



Photo: Farm Sanctuary

## Pollution from industrialized livestock production

**In recent decades, livestock production has increased rapidly, particularly in the developing world.**

Most of the increased production comes from industrial farms clustered around major urban centres.

Such large concentrations of animals and animal wastes close to dense human population often cause considerable pollution problems.

The rapid growth of livestock production highlights the urgent need for effective policies to regulate intensive livestock operations and support environmentally and economically sustainable approaches to handling waste.

Between 1980 and 2004, global meat production almost doubled. Most of the growth took place in developing countries, where production grew threefold, increasing at an annual rate of more than 5 percent. Although people in industrialized countries still eat three to four times as much meat as people in developing nations on a per capita basis, developing countries now produce and consume well over half the world's meat.

In many developing regions, this rapid growth has been spurred by dramatic shifts in the nature and location of livestock production. Traditional mixed farming systems, in which farmers raise a few animals alongside their crops, have given way to large industrial operations with thousands of animals. New production has shifted increasingly from cattle and other ruminants that graze on grass and fodder to pigs and poultry fattened on diets of concentrate feed. And the centre of gravity for livestock production has migrated from rural, farming communities to the outskirts of cities.

Much of the new production has been concentrated in large, industrial pig and poultry operations located in and around major cities, where farmers have ready access both to cheap supplies of feed and to good markets for their meat and eggs. In Asia, where growth has been most dramatic, large-scale industrial production accounts for roughly 80 percent of the total increase in livestock products since 1990. ▶



## Industrial production and pollution

Concentrated, large-scale livestock production often creates concentrated, large-scale environmental problems. Large industrial farms bring in massive quantities of nutrients in the form of concentrate feed. And they produce far more waste than can be recycled as fertilizer and absorbed on nearby land. When intensive livestock operations are crowded together, pollution can threaten the quality of the soil, water, air, biodiversity and ultimately public health. Pollution damage is especially harmful when large numbers of animals are concentrated in sensitive areas around cities or close to water resources. Effluents are commonly discharged into the environment or stored in vast “lagoons”, from which waste may spill or leak into nearby streams and groundwater supplies. Noxious gases escape into the atmosphere, subjecting downwind neighbours to sickening odours and contributing to atmospheric aerosol formation, build-up of greenhouse gases and acid rain.

Much of the increased risk of pollution is caused by rupturing the traditional “short cycle” between livestock production and crop production. In less intensive, mixed farming systems, animal wastes are recycled as fertilizer by farmers who have direct knowledge and control of their value and environmental impact. Industrial production leads to a longer cycle, in which large quantities of wastes accumulate far from croplands where they could be safely and productively recycled. So even though intensive systems tend to make more efficient use of resources (see graph), with lower levels of water use, nutrient excretion and gas emissions per kilogram of meat or milk produced, they often generate more pollution than less intensive farms where manure is better managed.

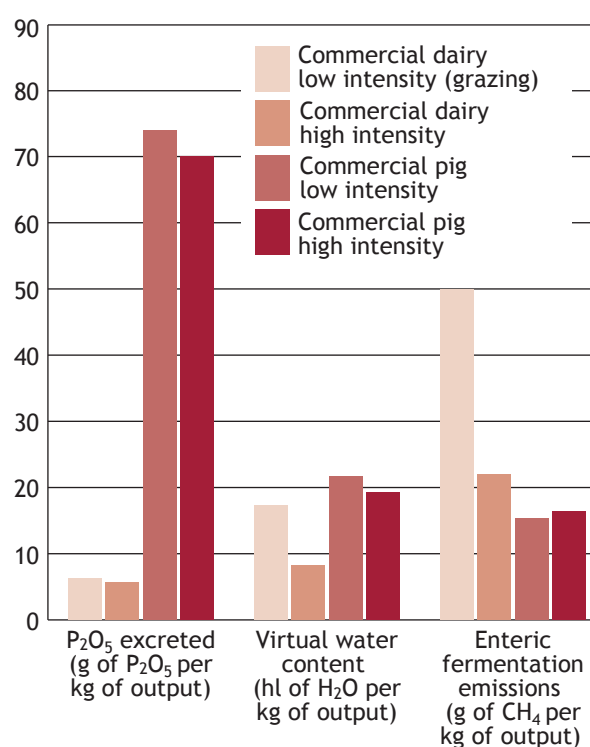
Dense concentrations of industrial livestock production

create regions with vast quantities of excess manure. The Netherlands, with the highest intensity of livestock production in the world, produces 15 million more tons of manure than can be safely applied to the land. Although much lower on a national scale, concentration of pig and poultry production in parts of China and Brazil is approaching and surpassing levels found in Europe and North America. So, too, are the threats to the water, soil and air from concentrations of animal wastes.

Major forms of pollution associated with manure management in intensive livestock production include:

- **Eutrophication of surface water**, as nitrogen, phosphorus and other nutrients are discharged or run off into streams, damaging wetlands and fragile coastal ecosystems, and fueling algae “blooms” that use up oxygen in the water, killing fish and other aquatic life. Livestock production has been identified as the major source of land-based nutrient pollution that has caused massive algae blooms in the South China Sea, including one in 1998 that killed more than 80 percent of the fish in 100 square kilometres along the coast of Hong Kong and southern China (see box, pages 4-5).
- **Leaching of nitrates and pathogens** into groundwater, threatening drinking water supplies. A 1998 study of 1 600 wells located near factory farms in the United States, for example, found that 34 percent of the wells had been contaminated by nitrates, with 10 percent registering nitrate levels above the drinking water standard.
- **Buildups of excess nutrients and heavy metal** in the soil, damaging soil fertility and shrinking arable land resources already strained by population growth, rising demand for food and conversion to other uses. In several Asian countries, fully one quarter of the total crop area suffers from significant nutrient overloads. Almost half the excess phosphorous supply comes from livestock.
- **Contamination of soil and water resources** with pathogens. This can be another common result of breaking the “short cycle” for nutrient recycling. When wastes are discharged into the environment or transported from industrial livestock operations for use on specialized crop farms, distance often erodes farmers’ ability and incentive to manage risks from bacteria, heavy metals or drug residues.
- **Release of ammonia, methane and other gases** into the air. Ammonia emissions contribute to acid rain and nitrogen deposition that damage crops and natural ecosystems, as well as to aerosol formation, which can cause health hazards. Livestock and manure management are also major contributors to greenhouse gas releases. Emissions of methane from ruminants digesting fibrous feeds and from manure storage facilities add up to nearly 90 million tons per year, accounting for about 16 percent of global annual production. Manure also produces nearly seven percent of total global emissions of nitrous oxide, which ranks among the most damaging greenhouse gas of all with an impact 296 times greater than carbon dioxide (graph 2).
- **Destruction of fragile ecosystems** such as wetlands, mangrove swamps and coral reefs - irreplaceable reservoirs of biodiversity that are the last refuge of many endangered species. Threatened coastal areas

### 1 - Pollution and production intensity



Source: LEAD, UNESCO-IHE, FAO

of the South China Sea, for example, have provided the habitat for 45 of the world's 51 mangrove species, almost all of the known coral species and 20 of 50 known sea grasses.

## An agenda for policy action

Proven policies and technologies exist that could manage and reduce the environmental damage caused by industrial livestock production.

Zoning regulations and taxes can be used, for example, to discourage large concentrations of intensive production close to cities and far from cropland where nutrients could be recycled. And taxes, certification programmes and other policy instruments can be used to support best practices in livestock production. Building barns and manure storage facilities to meet rigorous siting and construction standards can reduce effluent discharges. Use of quality feed and careful monitoring of nutrient inputs and outputs can help minimize releases of nitrates, phosphates and

heavy metals. Recycling manure and compost can provide livestock producers with an outlet for their waste and farmers with an inexpensive supply of organic fertilizer. Biogas generators can improve manure management while providing a valuable source of renewable energy.

But few countries have established policy frameworks that encourage farmers to adopt and invest in these technologies. Quite the contrary. In many countries, outdated and misguided policies actively promote environmentally unsustainable livestock production. Many developing countries, for example, provide subsidies for high-energy feed concentrates, chemical fertilizers, energy and credit. Although they do not directly target industrial systems, such subsidies tend to be of greater benefit to large, intensive operations. In parallel, failure to address environmental externalities effectively subsidizes cheap supplies of animal products at the expense of environmental sustainability, benefiting industrial systems. Although many countries have legislation on the books that might compel industrial producers to dispose of wastes responsibly or pay the price, these regulations tend to be weak and poorly enforced.

Correcting this situation requires changing policies and adjusting incentives at both the national and local levels. It also requires collaboration and cooperation between many different disciplines and government ministries, including those responsible not only for agriculture and the environment but also for economic development and public health.

In many developing countries, industrial and intensive mixed farming systems have enjoyed a competitive advantage. Policy distortions and the lack or poor enforcement of regulations have allowed them to avoid paying the costs of managing and disposing of manure and other pollutants. Taxes can be used to correct prices for uncharged environmental costs and encourage efficient use of resources. Taxation can also encourage recycling of nutrients by making manure more attractive as fertilizer, both to the livestock producers who must manage and store it and to the crop farmers who apply it to their fields.

Taxation and subsidies are typically matters of national policy. So is allocation of resources to develop infrastructure that has a major impact on the location and viability of livestock operations. Poor roads, high transportation costs and inadequate electrical and communication networks in rural areas encourage concentration of industrial livestock farms in urban areas. Investing in rural infrastructure can even the scales by providing outlets for livestock production and other rural industries.

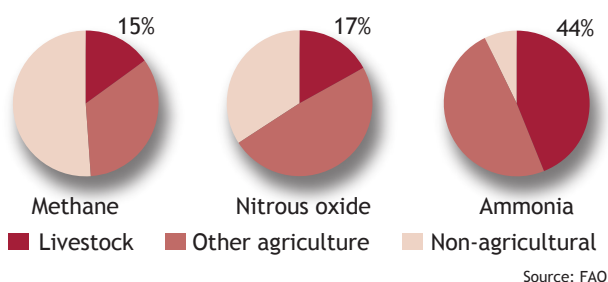
National environmental legislation and regulations can also play an important part in setting standards for effluent discharges and emissions and can provide a framework for negotiation and enforcement of provincial and local codes of conduct. But they cannot effectively reflect either the diversity of farming systems or the input of farmers and other stakeholders in different areas. National policies must be supplemented by regulations, awareness raising and extension service activities at the provincial and municipal level that address local farming systems and environmental conditions. Farmers themselves must also be actively engaged in shaping and implementing policies. If farmers are responsible for animal husbandry practices

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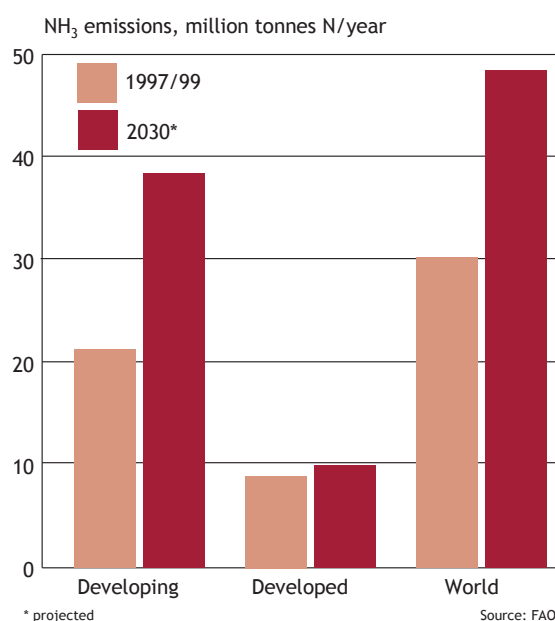
## 2 - Livestock's contribution to gas emissions

Livestock production is a major contributor to emissions of polluting gases, including nitrous oxide, a greenhouse gas whose warming potential is 296 times that of carbon dioxide.

Share of livestock production in human-induced emissions of gases.



## 3 - Ammonia emissions from livestock production 1997/99 - 2030







FAO/H. Steinfeld

## Asian boom in livestock production threatens fragile South China Sea, fuels drive for comprehensive regional, national and local policy response

Nowhere have the rapid growth of livestock production and its impact on the environment been more evident than in parts of Asia. During the decade of the 1990s alone, production of pigs and poultry almost doubled in China, Thailand and Viet Nam (*graph 4*). By the year 2001, these three countries alone accounted for more than half the pigs and one-third of the chickens in the entire world.

Not surprisingly, these same countries have also experienced rapid increases in pollution associated with concentrations of intensive livestock production. Pig and poultry operations concentrated in coastal areas of China, Viet Nam and Thailand are emerging as the major source of nutrient pollution of the South China Sea (*graph 5*). Along much of the densely populated coast, the pig density exceeds 100 animals per square kilometre and agricultural lands are overloaded with huge nutrient surpluses (*see maps, next page*). Run-off

is severely degrading seawater and sediment quality in one of the world's most biologically diverse shallow-water marine areas, causing "red tides" and threatening fragile coastal, marine habitats including mangroves, coral reefs and sea grasses.

The related booms in production and pollution have kindled plans for one of the most comprehensive efforts to forge an effective policy response - the Livestock Waste Management in East Asia Project (LWMEAP) - which has been prepared with the governments of China, Thailand and Viet Nam by FAO and the inter-institutional Livestock, Environment and Development Initiative (LEAD - [www.lead.virtualcentre.org](http://www.lead.virtualcentre.org)), under a grant from Global Environment Facility. The project will address environmental threats by developing policies to balance the location of livestock production operations with land resources and to encourage the use of manure and other nutrients by crop farmers.

### 4 - Pork and chicken production, 1990-2000

Production of pork and chicken increased rapidly in China, Thailand and Viet Nam during the 1990s.

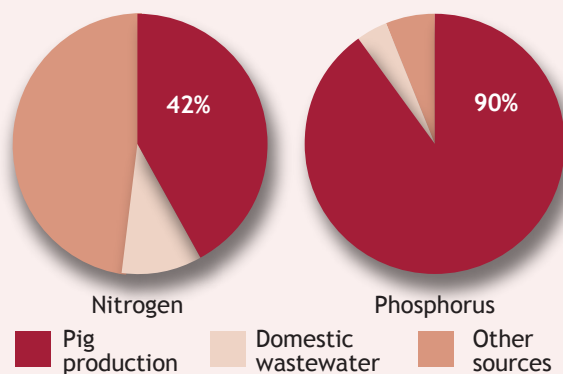
Increase in production, 1990-2000 (%)



Source: FAO

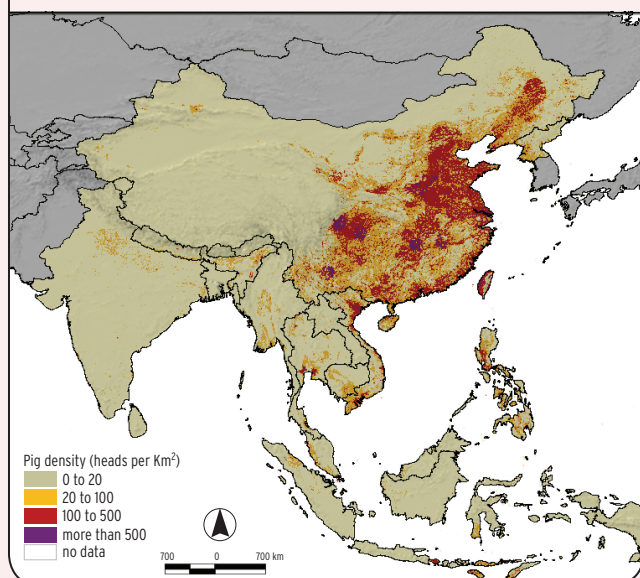
### 5 - Pollution in the South China Sea

Pig production accounts for an estimated 42 percent of nitrogen and 90 percent of phosphorus flows into the South China Sea from the Pearl River basin in Guangdong Province, the Chao Phraya River basin in Thailand and the Red River and Dong-Nai River basins in Viet Nam.



Source: FAO/LEAD

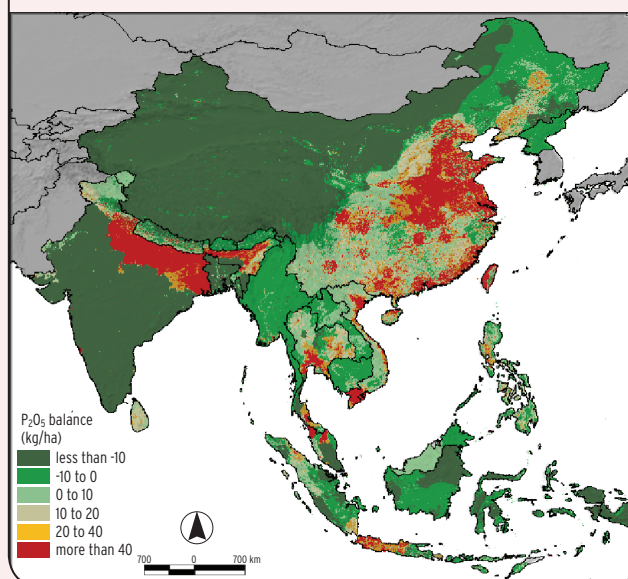
Estimated pig densities in Asia (1998-2000)



Pollutants from all three countries threaten the South China Sea. But the nature of livestock operations differs markedly among the countries. In Thailand, three quarters of pigs are now produced on large, industrial farms with more than 500 animals. In Viet Nam, on the other hand, very small producers with just three or four pigs account for 95 percent of production. While half of the pigs in Guangdong are still produced in operations with fewer than 100 animals, large-scale industrial operations are growing rapidly. Almost one quarter of the pigs in Guangdong are produced on farms with more than 3000 animals (*graph 7*).

The LWMEAP project outlines policies at both the national and local levels. At the national level, the project stresses the need for inter-agency cooperation to develop effective and realistic regulations on environmental protection and discharge standards and to undertake spatial planning for the location of future livestock development to create the conditions for better

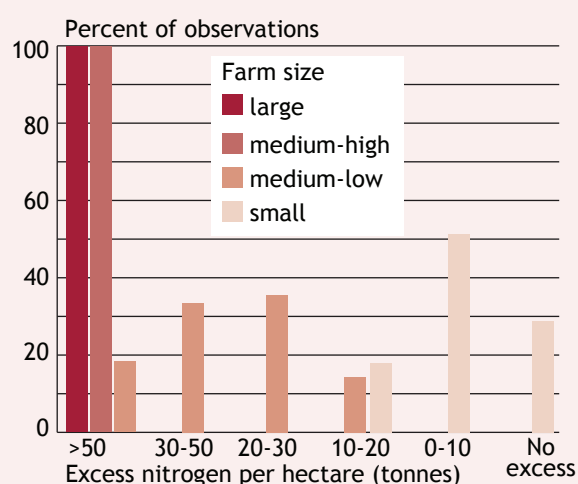
Estimated  $P_2O_5$  mass balance for agricultural land in Asia (1998-2000)



recycling of effluents. As a key tool for shaping and implementing policy at the local level, LWMEAP provides detailed templates for three different Codes of Conduct. Each of the proposed Codes has been tailored to address specific farming practices and environmental challenges that are representative of most pig production in the region.

All three templates emphasize the need for nutrient management plans and for manure storage facilities and disposal practices that minimize runoff and maximize recycling of available nutrients. But the template for some medium to large farms spells out special requirements for nutrient management plans and manure handling where livestock wastes are used in fish farming. And the template for small farms stresses the importance of technical assistance to help farmers organize waste management groups and prepare nutrient management plans and to ensure that they have access to functional biogas digesters in their villages.

## 6 - Excess nitrogen for pig production units surveyed in Thailand, 2002

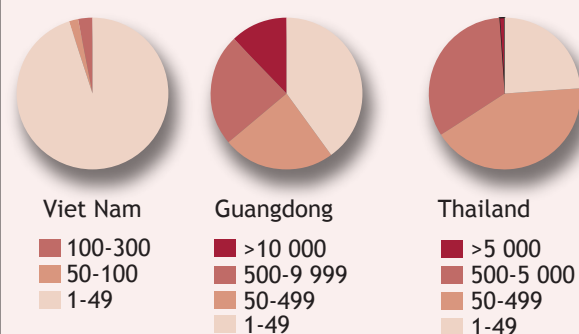


Source: FAO/LEAD

## 7 - Pig producers in East Asian countries

Small producers still dominate pig production in Viet Nam and Guangdong. In Thailand nearly 75 percent of pigs are produced on large-scale farms.

Share of producer categories (number of pigs reared) as percentage of total number of pigs produced



Source: FAO/LEAD

that are causing pollution, they are also the only ones who can change those practices and rectify the situation.

Livestock producers can be encouraged to set up shop further from cities and closer to croplands, for example, through a combination of local, provincial and national zoning and land use regulations, reinforced by taxes, incentives and infrastructure development. Suitable zones for livestock development can be identified by analysing possible impact on economic development, social equity, environmental quality and public health. Infrastructure development, such as improving roads and constructing a public slaughterhouse, will make these zones attractive to livestock producers. So will zoning regulations and taxes that discourage production in urban areas where it is more likely to cause severe pollution problems. Zoning and spatial planning of livestock production are powerful measures for controlling land/livestock and nutrient balances. In Thailand, for example, high taxes were levied on poultry production within a 100 kilometre radius of Bangkok. Chicken farmers outside that zone enjoyed tax-free status. Within less than a decade, the concentration of poultry production on the outskirts of Bangkok dropped significantly (graph 8).

Lessons drawn from international experience suggest that adoption of environmentally sound practices depends both on incentives, in the form of financial assistance and training, and on binding standards, enforcement and sanctions. In successful programmes, incentives for investing in technology to reduce pollution on existing farms frequently range as high as 75 percent of the cost. New and expanding operations, on the other hand, can be expected to factor the cost of environmental controls into the overall costs of doing business. Incentives are not applied to them. Certification programmes can also be used to encourage improved husbandry practices. Farmers can be rewarded, for example, by offering price premiums or market access privileges for produce certified as coming from code-compliant farms. Farmers may also require extension training and assistance to select and implement environmentally sound best management practices.

The authorities can also encourage livestock producers to adopt environmentally sound practices by putting

forward environmental standards and prescribing ways to meet these standards. Binding standards must be enforced. When they are violated, the authorities must consult with livestock producers to ensure compliance and punish repeated violations by imposing fines or banning activities.

The transfer of manure from intensive livestock production to potential users such as crop farmers or fish producers raises a number of issues associated with monitoring manure quality, including nutrient, water, heavy metal, drug residues and pathogen content. Manure is often transferred directly from producers to users, but middle men and processors can also be involved. Governments have a role to play in providing guidelines for marketing of manure and manure products, in defining quality standards and regulations and in assigning responsibility for monitoring and certification. Subsidies to manure processing and use can also be considered.

Meeting environmental standards implies a certain cost to the livestock sector. The OECD has estimated that the costs of environmental regulation range from 4 to 7 percent of overall production costs.

The costs of meeting environmental standards vary depending on the choice of policy instruments and techniques. Cost efficient measures include improved feed efficiency and increased use of nutrients in livestock manure to fertilize crops. For use of manure to be both cost efficient and environmentally sound, however, it must substitute for chemical fertilizers in meeting the nutrient requirements of crops. Decreasing the volume of waste by reducing water usage can also be cost efficient, since it lowers the costs of storing and transporting waste. Investment in manure processing facilities and biogas, on the other hand, tends to be a relatively costly way to solve manure problems. The additional costs might be offset, however, by income from energy production or sale of processed fertiliser.

Policy options must therefore be evaluated based on their cost efficiency, taking into account both the enforcement costs borne by the government and the costs of compliance borne by farmers. In addition to informing the choice of policy options, this cost efficiency analysis can also support other decisions, including phasing of policy enforcement and setting levels of taxes and subsidies.

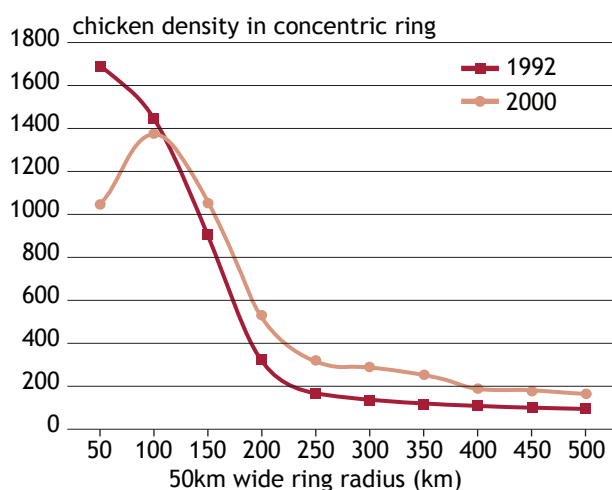
Creating a policy framework that will win widespread compliance requires a dialogue with stakeholders that will give them a clear understanding of why the policies are needed and what impact they will have on their lives. The task of establishing a code of practice or set of best management procedures can serve as an effective way to engage stakeholders in such a dialogue.

### Keys to best management practices

Effective codes of conduct or best management practice must cover all aspects of farm operation, including:

- **Farm siting and construction** - The environmental and public health risks of industrial feedlots and effluent lagoons can be limited by ensuring that they are not located too close to each other, to streams and aquifers and to densely populated communities. Environmental damage can be reduced further by encouraging and

## 8 - Poultry around Bangkok, 1992-2000





enforcing standards for the design and construction of buildings and lagoons to conform with approved manure management systems.

- **Monitoring nutrient balance** - Closely monitoring the amounts of nutrients that enter and leave intensive livestock operations has proven to be a key tool of policy enforcement in most areas (*see box*).
- **Manure separation and storage** - Separating solid manure from liquid wastes in barns minimizes the use and contamination of water. Solid wastes can then be dried or composted to provide marketable fertilizer that is more generally accepted for use on crops than liquid effluents.
- **Effluent storage** - Ponds or lagoons used to store effluents should be lined to reduce leaching and big enough to allow for manure storage at times when application on crops is not suitable, such as during the rainy season.
- **Land application with manure** - In order to maximize nutrient uptake by crops and minimize the risk of runoff and water contamination, solid manure and compost should be worked into the soil before crops are planted. Use of manure should be avoided near streams and wells, as well as crops that are consumed uncooked.
- **Water utilization** - Use of water for cleaning and cooling animals should be minimized in order to reduce the amount of contaminated water that must be treated or disposed of. As with management of nutrients, water utilization can be monitored and improved if operators maintain records of water usage.
- **Biogas disposal** - As much biogas as possible should be used on the farm to generate electricity and heat or should be sold locally. Surpluses should be flared at the source but never released into the atmosphere, where methane is 21 times more reactive than carbon dioxide

as a greenhouse gas.

- **Feed practices** - Providing training and incentives to use feed with only the amounts of protein, minerals, heavy metals and pharmaceutical additives essential for good animal health can improve nutrient transformation efficiency. Maintaining records of antibiotics and other additives helps reduce use of additives that pose a threat to the environment.
- **Biosafety** - Recent outbreaks of avian influenza have highlighted the risk to animals and humans of disease spreading within and between farms where large numbers of animals are confined in close quarters. Restricting visitor access to farms and barring other animals from hog production facilities can reduce the risk of disease being carried from one farm to another.

Establishing codes of conduct that address these and other environmental hazards can go a long way toward reducing the damage caused by industrial livestock operations. But only if the codes are backed up by policies and programmes to raise awareness about the environmental risks of non-compliance, to provide incentives that reward farmers who abide by the code, and to strengthen enforcement agencies with the resources to monitor compliance and penalize violations. Training must also be provided to familiarize farmers with the content of the code and the steps they will need to take to comply.

More work is also required to build awareness of the costs that pollution from livestock production inflicts on the environment and on society. Public awareness of the substantial costs for health care, water treatment, aquatic resources destroyed by contamination and unnecessary expenditures on chemical fertilizers can help justify the need for regulations and for the use of government funds to promulgate and enforce them.

## Nutrient balances - a valuable tool to control pollution

**Nutrient management plans** require farmers to maintain a balance sheet, recording all nutrients that enter the farm in the form of feed, forage, fertilizer or animals and all that leave as animals and animal products, manure and crops.

When tied together with incentives for compliance and penalties for unmanaged discharges or for exceeding nutrient disposal rates, nutrient management plans have been shown to help reduce both excess nutrients and use of water.

Not all farmers can be expected or required to maintain nutrient balance accounts on their own, however. Large farmers may have the knowledge and resources to monitor and manage nutrient flow.

But where large numbers of small farmers are engaged in livestock production, local authorities may need to encourage producers to form waste management groups and provide them with access to an extension professional with waste management training.

**Storage System Pig Manure**

**Slurry** Default: Values

Lagoon (with soil cover)	0	Concrete tank (with roof)	0
Lagoon (no soil cover)	100	Concrete tank (no roof)	0

**Solid Manure** Default: Values

Composting (with roof/with soil cover)	0	Stored on a heap (with roof/with soil cover)	0
Composting (with roof/no soil cover)	0	Stored on a heap (with roof/no soil cover)	0
Composting (no roof/with soil cover)	0	Stored on a heap (no roof/with soil cover)	0
Composting (no roof/no soil cover)	0	Stored on a heap (no roof/no soil cover)	100

**Liquid Manure** Default: Values

Lagoon (with soil cover)	0	Lagoon (no soil cover)	100
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Cancel OK

The Nutrient Balance Calculation Program, developed by the Livestock, Environment and Development Initiative (LEAD), calculates the balance between nutrients available from manure and nutrients needed by crops. The Nuflux model can be downloaded at:

[www.virtualcentre.org/en/dec/nutrientb/default.htm](http://www.virtualcentre.org/en/dec/nutrientb/default.htm)

## Keys to coping with pollution from industrialized livestock production

Intensive livestock operations can cause major environmental problems, especially when they are crowded together around cities or close to water resources. Effluents are commonly discharged into the environment or stored in vast “lagoons” from which waste may leach into streams and groundwater supplies and polluting gases escape into the atmosphere. Proven policies and technologies exist that could manage and reduce the environmental damage caused by industrial livestock production, including:

- ▶ Eliminating subsidies and adjusting taxes to make prices reflect true environmental costs and encourage efficient use of resources;
- ▶ Use of zoning regulations and taxes to discourage large concentrations of intensive production close to cities and far from cropland where nutrients could be recycled;
- ▶ Setting and enforcing standards for effluent discharges and recycling;
- ▶ Providing incentives for investing in technology to reduce pollution;
- ▶ Establishing certification programmes to encourage improved husbandry practices;
- ▶ Establishing guidelines, quality standards and monitoring mechanisms for marketing of manure and manure products;
- ▶ Engaging stakeholders in establishing codes of best management practices that encompass all aspects of farm operations, including: farm siting and construction; nutrient management plans; manure and effluent separation and storage; water utilization; biogas disposal; feed practices; and biosafety.

## FAO Livestock Policy Briefs

### Facing the opportunities and challenges of the livestock sector

Rapid growth of livestock production in recent years has fueled hopes for accelerated economic development, fears of increased social inequity and environmental degradation, and recognition that comprehensive and effective policies are required to ensure that continued expansion of the livestock sector contributes to poverty alleviation, environmental sustainability and public health.

Papers in this series of Livestock Policy Briefs explore issues related to livestock production, identify policy options that can be considered and highlight examples of approaches that have proven successful.

The Livestock Policy Briefs series has been prepared by the Livestock Information, Sector Analysis and Policy Branch (AGAL) of the Animal Production and Health Division of the Food and Agriculture Organization of the United Nations.

Additional information, including electronic versions of briefs that have been published, can be found at: [www.fao.org/ag/aga.html](http://www.fao.org/ag/aga.html) or [www.lead.virtualcentre.org](http://www.lead.virtualcentre.org)

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