of nitrogen

In order to compare the practices of fish farmers, intakes of fertilizers are converted and expressed as a quantity of nitrogen per sao and per year or in equivalent of pigs per sao. By adopting as a reference a daily intake of two 50 kg pigs, the recommended intakes are roughly 8 kg N/sao/year (240 kg N/ha/year). These intakes remain however much lower than fertilization rates arrived at experimentally in research centres (22).

The average nitrogen intakes of surveyed farms are 3.5 times higher (about 35 kg N/sao/year) than the recommended quantities. A quarter of them are above this average, however a little over half of them carry out intakes lower than or in the recommended bracket.

The quantities of fish harvested on the farms surveyed are very varied, between 13 kg and 414 kg/sao/year (0.36 and 11.5 t/ha/year) for an average weight of roughly 3.2 metric tons. One quarter of farms have a yearly harvest of over 4 metric tons per hectare. For Thuy Ninh commune, this same variation was found whatever the size of farms.

The quantities harvested are not proportional to nitrogen intakes (Figure 5). This reflects the great diversity of practices (stock densities, water management and intakes of organic matter) and more generally a very uneven grasp of how to conduct fish farming in a difficult context (floods, cold season, etc.). Fish farming remains a new activity for many farmers. Probably they have not all accumulated the necessary experience, received sufficient training or do not have the financial means to remove some of the structural constraints identified.

Table 9: *Recommended quantity of nitrogen (6, 10)*

	No./sao/year	***Qty N in kg/sao/year***
Chemical fertilizer		*4.68 to 9.36*
(10)	*1 to 3*	
Pigs	*36 to 126*	
Ducks	*2*	
Pigs (6)		

Result of these practices

Quantities harvested reflect the diversity of situations and practices
According to the recommended quantities, nitrogen intakes of 8 kg/sao/year equivalent to a constant stock rate of roughly 2 pigs per sao (60 50kg pigs per hectare) should make it possible to obtain fish yields of between 144 to 360 kg/sao/year (4 to 10 t/ha/year) depending on environmental factors (alkaline reserve, water availability, water temperature, etc.) and appropriate management (6, 10, 23).

Box 4: Fish farm yield (in kg/sao/year) depending on the quantity of nitrogen spread onto ponds (in kg/sao/year) (1)

A close monitoring carried out on some farms shows that the fish farm yield is proportional to the quantity of nitrogen dissolved in the pond. However, some anomalous farms can be observed where yield decreases when the quantity of dissolved nitrogen increases and vice versa.

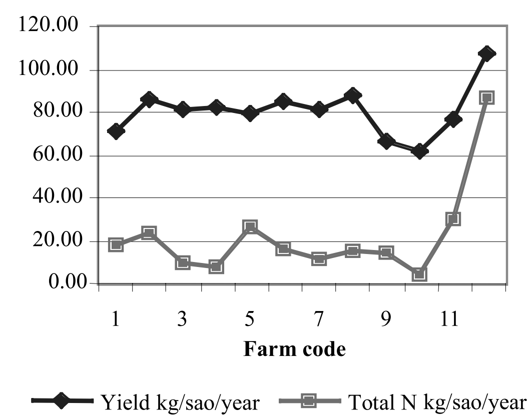

Table 10: *fish production in Thuy Ninh commune*

Farms	*Large*	*Medium*	*Small*
Average harvest (kg/ha/year)	*3,963±1,512*	*3,732±2,015*	*3,216±1,212*
Minima	*972*	*900*	*1,388*
Maxima	*6,173*	*8,896*	*5,345*

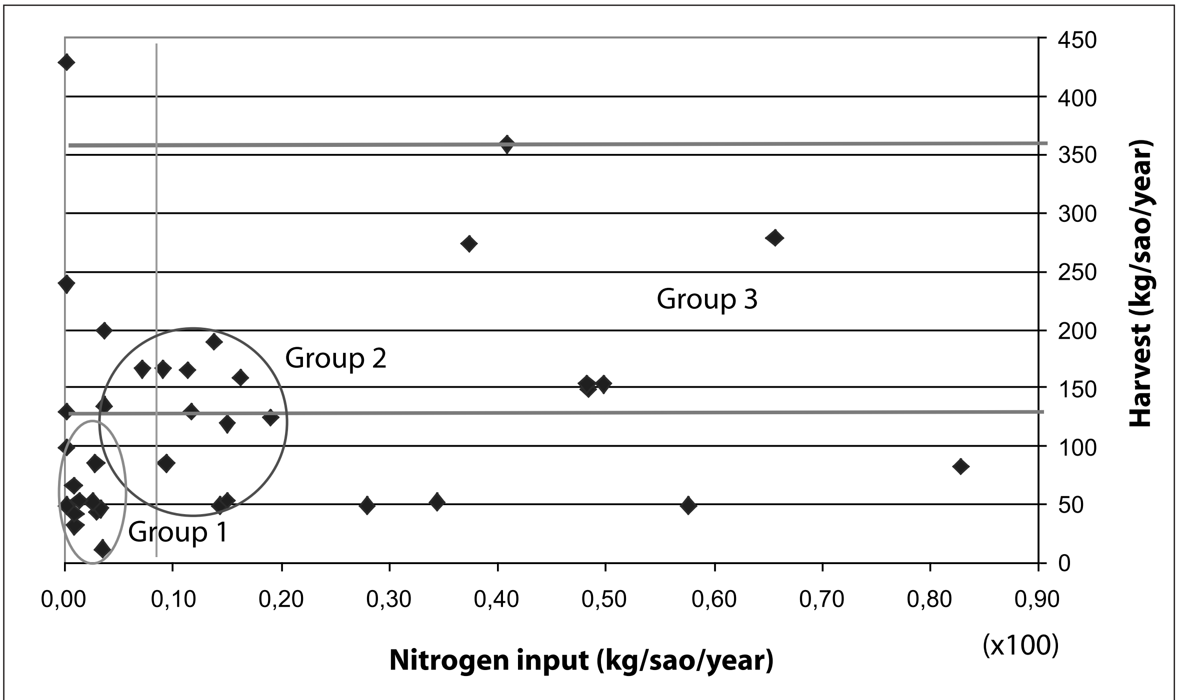

Figure 16: *Fish farm yield as a function of the quantity of nitrogen spread on ponds*

Depending on the target yield (Figure 5) from 144 to 360 kg/sao/year (4 to 10 t/ha/year) and the recommended quantity of nitrogen of 8 kg/sao/year (two 50 kg pig equivalents per sao), 3 groups of farmers can be distinguished:

Group 1: Pig herd of less than one 50 kg pig equivalent/sao – These are farms where nitrogen intakes spread onto ponds are less than 8 kg N/sao/year and where fish production is less than 144 kg/sao/year (or less than 4 t/ha/year). 3 farms appear to be "extraordinary" (top left) in that they obtain relatively high yields without any nitrogen intake. This can be explained, either by incorrect survey data, or by the fact that these ponds receive nitrogen passively (runoff of effluents coming from a neighbouring farm, for example).

Group 2: Pig herd of one to three 50 kg pig equivalents/sao - These are farms where nitrogen intakes spread onto ponds are between 8 and 20 kg N/sao/year and where fish production is less than 200 kg/sao/year (or less than 5.5 t/ha/year).

Group 3: Pig herd of more than three 50 kg pig equivalents/sao (all the farms located to the right of the other 2 groups on the graph) - These are farms where nitrogen intakes spread onto ponds are above 20 kg N/sao/year and where yields are very varied. All of these farms seem to have surpluses in nitrogen that for many of them manifest themselves by results that are not always explicable, because they seem much too low in relation to the quantities of effluents received and the initial stock density. This may be due to death of fish (linked to an excess of organic matter in the pond) or to incorrect survey data.

The group characteristics show that the growing intakes in nitrogen are not linked to pond surface areas but to the size of income earned from fish farming and the localization of ponds in areas of low-yield paddy fields.

Table 11: *Characteristics of the various groups*

Groups (pig equivalent per sao)	*< 1*	*1 to 3*	*> 3*
Number of farms of this kind	*43%*	*30%*	27%
Quantities of fish harvested (kg/sao/year)	*13-144*	*50 - 200*	50 - 350
Surface area of water (sao)	*5 to 20*	*5 to 15*	6 to 14
Income from fish farming > 50%	*25%*	*63%*	50%
Localization in areas of low-yield paddy fields	*50%*	*55%*	70%
Farmers' practices			
Nitrogen intake	*70%*	*100%*	100%
Purchase of effluents from elsewhere	*7%*	*27%*	10%
Effluents/pigs	*50%*	*82%*	100%
Effluents/poultry	*25%*	*36%*	80%
Effluents/cattle	*19%*	*9%*	10%
Effluents/humans	*6%*	*9%*	-
Urea intake	*19%*	*18%*	30%

The effluents management of tomorrow?

One-third of these farmers intend to develop fish farming further by digging more ponds, renting others, or intensifying their production. A larger number of them state that they intend to increase the number of pigs of which one-third with the aim of increasing the quantity of effluents to be spread on ponds. The building of a biogas digester constitutes the third kind of project in order of popularity.

More than a third of farmers have no projects due for the most part to financial difficulties (Table 12).

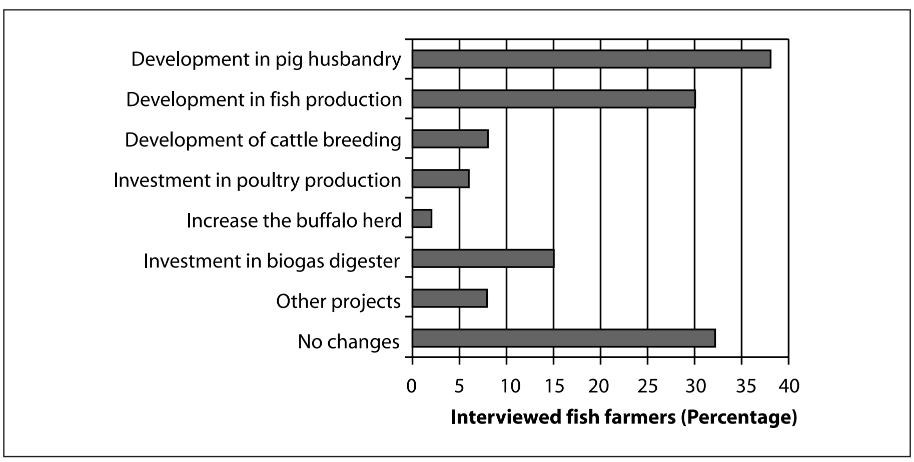

Figure 17: *Planned development projects of interviewed fish farmers*

Table 12: *Farmers' difficulties and propositions with regard to fish farming in Thuy Ninh commune*

Difficulties	*in %*	*Propositions*	*in %*
Financial	*35*	*Technical*	*66*
Technical	*17*	*Financial*	*50*
Young fish	*13*	*Young fish*	*28*
Labour	*4*	*Others*	*9*
Markets	*2*	*Markets*	_

Depending on the various kinds of farms defined previously, the evolution in the use of livestock effluents is not uniform.

Less than one 50 kg pig equivalent/sao
For these farms, an intensification of nitrogen intakes can be envisaged. It should manifest itself by an increase in fish yields. These fish farmers will be able to progress towards group 2 (from one to three 50kg pig equivalents/sao/year) on condition that they overcome the constraints with which they are faced: limited financial means (19% of cases), problems with flooding (56% of cases) and lack of fish farming know-how (13% of cases). These farms can therefore absorb still more livestock effluents and in this way contribute to dealing with the future increase in pig farms planned for the region. However, 38% of farmers of this kind state that they do not intend to make changes on their farm over the next few years because they do not have the financial means to expand. On the other hand, 19% plan to increase their pig herd, 12% to increase their surface area of ponds farmed and 12% to build a biogas digester.

From one to three 50 kg pig equivalents/sao
Given their current pond management, the fish farmers in this group have few possibilities of absorbing further organic matter. An increased use of livestock effluents will require an increase in pond surfaces or the abandon of urea intakes to be replaced by intakes of animal faeces or even by technical innovations such as pond aeration. The production of maggots in slurry to feed fish could also be an avenue worth exploring. 18% of farmers of this kind state that they do not intend to make changes on their farm over the next few years. On the other hand, 64% plan to increase their pig herd, 11% to build a biogas digester and 11% to increase pond surfaces farmed.

More than three 50 kg pig equivalents/sao
The quantities of nitrogen spread are much too high, the first priority is to optimize the management of livestock effluents (cease the spreading of urea), and they are possibly in a position to invest in new ponds. 40% of farmers of this kind state that they do not intend to make changes on their farm over the next few years. On the other hand, 50% plan to increase their surface area of ponds farmed (by rental or by conversion of low-yield paddy fields into ponds). Only 10% of fish farmers of this kind intend to increase their pig herd (near the ponds) and plan to build a biogas digester.
Appraisal of changes in the various groups.

In the coming years, farms in the second group whose nitrogen intakes are between one and three 50 kg pigs equivalents/sao will be in the ascendancy over other kinds. Some farms of the first kind (less than one 50 kg pig equivalent/sao) will be able to absorb more organic matter thanks to an increase in their pig herd, which explains their movement into the second group and farms of the third group (more than three 50 kg pigs equivalents/sao) who intend to increase the surface area of their ponds farmed will also move into the second group.

On the other hand, farms in the second group who intend to increase their pig herd without increasing the surface area of ponds farmed risk moving into the third group if their livestock effluents are poorly managed.

Box 5: What about biogas?

The encouragement from the authorities of the installation of biogas digesters on farms could become a problem in the years to come. On the farms of most farmers interviewed having already installed a biogas digester, the liquid that is discharged by the biogas digester is not channelled into a pond, but flows freely out into the environment where there is a danger that it will cause pollution problems because it contains high concentrations of nitrogen and phosphorous.
One of the farmers interviewed explained that he had stopped fish farming after installation of a biogas digester. In addition, none of the farmers interviewed who had installed a biogas digester know what the liquid that flows out of it contains. It should therefore be noted in the leaflet received by farmers when they build a biogas digester that the liquid that flows out of it is rich in nitrogen and phosphorous and can be poured into ponds to fertilize them. If the farmers are not informed of this, they will consider that they have no effluents to pour into their ponds and they will modify their practices accordingly to maintain yield levels identical to those they currently obtain: use of chemical fertilizers, development of other kinds of livestock farming such as poultry or cattle so that the level of organic inputs is maintained or even increased.

Conclusion

Farmers practise fish farming firstly with the aim of increasing their income and a large number of them plan to increase the surface area of their ponds. For others, it is above all their financial difficulties that prevent them from envisaging the development of their fish farming activity. Some even state that they wish to increase their pig herd to obtain more organic matter in order to assist their fish-farming project. This dynamic fits in perfectly with the Thai Binh authorities' ongoing projects concerning the conversion of low-yield paddy fields into ponds.

On the other hand, the political wish to develop monoculture tilapia farming to satisfy an export market does not appear to be in accordance with the local realities of fish farming and the pig farming development issue. The import of mixed feed from other provinces would aggravate the expected progression concerning surpluses in organic matter.

The constraints associated with water management and the temperature issue argue in favour of an optimization of current practices based on mixed fish farming integrated into production systems and more specifically into livestock systems. The hydraulic improvements that the authorities bring about within the framework of development of areas with low-yield paddy fields assist in this aim.

In addition, it is necessary to assess with the authorities and in partnership with farmers the possibilities to improve current livestock management: halting chemical fertilization; use of mechanical aeration; intra-pond composting; production of maggots in slurry. This probably presupposes a strengthening not only of fish farmer training but also an encouragement of experience exchanges between farmers.

To conclude, public policies could encourage the construction of an efficient local model based on an optimal use of organic matter. This model would be a kind of synthesis of the principles of the "VAC" system (integration of pig or chicken farming with fish farming) associated with development of tilapia. A similar model has been constructed in a small region of Brazil with a subtropical climate and a marked cold season (see Chapter 11-Box 1). It would of course be necessary to reconstruct a model adapted for Thai Binh that would take into account the local specificities, be they sociotechnical (species of fish, characteristics of slurry, etc.) or organizational (access to credit, creation of revolving funds).

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