

BACKYARD AND COMMERCIAL PIGGERIES IN THE PHILIPPINES: ENVIRONMENTAL CONSEQUENCES AND POLLUTION CONTROL OPTIONS

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1.0 INTRODUCTION

The increases in hog population have created and exacerbated various environmental, health and other problems (see the review of the literature in the next section). In the Philippines, what is ironic is that while hog output and operation is preponderantly backyard and the bulk of waste is generated in these farms, current regulations and instruments seem virtually unable to influence backyard operators to undertake pollution mitigating activities. Small commercial farms (21-999 heads as per BAS classification) are also practically exempt from monitoring and compliance because the wastewater discharge standard of 30 cu m per day is more or less equivalent to 1,000 heads of hogs being raised (Orbeta and Calara, 1996).

With the decentralization of government, the greater responsibility of monitoring compliance and environmental quality now lies on the local government units (LGUs). However, regulations and guidelines for small-scale projects like backyard and small commercial piggeries are very few, not clear-cut, and not uniform across municipalities. For the medium to large scale hog farms, although they face regulations, enforcement is weak, and this has been attributed largely to lack of political will and lack of funds (Alcantara, A.J. and R.G. Donald, 1996).

Indeed, there seems to be a limited amount of the local literature concerning the economic assessment of the environmental problems caused by backyard and commercial hog production as well as the pollution control options for curbing waste from these farms. It is in such areas that this project hopes to shed more light on.

1.1 Objectives of the Project

The general objective of this project is to provide an economic assessment of the environmental consequences of and pollution control options for backyard and commercial piggeries.

The specific objectives are as follows:

1. to trace the flow of waste from backyard and commercial pig farms and identify on-site and off-site externality effects of the activity;
2. to evaluate the extent to which backyard and commercial pig farms internalize (if at all) these externalities; and,
3. to evaluate the costs and benefits of particular technological and institutional options to address pollution from backyard and commercial pig waste.

1.2 Project Design and Methodology

The province of Laguna, which ranks fourth in backyard hog production and third in commercial hog production in Region IV (Southern Tagalog) has been chosen as the study area. Specifically, the municipality of Majayjay was chosen as the project site since its typology is believed to be an approximation of all peri-urban backyard and commercial hog systems. The absence of waste and wastewater treatment appears to be almost universal in commercially oriented hog operations in the Philippines. Majayjay is a good representative case in point. Hog raisers in this municipality dump their wastes directly into creeks, streams and canals that find their way into the rivers. Furthermore, an initial exploratory survey conducted in this municipality revealed that there were residents complaining of foul odors from pig pens although no collective formal complaint was raised.

A complete list of hog raisers (at least those who registered) and their respective inventories as of December 1998 was requested from the Municipal Agricultural Officer. For this project, the Bureau of Agricultural Statistics (BAS) classification of hog raisers was adopted. Thus, backyard raisers are those with 10-20 adult pigs and 20-40 young hogs. On the other hand, small commercial raisers are those with 21-999 heads. Medium commercial farms are those that raise 1,000-9,999 heads while large commercial farms are those with more than 10,000 heads.

Eighteen (18) barangays out of a total of forty constitute the total number of barangays which raise pigs in the municipality. Of the 18, 12 are located near or along the water path of the Balanac River and these formed the sample barangays of the project.

A total of 91 raisers were surveyed. To answer objective no. 1, raisers were asked about production information as well as waste disposal schemes and practices.

To identify possible on-site and off-site effects of hog waste:

1. A thorough review of the international literature was made to "come up with very rigorous evidence of the physical impact of pig waste on the environment and health".
2. Households of swine raisers (n=82) as well as households living within a 20-meter radius¹ from hog farms were surveyed (n=94). Respective perceptions of the effects of foul odors from pig waste on their health were asked. Medical costs incurred from exposure to malodours/pig waste were likewise roughly estimated.
3. An additional attempt to squeeze the health effects of hog waste was made by surveying 50 respondents who lived in barangays within Majayjay that did not have the air pollution problem from hog waste. The frequency of morbidity cases was then compared with that of households affected by the bad smell. Although the difference may not be entirely attributed (if at all) to the malodors from pig waste, the objective is to provide enough anecdotal evidence to drive the point that hog waste poses serious problems.
4. Pollution tests of wastewater from piggeries and water samples from affected water bodies were done and these were compared to the standards set by the Department of Environment and Natural Resources (DENR). Aside from this, households near hog farms were asked about their perceptions of the effects of pig waste on water bodies in the Majayjay. This was reinforced, again, by anecdotal documentation of the status and usage of these water bodies 50 years ago or before and after the proliferation of piggeries. A total of 10 key informants - septuagenarians and octogenarians who were born and have lived their entire lives in the municipality - were interviewed for the purpose.

For objective no. 2, costs and returns analysis was employed to determine whether or not hog farms are spending for waste minimization and/or treatment facilities as an indicator of internalizing the externalities caused by pig waste.

For objective no. 3, it was necessary to establish first that reducing pig waste discharges will indeed improve environmental quality. Thus, a watershed approach to pollution loading was used. The approach was concentrated on the river network that traverses Majayjay. Different activity zones within the watershed were identified and their respective contributions to pollution were estimated. In particular, the pollution contribution of piggeries vis-à-vis the other sources was determined to examine the potential effect of controlling pig waste discharges on

¹ This distance is arbitrarily set.

water quality.

Technically viable pollution control options were then identified and evaluated using both financial and economic cost benefit analyses. To be able to assess the political, institutional and communal acceptability of such options, dialogues with the barangay captains, hog raisers, municipal council and the mayor were undertaken. An informal discussion with the chief and staff of the Community Development Division of the Laguna Lake Development Authority (LLDA) was also conducted.

1.3 Limitations of the Study

Due to the extensive technical data requirements, only a partial economic analysis was carried out in evaluating the health and environmental impacts of the pollution control options for hog waste. It is recognized that a more meaningful analysis will require a valuation of all the potential on-site and off-site environmental effects of various pollution control options.

The financial and economic analyses of the control options also exclude a detailed market aspect of the output and by-product of the proposed pollution abatement strategies.

Thus, future research studies may address the above information gaps.

1.4 Organizational Structure of the Report

Section II gives an extensive review of the international literature highlighting the environmental, health and other effects of pig waste. A summary of these effects is provided towards the end of the section.

The on-site and off-site effects of hog waste from the perspective of raisers and non-raisers are discussed in **Section III**. It then proceeds with a description of the waste stream from commercial and backyard piggeries and ends with an evaluation of wastewater and surface water characteristics vis-à-vis national standards.

In **Section IV**, the discussion on the impact of reducing pig waste discharges in the water basin starts off with an assessment of the pollution loading of rivers traversing Majayjay. The importance of reducing such discharges is then linked to eventually reducing pollution loading into the Laguna de Bay which has several important economic uses.

After establishing the environmental and health effects related to untreated or improper handling of hog waste, and assessing the impact of reducing discharges

of such waste, another review of the international literature on pollution control options is presented in **Section V**. Thereafter, control options specifically for the project site are discussed and evaluated using financial and economic analyses. **Section VI** dwells on policy and institutional options for attaining the proposed pollution reduction targets.

Section VII gives the lessons learned from the case study and **Section VIII** presents the summary, conclusions as well as policy recommendations.

2.0 THE ENVIRONMENTAL AND HEALTH EFFECTS OF PIG WASTE

For this section, we review first the environmental effects related to hog waste. Then we review the health effects.

2.1 Review of the International Literature: Environmental Effects of Pig Waste

The environmental problems associated with hog wastes, include among others, the following²:

- a) *Vaporization and fugitive air emissions from factory plants causing air pollution and greenhouse gas emissions;*

Hog waste contains a significant amount of nitrogen that evaporates into the air as ammonia (a 'highly reactive and biologically available form of nitrogen') and falls back to the land and water bodies when it rains. A small portion of it is lost as nitrous oxide (N₂O) which is the "most damaging" greenhouse gas that depletes the ozone layer--320 times more damaging than carbon dioxide (Delgado, et al., 1999). Atmospheric nitrogen deposition, though beneficial to the extent that it may be easily absorbed as fertilizer if it falls (with rain) on a crop, can actually cause more harm than good to the environment. It can destroy natural habitats, trigger algal blooms that rob the water with oxygen and changes in population species if it falls at high concentrations on the wrong places. Research studies in North Carolina showed that airborne ammonia nitrogen released from hog farms were at levels that were higher than those from all the other state livestock and industrial sources put together.

Hydrogen sulfide is a gas associated with the decomposition of swine manure and this is toxic. In Minnesota, hydrogen sulfide emitted by hog wastes far exceeded the standards.

² See www.hogwatch.org/get_the_facts/factsheets/enviroimpacts.html.

Anaerobic lagoons which are used as treatment technology also produce methane gas as by-product. Methane is another potent greenhouse gas that could cause global climate change since it traps the sun's energy. Sixteen percent (16%) of the world's yearly production of methane is accounted for by livestock and manure management (Delgado, et al. 1999). However, hogs and poultry release relatively low amounts of methane since they cannot digest fibrous feeds.

b) Spills and leaks to the surrounding land allowing groundwater and surface water contamination;

Because most swine raisers do not confine hog wastes to their land, there have been numerous cases of waste spills.³ Animal wastes are carriers of parasites, bacteria and viruses including *salmonella*, *campylobacter*, *e.coli*, *cryptosporidium*, *giardia*, *cholera*, *streptococcus* and *chlamydia*. *Cryptosporidium* and *giardia* are found to be resistant to conventional chlorination and therefore there is greater probability of drinking water contamination when lagoons containing high concentrations of hog manure leak.

Of the 60% of rivers and streams in North Carolina that the US EPA identified as polluted, it found that agricultural runoff from production activities in hogs, poultry and cattle was the largest contributor to pollution. (North Carolina DENR).

Leaking nitrogen ammonia can also concentrate in the soil below the bottom of a lagoon. Once a lagoon cracks or dries out, nitrogen pollutants can be washed through the soil and seep into groundwater. On the other hand, inactive lagoons can fill up with rain and overflow or contaminants can leach into groundwater⁴ Lagoon leaks may be less visible but they are perceived to be more common and threatening.⁵

c) Spreading untreated sewage on farmland as an organic fertilizer when in fact it doesn't fertilize but runs off to the nearest river and lake, contaminating drinking water and recreation areas;

There seems to be a lack of aeration lagoons and secondary treatment facilities to neutralize hog waste before they are used or spread on farmlands.

³ In Indiana, fish kills resulted from more than a thousand spills of animal waste. Hog waste is the leading known cause. Since 1997, the State of Illinois has been suffering from major manure spills into the Illinois River and state streams. For more information, see proinfo@nrdc.org and www.starnews.com/news/metrostate98/apr/0422sn_facts.html;

⁴ See www.epa.gov/owmitnet for more details.

⁵ See Cantrell, P. et al. "The Environment (...and factory farms)" in www.inmotionmagazine.com/hwenv.html.

Waste disposal practices such as applying hog waste to farmlands can be dangerous when there is an oversight of the lands' and crops' capacity to absorb the nutrients (e.g., nitrogen and phosphorus) from the waste. When farmlands are already nitrogen-saturated or when wastes are improperly applied to wet fields, there is a great possibility of runoff and leaching that will send the excess nutrients into waterways.

There is now increasing evidence of huge nutrient surpluses that range from 200 to more than 1,000 kilograms of nitrogen per hectare per year in many areas of Western Europe, the northeastern United States, the coastal Southeast Asia and large plains in China (Steinfeld, et al. 1997 *in* Delgado et al. 1999). Such a situation is linked to the increasing demand for animal products that triggers animal concentrations beyond the waste absorption and feed supply capacity of the land.

d) Intentional direct piped discharges of hog waste to waterways and potential for bacteria epidemics of Pfiesteria piscicida (and heavy metals).

There are poorly managed hog farms that indiscriminately discharge their wastes directly into rivers and streams without any treatment. Phosphorus and nitrogen in hog wastes are major pollutants of water. At high concentrations, phosphorus has been found to be acutely toxic to fish; at lower concentrations, phosphorus and nitrogen causes *eutrophication* or the process of over-enriching water bodies leading to the production of excess algae (Okun, 1997). The problem here is that nutrient pollution has been linked to the growth of *Pfiesteria piscicida*, a toxic microorganism that can kill fish and can likewise endanger human lives. In 1997, *Pfiesteria piscicida* was implicated in major fish kills in the coastal waters of North Carolina (Natural Resources Defense Council, Inc., 1998).

Since hogs are fed with feeds fortified with heavy metals like copper and zinc to prevent disease and improve digestion (Delgado et al., 1999), this can pose a serious problem because in the long run, these heavy metals can be toxic to plants and animals even at low concentrations. These heavy metals end up in hog waste and eventually, in a solid sludge that accumulates at the bottom of lagoons for as long as 10-20 years until the sludge is removed.

The animals fed with these trace elements are also at risk of contracting diseases as evidenced by the residues of growth hormones, antibiotics, and insecticides which have been found in tissues of animals in highly commercial production systems (Delgado, et al., 1999).

e) Groundwater depletion

Raising hogs require large volumes of water for bathing, cooling, and drinking purposes and for flushing waste from pens or confinement sites into lagoons. Hogs consume an average of about five to eight gallons of water per head daily. In Missouri, it has been estimated that a farm with 80,000 heads per year has a daily water consumption of about 400,000-640,000 gallons. Thus, the concern is also for groundwater depletion over the years.

2.2 Review of the International Literature: Health Effects of Pig Waste

Animal wastes are carriers of diseases (Delgado, et al., 1999). Some of the components of pig waste that have direct adverse effects on human health are pathogens, nitrates, and hydrogen sulfide.

Pathogens can contaminate water and cause gastrointestinal diseases. These microorganisms are 10 to 100 times more concentrated in hog waste than in human waste, which is diluted with water in sewage treatment plants⁶.

High levels of nitrogen in drinking water increase the risk of *methemoglobinemia* or, more commonly known as the *blue baby syndrome*. The nitrate converts to nitrite as it enters the body and affects hemoglobin, the red corpuscles in the blood that carries oxygen throughout the body. With this, hemoglobin transforms into methemoglobin, which does not transport oxygen thus resulting to less oxygen getting to vital tissues, and most especially, to the brain. Critical cases may lead to brain damage or even death. Mainly vulnerable are six-month old infants, pregnant women and adults with immune deficiencies.⁷

Likewise, high nitrate levels may promote growth of *Pfiesteria* in the air and water. *Pfiesteria* is a harmful organism, exposure to which may cause skin irritation, short-term memory loss and other cognitive impairments. This organism, according to some medical reports, is also responsible for the open sores in the skin of individuals who spend a lot of time in water e.g., commercial fishermen, underwater divers.⁸

The vapor emitted by swine farms, which contains noxious gases such as methane, ammonia and hydrogen sulfide, filter through the skins and houses of people living near the farms. While methane and ammonia are large contributors to greenhouse effect, hydrogen sulfide greatly affects human health.

Hydrogen sulfide, usually associated with a "rotten egg" smell, has caused symptoms such as nausea, blackout periods, headaches and vomiting. The odor not

⁶ For more information, see www.igc.apc.org/nrdc/nrdc/nrdcpro/factor/cons.html

⁷ See www.checc.sph.unc.edu/rooms/library/docs/Hogs/hogcase.html;
www.igs.cpac.org/nrdc/nrdc/nrdcpro/factor/cons.html

⁸ For more information, look at www.checc.sph.unc.edu/rooms/library/docs/Hogs/hogcase.html.

only sinks itself into human tissue but also to clothing and furnishings.⁹ The odor, once absorbed into the lungs, moves into the bloodstream through gas exchange in the lungs. It then reaches the brain via the nasal route.

The unpleasant odor emanating from swine farms have significantly caused more tension, anger and fatigue in North Carolina residents who had lived near hog factories an average of 5 years than residents not exposed to hog odor at home (Schiffman, 1998). A study was done which found that people living near hog farms suffered from significantly higher levels of upper respiratory and gastrointestinal ailments than those living near cattle farms or in non-livestock farming community. Furthermore, well water testing results showed higher levels of nitrates in wells near hog farms posing risks to infants below 6 months old. Those people who were also living near hog farms suffered from headaches, runny noses, sore throats, excessive coughing, diarrhea and burning eyes (Wing, S. and S. Wolf, undated).

2.3 Other Effects of Hog Waste: Tourism and Property Values

The stench from uncontrolled, ill-disposed and untreated hog waste has been found to depress the real estate values of properties near hog farms. In an Illinois county, the property values for homes near hog factories were found to have declined by 30%¹⁰.

In North Carolina, there are concerns about the impact of odor and water pollution generated by industrial swine operation on tourism and fishing industries¹¹. The tourism industry is the second source of income for this state and supports an estimated 250,000 people. The coastal, commercial, and recreational fishing industries also bring in significant revenues and, thus, it is important that the waterways are kept from being polluted.

⁹ Visit www.inmotionmagazine.com/hwenv/html for more details.

¹⁰ Sierra Club, 1999 in www.sierraclub.org/cafos/report99.

¹¹ Visit www.checc.sph.unc.edu/rooms/library/docs/Hogs/hogcase.html for more details.

2.4 Anecdotal Documentation of a Local Case

In the Philippines, residents from Barangays San Juan de Mata and Sto. Domingo in the Municipality of Tarlac, Tarlac have been very vigilant in voicing out their complaints against the harmful effects of the operations of three large commercial hog farms (and poultry farms) on their health and the environment¹². The people complain about the hog stench from the piggeries within a one - kilometer radius. Aside from air pollution, the residents also claim that the Benig River is now biologically dead from the discharge points of piggery wastes. These swine farms, which raise about 30,000 heads each, are located in agricultural and residential areas and do not have any waste treatment facilities. They dump their wastes directly into the said water body. They also do not have locational and zoning clearance. The Benig River used to be home to varied aquatic life but due to the pollution, there has been a significant reduction in both quantity and quality of marine life. Before the establishment of the swine farms, farmers were still able to use the river for irrigation. There is also the proliferation of flies and insects and other disease vectors.

Residents also claim that the groundwater has been contaminated. People who live along the riverbank also suffer from skin and eye irritation. Moreover, there have been several cases of hepatitis. Two persons have already died and one is now bedridden. These cases are being linked to the indiscriminate dumping of massive hog waste that has been going on for years.

2.5 Summary of the Impacts of Hog Waste

From the foregoing review of the international literature, we have seen that hog waste, especially those generated from confinement or factory hog farms, cause environmental and health problems as well as decline in property values and tourism.

In particular, the environmental effects associated with hog waste include the following: a) air pollution and greenhouse gas emissions; b) groundwater and surface water contamination arising from waste spills and leakages from lagoons; c) fish kills; d) long run-soil toxicity to plants and animals due to accumulation of heavy metals included in medicine and feed supplements for disease prevention and improvement in digestion.

The health effects associated with hog waste are a) gastrointestinal diseases arising from groundwater contamination since hog wastes are carriers of pathogens

¹² Personal interview with Engr. Dionisio M. Ines, spokesperson of Brgy. San Juan de Mata Residents. Their case has been featured in a local television show that focuses on environmental watch.

and have high nitrogen content that transforms into nitrates; b) respiratory ailments, nausea, blackouts, headaches and vomiting primarily caused by noxious gases like hydrogen sulfide, methane and ammonia; c) skin irritation, short-term memory loss and other cognitive impairments as well as *methemoglobinemia* or the *blue baby syndrome* due to the growth of *Pfiesteria* in the air and water at high nitrate concentrations.

The literature also revealed declines in property values and tourism (for real estate properties located near hog farms) as a result of the stench from uncontrolled, ill-disposed and untreated hog waste.

3.0 ENVIRONMENTAL AND HEALTH EFFECTS OF HOG WASTE IN MAJAYJAY

3.1 On-Site Effects of Hog Waste

The focus of this discussion is on air pollution (foul odor) from pig waste and its perceived effects on households of swine raisers and households near swine farms.

These groups are constantly exposed to the bad smell since hog farms are only about 5-10 meters away from houses. There is a marked contrast in the responses of these two groups of respondents regarding the effects of malodours coming from the piggeries. While seventy-percent (70%) of households *near* piggeries admitted that they were affected by the stench of pig waste which they smell usually in the mornings as swine raisers clean their pens, only about thirty percent (30%) of households of swine raisers answered the same (Table 1). There seems to be a general tendency for households of swine raisers to be defensive in their answers and this can be partly attributed to their suspicion that they might be asked to discontinue production or be relocated elsewhere. But some interesting and worth noting views were shared by those thirty percent of households of swine raisers who, until now, are bothered by the smell coming from their pig pens. For these people, the major effects of their own piggeries according to their ranking are the sticking of foul odours to their clothes, difficulty in breathing, headaches and loss of appetite¹³. Furthermore, this particular group of households are fully aware of the negative effects of their piggeries (in the same way that we believe the rest of the respondents are, although they would not admit it) on themselves and on their neighbors and expressed their openness to possible options to solve or minimize the problem.

¹³ Our own experiences as researchers and enumerators attest to these in the short while that we stayed in their houses while conducting the interview.

Table 1. Perceptions of 176 sample households on the effects of malodours from the piggeries.

Effects on Households	HHs of Swine Raisers (n=82)			HHs Near Swine Farms (n=94)		
	Backyard (%)	Comm'l (%)	Total (%)	Backyard (%)	Comm'l (%)	Total (%)
Are you affected by foul odors?						
Yes	32	29	30	73	71	72
No	68	71	70	27	29	28
a. Malodours are source of nuisance						
- agree	15	27	21	69	64	67
- disagree	17	2	10	2	5	3
- undecided	0	0	0	2	2	2
b. When are malodours strongest?						
- early morning	15	17	16	56	43	50
- early afternoon	7	5	6	31	57	43
- early evening	5	10	7	27	21	24
c. How are you affected by malodours ¹						
- loss of appetite	5	4	4	2	2	2
- vomiting / nausea	4	7	5	5	3	5
- headaches	2	3	2	1	1	1
- sinusitis	7	5	6	7	6	7
- difficulty in breathing	3	2	3	4	5	4
- eye irritation	7	6	7	6	7	6
- odor sticks to clothes	1	1	1	3	4	3
- gas pains	7	8	8	8	8	8

Note:

¹ The numbers are the rankings of effects of malodours. A rank of 1 would be interpreted as the most common effect on the respondents.

² Would mean the second most common effect and so on.

On the other hand, households near pig farms were relatively vocal about their views regarding the effects of malodours which they have always considered a nuisance. The perceived major effects did not differ from those identified by swine raisers' households although there is a difference in how they ranked them and such is as follows: households suffered from headaches, loss of appetite, vomiting/nausea, odor sticking to clothes and difficulty in breathing¹⁴.

¹⁴ The effects of foul odor from pig waste cited above are much similar to the ones mentioned in the literature review.

3.2 Effects of Constant Exposure to Pig Waste Malodours on Health

For the sample, rough estimates of the health costs incurred by households in the past year for illnesses related to constant exposure to pig waste malodours were made. These estimates were calculated on a per household per year basis and are shown in Appendix Tables 1 and 2.

Respiratory problems such as asthma were reported to have been experienced by 12% of the 41 households of backyard raisers and the annual average expenditure per household was PHP 6,434. Twenty-four percent of 41 households of commercial hog raisers spent an average of PHP 7,722 for the same ailment. On the other hand, for households near piggeries (i.e., those that are less than 20 meters away from hog farms), the incidence of asthma was at least one for every 10 households. Specifically, health costs for those near backyard farms amounted to PHP9,546 per household while it was at PHP3,496 per household for those that were near commercial farms.

The incidence of bronchitis was relatively more common for households near commercial hog farms. Seventeen percent of the 42 respondents experienced the illness and their annual average expenditure amounted to PHP 12,756 per household.

Gastrointestinal problems like diarrhea was likewise common. Average expenditure for 21% of households near commercial piggeries (n=42) was at PHP 7,923. For the affected 12% of households near backyard hog farms (n=52), each household spent an average of PHP 4,288. Households of backyard hog raisers, on the other hand, incurred PHP 2,984 on the average, and this was reported by 17% of the respondents (n=41). Ten percent of households of commercial raisers (n=41) experienced the same illness and the average expenditure was PHP2,107.

Other ailments like conjunctivitis, influenza and allergies were prevalent among households of both backyard and commercial raisers and those near hog farms. Twelve percent of backyard households were affected with conjunctivitis and spent an average of PHP 4,354; 20% of commercial households incurred health costs of PHP2,000 on the average; 15% and 17% of households near piggeries incurred an average expenditure of PHP 6,223 and PHP3,454, respectively. The incidence for influenza was at 15% , 19% and 26% of backyard raisers' households and those near backyard and commercial pig farms. Average expenditure per household was at PHP 2,486, PHP 1,931 and PHP 3,595 , respectively. Lastly, skin allergies were also a common experience among households of hog raisers and those near hog farms. At least 10%-19% of all 176 respondents were afflicted. Those near backyard farms (17% of 52 households) had the highest annual average expenditure of PHP 3,677.

Of course, the above estimates have to be treated with utmost caution because for certain, the effect of factors other than excessive exposure to pig waste and malodours which are also contributory to the aforementioned illnesses, cannot be fully isolated. Nevertheless, despite the problems concerning computational accuracy, what the numbers tell us is that there are health effects related to constant

exposure to pig waste and malodours which should not be discounted especially because majority of the houses and swine farms are very proximate to one another. In fact the following anecdotal documentation would attest to this:

[A specific incidence was cited by a particular respondent in the course of our interview and she was about the only one in their barangay who was bold enough to speak her mind. She revealed that when she came to reside in her present abode 10 years ago, she was quite healthy and never complained of any respiratory illness. However, the pig farm was put up about 3 or 4 years later and because the farm was raising about close to a thousand heads, the gases and odors emanating from the piggery cannot really be avoided by the mere closing of house doors and windows. Day in and day out, the stench would penetrate their house and after some years of constantly inhaling the gases from the piggery, she was diagnosed to be suffering from a respiratory disease that was close to progressing into pneumonia had she not had treatment for several months. This has caused her a fortune and she needs medicines for maintenance. She actually asked the doctor's opinion whether her illness was really associated with excessive exposure to malodours and the answer was in the affirmative. Because of this she voiced out her complaint against the owner of the small commercial pig farm to the barangay captain, but no legal move was ever done. The major reason for this is that the owner of the swine farm happens to be the previous owner of the lands where the houses of the residents are built on. Had she known that there would be a piggery that would soon be established in the neighborhood and very near her house at that, she said that she would not have bought the lot on where her house stands in the first place. This particular sentiment of hers is actually shared by the two other respondents we interviewed. But, now, it is quite difficult if not altogether impossible for them to relocate elsewhere considering that they do not have the financial means to do so.]

A survey was conducted in some barangays of Majayjay with no established swine farms. This was performed to determine if there was a difference in frequency of morbidity cases between residents who are constantly exposed to malodour from piggeries and those who are not.

Sixty-one individuals were interviewed in three upland barangays of Majayjay, namely Bacya, upper Gagalog and Taytay. Of the total respondents, twenty-seven did not originally live in the barangay. The majority are from the Poblacion or town proper. This latter group transferred due to health and livelihood concerns. They claimed that their children frequently got sick in the Poblacion and they attributed this to the proximity of their houses to swine farms which are also too concentrated in that area.

The most common ailment reported by two-thirds of the respondents is colds which they largely attribute to the cold climate in the elevated lands. This is

followed by influenza (n=15/61) which they claim to be caused by fatigue and the unpredictable atmospheric changes. Diarrhea (n=3/61), which usually hits children, is thought to be induced by too much consumption of junk food. Only two out of 61 claimed they have asthma and skin allergy which they attributed to heredity.

A comparison of the frequency of morbidity cases between people who suffer from the bad smell from pig waste (10-20%) and those who do not (2-3%) would indicate very crudely that the incidence of illness is higher in those places where malodours are a problem. In the context of this study, although the difference in incidence cannot not be fully be attributed to the bad smell, the whole point of the exercise is to show that pig waste malodours can pose health risks if left unchecked.

3.3 Off-Site Effects of Hog Waste

For off-site externalities of hog waste, the focus of discussion is mainly on surface water pollution.

3.4 Perceptions of Households

Tables 2a and 2b depict the perceptions of households on the effects of piggeries on the quality of affected water bodies. It can be seen that households near swine farms and households of swine raisers are united in their responses. The majority (75%) of them agree that direct dumping of waste by piggeries has caused most rivers and creeks in Majayjay to become polluted and emit foul odours. They recalled that about thirty or so years ago, that is before the proliferation of swine farms in the area, rivers and creeks were clear and clean and many fish species can still be caught. They also mentioned that some rivers were deeper then and were fit for swimming, fishing and laundry.

As a reinforcement to the claim of household respondents above, 7 senior members of the community (i.e., 70 years old and above) who were born and lived their entire life in Majayjay were interviewed for the reason that they are the key informants who would be in the best position to compare the quality of the water bodies before and after the proliferation of hog farms. The similarity in their answers gives more bearing to their claims.

All of them claimed that about fifty years before, the rivers in Majayjay - Balanac, Oobi, Olla, and Majayjay Rivers, and the Initian Creek were deep, clear and clean. In these rivers, people swam, washed their clothes, got drinking water in a spring somewhere in the Balanac River, and even caught fish. Abundant aquatic species thrived there *before*. *Now*, although there are still fishes in these rivers,

nobody catches them because the water is cloudy and malodorous. Moreover, at one point in time, the fish that were caught contained wastes inside their bellies.

According to them, the quality of water deteriorated as years passed. They associated this to the increase in household population and to the establishment of piggeries in Majayjay. The wastes that come from piggeries, as well as from households, go to the rivers due to the indiscriminate dumping by households and hog raisers.

Table 2a. Summary of perceptions of 82 sample households of swine raisers on the effects of piggeries on the quality of affected waterbody.

Water Quality Perception	Frequency	%
1. Do you think Piggeries Affect Water Quality?		
- Yes	61	74.39
- No	16	19.51
- No answer	5	6.10
2. If yes, how?		
Water has become dirty and polluted		
- agree	56	68.29
- disagree	1	1.22
- undecided	4	4.88
- no answer	21	25.61
Water now emits foul odor		
- agree	48	58.54
- disagree	8	9.76
- undecided	5	6.10
- no answer	21	25.61
Destruction of Aquatic Habitat		
- agree	38	46.34
- disagree	11	13.41
- undecided	12	14.63
- no answer	21	25.61
3. Practices of swine raisers that contribute to water pollution		
- Direct dumping of wastes into river / canal	47	57.32
- No Answer	35	42.68

Note: The total number of samples of swine raisers located at the upstream is 39 while that of midstream is 43.

Table 2b. Summary of perceptions of 94 sample households near swine farms on the effects of piggeries on the quality of affected waterbody.

Water Quality Perception	Frequency	%
1. Do you think piggeries affect water quality?		
- Yes	81	86.17
- No	12	12.77
- No answer	1	1.06
2. If yes, how?		
Water has become dirty and polluted		
- strongly agree	76	80.85
- disagree	5	5.32
- undecided	3	3.19
- no answer	10	10.64
Water now emits foul odor		
- strongly agree	72	76.60
- disagree	14	14.89
- undecided	4	4.26
- no answer	4	4.26
Destruction of aquatic habitat		
- strongly agree	57	60.64
- disagree	23	24.47
- undecided	13	13.83
- no answer	1	1.06
3. Practices of swine raisers that contribute to water pollution		
- Direct dumping of waste into river / canal	94	100.00
- No Answer	0	0.00

Note: The total number of samples from near households located at the upstream is 51 while those at midstream is 43.

3.5 Waste Stream from Commercial and Backyard Piggeries

Eighty percent (80%) of the backyard and commercial farms deposit their waste products in nearby creeks and rivers

The manure production of swine depends on the age, size and digestibility of feed rations given to them. With the advent of new genetics with exceptional feed efficiency, the amount of manure produced by the pig will depend on the digestibility of the ration. Table 3 shows the estimated manure production for the *sample* hog farms. Manure production was estimated for the sow herd and grow-fin production systems on a per cycle, per day, and per kilogram of product produced

bases. Manure from *sow herd weanling production* was computed from breeding until the litter is sold as weanlings or feeder pigs (about 10 kgs.) These estimates consist of manure from the sows and a litter size of nine for 175 days. Manure from *sow herd to finish operation* was computed using a litter size of eight and pigs that are raised to 85 kgs. for 284 days. Manure from the *combination production system* made use of a litter size of eight, with the assumption that 50% are sold as weanlings and 50% are sold as finishers. It can be seen from Table 3 that a sow herd to finish operation produced the largest amount of manure at an average of 1.65 kg per head per day. Grow-fin production system produced a daily average of 0.26 kg per head. Table 4a shows the estimated annual total manure production for the sample by scale of production and according to production system. Across production systems, about 70% of the total hog waste come from grow-fin which are mainly produced by large scale commercial farms. The remaining 30% are from sows which are raised by small and medium scale commercial farms as well as backyard farms. For the sample of 91 farms alone, total manure per year for backyard and commercial farms reached about 672 tons. Extrapolating these to the entire swine population in Majayjay, and using an average of 1.65 kg./sow/day and 0.26 kg/grow-fin/day, approximately 6,900 tons of manure are produced each year (Table 4b).

Table 3. Estimated manure production of the different production systems, 91 sample swine farms.

Production System	Manure production (kg)		
	Per cycle ²	Per day ³	Per kg of products produced ⁴
Sow herd			
Weanling	154.82	0.88	1.72
Finishing	483.98	1.65	0.71
Combination	370.22	1.30	0.97
Gro-Fin	31.09	0.26	0.37

¹ Computed with the Stella program.

² The amount of waste produced by an animal in one production cycle.

Manure produced by a sow herd weanling production was computed from breeding until the litter is sold as weanlings or feeder pigs (10 kg). These estimates consist of manure from the sows and a litter size of nine (9) for 175 days.

Sow herd to finish operation, a litter size of eight (8) pigs are raised to 85 kg for 294 days. Combination made use of a litter size of eight. 50% are sold as weanlings and the other 50% as finishers. Production cycle is 294 days.

³ Total amount of manure produced per cycle divided by the production cycle in days.

⁴ Total amount of manure produced per cycle divided by total weight of products produced.

Weanling = 90 kg (litter size multiplied by 10 kg/piglet)

Finisher = 680 kg (8 litter size multiplied by 85 kg/hog)

Combination = 380 kg (4 pigs sold as weanlings, 40 kg and 4 pigs sold as finishers, 340 kg)

Table 4a. Estimated manure production of the different production systems per year¹, 91 sample swine farms.

Production System	Manure production (kg) ²		
	Backyard	Commercial	Total
	Swine Raisers	Farms	
<i>Sow herd</i>			
Weanling	8,351.20	44,004.40	52,355.60
Finishing	2,409.00	130,086.00	132,495.00
Combination	14,709.50	174,141.50	188,851.00
Gro-Fin	12,906.40	278,057.00	290,963.40
Boar for Hire	-	7482.50	7,482.50
Grand Total			672,147.50

¹ Based on Data set.

² Manure production was computed by:

- Determining the total number of animals per production system for both backyard and commercial farm.
- Total sow number for both backyard and commercial farms was multiplied by percent distribution of a sow herd system (Table 3).
- Manure produced/year = No. of animals multiplied by manure produced (kg/day) multiplied by 365 days.

Table 4b. Estimated manure production of all swine farms.

Hog Farm	Population		Manure production/day ¹ kg/day		Manure production/year ² kg/year	
	Sow	Gro-Fin	Sow	Gro-Fin	Sow	Gro-Fin
Large scale commercial farms		36,000	0	9,360	0	3,416,400
Medium scale commercial farms	995	17,700	1,642	4,602	599,239	1,679,730
Small scale commercial farms	1,354	2,930	2,234	762	815,447	278,057
Backyard farms	173	116	285	30	104,189	11,008
Total	2,522	56,746	4,161	14,754	1,518,875	5,385,195
<i>Grand Total</i>						<i>6,904,070</i>

¹ total population * estimated manure production/day

Sow = 1.65 kg/day

Gro-Fin = 0.26 kg/day

² Manure production per day * 365

Water spillage from almost all the farms evaluated are high considering that the water is readily available and that the payment for water consumption is considerably low. This is due to the fact that the project area is within the watershed of Mount Banahaw which still boasts of a thick vegetative cover and that the area is near the water sources of the mountain.

In general, because of the indifferent attitude of farm owners towards the need for an appropriate waste management and disposal scheme for the piggeries of Majayjay, and due to the seemingly lack of ordinances or their implementation, the waste stream or waste cycle in both the small commercial and backyard piggeries can be simply summed up in two stages: (1) the unmonitored use of resources (feed, water, and supplements) leading to greater wastage and production of more wastewater; and (2) the direct discharge of the wastewater to the nearest water channel.

3.6 Evaluation of Wastewater Characteristics

The tables on DENR Effluent Standards and the result of the wastewater characterization show that the quality of the wastewater and the surface water resources does not pass the standard even for just a Class C water (see Tables 5 and 6). Only the reading from the upstream area (Botocan River) passes the standard.

Although it can be seen from the characterization of the raw wastewater that the concentrations of the different parameters measured are lower compared to wastewater characteristics found in pig farms elsewhere in the country, still the values are high compared with the standards.

Table 5. Effluent standards for Class C¹ waters (DENR AO No. 35, 1990).

Parameters	Unit	Concentration (OE)	Concentration (NP)
Color	PCU	150 ²	150 ²
Temperature °C rise	mg/L	3	3
pH range	mg/L	6.0-9.0	6.5-9.0
COD	mg/L	150	100
Settleable solids	mg/L	0.5	0.5
5-Day 20°C BOD	mg/L	80	50
Total suspended solids	mg/L	90	70
Total dissolved solids	mg/L	--	--
Surfactants	mg/L	7	5
Oil/Grease	mg/L	10	5
Phenolic substances	mg/L	0.5 ³	0.5 ³
Total coliforms	MPN/100 mL	10,000	10,000

Note: ¹ Class C waters are fresh surface waters whose beneficial uses include (1) Fishery Water for propagation and growth of fish and other aquatic resources; (2) Recreational Water Class II for boating and other activities not entailing personal contact with the water; and (3) Industrial Water Supply Class I (for manufacturing processes after treatment).

² For waste waters with initial BOD concentration over 1,000 mg/L but less than 3,000 mg/L, the limit may be exceeded up to a maximum of 200mg/L or a treatment reduction of ninety (90) percent, whichever is more strict.

³ Not more than 60 mg/L increase (dry season) OE -old and existing piggery NP -new piggery.

Table 6. Wastewater and Surface Water Characteristics ^a.

Sampling Points/ Source	Characteristics						
	DO (mg/L)	pH	Total Dissolved Solid (mg/L)	Total Suspended Solid (mg/L)	Total N (mg N/L)	Total P (mg P/L)	BOD (mg/L)
Raw Wastewater	1.80	7.82	332	652	65.40	13.80	325
Initian Creek	2.00	7.74	223	427	47.20	7.80	226
Oobi River	4.50	7.85	78	179	23.90	3.50	123
Balanak River (downstream)	3.00	8.10	67	154	37.90	10.10	110
Botocan River (upstream)	7.00	7.10	55	83	18.40	2.90	37

^a Source: Results of water pollution tests, selected sampling points, Majayjay, Laguna, 1999.

It should also be emphasized that the project area is within the watershed of Mount Banahaw which still boasts of a good vegetative cover particularly on the side covering the project area. This means that the surface and groundwater resources within the watershed can be expected to *be still of good quality which can even be used for drinking and bathing*. However, measurements obtained that are shown in the table indicate otherwise. The values show a river resource *which is not even fit for non-contact recreation*. Considering the activities within the watershed, which is essentially farming, the sorry state of the river resource can only be traced to the dumping of waste coming from both the agricultural and livestock farms.

4.0 THE IMPACT OF REDUCING DISCHARGES OF HOG WASTE IN THE WATER BASIN

4.1 Watershed Approach to Pollution Loading

Figure 1 shows the river network that traverses Majayjay eventually discharging to Laguna de Bay. Although discussion on pollution loading will be concentrated on the rivers in Majayjay, it is emphasized that all these will eventually be transported downstream. The landuse map of Majayjay is shown in Figure 2 and this will reveal the different activities that can contribute to the pollution of the river aside from those coming from the piggeries. The different activity zones within the watershed of Majayjay and Lucban (Oobi) Rivers will include coconut areas with shrubs and cultivated areas, rice zone (irrigated) areas, and the built-up areas which will include the household and concentration of the piggeries. Figure 3 shows a detailed map of the built-up area which is essentially the town proper. Also shown in this figure are the houses and piggeries, and the rivers and creek. It can be seen from Figure 3 that majority of the houses and

piggeries are within the town proper and therefore the pollution loading analysis is concentrated on this area.

The pollution loads that can be expected from the different identified sources are shown in Figure 4. The BOD loads in the figure pertain to the built up area only as this is where the hogs and households in Majayjay are largely concentrated. It is evident that majority of the loads come from piggery waste and household waste with little contribution coming from the activities from the coconut and rice areas. A computation of these loads in relation to the actual volumetric flow coming from the rivers shows that the pollution load will raise the BOD levels on the average to only about 35 mg/l. This level however is low compared to the actual load measured during the conduct of the study which is in the range of 110-226 mg/l. This large difference can be due to the characteristics of the river beds which are laden with stones and rocks and to the nature of the rivers which are wide in some stretches but are too narrow in some parts. These characteristics can contribute to the ability of the river to retain the solid part of the pollution thus producing an actual higher BOD reading compared to a theoretical computation. Nonetheless, due to the high flow of the rivers which exhibit their ability to flush-out waste, the rivers can be expected to attain part of its original status within a five year period if proper waste management is adopted not only for the farms but for the other pollution sources as well.

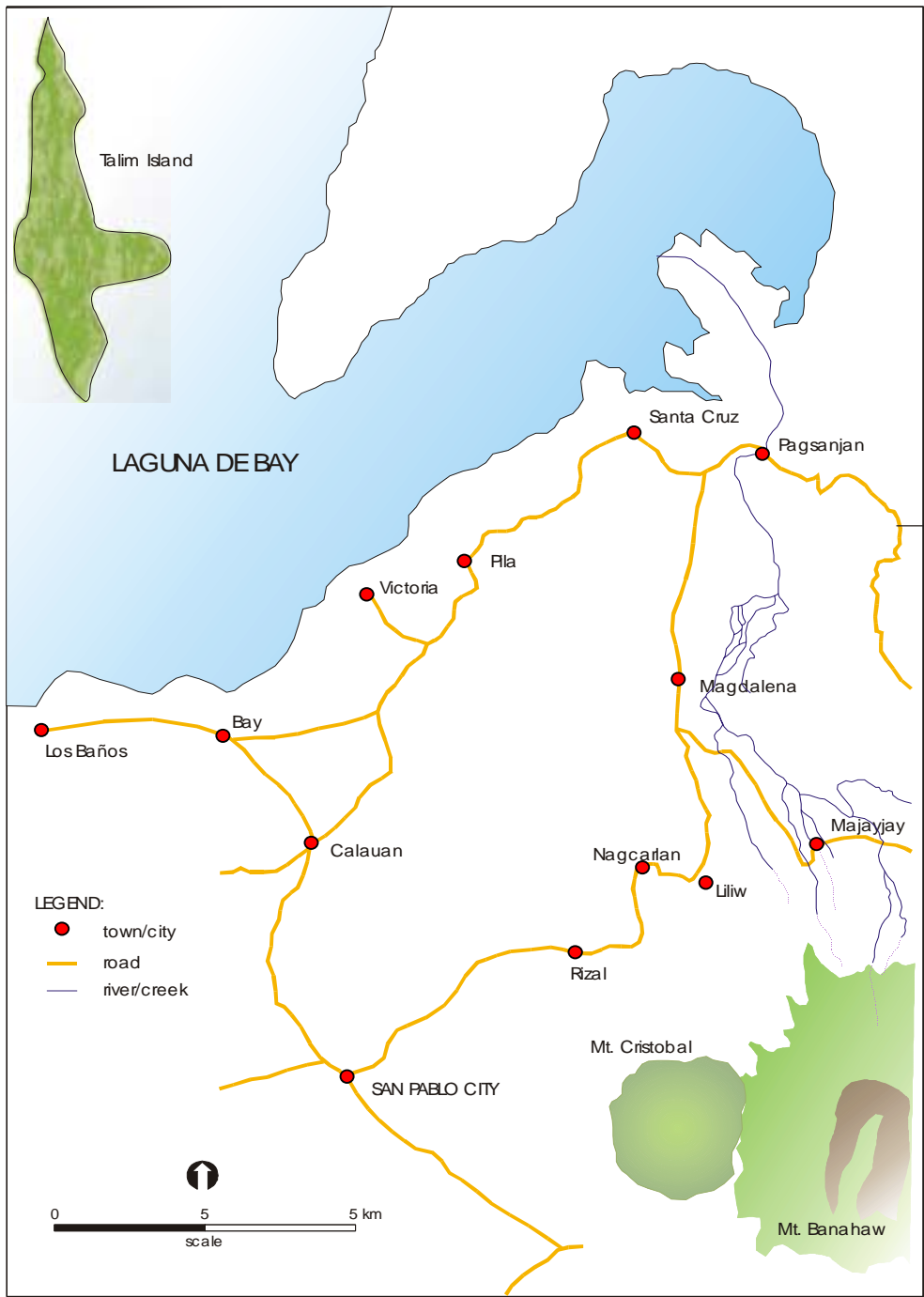


Figure 1. Map showing road network and the river network that traverses Majayjay eventually discharging into Laguna de Bay.

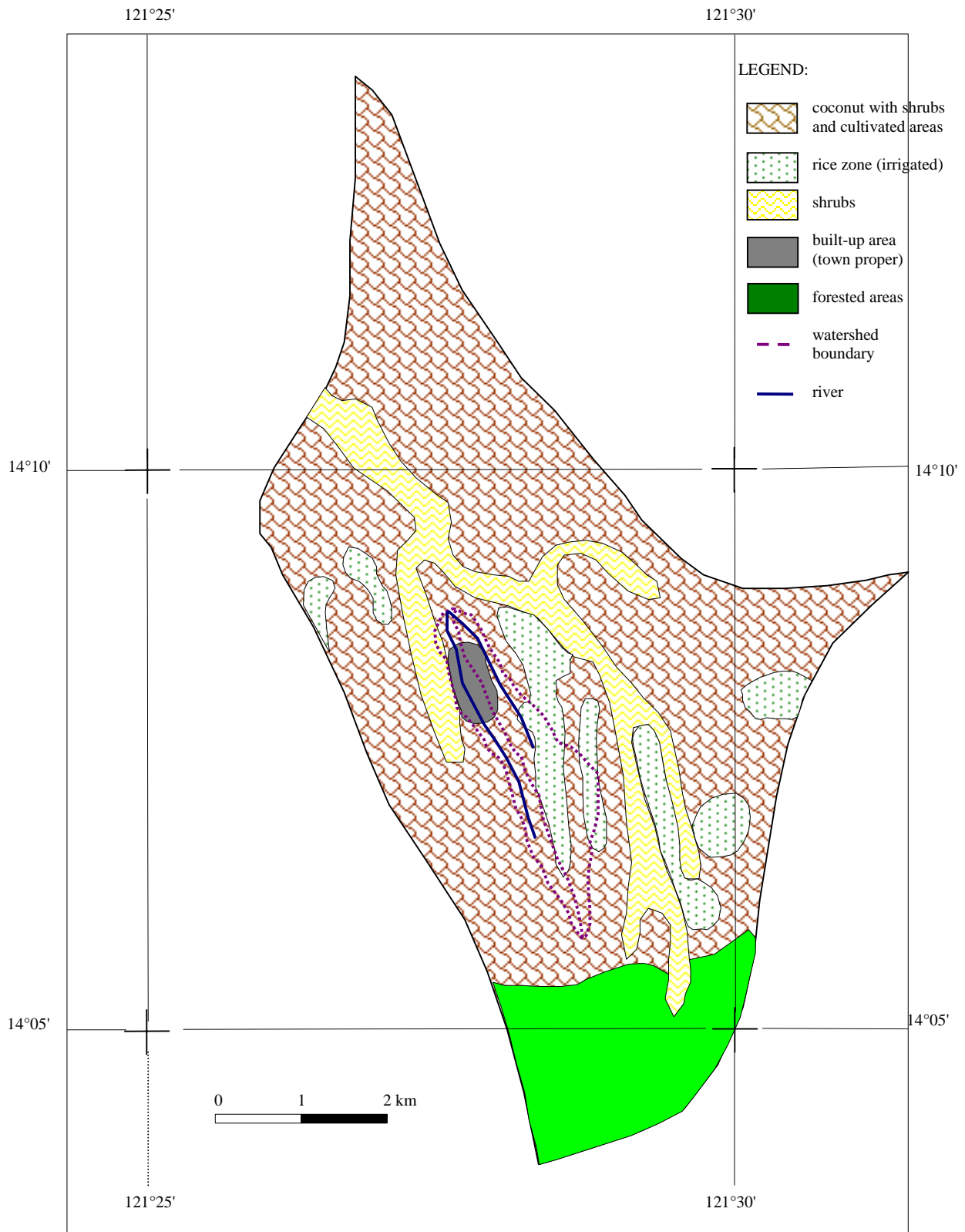


Figure 2. Land use map of Majayjay, Laguna and watershed boundaries of Lucban and Majayjay rivers traversing the town.

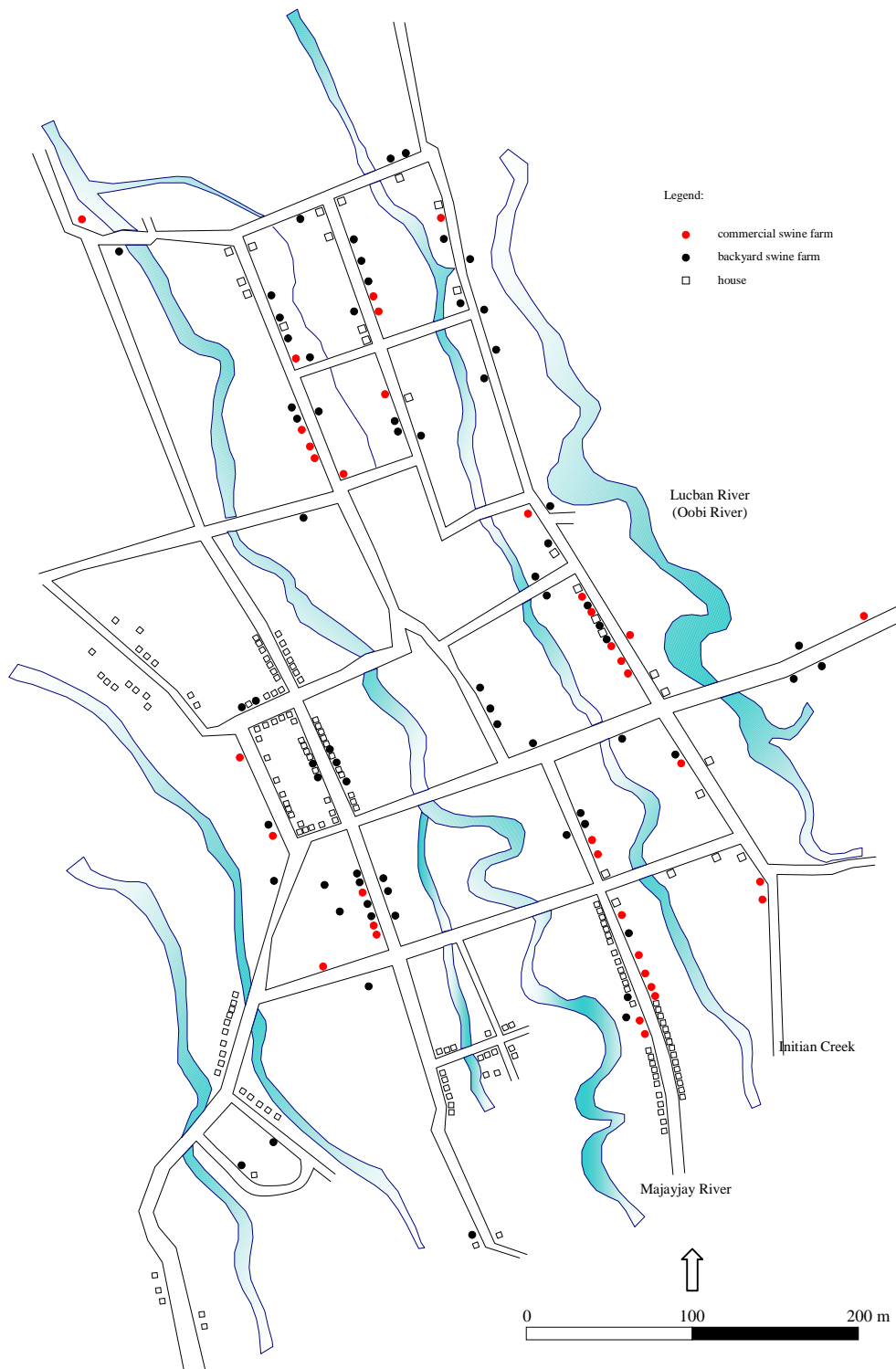


Figure 3. Location of backyard and commercial swine farms in the town proper of Majayjay, Laguna.

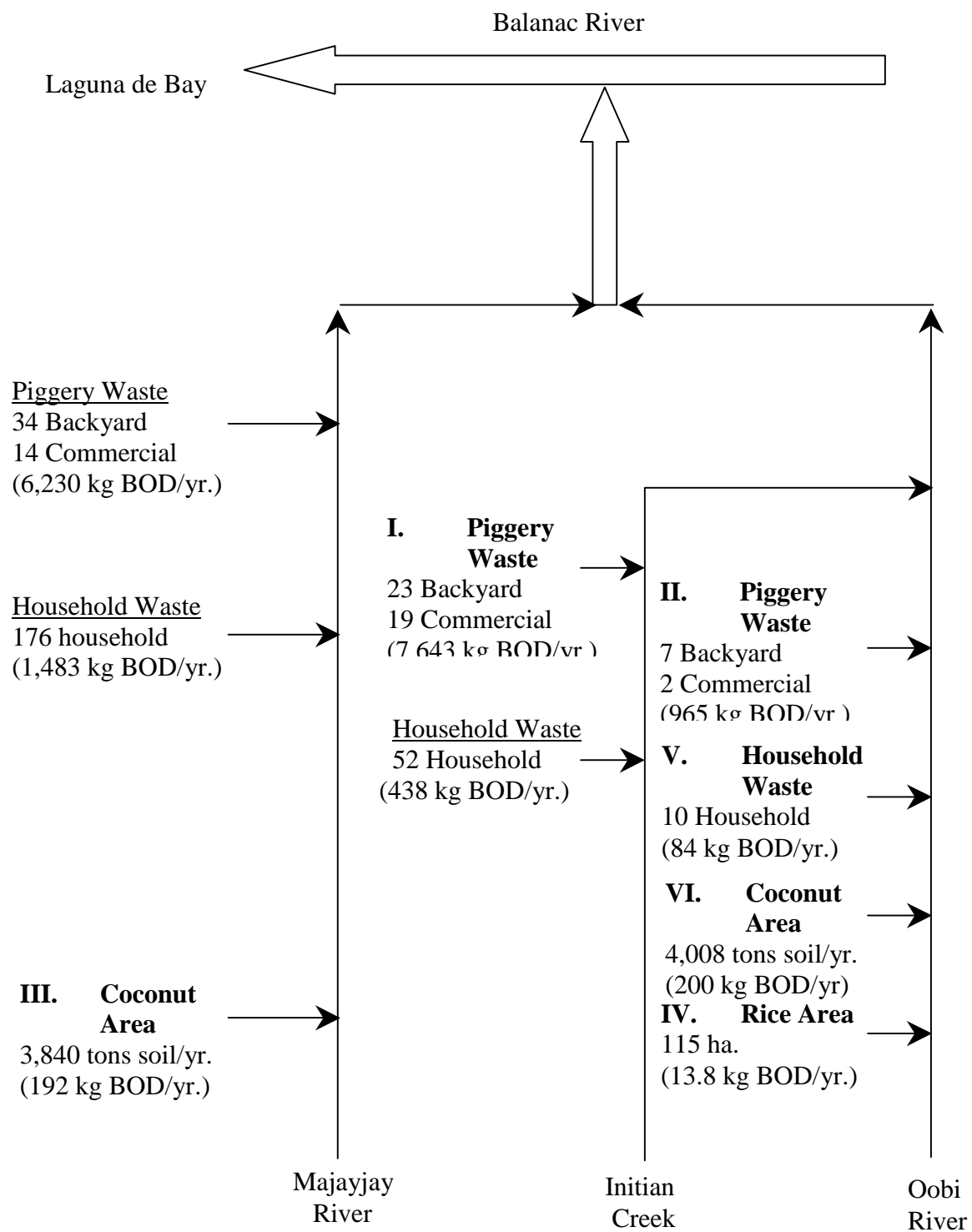


Figure 4. Schematic diagram of wastewater BOD loading into Lucban River, Initian Creek, and Majayjay River (built-up area).

A very important impact of reducing discharges of pig waste in the watershed is that the river network traversing Majayjay converges into the Balanac River which is one of two major tributaries that comprise the main Pagsanjan/Lumban River System. The Pagsanjan/Lumban River System is the biggest contributor of fresh water into the Laguna Lake and it is located in the southeastern part of the Laguna de Bay Basin. The Laguna de Bay Basin encompasses the lake and the southeastern parts of Metro Manila, the provinces of Laguna and Rizal, portions of the provinces of Batangas, Cavite and Quezon. The lake is used for fisheries, irrigation, power generation, transport and navigation, reservoir for floodwaters that threaten Metro Manila and a huge sink for solid and liquid wastes.

There is, at present, a River Rehabilitation and Management Program of the Pagsanjan/Lumban River System being undertaken by the Laguna Lake Development Authority (LLDA)¹⁵. This river system has become polluted due to the lack of waste disposal facilities for solid and liquid wastes coming from domestic and commercial/industrial activities in the watershed. The animal waste discharges into the river by backyard and commercial piggeries as well as poultry establishments have also been identified as contributing a substantial amount to the river pollution. Thus, the program encourages multi-sectoral and multi-agency involvement in the effort to save the rivers and ultimately the Laguna de Bay from further degradation.

5.0 CONTROL OPTIONS

5.1 Review of the International Literature: Control Options

5.1.1 Technical Options

Technical options to reduce pollution from hog waste include, among others, the installation of biogas digester systems, construction of lagoons, and applying or spraying treated manure onto lands or fields. These are considered techniques that involve "end-of-pipe" waste treatment and recycling. Treated wastewaters and sludge are usually reused for irrigation, energy generation and fertilization (IEMP, 1994).

¹⁵ Source: Accomplishment Report-Year 1 (1998) by the Community Development Division of LLDA on the Basin Approach to the Rehabilitation and Management of the Pagsanjan-Lumban River System under the Integrated Action Program for the Rehabilitation of Laguna de Bay.

The use of biogas digesters and lagoons involves anaerobic bacteria that break down or digest organic material in the absence of oxygen and produce biogas (i.e., methane) as a waste product. Anaerobic processes naturally occur in swamps, water-logged soils and ricefields, deep bodies of water and in the digestive systems of termites and large animals.¹⁶ Nutrient recycling, waste treatment and odor control are said to be the primary benefits of anaerobic digestion and the production of biogas is treated as a secondary benefit except in very large systems.

Biogas can be used for heating, cooking, and operating an internal combustion engine for mechanical and electric power. For engine applications, it may be necessary to remove hydrogen sulfide first to avoid corrosion or toxicity. Very large commercial farms/producers may be able to sell the gas to natural gas companies if the carbon dioxide is scrubbed out. To eliminate odor, a plastic tarp is used to cover the hog waste pit. Methane gas is captured inside the tarp and piped to a gas-run generator that helps supply power to the farm.

For individual households, benefits from biogas digesters are many but oftentimes not easily quantifiable. These may include the 1) expenditures saved by the substitution of other energy sources with biogas and substitution of mineral fertilizers with bio-fertilizers; 2) savings in cost of disposal; 3) time saved for collecting and preparing previously used fuel materials; and 4) rising productivity in agriculture¹⁷.

On a macroeconomic level, the use of biogas to replace traditional fuels like kerosene or firewood, provides for conservation of the environment. Biogas production also creates external economies in that it provides for better sanitation and hygiene for consumers and, thus, decreases risks and costs to the health of society.

In countries like the United States where there is an abundance of inexpensive fossil fuels, the use of digesters for the sole purpose of biogas generation is rather limited. However, there is an increasing interest in the waste treatment and odor reduction benefits of anaerobic digestion particularly for factory-scale livestock production operations. On the other hand, in countries like China, where fossil fuels and electricity are either expensive or not available, anaerobic digesters are an attractive option¹⁸.

Lagoon system is a simple method of treating waste from the piggery through biological means or mainly through the actions of microorganisms. The design of the lagoon is a simple dug-out pond with a 1:5 width to length ratio. The

¹⁶ See www.eren.doe.gov:80/consumerinfo/refbriefs/ab5.html.

¹⁷ *Ibid.*

¹⁸ *Ibid.*

wastewater from the farm is simply allowed to enter the lagoon pushing out the previously stored wastewater which has already undergone treatment. The treated wastewater can be recycled as a supplemental irrigation water to the adjoining field. This also contains nutrient, particularly nitrogen, needed by the plant (Dorado, 2000).

While developing countries seem to have had a late start with the use of lagoons as a waste treatment method, states in developed countries such as the United States have been filing court cases against hog factories for the improper management of lagoons. For instance, in North Carolina, affected citizens have filed formal complaints and petitioned for the phase-out of such waste treatment option. Over the years, it was observed that open air waste lagoons and sprayfields were just inadequate to take care of environmental problems related to hog waste. In fact, improperly managed lagoons created further environmental and health problems like emission of foul odors and other pollutants of the air, contamination of groundwater and drinking wells, and pollution of wetlands and waterways.

Other technical options found in the literature include 1) planting nitrogen-eating trees called *Paulownia elongata*, native to China, that can suck up the equivalent of 52,000 pounds of hog waste per year. After ten years, the trees can be marketed as pulp wood 2) recycling --e.g., combining peanut shells and hog manure to come up with feed or fertilizer or combining animal carcasses and discarded sweet potatoes for animal feed purposes (Warrick, 1995); 3) sewage treatment plant for hogs; 4) using aerobic thermophilic bacteria to convert hog waste into a cheap energy source (Jaehnig, 1999); and 4) using as feed maize varieties that produce more lysine and methionine because this will result in improved feed efficiency which also means less manure production and therefore, less pollution and odor¹⁹.

While almost all of the above options pertain to waste treatment and recycling, the US Environmental Protection Agency and the U.N. Environmental Program recommend that pollution from hog waste should be addressed using the waste management technique that focuses on *wastewater minimization and waste reduction from the source* (Waste Minimization Opportunity Manual, 1988). The inverted pyramid configuration places emphasis on Source Reduction over the other techniques that include Recycling/Reuse, Waste Treatment and Disposal, in order of importance. Waste minimization and reduction from the source include techniques such as the use of water meters, automatic/mechanical feeders, mechanical drinkers, pressurized water hose for cleaning pens and scraping/ drying of waste before disposal.

5.1.2 Policy and Institutional Options

¹⁹ For more information, see www.newscientist.com

A variety of policy and institutional options are cited in the literature based on empirical attempts to control pollution from hog waste. The list below draws heavily from the North Carolina experience.

Due to the aftermath of Hurricanes Dennis and Floyd where the residents of North Carolina bore the brunt of ensuing floods and contamination, the USEPA and USDA have developed a plan to reduce pollution from hog waste by subjecting most factory livestock farms to the regulations under the federal Clean Water Act. The plan consisted of the following:²⁰

- Two-year moratorium on new hog factories in North Carolina to provide "opportunity to develop lasting solutions to factory hog farm pollution problem".
- Phase-out of open-air anaerobic lagoons and sprayfields as the primary method of disposing of swine waste since these have adverse impacts on public health and the environment.
- Implementation of sampling program to determine the "efficacy of agronomic rates in protecting groundwater from possible contamination".
- Giving of incentives to use public assistance for innovative technologies.
- Closure of lagoons that result in offsite groundwater contamination and require hog raisers to mitigate offsite contamination as possible.
- Annual monitoring of heavy metal concentrations in lagoon sludge; installation of wells near hog farms and regular monitoring of such wells for groundwater contamination.
- Require installation of "biocovers" (floating material like straw or pumice) to be replaced by more effective covers when possible.
- Develop metal concentration standards for lagoons to determine when remediation and/or closure should be required.
- Permits required for all new and expanding operations.
- Zoning regulations where hog factories are not allowed to be located "too close to neighbors, or in flood plains, wetlands, vulnerable watersheds or environmentally sensitive areas".
- Give citizens and local governments more say in deciding whether factory hog farms are constructed in their communities.
- Enforce existing laws and regulations.
- Hold farm owners liable for any environmental violations.

In the Philippines, effluents are regulated by the DENR through 1) standards that specify the amount of allowable concentration of pollutants and set on case-to-case basis (e.g., 50 mg/l for BOD5 for class C inland water); 2) penalty fees for polluting a body of water (i.e., P5/kg BOD discharged in excess of allowable limit);

²⁰ For more details, see www.hogwatch.org/resourcecenter/online/articles/phaseout/execsummary.html.

3) requirement of Environmental Clearance Certificate (ECC) for piggeries with capitalization of P500,000 and employing more than 20 persons; and 4) issuance of a cease and desist order imposed through reduction of pig population to non-polluting level. The only setback is that regulations previously covered only large agricultural enterprises which discharge at least 30 cu.m. of wastewater per day. Thus, backyard farms and small commercial farms are "virtually exempt" from monitoring and compliance since 30 cu.m. per day wastewater implies a capacity of at least 1,000 heads -- capacity of medium to large scale commercial farms (Orbeta and Calara, 1996). They are not, however, exempt from the discharge permits that are required of those who discharge less than 30 cu.m. of wastewater.

5.2 Proposed and Preferred Pollution Control Options in Majayjay

5.2.1 Proposed Pollution Control Options

The problems generated by the wastes from the piggeries of Majayjay, Laguna should be addressed using the waste management technique that focuses on waste minimization and reduction from the source. Figure 5 shows the waste management hierarchy adopted from the U.S. Environmental Protection Agency and from the U.N. Environmental Program (Waste Minimization Opportunity Manual, 1988).

Based on the interviews that were conducted, though the raisers are aware of harmful consequences that can come from the direct disposal of waste to the adjoining rivers and creek, the raisers do not see the urgency or chose to ignore the urgency of the problem. A unique factor that can be cited which could have contributed to this attitude, aside from the most common reason always given which is the additional investment in time and money in the use of waste management techniques, is the presence of Mount Banahaw. This mountain offers a watershed with still thick vegetation, thus providing a sustained flow in the rivers and creeks. This condition then suggests that the rivers and creek which include Oobi, Balanac, and Botocan Rivers, and Initian Creek have strong flushing characteristics. This means that the wastes disposed to the water channels will not accumulate at the point of disposal but can be carried downstream. Although this unique characteristic offered by the shelter of Mt. Banahaw is not an excuse for the raisers to wantonly dispose of their waste to the adjoining water channels, this could have contributed greatly to their indifferent attitude to having a proper waste management scheme.

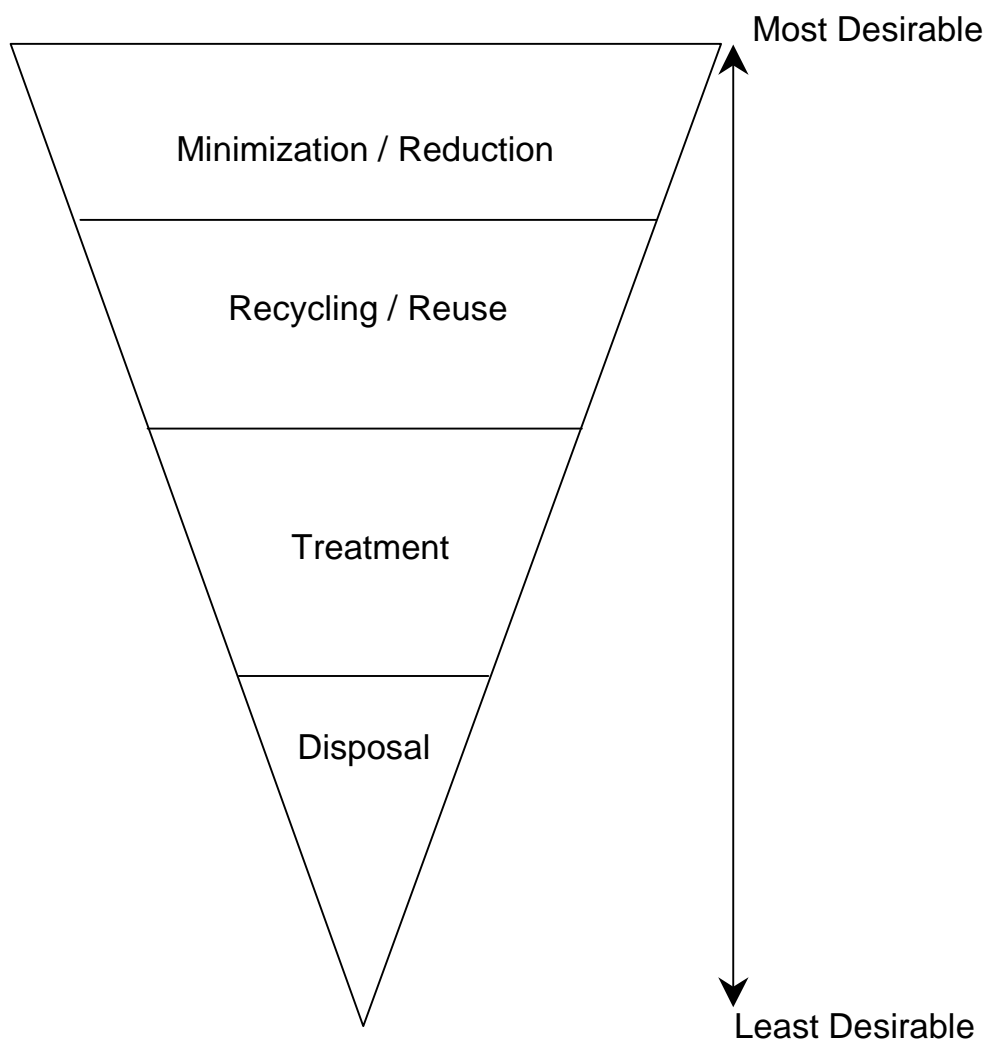


Figure 5. Recommended waste management hierarchy.

Another major contribution of the mountain to the problem of waste from the piggeries is the free water that is available for use in the farm. Although the availability of water is highly favorable for the farm, being free can also have its disadvantage for waste management which was observed for Majayjay. The majority of the farms use, on the average, thirty (30) liters of water per head of swine per day compared to the technical requirement of only about ten (10) liters. Although the use of more water will make the wastewater more diluted, it will unnecessarily make the handling of wastewater more difficult due to the greater volume, thus magnifying further the problem on waste.

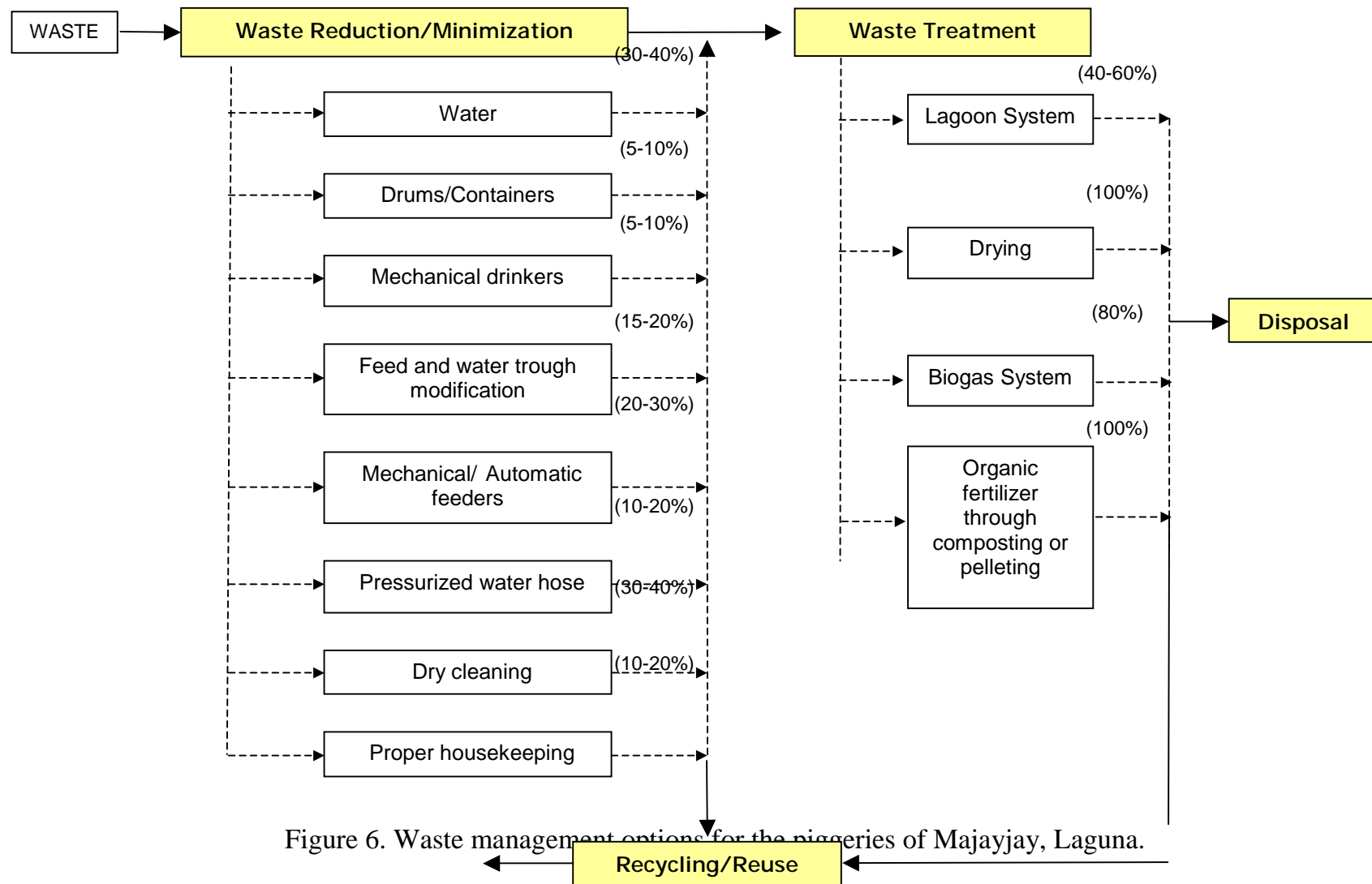
In light of these observations, an intensive information and education campaign (IEC) will be needed to be able to address the problem. Creating a municipal wide awareness on the harmful effects of improper waste handling and disposal can reverse the present indifferent stand of farm owners, as well as the

quiet stand of non-raisers, on the adoption of proper waste management schemes. At present, non-raisers have their individual complaints on the water and air pollution coming from the piggeries but they have not made it as a collective stand to raise the issue. Through the conduct of IEC, the non-raisers will be given an opportunity to actively participate in the various discussions. The IEC should be conducted in a consultative manner wherein all stakeholders will be heard, their views presented, and further discussed.

Activities on IEC were conducted by the group. These included consultations with the Association of Barangay Captains, swine raisers (both small and commercial), and Municipal Council of Majayjay. During the consultations, the different waste management options that were prepared by the group for possible adoption in Majayjay were presented. The options were based on the waste management hierarchy earlier presented, on the experiences from farms around the country, on available new technologies, and more importantly on the prevailing condition in Majayjay. The objective of the consultation was to obtain comments and suggestions from the different groups and be able to determine which among the options will be most likely adopted in the area.

Figure 6 shows a flow chart of the proposed waste management options that were presented to the different groups. The options are clustered into two groups, waste reduction/minimization and treatment options, with both groups having options for recycling or reuse. Although as presented, disposal is an option under the treatment cluster, this however is not encouraged and is to be used only as a last alternative. It is also to be emphasized that the flow chart indicates that before recycling/reuse, or treatment, or disposal is adopted, management of the waste should first undergo reduction or minimization. The presence of a treatment system or a proper disposal site should never be an excuse for generating large volume of waste.

Under the wastewater reduction/minimization group, the different strategies that may be appropriate for Majayjay include (1) water metering/monitoring, (2) drums/water storage tank, (3) mechanical drinkers, (4) feed and water trough modification, (5) mechanical/ automatic feeder, (6) pressurized water hose, (7) dry cleaning, and (8) proper housekeeping. For the waste treatment group the strategies include (1) lagoon system, (2) drying, (3) biogas system, and (4) organic fertilizer/pelleting plant.



5.2.2 Preferred Pollution Control Options of Backyard and Commercial Raisers

Table 7 presents the preferred pollution control options of backyard and commercial hog raisers in the survey area as well as the respective percentage reduction of pollution load and ambient concentration of the options.

Table 7. Percentage reduction in pollution load and ambient concentration under various pollution control options.

Pollution Control Options	Backyard		Commercial	
	Pollution Load	Concentration	Pollution Load	Concentration
<i>Option 1:</i> Wastewater reduction	31-48.2%	325 mg/l	56.50%	325 mg/l
<i>Option 2:</i> Lagoon	58.6-79.3%	68 mg/l	90%	32.5 mg/l
<i>Option 3:</i> Biogas	86.2-89.6%	30 mg/l	95%	16 mg/l
<i>Option 4:</i> Organic Fertilizer/ Pelleting Plant	100%	0 mg/l	100%	0 mg/l

Option 1. From the consultations conducted with backyard and commercial raisers, the waste management option that they would most likely adopt is composed only of wastewater reduction/minimization and disposal. Waste treatment and recycling/reuse are not included in their options since they see waste treatment strategy as an additional expense.

Mechanical feeders and automatic feeders are additional expense and so the farmers are not too keen on using this device. They see dry cleaning as very laborious and handling of waste offensive, therefore this method is not also included.

The total percentage reduction in the volume of waste that can be achieved from this option is around 31.0-48.2% for backyard farms and 56.5-75.1% for commercial farms. However, the concentration of the waste will not pass the standard for BOD level at 80 mg/l since only the volume is reduced but not the concentration.

Option 2. Some raisers, particularly those with *available space* have indicated the adoption Option 1 with the addition of lagoon system as a waste treatment option. With the inclusion of the lagoon system, the level of reduction in the volume of pollution load can range from 58.6-79.3% for backyard farms

and 90% for commercial farms. This option can reduce concentration to around 68 mg/l for backyard farms and 32.5 mg/l for commercial farms. These levels are already within the acceptable limits. However, they will still put the receiving river to a non-contact use like navigation, irrigation and the like.

It has to be emphasized, though, that a lagoon system is not profitable at all and will not be recommended if the sole basis for choosing an option is the financial return. However, this does not preclude raisers from using it as a waste treatment option because the unmonetized environmental benefits could be high.

Option 3. This option has the same components as Option 1 with the inclusion of biogas system as a waste treatment method and an option for recycling/reuse particularly for the biogas that will be generated. This method can be done by individual commercial raisers and in pairs for backyard raisers, particularly those with small farms. A reduction in the pollution level in the range of 86.2-89.6% and 95%, respectively for backyard and commercial farms can be achieved. This can bring the BOD level to around 30 mg/l for backyard farms which puts the receiving water safe for non-contact activities. For commercial farms, the reduction in BOD level can up to 16 mg/l which makes the receiving water safe for contact activities like bathing and other recreation. With more recycling, zero discharge to the rivers can actually be achieved.

Option 4. This option includes composting or pelleting as a waste treatment method in addition to Option 1. Also, dry cleaning is included into the waste reduction/minimization methods. This option is not limited to the activities of individual raisers but should be done as an organized group. This option can achieve a 100% reduction in the pollution load due to achieving a zero discharge to the river.

5.3 Financial Analysis of Technically Viable Options

The following discussions refer to the available waste pollution options which include an organic fertilizer/pelleting plant, and biogas system. The choice of these options was, in more ways than one, influenced by the availability in the country of their respective technology and their relative and inherent simplicity in operation. The lagoon and the wastewater reductions option were deleted in the analysis because benefit appraisal, particularly of the lagoon project, has encountered certain difficulties. While this project is clear in terms of output, the quantification of wastewater by-product, *vis. a vis.*, irrigation water and fertilizer, proved to be quite difficult. Moreover, the methodology for estimation of productivity improvement at the moment remains wanting as certain isolation problems, i.e., increase in productivity due to pure wastewater effect, exists. Furthermore, initial calculations showed that these were not profitable.

On grounds of analytical convenience, a price static multi-period approach was adopted to suit the objective of this viability study. The generalization to a static multi-period framework is straightforward with financial viability assessed in terms of the net present value (NPV). NPV is the only criterion to use to choose the best option. However, we also present the benefit-cost ratio (BCR) and the financial rate of return (FIRR).

It is recognized in this study that there is no single key that will open the door to complete accuracy in the estimations for project analysis. It is not remote that these assumptions may deviate from the events in the future. Thus, *sensitivity analysis* was performed.

As a starting point, the various options were evaluated on a single module basis so that interested raisers will have an idea of what it will cost them to engage in such options. The plugflow biogas system for backyard farms is based on a 12-head module (the average for the sample) that involves sharing the digester with another since majority of the farms are close enough to each other. The reduction in total waste for a single module is equivalent to 0.02 ton/day or 5.7 tons/year. This value is approximately **0.08% reduction** in overall pollution generated by all piggeries in Majayjay in a year (i.e., .08% of 6,904 tons/year). The biogas module for individual commercial farms is for 123 heads (again, the average for the sample). This is roughly equivalent to **0.4% reduction** in total hog manure per year. On the other hand, the one-ton per day pelleting plant involves about 1,846 heads (at a weighted average of 0.65 kg manure/head/day) and results in a **6.3% pollution reduction**.

Since a meaningful comparison for the purpose of selecting the best option cannot be made on a single module basis as these options entail different levels of pollution reduction, certain targets of pollution control were set and the corresponding adjustments in the number of modules across options were done. Thus, overall reduction in pollution levels were set at **6.3%, 25% and 50%**. These are equivalent to reductions of 438, 1,752, and 3,504 tons of manure per year. Ideally, given the present state of the receiving waters in Majayjay, (and the need to pass the LLDA wastewater discharge sample test), a 95-100% pollution control is required to make these waters fit for contact activities like bathing and other recreation in a span of about 5 years. However, with the objective of being more *realistic* in our approach in terms of considering the rate of probable compliance of hog raisers in the short run as well as the willingness and capability of the raisers themselves and potential investors to shoulder the costs involved, we have limited the levels of pollution reduction to 50%. The 6.3% is actually the equivalent reduction in total waste if a one-ton-a-day organic fertilizer pelleting plant (whose capacity is technically efficient) is put up in Majayjay. Furthermore, since there are much fewer hogs raised in

backyard farms relative to those produced in commercial farms, the biogas option for backyard raisers will correspond to a reduction in overall pollution by a maximum equivalent of 6.3%.

With reference to Table 8 for more clarity, 6.3% pollution reduction will require an equivalent of 77 biogas modules for backyard farms or 15 biogas modules for commercial farms or one one-ton organic fertilizer pelleting plant. On the other hand, a 25% pollution reduction will entail the putting up of 60 biogas modules for commercial farms or 4 one-ton organic fertilizer pelleting plants. Lastly, if a 50% pollution control target is set, this will require 120 biogas modules for commercial farms or 8 one-ton organic fertilizer pelleting plants.

Having laid down the essential clarifications regarding the options *vis-a-vis* pollution control targets, evaluation of such options are as follows.

Investment Costs. Across all levels of pollution control, the organic fertilizer/pelleting plant commands the least investment within the range of PHP 0.5 million for 6.3% pollution reduction to PHP 4.2 million for a 50% reduction. The plugflow biogas project needs four times as much for both the backyard and commercial scales. Between backyard and commercial scales, there seems to be evidence of economies of size for the latter particularly where land and training costs are concerned. For all options, the core of investment is on land and equipment. Altogether, they represent more than 90% of total investment.

Operating and Maintenance Costs. The trend in the magnitude of periodic operating and maintenance (O&M) cost across hog waste disposal schemes runs counter with that of the pattern in investment costs. This time, the organic fertilizer/pelleting plant has been estimated to incur the *highest* annual O&M cost in the neighborhood of PHP 0.9 M, PHP 3.7 M and PHP 7.4 M for 6.3%, 25% and 50% pollution reduction, respectively. This may be attributed to the fact that more activities are involved in operating and maintaining the pelletizing plant. Skilled labor is also a requirement. Moreover, the collection of and the proposed incentive scheme for hog waste exact a heavy toll on the operating cost of the plant. Thus, an important implication is that there can be tremendous cost cutting particularly in the collection activity if we use the waste of commercial farms for the pelleting plant. In sharp contrast, the *commercial* scheme for biogas requires the *least* O&M cost with only PHP 0.2 M, PHP 0.7 M and PHP 1.6 M, respectively (Table 9). Again, there is an indication of economies of size for commercial farms *viz.* backyard farms with respect to labor requirements and cost.

Table 8. Characteristics of technically feasible pollution control options for hog waste.

Option	No. of Modules			No. of Hogs per module per year			Waste Reduction ^b (tons/ year)			Equivalent BOD Reduction ^c (tons/ year)		
	Pollution Reduction			Pollution Reduction			Pollution Reduction			Pollution Reduction		
	6.3%	25%	50%	6.3%	25%	50%	6.3%	25%	50%	6.3%	25%	50%
C. Biogas Project												
A.1 Backyard	77	-	-	24 ^a	-	-	438	-	-		-	-
A.2 Commercial	15	60	120	123	123	123	438	1,752	3,504	3,548	14,191	28,382
D. Organic Fertilizer/Pelleting Plant (@ 1 ton/day)	1	4	8	1,846	7,384	14,768	438	1,752	3,504	3,548	14,191	28,382

^a twin-sharing of biogas system @ 12 hogs/farm

^b Refers to tons of manure per year @ weighted average of 0.65 kg manure/head/day. Sows generate about 1.65 kg manure/head/day and grow-fin generate about 0.26 kg manure/head/day. Approximately 28% of total hog population in Majayjay are sows; 78% are grow-fin.

^c BOD of fresh manure (I.e. without water from cleaning and wastage) is 9750 mg/l. Equivalent BOD (i.e., density of fresh manure) is 1200 kg/m³. 1 kg manure will have an approximate volume of 0.833 liters or an equivalent of 8,100 mg BOD.

Table 9. Financial analysis: Investment and annual operating and maintenance cost of pollution control options for hog waste.

Option	Investment Cost ('000,000 PHP)		
	Pollution Reduction		
	6.3%	25%	50%
A. Biogas Project			
A.1 Backyard ^a	2.1	-	-
A.2 Commercial	2.4	9.8	19.6
B. Organic Fertilizer/Pelleting Plant	0.5	2.1	4.2
	Annual Operating and Maintenance Cost ('000 PHP)		
	Pollution Reduction		
A. Biogas Project			
A.1 Backyard ^a	596	-	-
A.2 Commercial	194	776	1,555
B. Organic Fertilizer/Pelleting Plant	920	3,679	7,359

^a For a 6.3% reduction in pollution, 77 plugflow biogas modules will be needed. On the assumption of twin-sharing of biogas systems among backyard raisers, 154 farms shall be involved and waste will be generated by about 1,848 heads. This number approximates the total population of backyard hogs in Majayjay. Thus, backyard biogas options for 25% and 50% pollution reduction were not considered anymore.

Reflecting on the value and structure of the costs among project alternatives, the biogas project requires operating and maintenance that is predominantly labor in nature and not so much in value but the investment on the digester could pose certain adoption resistance to some hog raisers. A more pessimistic scenario can be painted for the fertilizer/pelleting plant. Unless one sees an investor or a group of investors for that matter, who may be willing to shell out about PHP 1.4 M for a hog waste project, or unless there is a concerted effort among the local government, hog raisers, non-government organizations, the community and other concerned entities to raise PHP 1.4 M for a hog waste project, it may be hard to imagine an organic fertilizer pelleting plant in Majayjay. Perhaps, the only way the proposed projects may take off in Majayjay is when the projects show economic and social returns that are sufficient enough to overshadow the fears of hog raisers on new investment and change in current farm practices.

Benefits. An attempt was made to quantify the benefits from the proposed projects using market prices. Benefits were mostly derived from the output to be generated by the projects or from savings that the adoption of proposed farm practice or operation create.

As mentioned in earlier sections of this report, at 6.3% pollution reduction target, a one ton organic fertilizer pelleting plant is capable of producing 20 50-kilogram sacks of fertilizer pellets per day. At 50% reduction in

pollution, a total of 160 sacks of pelletized fertilizer a day will be produced from 8 one-ton plants. A sack of pelletized fertilizer commands currently a market price of PHP 150²¹ which is about a third only of branded inorganic fertilizer. This means that if the daily production of pellets from the plants does not impact on the market for pellets, then a revenue generation of PHP 1.1 M to PHP 8.6 M per year at full capacity for pollution targets of 6.3% to 50% reduction will be realized.

It may be worth noting that studies by Casas (1998) and IMO (1997) revealed farmers' heightened knowledge of the long-run disadvantages or negative externalities of chemical fertilizers and an increasing demand for organic fertilizers. Corn farms are said to be the largest users of organic fertilizer in the Philippines followed by rice farms and large scale plantations in Mindanao as well as vegetable farms. The province of Laguna has also engaged in a project that showcases organically grown crops. Although there are close to 30 organic fertilizer manufacturers in the country, Casas' study forecasts that the supply will not be able to meet the growing demand in the next five years or so. Thus, there appears to be a good market potential for pelletized organic fertilizer.

Majayjay is basically an agriculture-dependent municipality. More than 6,000 hectares of its total land area are classified as suited and best for agricultural cultivation (Socio-economic Profile of Majayjay, 1998). Rice farming is the primary livelihood and vegetables and other crops are also extensively grown in the area. Hence, with intensive education campaign and support from local government, farmers in the municipality can readily be a captured market for organic fertilizer in pellet form. Nearby agricultural municipalities can likewise be explored as potential markets.

The biogas project, on the other hand, assumes a production capacity equivalent to 3 tanks of liquefied petroleum gas (LPG) for every 12,000 liters of wastewater. Using a retail price of equivalent LPG at PHP150 per tank and by extrapolation, a backyard biogas project of 77 modules for a 6.3% pollution reduction can therefore manage an implicit gross revenue of PHP 1 M per year. A biogas project of commercial scale (15 to 120 modules) can generate annual returns ranging from PHP 1M to PHP 8M per year across pollution reduction targets. In addition to savings in using biogas as fuel for cooking, there are also savings in using the sludge from the digester as soil conditioner. Conservative estimates of such savings assumed a sludge value of one-fourth the price of a 50-kg bag of organic fertilizer pellet. Thus, additional benefits range from PHP 49,000 to PHP 388,000 per year.

²¹ Casas (1998); The same information was shared by Engr. Jaime Q. Dili-dili of the Cavite State University at the Waste Utilization Technology Seminar for Hog Raisers in Majayjay, Laguna on May 30, 2000.

Biogas can also be transformed into fuel briquettes or used as fuel to run specially designed generators²². However, briquettes may not be suitable by-products of biogas in Majayjay because space for drying the waste is not sufficient nor available for most farms in the municipality. As for energy savings, initial computations made by the team revealed that it is not financially feasible for backyard and small to medium commercial farms since significant additional costs like the purchase of generators suitable for this purpose tend to squeeze out potential benefits. Large scale piggeries seem to benefit more from this venture and the highest NPV is obtained at a 50% reduction. This is because a positive NPV is obtained for the installation of one biogas system. Since the same system is installed a number of times, and with the assumption of the same individual benefits and costs, the more systems installed, the higher will be the aggregate NPV.

Unlike the other options, benefit appraisal of the lagoon project has encountered certain difficulties. While this project is clear in terms of output, the quantification of wastewater by-product, *vis. a vis.*, irrigation water and fertilizer, proved to be quite difficult. For one, the absence of reliable characterization of the farming systems in the study area makes it hard to estimate the benefits. The type of crops grown over the years cannot be readily established because of the relatively subsistence nature of farming in the study site. Hence, benefits in the form of productivity gains can not be estimated. Moreover, the methodology for estimation of productivity improvement at the moment remains wanting as certain isolation problems, i.e., increase in productivity due to pure wastewater effect, exists. In other words, the concept and mechanics of decomposition analysis remains wanting. Definitely, its absence serves as a significant stumbling block to benefit valuation. It is for this reason that this particular concern has been suggested for inclusion in the researchable areas in the future.

Cash Flow Analysis. Table 10 shows that all of the proposed projects are financially viable at 10% discount rate and across pollution reduction targets. However, the biogas project, particularly at the commercial mode, appears to be more acceptable as shown by the highest net present value of PHP 1.7 M, PHP 6.8 M, and PHP13.6 M for pollution reduction targets of 6.3%, 25% and 50%, respectively. Its FIRR of 51% is higher than the assumed opportunity costs of 10%.

The plugflow biogas project of backyard scale generates a net present value (NPV) equal to PHP 499,000. It has a financial internal rate of return (FIRR) of 21%.

²² See International Maritime Organization (IMO, 1997) for details.

Table 10. Financial analysis: NPV, BCR and FIRR of pollution control options for hog waste.

Option	NPV @10% ('000 PHP) Pollution Reduction			BCR	FIRR
	6.3%	25%	50%		
A. Biogas Project					
A.1 Backyard	499	-	-	1.12	21%
A.2 Commercial	1,707	6,828	13,656	1.58	51%
B. Organic Fertilizer/Pelleting Plant	374	1,497	2,995	1.09	48%

The organic fertilizer/pelleting plant generates an NPV of PHP 0.37 M, PHP 1.5 M and PHP 3M at 6.3%, 25% and 50% pollution reduction, respectively. The project yields an FIRR of 48%.

With regard to cost effectiveness of the projects, the biogas project at the commercial scale appears to be the one that yields the lowest total (discounted) cost in reducing pollution by 6.3%, 25% and 50%.

Sensitivity Analysis. Several scenarios were simulated to see if the proposed projects are sensitive to certain deviants. These included the possibilities of increases in investment and operating and maintenance cost, decrease in benefits either due to decrease in the market price of output (i.e., pellets or biogas) or production capacity (i.e., of the palletizing plant or biogas digester), and combinations thereof. Table 11 presents a summary of these results.

The commercial and backyard biogas project seem to withstand the risks and uncertainties stipulated in the analysis while the organic fertilizer plant proved to be quite sensitive to particular untoward events. Investors must be forewarned against the repercussions of a 10% decrease in production capacity of the pelletizing plant, and the possibility of a combined incidence of a 10% increase in O&M and investment cost. Their incidences would reverse the acceptability of the project as they disallow the project to register a positive NPV and a respectable financial rate of returns. This is to be expected since the organic fertilizer plant entails relatively large O&M cost.

At any point in time, production capacity can decrease due to production inefficiencies or failure in the implementation of a conceived design. In the case of the biogas project, two scenarios were painted: for backyard operators having an average of 12 heads of pigs, and for commercial raisers with approximately 123 pigs capacity. At a simulated 10% decrease in production of biogas, the backyard biogas project still remains viable given the positive, albeit low NPVs and FIRRs that are quite close to the 10% discount rate.

Table 11. Financial Analysis: Summary of sensitivity analysis of pollution control options for hog waste.

Scenario	Option	NPV @10% ('000 PHP) Pollution Reduction			BCR	FIRR
		6.3%	25%	50%		
<i>1. Base Case</i>	A. Biogas Project					
	A.1 Backyard	499	-	-	1.12	21%
	A.2 Commercial	1707	6,828	13,656	1.58	51%
	B. Organic Fertilizer/ Pelleting Plant	374	1,497	2,995	1.09	48%
<i>2. 10% Increase in O & M Cost</i>	A. Biogas Project					
	A.1 Backyard	273	-	-	1.06	16%
	A.2 Commercial	1,633	6,532	13,064	1.54	49%
	B. Organic Fertilizer/ Pelleting Plant	26	104	208	1.01	12%
<i>3. 10% Increase in Investment Cost</i>	A. Biogas Project					
	A.1 Backyard	303	-	-	1.07	16%
	A.2 Commercial	1,485	5,940	11,880	1.47	42%
	B. Organic Fertilizer/ Pelleting Plant	326	1,304	2,608	1.08	40%
<i>4. 10% Increase in Investment and O & M Cost</i>	A. Biogas Project					
	A.1 Backyard	77	-	-	1.02	12%
	A.2 Commercial	1,411	5,644	11,288	1.43	40%
	B. Organic Fertilizer/ Pelleting Plant	-22	-88	-176	0.99	8%
<i>5. 10% Decrease in Production Capacity</i>	A. Biogas Project					
	A.1 Backyard	97	-	-	1.02	13%
	A.2 Commercial	1,306	5,224	10,448	1.44	40%
	B. Organic Fertilizer/ Pelleting Plant	-41	-164	-328	0.99	7%

The backyard biogas project is found to be sensitive to a decrease in the number of households sharing the digester. It must be recalled that the proposed backyard biogas project is designed to be shared by two producers on account of investment costs and supply of wastewater. If the use is limited to only one instead of two household-producers a reversal in decision cannot be avoided. NPV becomes negative.

Given the above scenarios and their effects on the viability of the proposed projects, it appears that the commercial biogas project is the best option for reducing pollution from hog waste. The NPV continues to show robustness for the project even amidst adverse eventualities.

5.4 Economic Analysis of Technically Feasible Options

Economic analysis goes beyond financial analysis. While the latter may be of interest especially to potential investors, it is recognized that "market prices do not always reflect the true economic value of inputs and outputs of projects." Thus, to determine the costs and benefits to society of the proposed investment projects for hog waste pollution control, market prices used in the financial analysis need to be adjusted to reflect the true scarcity values. Economic analysis also differs from financial analysis by the inclusion of environmental and health effects.

For the purpose of roughly adjusting the market prices of some of the major inputs and outputs of the control options, this study, in general, adopted a shadow exchange rate factor of 1.2 for tradable items and a standard conversion factor of 0.6 for unskilled labor. These figures were based on the Investment Coordinating Committee (ICC) which is one of the National Economic and Development Authority (NEDA) Board's cabinet level interagency committees. Using a shadow exchange rate has the effect of making tradable goods and services more expensive in domestic currency by the amount of the foreign exchange premium. On the other hand, when market prices are perceived to overstate the economic values, a standard conversion factor is used.

For both the biogas project and the organic fertilizer pelleting plant, the focus of economic analysis was on those financial accounts which are likely to create a significant difference to the project investment decision. Thus, land, labor, building and equipment, gasoline, electricity, water, equivalent liquefied petroleum gas (LPG), truck rental and fertilizer are among the inputs and output considered as significant. We shall discuss in general how the prices of these items were treated in the analysis.

Since there is not much alternative use of the *land* in the project site except for agricultural purposes, the value of land was adjusted from the going market price for residential lots of P1,000 per sq. m. to the average price of agricultural lots of P500 per sq. m.. As for *labor*, a conversion factor of 0.6 was used for unskilled labor. This is because the majority of the activities for biogas and pelleting plant operation involve the employment of unskilled labor. Furthermore, there is a relatively high unemployment rate of 37% in Majayjay (Socio-economic Profile of Majayjay). Thus, if we are to use a minimum wage of P180/day for activities that require more of unskilled labor, we are actually overstating the value of that resource. The rest of the other activities that require skilled labor made use of the minimum wage rate. For instance, the wages paid to the manager and bookkeeper are assumed to represent the true marginal value product of these workers since skilled labor in Majayjay is considered to be in

short supply and would probably be fully employed even without the project. *Building* and *equipment* such as biogas digesters, and pelleter/dryer are assumed to contain significant importable components and therefore, a shadow exchange rate of 1.2 was used to correct price distortions in the market. *Gasoline* is considered a tradable good and a shadow exchange rate of 1.2 was used to account for the foreign exchange premium. As for *electricity*, prices are usually administered by the National Power Corporation and , thus, are not competitive prices. These prices also are subsidized and a rate of 15% subsidy was assumed. Since subsidies are a form of transfers, these were taken out from the financial accounts. *Water* in Majayjay generally comes from Mt. Banahaw. As such, each household is asked to pay a distorted price of only 10 pesos per month. Thus, the value for water (as an input) used in the economic analysis is zero as marginal cost is also equal to zero. The price of equivalent liquefied petroleum gas is set *Fertilizer* is also considered a tradable item. The economic value of a 50-kg bag of organic fertilizer pellets as output of the pelleting plant is assumed to be the average of a 20% decrease in the market price owing to the impact of an increase in supply of pellets and a 20% increase in the market price due to adjustment using the shadow exchange rate of 1.2 for tradable items like fertilizer. On the other hand, since the use of fertilizer in the study also involves recycling of sludge as soil conditioner, the value of the sludge was assumed to be only one-fourth of the price of a 50-kg bag of organic fertilizer pellet to account for its relatively lesser potency in the absence of chemical 'enhancers'. This value is the same as the one used in the financial analysis. Given the aforementioned assumptions for the market price adjustments, we now turn to the results of the economic analysis of the pollution control options. It is recognized, though, that at this point, the level of accuracy in the adjustments of market prices could very well still be wanting but the idea is to make an attempt at coming up with a reasonable economic analysis given the data availability and time constraint.

Table 12 shows the investment and annual operating and maintenance costs for the various options.

Investment cost is directly proportional to pollution reduction rate and project size. After the necessary economic valuation adjustments in investment items were made, the 6.3 % pollution reduction option via a biogas project of backyard mode requires PHP1.8 M while that of commercial mode demands PHP2.3 M for its fixed investment. Increasing the pollution reduction target to 25% and 50% would need a capital outlay worth PHP9.2 M and PHP18.4 M, respectively. The organic fertilizer/pelleting plant, on the other hand, turns out to be less capital intensive as the cost for investment totals only to PHP0.5 M given a 6.3% pollution reduction target and increases to PHP2.0 M and PHP4.0 M under a 25% and 50% pollution reduction program. These values are worth only a quarter of the investment requirement using the biogas alternative.

Table 12. Economic analysis: Investment and annual operating and maintenance cost of pollution control

Option	Investment Cost ('000,000 PHP)		
	Pollution Reduction		
	6.3%	25%	50%
A. Biogas Project			
A.1 Backyard ^a	1.8	-	-
A.2 Commercial	2.3	9.2	18.4
B. Organic Fertilizer/Pelleting Plant	0.5	2.0	4.0
	Annual Operating and Maintenance Cost		
	Pollution Reduction ('000 PHP)		
A. Biogas Project			
A.1 Backyard ^a	358	-	-
A.2 Commercial	116	464	928
B. Organic Fertilizer/Pelleting Plant	892	3,570	7,140

^a For a 6.3% reduction in pollution, 77 plugflow biogas modules will be needed. On the assumption of twin-sharing of biogas systems among backyard raisers, 154 farms shall be involved and waste will be generated by about 1848 heads. This number approximates the total population of backyard hogs in Majayjay. Thus, backyard biogas options for 25% and 50% pollution reduction were not considered anymore.

Compared to investment costs, lesser capital is necessary in operating and maintaining the biogas project at both backyard and commercial modes. At a targeted 6.3% pollution reduction scale, annual operating and maintenance costs amount to PHP358,000 for the backyard biogas project whereas its commercial counterpart requires PHP116,000. To explain the large difference in O&M between modes, it has to be recalled that there are 77 backyard biogas modules as compared to only 15 commercial biogas modules in order to achieve a 6.3% pollution reduction target. On the other hand, periodic expenses for the operation of the organic fertilizer/pelleting plant for a 6.3% pollution abatement are much higher at around PHP900,000 per year. Since linearity is assumed across pollution control targets, the O&M costs will increase four times and eight times as much for 25% and 50% targets, respectively.

Calculations of discounted measures of project worth reveal the projects' acceptability, regardless of type and mode. All the control options are economically viable. In terms of NPV, the economic returns are all positive although moderate to sharp variations can be noted across options and modes. In the case of biogas, the commercial mode shows slight superiority over the backyard mode as shown by their respective returns of about PHP 1.9 M and PHP1.4 M under a 6.3% pollution reduction target (Table 13). The organic fertilizer/pelleting plant yielded much lower NPVs, registering only about one-fourth of the values for the commercial biogas project. Comparing the pollution control options, biogas is more preferred than the organic fertilizer/pelleting plant.

Table 13. Economic analysis: NPV, BCR and EIRR of pollution control options for hog waste.

Option	NPV @10% ('000 PHP) Pollution Reduction			BCR	EIRR
	6.3%	25%	50%		
A. Biogas Project					
A.1 Backyard	1,379	-	-	1.45	56%
A.2 Commercial	1,876	7,504	15,008	1.74	64%
B. Organic Fertilizer/ Pelleting Plant	461	1,844	3,688	1.12	66%

With respect to EIRRs, all of the control options yielded values way above the discount rates of 10%. The same EIRR values can be expected across all pollution reduction rates since linearity in the costs and benefits were assumed in all options.

As explained earlier, sensitivity analyses were likewise carried to evaluate the acceptability of the projects under different environments. It should be pointed out that the same scenarios used in the financial analysis were adopted in the economic analysis except for the shadow pricing. In order to take account also of the uncertainty in the financial market, sensitivity analysis were subjected to a discount rate of 10%. As shown in Table 14, both the biogas and organic fertilizer/pelleting plant projects remain acceptable given all of the scenarios.

From all indications, it could be deduced that the biogas project is superior than the organic fertilizer/pelleting plant as a pollution reduction measure.

It ought to be pointed out, however, that the economic analysis that has been done in this study is essentially only a partial analysis since there are still some other potential health and environmental impacts of the pollution control options which have not been valued. For one, the analysis has been limited by the difficulty of monetizing the health benefits from reduced air pollution if control options are implemented. Second, the improved soil productivity due to the application of the sludge (as soil conditioner) from biogas operation cannot be easily determined and quantified given the technical data limitations. Third, the benefits from improved productivity of affected water bodies on-site and downstream from significant reduction (via biogas option) or zero discharge (via pelleting plant option) of hog waste is recognized but again, the quantification of such benefits proved to be quite tedious and difficult to obtain.

Table 14. Economic Analysis: Summary of sensitivity analysis of pollution control options for hog waste.

Scenario	Option	NPV @10% ('000 PHP) Pollution Reduction			BCR	EIRR
		6.3%	25%	50%		
<i>1. Base Case</i>	A. Biogas Project					
	A.1 Backyard	1,379	-	-	1.45	56%
	A.2 Commercial	1,876	7,504	15,008	1.74	64%
	B. Organic Fertilizer/ Pelleting Plant	461	1,844	3,688	1.12	66%
<i>2. 10% Increase in O & M Cost</i>	A. Biogas Project					
	A.1 Backyard	1,243	-	-	1.39	51%
	A.2 Commercial	1,833	7,332	14,664	1.71	63%
	B. Organic Fertilizer/ Pelleting Plant	122	488	976	1.03	22%
<i>3. 10% Increase in Investment Cost</i>	A. Biogas Project					
	A.1 Backyard	1,211	-	-	1.38	46%
	A.2 Commercial	1,668	6,672	13,344	1.61	52%
	B. Organic Fertilizer/ Pelleting Plant	415	1660	3320	1.11	54%
<i>4. 10% Increase in Investment and O & M Cost</i>	A. Biogas Project					
	A.1 Backyard	1,075	-	-	1.32	41%
	A.2 Commercial	1,624	6,496	12,992	1.58	51%
	B. Organic Fertilizer/ Pelleting Plant	77	308	616	1.02	17%
<i>5. 10% Decrease in Production Capacity</i>	A. Biogas Project					
	A.1 Backyard	977	-	-	1.32	41%
	A.2 Commercial	1,476	5,904	11,808	1.58	50%
	B. Organic Fertilizer/ Pelleting Plant	46	184	368	1.01	14%

Other external economies arise from biogas production which have likewise not been quantified. For one, biogas from hog waste is a good substitute for conventional fuels like firewood and thus, would be environment-friendly as it will slow down, if not prevent, soil erosion and deforestation. (An economic cost, however, is the possibility of lower incomes for owners of "traditionally traded energy sources".) It is time-saving as well since rural households, in particular, will not be spending too much time gathering wood or cleaning dirty pots and pans. Biogas as a "decentralized" source of energy is also beneficial in the sense that it reduces cost for, say, electricity, and energy is provided minus the distorted prices arising from imperfect competition. In relation to this, assuming nationwide adoption of biogas, there is also the benefit of reducing dependency on imported petroleum which then translates into foreign exchange savings.

Such unmonetized benefits are very likely to improve the economic analysis on net present values of the control options. However, unless monetary values are attached to these benefits it is not certain whether the commercial biogas option will still maintain its "superiority" over the backyard biogas option and organic fertilizer plant with respect to generating the highest NPV.

6.0 POLICY AND INSTITUTIONAL OPTIONS²³

Theoretically, market-based instruments such as pollution taxes, user fees or pricing water properly can be used to discourage hog raisers from using more wastewater than necessary. This, then, could induce them to adopt the wastewater minimization measures being proposed prior to waste treatment. Currently, people in the municipality are charged a very minimal rate of PHP10 per month for any level of water consumption because water comes from springs. There are no water meters at all in the municipality. Thus, hog raisers have minimal consciousness, if none at all, to be wise in water usage. But if the price of water were to increase to reflect its true market value, then, *ceteris paribus*, demand for water will fall because hog raisers will tend to economize. As a consequence, the volume of wastewater will also fall thereby making pollution reduction more manageable. However, this policy option could be met initially with vehement objection not only from hog raisers but also from the constituents because the issue of a virtually free water resource will likely be raised. A very recent experience of the Laguna Lake Development Authority²⁴ involved charging a fee of PHP1.00 per day for solid waste collection in an effort to clean up the rivers. To their surprise, people rejected the proposed fee and bargained instead for a mere PHP0.50 per day charge! Thus, it will take a strong and decisive political will to encourage conservation of water.

An alternative strategy would be to continue with the Information and Education Campaign (IEC) that this project team has already initiated. It has been observed that people's awareness on the negative environmental and health effects of pig waste was heightened during the sessions conducted in the municipality²⁵. With considerable effort for *follow-through* on the part of the

²³ A link with the LLDA has been established since the presentation of options to various groups. LLDA is also interested in reducing pollution from pig waste. While they have initially started with solid waste management in an attempt to clean up the rivers, they also believe that something has to be done to control the harmful environmental effects of untreated/ill disposed pig waste. They are glad that the team has made the initial efforts.

²⁴ Personal interview with LLDA Community Development Division Chief, Mr. Jose K. Cariño.

²⁵ In fact, a backyard and a commercial raiser asked the waste management consultant of this project to visit their respective farms and sought his advice on biogas installation and construction of lagoons as well as adoption of certain wastewater minimization options.

local government unit to further convince raisers that environmental quality will improve when pollution control options are adopted, raisers can be encouraged, in the short run, to follow the relatively cheaper wastewater minimization schemes that they prefer. In addition, since *waste reduction from the source* is a must before moving to the treatment options, the municipal council can, in fact, issue an ordinance to this effect and enforce it *with conviction*. Raisers will not really be too burdened with the costs since their net income from hog raising will allow them to purchase the needed devices. Moreover, it may also be "imposed" on hog raisers as a way of making them internalize the cost of the externality from hog production.

Regarding the commercial biogas system, which proved to be the best option for pollution control, the local government unit can also pave the way for indirectly subsidizing this project (e.g. through low interest credit schemes) since investment costs are high but environmental benefits will tend to outweigh the costs especially in the long run. Backyard raisers, in particular, can also take advantage of cost-sharing (e.g., 2 hog raisers to one digester). Once more, the local government unit can tap the assistance of the LLDA. At the time that the team presented the options to the raisers, representatives from LLDA were also present. The LLDA is now promoting low-cost biogas digesters (i.e., TPED or tubular polyethylene digesters) to backyard hog farmers in various parts of Laguna to enable them to treat their waste but LLDA needs volunteer raisers. Demonstration projects like these are quite important in convincing target clientele to adopt proposed technologies. It has to be mentioned here that some raisers have tried using the biogas system in the past but because of insufficient training regarding its operation and maintenance, and perhaps, compounded by the lack of follow-through or monitoring from the previous proponents, the biogas digesters eventually malfunctioned and the raisers simply disregarded the technology despite its potential benefits.

As for the organic fertilizer/pelleting plant, it will help if hog raisers organize themselves formally to enable them to have a collective representation on decisions on how to go about this option. Since investment cost for the plant is very huge, the local government can consider subsidizing the cost of the plant²⁶(which could probably be done by donating available municipal land for the required space, or by financing). Revenues can then be shared. Institutional networking for sourcing of funds (e.g. with LLDA) can likewise be resorted to since LLDA is also interested in reducing pollution from pig waste as part of its river rehabilitation program. Part of the institutional networking could also involve creating new and maintaining existing markets for pelletized fertilizer in the neighboring communities. On the other hand, private firms or potential

²⁶ One of the members of the Municipal Council commented during our presentation that there are some municipal funds available for such a project.

investors can also be tapped to engage in this endeavor since the project is both financially and economically viable. An alternative can also be to pressure large and medium scale commercial hog farms to combine their resources and put up the pelleting plant themselves since a large extent of the surface water and air pollution come from their hog farms. Besides, since collection costs are high, it seems practical to use the waste from commercial farms for the pelleting plant instead of collecting the waste from backyard farms. This will then allow commercial farms to cut on this specific cost and likewise avoid the cost of giving monetary incentives to raisers for their dry waste.

Where suitable lands are available, lagoons can always be an option. About 60 percent of hog raisers in Majayjay are said to possess lands where lagoons can be dug. Based on team's dialogue with raisers, this appears to be a treatment option that raisers are interested in despite the fact that lagoons do not provide any financial returns for them. They can, however, reduce their costs by sharing lagoons. Based on the cost and returns analyses, most commercial raisers can afford to put up lagoons. As such, the local government unit can very well encourage their construction on *suitable* lands. However, raisers must be well-advised technically about the construction and regular monitoring of lagoons to avoid adverse environmental and health impacts as cited previously.

In an interview with the Mayor, it was revealed that there is a land use plan for Majayjay that is awaiting approval. If and when the land use plan gets approved, the zoning clause on moving out old piggeries from the town center and establishing new ones away from designated residential areas will certainly help in reducing air pollution. Nevertheless, wastewater minimization and treatment options ought to be encouraged as well to significantly reduce water pollution.

Another policy option that could encourage raisers to adopt pollution abatement technologies is to provide tax incentives to those raisers who adopt wastewater minimization measures or install treatment facilities such as biogas systems, lagoons or organic fertilizer plants.

As of this writing, the LLDA has already sponsored a symposium on waste minimization and treatment technologies for hog waste. The flowchart on pollution control options presented in earlier sections of this study has been disseminated to the raisers with certain additions/modifications. Shortly after that symposium, LLDA has started getting samples of wastewater from hog farms and subjecting these to laboratory tests to determine whether the set standards for effluent discharge are met. Some hog farms have already been issued notices of violation and the fees imposed by LLDA are quite prohibitive.

Avoidance of such environmental user fees²⁷ should already serve as an incentive for the adoption of wastewater minimization and waste treatment options considering that both in the short run and in the long run, these fees are relatively higher than the abatement costs.

7.0 FROM MAJAYJAY TO LAGUNA DE BAY: WHAT HAVE WE LEARNED?

Taking Majayjay as a case in point, we have seen that the establishment of piggeries, especially within residential areas and critical watersheds, creates environmental and health problems.

The fact that piggeries, not only in Majayjay, but in other parts of Laguna and the country as well²⁸, coexist with human shelter and population could well be a reflection of the local government's inability to either create an ordinance prohibiting such or implement and enforce existing ones.

Laguna de Bay, insofar as it is being considered a potential source of drinking water in the future, notwithstanding the current economic benefits derived from it, will certainly improve its ambient quality if pollution load from hog farms that discharge their waste indiscriminately into the bay's tributaries is greatly reduced. According to the BAS, as of 1999, there are approximately 220,000 heads of pigs in the province of Laguna alone. Assuming all wastewater from pig pens in Laguna discharge eventually into Laguna de Bay, and with an average of 1.65 kg manure per head (sow) per day, there is an estimated pollution loading into the Laguna Lake of 363 tons of manure per day or 132,500 tons of manure per year from hog farms alone. If left unabated, the level

²⁷ From the team's viewpoint, such fees charged by LLDA are rather high especially for backyard raisers. For instance, the fixed cost of about PHP5,000 for every sample of those who discharge 0 -30 cu.m./day of wastewater (backyard farms fall under this category) seems quite prohibitive. Furthermore, the PHP1,000 penalty for each day that the effluent standards are not met from the day of sampling seem to be exorbitant considering that relative to the present state of technology for waste treatment in Majayjay (or the absence of it), the standards are already too stringent .

²⁸ The team made a trip to Batangas, a province in Southern Tagalog, to visit a multi-purpose cooperative that provides contract-growing to commercial and backyard hog farms. As of this writing, it has not come up with waste treatment facilities for either backyard or commercial contract farms. Waste is dumped directly into rivers and creeks. Another trip was also made to inquire about the status of a 1997 IMO research recommendation for the establishment of an agricultural waste management system for the Batangas Bay Region. Unfortunately, according to Ms. Sollestre, of the Batangas PENRO Office, no such project has been put up yet.

The Tarlac experience (outright pollution of Benig River) also attests to the inability of local government units or DENR to require concerned establishments to secure environmental certificates of compliance and impose penalties on violators.

of BOD that gets into the lake each year from piggeries in Laguna is about 913 tons. This is based on the assumption of 325 mg/liter BOD concentration (from wastewater) and 35 liters of water consumption in pig farms per day. In addition, zero growth rate in hog population is also assumed. However, in the last 10 years, statistics show that for the province of Laguna, the hog population grew at a simple annual rate of about 3.48%²⁹. Hence, total hog population in Laguna will reach up to 320,500 by year 2010 and 450,000 by year 2020. These figures translate into 1,330 tons of BOD/year ten years from now, and 1,870 tons BOD/year 20 years from now, *ceteris paribus*.

It is recognized that this animal population will increase in the years to come because hog raising is an important economic activity and a primary or secondary source of income for many. Food security in pork production has to be considered as well. However, it is also recognized that with the increase in hog population, the probability of exacerbating air and water pollution associated with increased generation of untreated waste will also rise. Hence, the issue is not so much in reducing hog population to non-polluting levels as making sure that wastewater minimization and/or waste treatment options across production scales are widely adopted.

For certain, there are a whole range of other control options that hog raisers not only in Majayjay can choose from besides biogas and organic fertilizer pellets. Somewhere in the literature (Delgado, et. al, 1999), the importance of efficiency in hog feed digestion was underscored in order to minimize animal waste generation. If this technology is perfected and widely commercialized, then it could very well be a potential hog waste pollution control alternative.

In the meantime, this study has shown the potentials and economic viability of biogas technology and organic fertilizer pelleting plant as pollution control options with commercial biogas system yielding the highest NPV. However, in light of the relatively large investment and operating and maintenance costs of the said options (particularly for backyard hog raisers), the wastewater minimization techniques can be adopted as an immediate or short-run measure toward pollution abatement. On the other hand, the results of the financial and economic analyses would warrant investors - perhaps, a public-private sector consortium - to purchase the waste and put up consolidated facilities for dealing with the waste. In this regard, local government units, other entities and institutions and even the communities concerned have an immensely important role to play toward making this public-private venture a reality.

²⁹ This is using 1990-1999 data on hog population for Laguna, BAS.

8.0 SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

This study examined the environmental, health and other effects of hog waste. Foremost of these environmental effects are air pollution from foul odors as well as greenhouse gas emissions. Surface water and groundwater contamination also result from waste spills and lagoon leaks. On the other hand, respiratory and gastrointestinal ailments, among many others, are related health effects. Other effects of uncontrolled or improperly treated hog waste also include losses in property and tourism values.

The study site is in Majayjay, Laguna, where hog-raising is the most important economic activity next to rice farming. Backyard (those raising less than 20 heads) and commercial hog farms were surveyed regarding their waste disposal/treatment practices. It was found out that more than 80% of the raisers do not have any treatment facilities at all, and in fact, dump their waste directly into rivers and creeks that are tributaries of the Laguna de Bay.

Households of swine raisers, households near pig farms and the older citizens of the municipality were also surveyed. All groups perceive that the growing human population, the tremendous proliferation of piggeries and the incessant indiscriminate dumping of hog waste have led to the deterioration of the quality and loss in productivity of affected rivers and creeks. Moreover, most of the health effects mentioned in the literature have been confirmed empirically in the survey.

An evaluation of the characteristics of wastewater from hog farms and affected surface waters revealed that these do not pass the standards set by the Department of Environment and Natural Resources even for Class C waters except for the one coming from upstream. Thus, it is quite important that waste coming from piggeries not only in Majayjay but in all municipalities in Laguna as well be treated prior to disposal since Laguna de Bay (where all wastewater eventually settle) is being eyed as a possible source of drinking water in the future.

Pollution control options for hog waste were evaluated at 6.3%, 25% and 50% reduction targets. These targets were largely based on the likely number of hog raisers that will adopt or comply with the proposed pollution abatement technologies. On the basis of being pragmatic, the relative affordability of the options was also considered. Results of the financial and economic analyses showed that all control options (biogas for commercial and backyard modes and organic fertilizer/pelleting plant) are viable with the commercial biogas system yielding the highest NPV.

Sensitivity analyses were likewise carried out to evaluate the acceptability of the projects under different environments. The same scenarios used in the financial analysis were adopted in the economic analysis except for the shadow pricing. In order to take account also of the uncertainty in the financial market, sensitivity analyses were subjected to a discount rate of 10%. Both the biogas and organic fertilizer/pelleting plant projects remain acceptable given all of the scenarios. From all indications, it could be deduced that the biogas project, particularly at the commercial scale, is superior than the organic fertilizer/pelleting plant as a pollution reduction measure.

The use of biogas or pelletized organic fertilizer, while shown to generate high economic returns, still has to be "promoted" since hog raisers and even households, particularly in developing countries like the Philippines, have to be convinced of their profitability via actual demonstrations. In developed countries, it is already quite common to see firms or farms feed surplus electric energy produced by biogas-driven generators in the grid. The slurry from biogas as fertilizer is also easily marketable since it can be transported with ease and at reasonable cost. Moreover, waste and wastewater treatment regulations are strictly enforced in such countries; hence, farmers are bound to adopt technologies that will cut on their costs or fees. In the Philippines, there has been empirical evidence regarding the difficulty, or to a certain extent, resistance of farmers to switch from traditional practices to new technologies. This particular behavior can be traced to the asymmetry of information between the project and target clientele and this tends to lead to the non-acceptance of the proposed technology. An intensive education campaign (coupled with demonstrations) which can, therefore, bridge this information gap, is an imperative.

There are other economic benefits from using the biogas technology but it is quite unfortunate that until now, its use has not been commercialized nor widely adopted in the country³⁰. Monetizing such benefits has not been easy (and hence, have not been included in the benefit-cost analysis of this study) but suffice it to say that there are external economies arising from biogas production. For one, biogas from hog waste is a good substitute for conventional fuels like firewood and thus, would be environment-friendly as it will slow down, if not prevent, soil erosion and deforestation. (An economic cost, however, is the possibility of lower incomes for owners of "traditionally traded energy sources".) It is time-saving as well since rural households, in particular, will not be spending too much time gathering wood or cleaning dirty pots and pans. Biogas as a "decentralized" source of energy is also beneficial in the sense that it

³⁰ A few large commercial hog farms in the provinces of Laguna, Batangas and Rizal are actually using biogas digesters and they have testified to the cost savings in energy consumption. However, they also attest to the huge amount of initial investment needed to put up the digesters which do serve as a constraint for other farms to follow suit.

reduces cost for, say, electricity, and energy is provided minus the distorted prices arising from imperfect competition. In relation to this, assuming nationwide adoption of biogas, there is also the benefit of reducing dependency on imported petroleum which then translates into foreign exchange savings.

What policy options then are available to encourage adoption of the abatement technologies? Efficient pricing of water could be resorted to reflect its true economic value and consequently force hog raisers to significantly reduce the amount of wastewater. This is tantamount to adopting the proposed wastewater minimization techniques. A lesser volume of wastewater would also mean more manageable pollution reduction.

Another policy option is to subsidize the investment cost of the control options through more affordable credit schemes or outright donation or lease of unused alienable and disposable public lands (at minimum rent) on which to build the biogas or pelleting plant(s). In lieu of credit or investment subsidies, local government units can perhaps give tax incentives to raisers who adopt pollution abatement technologies.

Since the LLDA has already initiated the charging of environmental user fees to polluting firms in the course of rehabilitating the Laguna Lake, and has likewise started issuing notices of violations to hog farms whose wastewater samples did not pass the relatively stringent standards on effluents, it can probably continue doing this although the research team still believes that there is some merit in reevaluating the set standards and aim for a higher probability of compliance. On the other hand, the user fees can then be channeled back to the community by installing communal waste treatment facilities.

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