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The situation in Thai Binh province offers a significant number of assets to be capitalized upon in terms of recycling of effluents, but the stakeholders concerned have an urgent need for strong measures to help them live from their livestock farming activity while protecting an endangered environment. We will highlight here additional agronomical and economic references as well as decision-making tools that still need to be acquired, and technical and organizational solutions that will need to be tested or promoted more widely.

While the stakeholders of Thai Binh province are concerned about maintaining their quality of life, they are very much aware that without a set of appropriate measures for dealing with it, the problem of pollution associated with the development of livestock farming will rapidly get worse. However, opinions remain divided: some can see no solution and fear that livestock effluents will affect human health similarly to the avian influenza epidemic in 2004-2005; others, inhabitants and producers, think that the situation will deteriorate until the authorities decide to implement actions to improve the management of these effluents. Our intention in this final chapter is to clearly highlight a certain number of existing options capable in part of responding to these expectations and identifying the key issues for the future and the establishment of a hierarchy of priorities in terms of support for agricultural development, necessary local know-how and avenues of research to study in more depth the complex problems encountered in North Vietnam. We will highlight additional agronomical and economic references, the decision-making tools that still need to be acquired, and the technical and organizational solutions that will need to be tested or promoted more widely.

On the basis of information gathered during our diagnosis, the situation in Thai Binh province offers certain assets, in particular (i) a widespread intermingling of livestock - plant and fish farming production, (ii) a tradition of recycling of organic matter, to be capitalized upon in terms of recycling of effluents, but the stakeholders concerned are in urgent need of strong measures to help them live from their livestock farming while protecting an endangered environment. The basic idea for the province is to encourage a better distribution of organic matter (OM), supporting in particular pigs-fish farming integration, "reasoned" fertilization of crops with organic matter, economic exchanges and co-ordination between producers and consumers. The aim in this context is to develop a commodity chain for transfer or even treatment/processing of waste to ease transport in the province and to improve knowledge of the quality of organic matter transferred and of co-products produced by treatment/processing in order to guarantee fertilizer inputs for farmers. At the farm level, storage capacities and treatment procedures for liquid effluents must be adapted to avoid direct discharges into watercourses while preserving or adapting traditional practices that make it possible to lessen overall levels of nitrogen. A wide-ranging provincial programme must therefore anticipate the development of pig farming through precise regulation, appropriate inspections and a co-ordination of research and training efforts.

Encouraging a better distribution of organic matter on fields and fish farm ponds

Intensification of integrated pig-fish models

With the help of the spatialized model chosen in chapter 10, ponds represent an essential consumption area of liquid and solid effluents that can absorb in 2010 nearly a quarter of the total nitrogen from livestock effluents that will be produced in the province.

The key idea here is to promote the direct recycling of all livestock effluents as fish feed, and organic fertilizer for the pond microflora that offers numerous advantages. From an economic point of view, it makes it possible to reduce costs of chemical inputs. From an environmental point of view, it limits the risks of uncontrolled discharges because all effluents are directly recycled into the pond. This solution is viable on condition that it respects the ad hoc ratio of animal stock/pond area, in order to preserve favourable environmental conditions for the development of aquatic flora and fish. The establishment of optimal dosages of organic matter (OM) to be used to increase the productivity of ponds will be a research subject to be supported, integrating the concept of negative impact for the health of the pond ecosystem.

Chapter 6 highlights the major constraint in Thai Binh: the cold season. This season, both cold and dry, corresponds to the period during which the ponds are drained. This makes it appear very difficult to synchronize fish farming with that of pigs in an overall manner.

Pig production is not linked to the climate even if the herd increases in winter before the festivities for the lunar New Year at the end of January – beginning of February. In contrast, the capability of ponds to absorb pig effluents is closely tied to the water temperature. In the cold season, the effluent absorption capability of a pond of 1 sao (360 m2) is 2 to 3 local pigs maximum. Fish farming must therefore regulate its inputs in winter. In addition, fields are left fallow during the winter despite the expansion of dry crop growing such as maize, which accentuates the imbalances. A technico-economic optimization remains to be achieved with the imperative of an improved understanding of the interactions between production operations and pond ecology.

Tilapia farming seems difficult to promote given the long cold season in North Vietnam, even though, in Brazil where thermal conditions are comparable, tilapia is being developed. (Box 1). The development initiatives based on tilapia monoculture in Thai Binh province seem very dangerous. Pig effluents must be considered as an opportunity for fish farming and not as a constraint; constraints are more applicable for pig farmers or the authorities. Industrial feeds in granulated form constitute a second step, generally poorly “reasoned” by fish farmers and anti-sustainable. They should therefore be reserved for only the final weeks of raising with all forms of farmed fish (in fresh water) even for operations classed as commercial.

The intensification of organic matter inputs of animal origin to increase fish yields in this context of putting to good use and absorbing pig effluents supposes the continuation of mixed farming (for example tilapia as a main species associated with local carp) to ensure an optimal water quality; but three other factors are important to respect in this case: the water supply must be guaranteed; the depth of ponds must be sufficient (with a minimum level of water even in the dry season) and mechanical aeration must be used.

Mechanical aeration encourages aerobic decomposition of organic matter, the destratification of the pond, the homogenizing of oxygen levels as well as of the temperature in the body of water. It would be pertinent for the authorities to encourage, in the form of a targeted investment programme, the use of aeration in fresh water, and particularly on commercial farms, in the same way as in shrimp production.

Box 1: Example of a successful integration model between pig farming and fish farming in ponds

A pig-fish farming integration model has been built in a small region of Brazil with a subtropical climate and a marked cold season. Called "Modelo Alto Vale do Itajaï da Piscicultura Integrada" (1), this model offers the following technical characteristics:

- *Inspection of water coming in and going out;*
- *Mixed farming centred on tilapia: 75% tilapia, ± 10% common carp; ±10% Chinese carp, ± 5% catfish;*
- *Integration with pig farming: 60 pigs per hectare of pond;*
- *Mechanical aeration;*
- *Use of artificial feed only at the end of the cycle when a slowing of growth is observed;*
- *Renewal of water at least 5% per cycle in addition to compensation of losses by evaporation and leaching;*
- *Good management practices: mid-cycle fishing, biometry and performance inspections, monitoring of water quality;*
- *Expected results: 8 metric tons of fish per hectare per year.*

"Reasoned" use of effluents on agricultural land

In parallel to being put to good use in ponds, the recycling of farm fertilizers on cultivated land remains a traditional solution to be encouraged and represents the best agronomical and economic option given the low level of investment needed at the farm level. The remoteness of buildings in relation to cultivated land or ponds is however a limiting factor for the use of pig excreta. The creation of specialized structuring areas and the installation of buildings nearer consumption areas should make it easier to use effluents profitably, on condition that spreading is accepted by neighbours. It also makes it possible to ease congestion of land used for dwellings and villages. Distancing large livestock operations from the centre of villages would however only concern these farmers having the desire and the means to move. Management solutions on the farm remain to be defined in order to better integrate waste on farms, often located within villages, by testing innovative technologies enabling a reduction in labour demand and the unpleasantness of operations.

The tradition of using farm fertilizer as organic fertilizer on crops is still current. Efforts of communication and acquisition of references are essential here to promote the fertilizing value of livestock effluents in the fertilization and enrichment of crops and the partial substitution of costly chemical inputs by waste produced on the farm. In order to advise farmers better, agronomical research must still however obtain additional information that has not yet been established in Vietnam, particularly concerning the real nutritional needs of plants in order to adapt inputs, the biological and physico-chemical characteristics of Red River Delta soils, as well as the physico-chemical behaviour of organic matter in soils. The potential for nitrogen absorption and the ratios of nitrogen use by plants taking into account the soils and local pedological characteristics would make it possible to verify whether the working hypotheses, particularly those of the spatial modelling work in Chapter 10, were realist with regard to the absorption capabilities of plants in the North Vietnamese tropical environment.

We can also highlight the need to pursue research into denitrification in rice farming, contextualizing it i) within the Thai Binh region, ii) with the increased use of OM, iii) with the form of OM used (fresh or composted). Without this kind of study that examines losses by emissions into the atmosphere, giving fertilizing values to farm fertilizers while respecting the environment (overdoses, input periods) would be a hazardous exercise.

In order to better understand practices and become familiar with the properties of farm fertilizers, some field work must be carried out: 1) a regular monitoring broken down by farm type (compost preparation times for example) in order to determine real practices and the factors influencing livestock farmers' tactical choices in terms of effluent management over the course of the year; 2) exhaustive sampling and characterisation campaigns (including gaseous emissions from storage of this matter or during their treatment/processing) of the various identified products in order to create local references: nitrogen, phosphorous, dry matter content, etc; and 3) practical experiments in order to determine the effluent absorption capabilities of ponds and the fertilizing value of organic fertilizers on local crops with the aim of optimizing their use. These additional scientific investigations will make it possible to establish levels of substitution depending on crop systems (control of water, the kind of plant) if total organic fertilization cannot be practised; but also arbitration rules for OM on crops, dosages and application calendars depending on the yields hoped for, introduce the concept of piloting of nitrogen fertilization by crop systems integrating animal organic matter.

Support economic organizations and negotiation tools to promote effluent trade

The contrast observed between communes imposes the need above all to strengthen transfers between farms and between communes with an excess of animal waste and those seeking farm fertilizer. The very numerous small-scale pig farmers (farms of type III, IV defined in Chapter 5) lack farm fertilizer to fertilize their own crops. The quantity available also seems to be a very limiting factor at the level of certain communes; some even import compost from Hanoi, sign of the importance given to this organic matter. There are already compost-marketing networks from big farms towards smaller ones.

Transfers of effluents, generally sold, could be more efficient, if aspects of organization and production improve through the development of effluent treatment/processing techniques that would make it possible to reduce volumes, to supply dry co-products, to minimize smells and for which quality controls are carried out. The stakeholders have clearly identified and have sometimes already tested means of concerted action to treat and better distribute animal waste on their agricultural territory (Chapter 4); they already mention the establishment of collective systems of effluent management (pond, compost, canals, collection system, etc.), the development of manure storage and treatment/processing systems (particularly in a "hygienic and odourless" form to reduce nuisance and sanitary risks and to ease transport, and also the co-ordination of exchanges between producers and consumers. However, the factors limiting these transfers are numerous: the product remains difficult to handle, the market is not very organized owing to the irregularity of supply and demand. Rather than agronomical considerations, they worry above all about the organization and the honesty of exchanges (Chapter 9). The promotion of a commodity chain therefore requires the recognition of stakeholders and of their roles, the treatment/processing and description of products exchanged.

The co-ordination of stakeholders encourages the economy and development of commercial flows of compost within and between communes

The conclusions of chapters 4 and 9 highlight the point that organization and co-ordination of producers would make it possible simultaneously to establish shared systems for storage and treatment, and to encourage effluent exchanges. Two pivotal stakeholders have been identified and seem able to play a part in a dynamic for change thanks to their capability to engage with producers: they are the communal co-operatives and the farmers' unions. The communal co-operatives that are currently responsible for supplying farmers with chemical fertilizer could widen their range of products by co-ordinating compost exchanges. These organizations in contact with the field appear capable of identifying livestock farmers who declare that they have surplus production of organic matter and customers seeking fertilizers. According to communes, the farmers' unions or even, more surprisingly, the women's unions, have been mentioned by stakeholders as potential intermediaries to co-ordinate these exchanges and to guarantee the honesty of transactions between stakeholders.

A clear political will should support these kinds of stakeholders in this activity and assist them in the establishment of pilot models of organization and production of co-products with the crucial intervention of co-operatives and farmers' unions in the definition of operational rules, negotiations between stakeholders of the commodity chain and the contractualization of exchanges. Considering the exploratory aspect of these modes of organization and of introduction of new forms of organization, the dynamics of adoption (or of rejection) of these innovations by the stakeholders should be the object of a socio-economic monitoring in order to learn the necessary lessons for its extension into other areas of production.

Process the products to ease transfers

The quality of the road system and the omnipresent hydraulic system make travel difficult; the low level of mechanization in the countryside complicates transport and spreading onto fields. The motorization of transport can thus be studied as a collective solution developed within agricultural co-operatives or as a private activity with the appearance of an intermediary stakeholder who takes over this kind of transport with the help of small tractors or motorized barrows. To the extent that surpluses of nitrogen and phosphorous have been characterized locally, the processing/treatment of effluents must improve the quality and the transportability; in this way, it must make the "farm fertilizer" product less strong-smelling, easier to transport and handle, healthy, and therefore marketable. A choice remains to be made however between an industrial unit of significant size or/and small-scale traditional treatment/processing, but present in most communes with a surplus.

Taking into account the high level of investment and the complicated daily operation in terms of management of inputs and outputs of matter, the choice of a centralized industrial technology of a very large size would seem to be a dangerous experiment for the commodity chain, above all if one considers the economic failures of industrial tools which have run into very serious problems of supplies (cassava processing factories, fruit juice bottling plants) and poorly managed marketing.

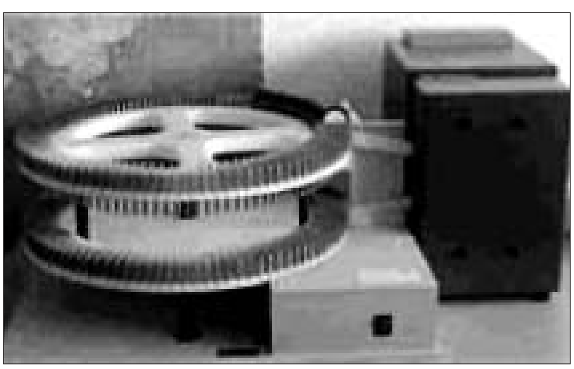
Processing units distributed throughout the province, using appropriate technology and responding to the needs of a limited number of communes, would offer multiple advantages and would reduce the economic risks; a network of small-scale processing units could cover all of the difficult areas by minimizing the distances between waste suppliers and fertilizer consumers. They could be the work of private entrepreneurs (large-scale farmers of type IC with a high surplus effluent rating) but also of a group of medium-sized producers who, with financial aid and technical support, could carry out this processing collectively. The choice of processing technology (see below) and the sizing would take into account the needs and inputs of surrounding communes as well as the contractual relationships between stakeholders.

To organize this processing and to be sure of finding markets for the manure, a wide-ranging awareness-raising and extension campaign is necessary aimed at technical offices of local authorities and farmers. Manure, despite the price being relatively high in comparison to other fertilizers, suffers from its image as worthless "waste". But in a context where the prices of all fertilizers are rising, in particular those of chemical fertilizers, it seems likely that farmers may be receptive to a change in practices. The aim would be to change the perception of OM as waste towards a perception of OM as product (i.e. like farm fertilizer). The collective running of such operations would be as much a development issue as one of research into socio-economics and processing technology.

Box 2: Composting in an aerobic environment

Composting can be defined as a controlled biological process of conversion and profitable use of organic matter (by-products of biomass, organic waste of biological origin, etc.) into a stabilized, hygienic product, similar to leaf mould, rich in humic compounds: compost. Composting is an operation that consists of fermenting, in controlled conditions, of organic waste in the presence of oxygen from the air. Two phenomena occur consecutively in a composting process. The first, bringing the waste to a state of fresh compost, is an intense aerobic fermentation: it is basically the decomposition of fresh organic matter at high temperature (50-70°C) through the action of bacteria; the second, by a less vigorous fermentation, transforms the fresh compost into a mature compost, rich in humus. This phenomenon of maturation, which takes place at lower temperature (35-45°C), leads to the biosynthesis of humic compounds by fungi. To avoid putrefaction of the product and to ensure a homogenous fermentation throughout the mass, it is necessary to restore the aerobic conditions of the environment by aeration and mixture (redistribution of elements (C, N, O_2, H_2O, mainly). In this manner it is possible to prolong fermentation at high temperature. Pathogens, parasites and weed seedlings are destroyed by the high temperature, bad smells are avoided, decomposition is quicker. As soon as the temperature no longer increases after aeration, fermentation can be considered as complete.
Composting is an ancient, simple technique, rehabilitated in Europe thanks to a recent mechanization of aeration by turning. This farm fertilizer has little smell. Much more than a fertilizer, it is an enriching agent stabilized for many years. Humus thus formed mineralizes progressively during the years following spreading, slowly releasing mineral nitrogen. In this way, the nitrogen is easily absorbed by the plants, which makes it possible to avoid pollution of aquifers, soil destructuring and acidification (the straw serves as a buffer here). Given the large decrease in weight of the composted product, namely its lower water content, the unpleasantness of transport is also reduced. The reduction of smells makes this dry product marketable and stable.

Knowing more about the quality of composts
When commercial negotiations exist, the nature of products exchanged must be precisely known; in our case, the composition of composts in fertilizing elements must be as precise as possible and validated to provide customers with a better guarantee of the product; the need for an analysis technique will arise. The analysis technique with near infrared spectrometry (NIRS) has shown promising preliminary results in terms of prediction of nitrogen and phosphorous (chapter 7) and should be developed. If more data is added to the farm fertilizer analytical database and the prediction equations are strengthened, the NIRS technique would enable an indirect, rapid and very inexpensive evaluation; it would help small-scale processors or village co-operatives to define their products and the authorities to monitor the products exchanged. This characterization of the quality of farm fertilizers should be conducted conjointly with the construction of a technical frame of reference on the use and real needs (fish, crops, vegetable production) in terms of composition, form and sanitary standards.



Promote on-farm environmentally-friendly practices, develop innovative technological solutions

Associated with organizational issues are technological constraints derived from the very nature of the polluting products. The problems caused by liquid effluents have been discussed at length. Consequently, we should consider what might be possible solutions to the problems caused, either before (scraping practices) or after (processing, constructive use) production of these liquid effluents.

Bringing structural changes to the farm and adapting the waste storage capabilities

The seasonal use of farm fertilizers on crops demands management capabilities that respond to this seasonal rhythm; to be able to store waste on the farm (without discharging it into a nearby river, of course!) makes it possible to adapt supply and demand while creating a situation of safety at the time when demand is low, particularly in winter when neither dry crops nor ponds enable the use of any of the OM produced by a pig production with surplus waste. The capacity of storage structures must be correctly determined. Pits must have a minimum storage capacity sufficient for the 3 to 4 winter months (from November to February).

Reiterating the classification from chapter 5, creation of storage pits of appropriate size, renovation of effluent evacuation channels, covering of storage areas exposed to the rain to avoid increase in effluent volumes are all propositions that would enable medium-sized and large pig farms to considerably reduce environmental risk. For small farms of type I, equipment with a storage pit for biogas wastewater seems difficult. Installation of canalizations leading to ponds or paddy fields could be considered. An area of filtration/impregnation over straw at the outlet of the biogas digester could be imagined in order to encourage the volatilization of nitrogen and to reduce the volume of liquid. For farms (type IIIC) whose building is located on a pond, an intermediary storage structure seems to enable an improved regulation of liquid flow. This control considerably reduces the risk of pond contamination.

While the adequacy between supply and demand of farm fertilizer on crops does not seem problematic in the very short term, it will probably become so before 2010, with significant management difficulties in winter.

The creation of storage solutions on or near the farm will therefore be a key investment to be supported and regulated by legislators.

A practice to be preserved: separation of liquid and solid effluents on pig farms

Making good use of livestock effluents as organic fertilizers for crops, in the case of pig production, currently only concern “solid effluents”. In Thai Binh province, most pig farms, of whatever size, scrape pig pens 1 to 3 times a day. Scraped faeces are then put to use as organic fertilizers for ponds, or for crops via a “composting”. This practice reduces volumes of excreta to be managed and concentrates nutrients into solid products. This represents a distinct advantage, contrary to European countries where slurries, created by mixing liquid and solid waste, generate many constraints in terms of pig effluent management and the first step for treatment then consists of separating these solid and liquid forms.

Treatment of liquid manure

We have seen that the specialization plans decided by the districts seem to have little impact on solid effluent balances, but that they concentrate liquid effluent surpluses in the communes specialized in pig production. At the farm level, we make a difference here between treatment technologies adapted for very small pig farms (<10 pigs) and those for larger ones.

The case of very small pig farms

We recommend a complete elimination of liquid waste in this situation. It would be advisable to reduce the quantity of water used at least by equipping farmers with scrapers and adaptable flow reducers on the flexible pipes that they use for cleaning. In this case, the quantity of water used can decrease drastically to 20 l/head/day. This liquid manure could then be absorbed by a “bio-bed” made up of rice straw. In this bio-bed, combined evaporation and fermentation would occur to eventually produce compost. The bio-bed is simply a concrete watertight pit filled with rice straw and protected from the rain by a lightweight roof (Figure 1). The technical principle consists in maintaining the water content at less than 70% in the bio-bed. A turning and mixing of the straw bed is necessary after the first two months and then once every month. After one year, the compost must be evacuated and the bio-bed filled with fresh rice straw. The size of bio-bed decided on depends on the flow of liquid manure, humidity and ambient air temperature and the capacity of absorption of the rice straw. In a first approach, on the basis of a bio-bed section of 2 m width and 1.5 m height, we would propose to size the bio-bed according to 0.067 m length/litre of manure. The initial bulk density of the straw must be close to 50 kg per m^3 and it will require a strong compression to reach this value with dry straw.

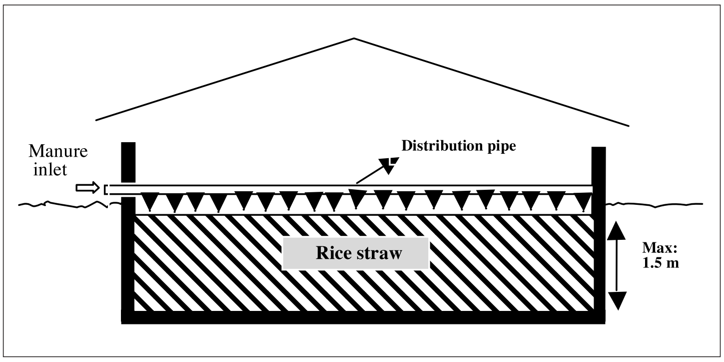


Figure 1: *Figure 1: diagram of bio-bed equipment on a small pig farm*

The case of large pig farms

Anaerobic digestion in biogas systems is a first step to reducing the organic load of manure, but it is not sufficient. A reduction of water consumption is always the first step, as for the small pig farms. In the case of a biogas digester, this will improve its performance by increasing the residence time. Remaining manure could be stored and spread in the closest fields using an appropriate system. Indeed, it is important to note that the treatment of pig manure is expensive and requires a certain level of technical know-how. In our opinion, these techniques will be accessible only to the largest pig farms. The proliferation of biogas digesters on large and medium-sized farms (types I et II according to the classification in chapter 5) raises the problem of treatment of wastewater. However the considerable comparative advantages of biogas (gas production, storage), identified by the analysis of the overall operation of farms, makes it difficult to foresee a suppression of this system. The following avenues could be explored in the context of Thai Binh province:

(1) installation of a straw filter directly at the outlet of evacuation channels would make it possible to retrieve solid manure, with a large proportion of organic nitrogen (the more so given that the manure is separated in its fresh state), almost all the phosphorous and some of the potassium. The nitrogen content of the liquid flowing from the filter would be greatly reduced. The straw filter must be regularly mixed to activate processing. It could then be easily composted, mixed or not with products from scraping, before use on crops.

(2) preservation of total scrapings of buildings in farms equipped with biodigesters. Only liquids would then go into the devices. If preserving scraping is impossible, the straw filter solution between the livestock evacuation and the digester input would reduce the nitrogen concentration in wastewater. Only the liquid waste would be used to make gas. The filter solution seems better adapted to the biogas system because these farms no longer use straw for burning. However, the smooth operation of the digester could sometimes require the addition of raw effluents to provide more carbon than the filtered liquids.

(3) establishment of pilot treatment units using alternative processes or adapting them to the specificities of the Red River Delta. Composting in an aerobic environment and the AGRIFILTRE or TRANSPAILLE processes (2, 3), used in Europe, Africa or South America, can legitimately be tested in this Vietnamese context. Questions remain on the technological aspects, particularly concerning mass balances according to the various composting processes, and on the physico-chemical behaviour of carbon-bearing matter such as rice straw or other green waste used locally as a substratum. Once again, experimentation on the farm of these treatment devices, and possibly associated with the use of a digester, would make it possible to plan for innovative depolluting systems adapted to local constraints. Composting can also use rice straw as carbon-bearing matter. The question is to know what is its absorption capacity, in other words to what extent must it be used in order to enable a satisfactory impregnation of slurry to supply good quality compost.

The rice straw produced in large quantities and relatively little used could play a key role in Vietnam. It is burned on fields in winter and mixed back into the soil by ploughing in summer. In a global vision of the management of greenhouse gas emissions, a rotation of the removal of straw could limit emissions of CO_2. Its use as ligno-cellulose filtering matter for composting or for the AGRIFILTRE process would be a sustainable alternative to burning on fields at harvest time. In France, it is wheat straw that is generally used; it has been the subject of several tests in laboratories and in industrial pilot units. In the particular case of Vietnam and rice straw (or other kinds of available green waste), it is vital to test it to specify the operating conditions of a treatment platform and to establish the local parameters used in the modelling of the process (capacity of liquid absorption, reduction of matter in suspension, of phosphorous, of nitrogen, speed of filtration, optimal compaction rates, variations in pressure).

The acquisition of technical and economic references would make it possible to assess the constraints in terms of labour and man hours but also in technical terms (incorporation into composting) or in terms of co-ordination of stakeholders. In the hypothesis of a collective composting platform, it would be necessary to build it jointly and support the negotiation mechanisms between rice farmers and compost processors in order to ease straw exchanges, the running of technical operations and the distribution of the end products. Development action propositions such as the establishment of pilot waste treatment units must therefore include the definition of operational specifications, the choice of technology(ies) to be tested, technico-economic management support, even the simulation of supply of collective platforms. In this configuration of collective operation on the scale of a group of farmers or a village, tools exist to assist in decision-making for the choice of processing technology and supply policy (see below the Macsizut and Approzut models) and can be adapted to local characteristics depending on the candidate methods and local costs.

Box 3: The AGRIFILTRE and TRANSPAILLE processes

The AGRIFILTRE process: Originating in technology developed and patented by the CIRAD, the AGRIFILTRE has been adapted for the treatment of livestock effluents in collaboration with the company Evialys. An AGRIFILTRE unit can be sized to treat 3000 m3 of slurry a year. It is a treatment process for pig slurries and organic mud. Treatment of waste liquids takes place in three stages: 1) elimination of the largest particles of matter in suspension by passing the liquid through a filter; 2) it is then passed against the current over a bed of straw to eliminate most matter by filtration/decantation; and 3) nitrification denitrification in order to eliminate the nitrogen present in the liquid. The sequential renewal of the straw prevents blockages of the filter.

Characteristics and performances: the consumption of straw varies, depending on the effluent to be treated, between 15 to 30 kg per cubic metre. In the case of pig slurry, the installation of a filter before the liquid goes into the AGRIFILTRE gives a reduction in straw consumption. Filtration over straw enables 1) a loss of liquid volume of 25% (this is absorbed by the straw or retained by its sprigs), 2) a reduction of matter in suspension of an order of 85%, 3) a reduction in total nitrogen of an order of 40%, 4) a reduction of phosphorous of 80%.

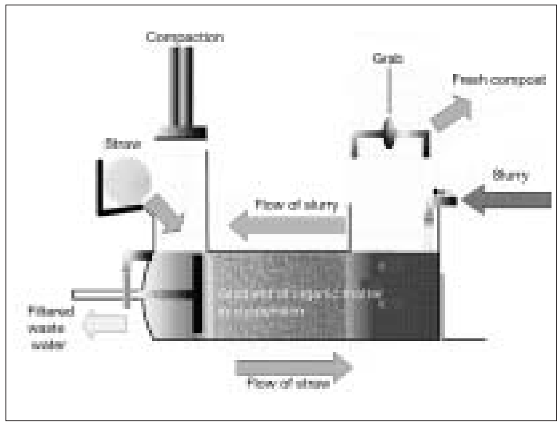
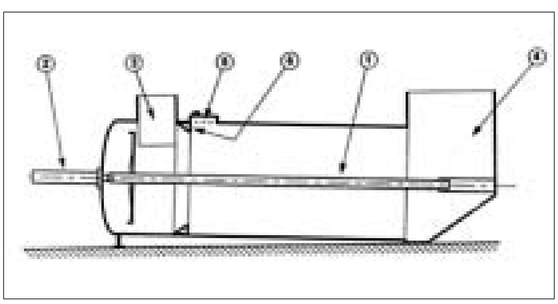


Diagram showing the principle of operation © CIRAD

The TRANSPAILLE process: this innovative principle enables the simple and continuous treatment of solid substrata in a single cylinder, to produce biogas and pre-compost. To achieve this, the digester (25 m3) consists of a slightly tilted (5%) metallic cylinder within which the methane-producing solid substratum (manure with straw in it) is introduced with the help of a shield extended by a central horizontal mobile axle equipped with profiled lugs. Compression is carried out by a hydraulic jack worked by a manual lever (hydraulic pump). The transfer of the fermentable substratum, fermentation and retrieval of biogas take place over a period of 30 to 40 days with a maximum productivity (1 m3 biogas/ m3 / jour) and a maximum retrieval of biogas potential (200 litres biogas/ kg dry manure). The biogas is retrieved by flow of gas along the upper inner surface of the inclined cylinder. The introduction of the substratum takes place in a rectangular hopper with the help of forks. The optimal capacity is 5 kilos of dry manure per m3 per day. Evacuation takes place naturally by expansion and light pre-compost impregnated with gas bubbles floats in a wide hopper located at the other end of the cylinder. Many of these have been installed in Africa and in South America.



Transpaille © CIRAD
1: toothed axle with compression shield
2: double-action jack
3: loading hopper
4: evacuation pit
5: biogas collector
6: water gasket

Reducing the quantities of nitrogen to be managed at source

The strategies or alternative practices that can be envisaged for effluent management usually depend on problems specific to each farm. The greatest risks concern farms of type I (large modern farms) and, to a lesser extent, medium-sized farms in the process of intensifying (type II: see Chapter 5). Although it is harder and above all slower to act upon structural constraints (storage, treatment), it is nevertheless possible to envisage acting upon livestock farming practices.

"Reasoned" diet – Levels of discharges are influenced by zootechnical criteria. During post-weaning and fattening, it is mostly the consumption and live weight gain indexes that affect discharge per animal produced (4). Below a consumption index of 3.2, a gain of 0.1 of an index point would enable a reduction of nitrogenous excretion of 4.5% resulting in an increase in lean tissue. Above 3.2 (the most frequent case under Vietnamese conditions), an increase in the consumption index of 0.1 of a point leads to a relative increase in nitrogenous discharges of 3% (5). On average, 60 to 80% of the nitrogen and phosphorous ingested are excreted. For potassium, the level is over 90%. By working on pigs' diet, significant reductions in excretions of nitrogen and phosphorous are possible (5).

The significant differences in the level of feed consumption between pig farms amplifies the contrasts in consumption and therefore of total discharges of phosphorous and nitrogenous matter. In addition, for an equivalent ingestion of total nitrogenous matter, the quantity excreted can be different according to the origin of the raw material. It is also dependent on the adaptation of inputs to the real needs of the animals, particularly at the time of gestation or at the end of fattening when inputs are often too great when a single kind of feed is distributed.

The heterogeneousness of modes of rationing remains significant in the Red River Delta, with the frequent use of original agro-industrial by-products (rice residue, household waste, waste from making tofu, rice alcohol, cassava); reduction of the excretion of mineral elements can be carried out at source by an improved adaptation of dietary inputs: either by use of two feeds (biphasic or multiphase feeding) in order to adjust sequentially or progressively nitrogen and phosphorous inputs to the real needs of pigs; or by use of a single feed with reduced levels of total nitrogenous matter and supplemented with synthetic amino-acids (lysine, methionine, threonine, tryptophane), this input to be considered according to the real chemical composition of raw materials used locally. It is possible to reduce nitrogenous excretion by about 15-20% by lowering protein content in diet by 1.5 to 2 points with a simple supplement of industrial lysine (6).

It appears vital to make a significant effort to characterize raw materials used and to offer advice in livestock feed formulation. Many unknowns remain, linked to animal genetics, producers' strategies, production types, variable local composition of rations, rationing techniques and expected technico-economic performances. The real levels of animal production in a tropical environment as well as their varied genetic characteristics make difficult a precise evaluation of their dietary needs during growth.

For phosphorous, a significant reduction can be obtained by the incorporation of phytase into feed. This enzyme improves the digestibility of the phosphorous in foodstuffs of plant origin that is poorly absorbed in its form as phytic acid by non ruminant animals. Discharges of phosphorous are reduced by 15 to 35% in this way, depending on the incorporation of phytase, the nature of the diet and the physiological stage.

Influencing choice of livestock farming modes – On large-scale modern farms (type I described in Chapter

5) and those in the process of intensifying production (type II), the scale of management problems, partly linked to the reduction in liquid-solid separation practices, leads to the proposal of production of solid effluents or the processing of liquid effluents into solid products, in particular when export possibilities exist: installation of a straw litter in winter would make it possible to greatly reduce the liquid part of effluents at a time when the livestock herd is at its highest (Têt). Manure, possibly compostable, directly produced under the animals would easily be put to profitable use, so long as transport possibilities and distance constraints are no obstacle. This model based on livestock farming on sawdust and the use of automatic watering systems is known is Asia, particularly in Thailand. This solution however competes with the use of straw by farmers for burning. Moreover, in the summer, the frequent cooling of animals and the heat produced by the straw litter would make it harder to envisage such a solution. In addition, livestock operations on metal grating floors, which, it is true, are few, would not be involved. With animals on litter, the proportion of fibres ingested also increases and thus contributes to increased excretions of nitrogen and phosphorous (7).

Box 4: raising fattening pigs and weaned piglets on accumulated litter (8)

The pigs live on a litter that progressively accumulates under them. It is this practice that is known as livestock farming on accumulated litter. In a fattening pigsty equipped with metal grating floors, the labour needs are about 15 minutes per pig. When pigs are raised on accumulated litter, an extra ten minutes or so must be counted. Compared to slurry, the manure nevertheless presents recognized advantages. For one thing, it is agreed that the use of litter, by enriching the pigs' habitat, improves their wellbeing. For another, as the manure generates fewer bad smells than slurry, it is often considered as a potentially less polluting livestock effluent. The space required per animal, during housing on accumulated litter, is 1.2 m2 for fattening pigs and 0.5 m2 post-weaning. This practice can however seem to be in contradiction with elementary principles of hygiene. In pigsties with metal grating floors, cleaning and disinfection of pens between two batches are basic recommendations. Studies carried out with fattening pigs and weaned piglets have however shown that it is possible not to penalize performances (growth speed, consumption index) in such conditions of housing and that sanitary problems there are not necessarily more frequent than on metal grating floors. It is advisable however to be more attentive to prevention of parasitic diseases (ascariasis) and to check on the sanitary quality of piglets upon arrival.
The use of about 80 kg of sawdust or 45 kg of straw during the raising of 3 to 4 batches of fattening pigs on the same litter gives an average production of 123 kg of compost made with sawdust and of 159 kg of straw-filled manure. These values are 2 to 3 times lower than that corresponding to the collection of excreta in the form of slurry whose average production is 344 L per pig, or a little over 350 kg. Raising weaned piglets on accumulated litters with a use of 15 kg of sawdust or 6 kg of straw gives a production of about 17 kg of sawdust compost or an equivalent quantity of straw-filled manure. The difference between the weights of compost and slurry recorded comes mostly from the evaporation of water from the excreta within the litter, whose temperature at depth varies between 30 and 40°C. Livestock farming on accumulated litters would therefore make it possible to reduce effluent nitrogen production by, on average, 50 % if sawdust is used and 25 % with straw.

Alternatives uses of farm fertilizers

Apart from classic situations of compost and slurry use in the fertilization of rice crops and fish farm ponds, we can try and identify cultivated land that could play a part in the treatment of waste: maize growing, which is in constant expansion in the province offers a significant potential for absorption of nitrogen particularly during the cold season, as well as the vegetable growing activities which are spread all around the edge of the urban area and that are large consumers of organic fertilizers; we can also envisage putting the sloped sides of dikes to use as pasture for ruminants.

Vegetable growing – While the development of the pork commodity chain could be compromised by the difficulty in putting to good use liquid effluents that contain about a third of nitrogen discharged by pig farming, only gardens and vegetable production are considered as potential consumption areas in our simulation model (chapter 10). There is however a high level of inadequacy between supply and demand, since barely 22% of the volume of liquid effluents produced can be recycled on gardens in 2004, then 14% in 2010. The rest (3,234 metric tons of nitrogen in 2004, about 4,800 metric tons in 2010) is discharged into watercourses, a phenomenon observed in the field. Vegetable production is already included in the province's development objectives; associated with the use of organic fertilizers, this strongly increasing production of vegetables for urban markets would profit from an input of low-priced organic fertilizers; the necessary processing of waste, the levels required, a calendar of application and arbitration rules of effluents for crops however remain to be better defined. Knowledge of the kinetics of mineralization of organic matter in Vietnamese soils should be deepened to "reason" the integration of organic matter into quality agricultural production patterns.

Making profitable use of dikes and the production of green forage - Decision N012- NQ/TU of 02 August 2004, published by the Executive Committee of the Provincial Communist Party supports the strengthening of livestock farming over the period 2004-2010; it requests that the province increase production of forage for ruminants. In this context, it could be interesting to consider the use of slurry and compost on available land, and in particular on dikes to increase yields of forage. This hypothesis nevertheless raises certain research questions as much technical as sociological to take into account major constraints such as, among other things: not damaging the soil of dikes that must conserve their primary role of defence against flooding; using forage species that resist the low temperatures during the winter; managing free pasturing by collective organization to achieve a reasoned management of available land; avoiding risks of vegetation being washed away by high rainfall (1,200 mm/year). The possible options include adjusting practices, i.e. a rotation of plots between spreading and pasture, or the creation of social organizations to regulate land use.

Box 5. forage species present on dikes

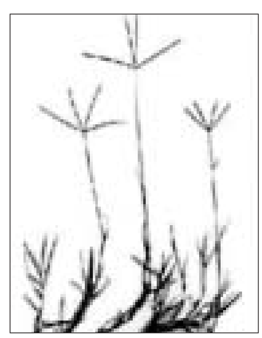
The dikes that run several hundreds of kilometres through Thai Binh province are surfaces used for pasture and are potentially usable for the production of forage. The species presented below are large consumers of the nitrogen that effluents could bring to the soil.

Couch grass, Synodon dactylon (9)

This plant with surface roots can stand the cold; large consumer of nitrogen (200 kg N/ha/year). A good basic fertilizer with additional levels of nitrogen according to purpose. C. dactylon fixed 30 kg N/ha in 100 days.

Brachiaria brizantha (10)

This perennial plant withstands several types of acid soils. It can be grown intensively on condition it receives appropriate nitrogen dosages. The hypothesis of putting to profitable use a plant species like Brachiaria, characterized by its potentially powerful root system, is that a production of 80 to 150 t/ha of biomass at 18%MS (or >18 metric tons of MS/ha/year) would make it possible to cover the nutritional needs of 7 to 10 bovines per hectare and per year.



Cynodon dactylon
Photo: FAO ©

Launching a major support programme to regulate, monitor and support pig farming

At the district and provincial levels, agricultural and environmental departments as well as communal leaders (Chapter 4) are the key stakeholders who strongly influence producers and communal offices. The latter expect strong support from the former in terms of regulation, monitoring and definition of management rules.

The environmental impact of livestock operations is mainly regulated under the Law on Environmental Protection (December 27, 1993). Decree 67 (January 2004) on wastewater discharges imposes fines on non-compliant polluters and may have an immediate impact on larger livestock operations. Much greater concern than for livestock and agriculture is voiced about effluents from polluting industries. The principal government agencies responsible for regulating the sub-sector are the Animal Husbandry Department within the Ministry of Agriculture and Rural Development (MARD) and the Departments of Land Use and Environment within the Ministry of Natural Resources and Environment (MONRE). At the provincial level in Thai Binh, local statutes regulating livestock operations exist but they focus more on agricultural production than environmental issues. Thai Binh province could be the first province to promulgate a relevant environmental policy to balance both livestock development and environmental protection.

A major programme of environmental protection with several components should figure among the priorities of people's committees in order to tackle these regulatory aspects, to create the organs capable of drawing up, carrying out and assessing the impact of necessary control and monitoring measures; it must make it possible to define the compulsory measures to be taken on farms, but also support and co-ordinate scientific programmes to respond to questions left unanswered, support the efforts of stakeholders in their innovation process, and finally to intensify the efforts of training and circulation of information.

Co-ordinating stakeholders and waste commodity chains

A provincial regulation must support strong triggers, capable of advancing the environmental issue: the organization of stakeholders, the definition of their rights and responsibilities in relation to environmental protection and the co-ordination of research and extension efforts. This underlines the importance of working for a clear definition of roles (and particularly the roles of co-ordinators and mediators), for the establishment of new forms of co-ordination at the various administrative levels and for the definition of directives recognizing the importance of what is at stake and giving the general impetus to face up to it. Local regulations must, secondly, legitimize and strengthen directives and new forms of organization.

At the communal level, the organizational aspect of commodity chains for the marketing of farm fertilizers mentioned previously as the co-ordination between stakeholders and commodity chains, the definition of roles or the creation of crosscutting groups can only be effective if directives are drawn up; they must recognize the existence of these commodity chains and their importance for the future of agricultural production and encourage their establishment in a tangible way, their modes of operation, their missions and their sphere of responsibility.

In the districts, an arbitration system bringing together several institutions could also make it possible to treat questions of land exchanges, for example at the time of land reallocations for the construction of waste treatment platforms, or in the case of conflicts when poor effluent management leads to consequences for the economic activities of a third party. They could be the level of jurisdiction for transparent negotiations between public authorities, intermediaries and producers on the subject of the programmes of targeted investments.

Establishing an environmental inspection of livestock farms

Identifying and inspecting livestock farms – The inspection of farms appears to be a necessary variable for any reasoned environmental policy because, without it, all efforts of regulation and extension are usually fruitless. The struggle to control avian influenza introduced certain regulatory measures that it could be pertinent to retain in the management of environmental pollution due to livestock farming, particularly the obligation of registration (brought to the attention of the authorities or strict declaration depending on the size of the flock or herd) of pig and poultry farmers with the authorities. This measure would encourage efforts of inspection and planning. The Livestock Farm Environmental Diagnosis ("DEXEL" in French) carried out in France is an example of the supporting actions that Thai Binh province could establish once it has been adapted to the local context (Box 6).

The establishment of solutions will only be possible if there is an improved knowledge of systems and of their operation over time. Often, these solutions exist or have already existed in certain communes and a few adaptations may enable their circulation. Modifications to the statistical census must bring in necessary information at the farm level, and not just at the communal level; this would make it possible to supply information usable for planning inspections and for development measures. The deployment of tools for technico-economic monitoring, in addition to supporting the management of commercial farm productivity indicators, could simultaneously be useful in the monitoring of environmental indicators, such as the consumption index or annual production correlated to waste production and to their chemical composition (chapters 5 and 7).

Since problems are principally located at the level of certain communes with local surpluses, with intensive livestock farmers who pollute their environment locally, there is a need for a policy of improvement of buildings and of inspection. Inspections by the authorities, or perhaps even official certification, must also target businesses and the self-employed working on the construction of biogas digesters and livestock buildings.

Defining responsibilities - The competent administrative services must be defined to carry out livestock audits and regulatory measures in terms of obligations and sanctions. The involvement of the veterinary services and independent animal health agents in communes could be an interesting innovation and would manifest itself in the field by the drawing up of a contract between the administrative structures and these animal health agents to fulfil a public service in the domain of environmental protection; this co-operation could be linked, in exchange for payment, to the establishment of an official sanitary mandate for veterinary agents to work in favour of animal diseases control and epizootic containment thanks to their role in epidemiological surveillance systems.

Taking into account the diversity of Vietnamese farms - The solutions currently being developed for the coming years are mainly the movement of livestock farms and the installation of biogas devices. The effect of the removal of livestock farms from villages is to reduce the impact of effluents on the immediate neighbourhood. The establishment of these specialized areas is however an extremely risky gamble, since this project relies upon the installation of a still inexistent collective treatment system and excludes most low-income pig producers. This solution is only accessible to livestock farmers with a significant investment capability: small-scale livestock farmers in villages rarely have available funds or the ability to borrow. Big farms located in villages have often exhausted their land resources and their capacity to invest by developing their herds and constructing buildings. Many stakeholders interviewed fear that the establishment of regulations will heavily penalize small-scale livestock farmers. The potentially disastrous consequences on the social fabric of the province are a worrying prospect.

Box 6: Livestock Farm Environmental Diagnosis ("DEXEL" in French)

In France, the "DEXEL" is a compulsory diagnosis for any farming activity covered by the Agricultural Pollution Control Programme. A registered technician carries out the diagnosis by an appraisal of existing installations; s/he assesses the pollution risk levels of each building or livestock-farming situation as well as auxiliary structures (storage of excreta). The DEXEL examines the muckspreading potential of farm structures, estimates the possibilities and the restrictions. The agricultural practices concerning crop rotations and their organic and mineral fertilization are inspected and assessed in terms of risk associated with nitrogen use. The cost of the DEXEL is wholly covered by the State when it is requested and validated within the time limits for data collection. All the information collected and transcribed in the DEXEL is passed on to the relevant administrations. This initial appraisal helps identify work necessary to conform to regulations and to determine the total value of aid linked to work in order to conform to standards.

Strengthening research and impact measures

Co-ordination of research – We have introduced certain avenues of pure and applied research into this final chapter covering agronomical sciences but also organizational sociology, waste technology, zootechnics or physical and human geography. At the provincial or better still national level, it appears vital to maintain a co-ordination of the numerous Vietnamese and international research efforts. The research programmes should be identifiable at the Ministry of Agriculture and Rural Development (MARD) level, particularly through its website, after having been the subject of a clear tendering process between official bodies (State or provinces) and research bodies. This transparency must guarantee a pooling of results at the level of competent Vietnamese agencies and a rationalization of budgetary spending in this field. Voluntary co-ordination could be carried out by a working group bringing together representatives of the ministries concerned (MARD, the Ministry of Sciences and Technologies and the Ministry of Education and Training), and the boards or senates of research institutes and universities mandated to participate in research efforts for environmental protection. This co-ordination of efforts of those distributing funding is vital to specify questions of priority research, to avoid overlapping and to encourage scientific complementarity. This co-ordination must also be established at the provincial level in Thai Binh.

Strengthening research capacity by multidisciplinary programmes – As we have seen all through this final chapter, acquisition of complementary knowledge on treatment technologies, on the use of effluents as an agronomical input and on the pollution situation must go hand in hand with the development of the system. This dimension influences the stakeholders because it brings organizational solutions and innovative techniques. We will now propose some avenues of research complementary to the classic agronomical ones already mentioned in this study. They involve the use of simulation models, as a tool to support decision making (Box 7), to test management scenarios and assist development processes including choices of technology, establishment of regulations, compensations and subsidies or even taxes on polluters. The monitoring and impact measurements of development actions are two more important points to be followed up.

Teledetection (chapter 3) and balance calculation (chapter 10) approaches innovate by introducing satellite images, spatialized calculations and simulation to imagine possible scenarios depending on the priorities and decisions of stakeholders. It would be interesting to supplement them by environmental impact studies, and a monitoring of water quality to better appreciate the link between pig production and real pollution of water resources. With a global vision, greenhouse gases can also be taken into account in alternative scenarios; the study of the complex epidemiological relationships between water pollution and human and animal health would also be pertinent.

Box 7: Models in animal waste management

The CIRAD has a decade of experience on the island of Réunion in animal waste management and soil fertility transfers. The development of agriculture on Réunion encounters two problems related to the management of organic material. These are the risk of pollution generated by livestock farming (principally located in the highlands) and the necessity to maintain soil fertility (mainly in the lowlands, where sugar cane and vegetable crops are grown). While importing inorganic fertilizers is expensive, a solution being considered is an improved organization of the transfer of organic material from livestock units to crops, either to individual farms or at the district level. Using simulation models, either coupled together or in isolation, allows one to address a great diversity of management situations, concerning: the operation of liquid or solid manure transfers at the farm level and risk assessment in terms of nitrogen released into the environment; the evaluation of mass balance, technical parameters, investment/operating costs and supply policies of pig slurry treatment units using various processes; the transfers of organic material surpluses from livestock farms to recipient crop farms in rural areas; the assessment of environmental measures taking into account the farmers' economic behaviour. Here are more details about simulation models to improve individual and collective management of pig effluents on Réunion:

Macsizut: a model to choose pig slurry treatment *- Macsizut is a spreadsheet model devised to calculate OM balances and assess investment and running costs of pig slurry treatment plants. It also makes it possible to define the technical and economic components required for effluent modelling at farm level and at the collective level (a group of farms with a treatment unit) (11).*

Approzut: a simulation model to test supply policies of a collective treatment plant *- Approzut is a hybrid dynamic system (i.e. with both continuous and discrete-valued variables) to evaluate various management policies, where farms must supply a collective treatment plant with pig slurry.*

Biomas: a model to simulate flows of organic material fluxes within a given territory *- The Biomas multi-agent system allows us to simulate flows of organic matter transferred amongst a set of farms located within a certain territory.*

Magma: a simulation model to manage organic matter at the farm level *- Magma is a hybrid dynamic system (i.e. with both continuous and discrete-valued variables) allowing the simulation of management of various kinds of animal manure or slurry production and utilization modes (waste spreading on cultivated crops and fallow land and compost making). It can support decision making to help better manage such potentially hazardous organic matter at the farm level with the aims of environmental risk minimization, agricultural efficiency and farming sustainability (12).*

Targeted investments programme: training, information, equipment and pilot processing units

Subsidizing environmental investments – The State has a role not only in development support for economic commodity chains but also in the protection of public property, particularly the environment. It must provide a strong response to operational and investment difficulties i) to train the agents of local administrations and establish farm inspections, ii) to come to the aid of livestock farmers to bring their installations up to standard (storage pits, mechanical agitators), iii) to support communities in the adoption of collective treatment technologies (composting platforms, treatment processes of the AGRIFILTRE kind, sewage lagoons).

Circulating knowledge to communities – Finally, the extension of research results appears to be a powerful driving force, but a neglected one for the moment, in making progress on environmental issues. Lack of information sharing appears to be a limiting factor for progress on pollution problems and extension; information transfer from research to producers, training in treatment techniques or awareness raising of stakeholders represents a significant response. The strengthening of agricultural extension structures on the environmental issue remains a huge challenge in terms of organization and means. The link between research efforts and circulation of experiences can be built up with the help of pilot units in the field to demonstrate and circulate new technologies. It remains the case that efforts to create teaching aids such as a Guide to Organic Matter or a Teaching Guide to Treatment Technologies would be vital work towards spreading information to stakeholders involved. If research responds to the practical problems of the various kinds of farmers, if material and financial means are deployed to implement these training courses, and if stakeholders' roles are clearly defined in order to ensure quality training, this training, extension and awareness raising to techniques will be all the more effective.

Box 8: Incentive tools associated with the strengthening of regulations

Linked to the establishment of a Livestock Farm Environmental Diagnosis, financial incentive constitutes one of the public policy levers alongside regulatory action. The State, provinces and districts can establish significant subsidy policies in order to encourage the implementation of actions corresponding to their objectives. Such financial support can be awarded in a precise manner, on a single subject and destined for a single beneficiary, or be structured in a wider context with multiple objectives as is the case with some contractual approaches.
As an example, in France, the ***Agricultural Pollution Control Programme****, (PMPOA in French), was developed in October 1993 by the Ministries of Agriculture and the Environment. One of the objectives was to make livestock buildings conform to antipollution standards, particularly by the construction of holding tanks for animal excreta and the establishment of rules for the spreading of these excreta. Each farmer must draw up, in collaboration with agricultural offices, a livestock farm environmental diagnosis (the DEXEL) that includes a plan of installations, a study of work to be carried out to control effluents, and a cost evaluation. Financing for operations is provided by the State and the local authorities (one third), water agencies (one third) and farmers (one third).*

Conclusion

The obstacles observed during our diagnostic phase call for innovative technical and organizational solutions. The technological limits mostly affect liquid effluents made up of wastewater that flows away following daily cleaning operations and spraying of animals in order to cool them down in the hot season. Aside from associated pigs-fish farming, where the pond receives all effluents directly, this waste is difficult to put to good use owing to its volume, as much in terms of storage – the available space for livestock farming being in general very tight – as of transport. This latter factor comes into play particularly for its use on crops, which represents the largest potential place of consumption in terms of area. Some of these effluents are used directly on gardens, where fruit trees are usually planted.

A set of specifications have been outlined here to help lay down avenues for a sustainable development. This possible outline of a plan of environmental support of livestock farming must take into account a series of necessary factors to guarantee a successful development but above all an improved spatial distribution of organic matter: Thai Binh province is not in a situation of structural surplus; the area of soils and ponds theoretically necessary for spreading is sufficient to absorb all of the effluents produced; conditions must therefore be specified at the spatial level to better distribute nitrogen between communes with a surplus and communes with a shortfall, often close to each other. Treatment of localized pollution around certain farms and discussion of necessary inspections and corrective measures to be established must not of course be omitted.

Whatever the solutions proposed, they can only be brought about if certain measures are established beforehand: the authorities must also draw up environmental regulations specifying the target objectives and implement these regulations taking into account existing practices and perceptions of the system's various stakeholders. It will be necessary in particular to clarify in a concerted manner the status and mission of each political, administrative and technical stakeholder; following these decisions, the various stakeholders and above all the communal offices and socio-political organizations will then be allowed to play their part fully in training and raising the awareness of producers, arbitrating conflicts, co-ordinating actions between livestock farmers (or between livestock, fish and crop farmers), and carry out livestock farm audits. The research sector must respond for its part to agronomical, technological and socio-economic questions from stakeholders in the field in a pertinent and co-ordinated manner in the form of a major scientific programme that it now only remains, with the participation of all involved parties, to construct together!

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