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Review of Aquaculture Practices and Anthropogenic Activities in Manila Bay Aquaculture Farms

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Abstract

Environmental problems arising from aquaculture activities have been a concern worldwide, especially in Manila Bay. Thus, this study was implemented to identify the aquaculture practices of fish farmers and assess whether these practices are in accordance with the good aquaculture practices (GAqP) guidelines. Information was collected through survey and interview of fishpond operators from provinces around the bay. The study found that most fish farmers around the Bay do not observe the guidelines on GAqP evidenced by their high non-compliance with buffer zone, lack or utilization of improper water quality monitoring methods, non-implementation of important steps in pond preparation (e.g. soil testing), and application of illegal and noxious chemicals (e.g. cyanide). The calculated FCR, DMR and WPR in selected farms greatly varied. Farmers domesticated and/or allowed wading of animals on pond embankments predisposing contamination of both water and culture species. Anthropogenic activities such as sewage and garbage disposal, industry, and agriculture possibly added to deterioration of water quality in the fish ponds. On the other hand, notable practices were also observed in the areas such as the adoption of polyculture and semi-intensive fish farming methods, and the stocking of seeds from hatcheries.

Keywords: aquaculture, GAqP, anthropogenic activities, Manila Bay

Introduction

Aquaculture in the Philippines is believed to have started as early as the 14th century and involved the culture of several finfish and invertebrate species employing different farming practices applied in diverse ecosystems. Since 1976, production from aquaculture has been continuously augmenting compensating the unstable and plateauing fish supply from capture fisheries (BFAR, 2005; 2013). It has started to surpass the production of municipal and commercial fishery sectors since 1996. According to statistical data, production in 2003 corresponding to 1, 454, 503 MT rose to 2, 541, 965 MT in 2012, giving an increase equivalent to roughly 57% in just a decade (Lopez, 2006; BFAR, 2012). In 2013, aquaculture production was approximately 2, 373, 386 MT or 50.46% of the total fisheries production of the country (BFAR, 2013).

The sustained increments in aquaculture production have benefitted the country, especially the low income consumers, who continue to subsist on fish as a major protein source. Aquaculture adequately provides the supply needs of both local and international markets. In fact, approximately 18% of the food fish supply currently comes from aquaculture (PHILMINAQ, 2008). Commercially viable businesses have also been opened in the country ranging from small-scale wet market trading to large scale fish processing plants. With these businesses, employment has been generated especially in rural areas where work opportunities are scarce. According to the 2002 Census of the National Statistics Office (NSO), 226,195 individuals are directly employed in the aquaculture sector (BFAR, 2013). However, the industry estimates employment generation to be higher since the Seaweed Industry Association of the Philippines (SIAP) claims that in 2002, around 1, 017, 925 individuals are engaged in the seaweed industry alone (Monzales, 2003). In addition, the national fish export of the country has increased. BFAR data of 2013 showed that there was a 101% increase in the fishery export volume of the country, as seen in the comparison of volumes produced from 2012 to 2013 (165, 324 vs. 333, 465 MT). The difference is attributed to the increase in seaweeds and shrimp/prawn production, which mainly come from the aquaculture sector. Seaweeds ranked 2nd in terms of export value with a 64% increase from US $185.6 million in 2012 to US $218.7 million in 2013. On the other hand, shrimp/prawn ranked 3rd in 2013 with a total contribution of US $67.5 million to the total export value, or 55% higher than 2012’s export earnings of US $37.3 million (BFAR, 2013).

In an effort to optimize benefits from aquaculture, several laws and administrative orders were passed. For example, to further boost aquaculture production, Presidential Decree (P.D.) 704 of 1975 provides for the (a) establishment of fish hatcheries, nurseries, and demonstration fishponds; (b) conduct of experiments and technical demonstrations on the culture of fishery products; and (c) issuance of Fishpond Lease Agreements (FLAs) and permits to operate fish pens and set aside public lands to be subdivided into family-sized fishponds for leasing. The conversion of mangrove areas to fishponds was legalized thru P.D. 705, which stipulates that suitable mangrove areas for fishpond purposes be placed under the administrative jurisdiction of the Bureau of Fisheries and Aquatic Resources (BFAR). Meanwhile, in 1991, the cutting of any mangrove species was prohibited by virtue of Republic Act (R.A.) 7161. Moreover, BFAR Fisheries Administrative Order (FAO) 125 converted fishpond lease agreements from 10 years to 25 years.

Several environmental risks and hazards of aquaculture have been identified as follows: (1) biological pollution or the release of non-endemic species into the water bodies; (2) habitat modification, which happens when aquaculture activities alter landscapes of aquatic systems resulting in habitat destruction and loss of biodiversity; (3) chemical; and (4) organic pollution mainly from the different inputs during the aquaculture activities (Erondu & Anyanwu, 2005). The expansion of the aquaculture sector in the country therefore has not been without problems. Environmental problems arising from aquaculture activities have been a major concern in different areas in the country, including the Manila Bay area.

Manila Bay is an important water resource in the country as it is used for various purposes including aquaculture, which accounts for as much as 59% of the total economic value of the bay (PEAMSEA, 2006). This becomes more and more evident as fishponds, fish pens, and shellfish pens continue to proliferate along provinces surrounding the bay namely Bulacan, Bataan Pampanga, Cavite, and the northern Metro Manila coastlines, which cover an aquaculture area of almost 60,000 hectares (Perez *et al*, 1999).

Several reports on the possible harmful environmental effects of aquaculture in the bay have been released. In July 2013, for instance, the Philippine Daily Inquirer reported on the biological pollution of an exotic species of tilapia, also known as *tilapiang Gloria* or black chin tilapia (*Sarotherodon melanotheron*) in Bataan. It was believed that the species was introduced into the aquaculture areas of Bataan several years ago. In addition, approximately 63.6% of mangrove loss from 1995 to 2006 was primarily attributed to the rampant conversion of mangrove swamps into aquaculture areas (PEMSEA, 2006). This is probably one of the reasons for the decline in the catch of wild shrimps and crabs in the rivers around the area. Chang *et al* (2009), also reported that Manila Bay is highly eutrophic due to organic pollution that yield nutrients like nitrogen. Mendoza (unpublished data, 2010) also observed that heavy metals such as As, Cd, Cu, Mn, Ni, Zn, Pb, Cr, and Hg have been detected in milkfish, tilapia, prawns, green mussel, clam *"paros"*, and oysters collected from fishponds in Bulacan.

Cognizant of the environmental problems emanating from aquaculture activities and in an attempt to address and limit these problems, BFAR issued FAO[1] 214 or the Code of Practice for Aquaculture (BFAR, 2001), in response to Section 47 of R.A. 8550 (as amended by RA 10654). The code outlines the general principles and guidelines for environmentally-sound design and operation for the sustainable development of the aquaculture industry. The Code of Good Aquaculture Practices (GAqp) released by the Philippine National Standard – Bureau of Agriculture and Fisheries Standards (PNS-BAFS, 2014), on the other hand, aims to minimize aquaculture risks.

It is against this backdrop that this study was implemented to generally identify fish farming practices employed by pond owners and assess whether or not these are in accordance with the guidelines on good aquaculture practices. Aquaculture ecological indicators such as feed conversion ratio (FCR), dry matter ratio (DMR), and waste production ratio (WPR), were also estimated. Possible support and interventions to enhance the adoption of good aquaculture practices among pond operators in and around Manila Bay were also recommended.

Methodology

Sampling Scheme

Sampling of the different aquafarms in provinces around Manila Bay followed a blocking strategy since Manila Bay is an estuary with a gradient of anthropogenically modified environments. Block 1 is Eastern Bulacan nearest to the National Capital Region. It is hypothesized to have more contamination. Block 2 is Western Bulacan with Angat River and Pampanga River delta. Block 3 is Northern Bataan, adjacent to Pampanga River delta. Block 4 is Southern Bataan, towards the mouth of Manila Bay. Block 5 and Block 7 are in Cavite and Pampanga areas, respectively. Figure 2.1 shows the blocking scheme and the number and location of different sampling sites in each block.

The number of sampling sites per municipality was computed using the confidence interval method expressed as a precision for small samples (10% precision) based on the data on location provided by the LGUs. Using this approach, the total number of sites for the whole area was 160. Divided among 6 blocks, this gave 27 sites per block. Due to budgetary considerations, the minimum sampling size was set at 60% of the computed sampling size per block. This is equivalent to 16 minimum sampling sites per block. However, this

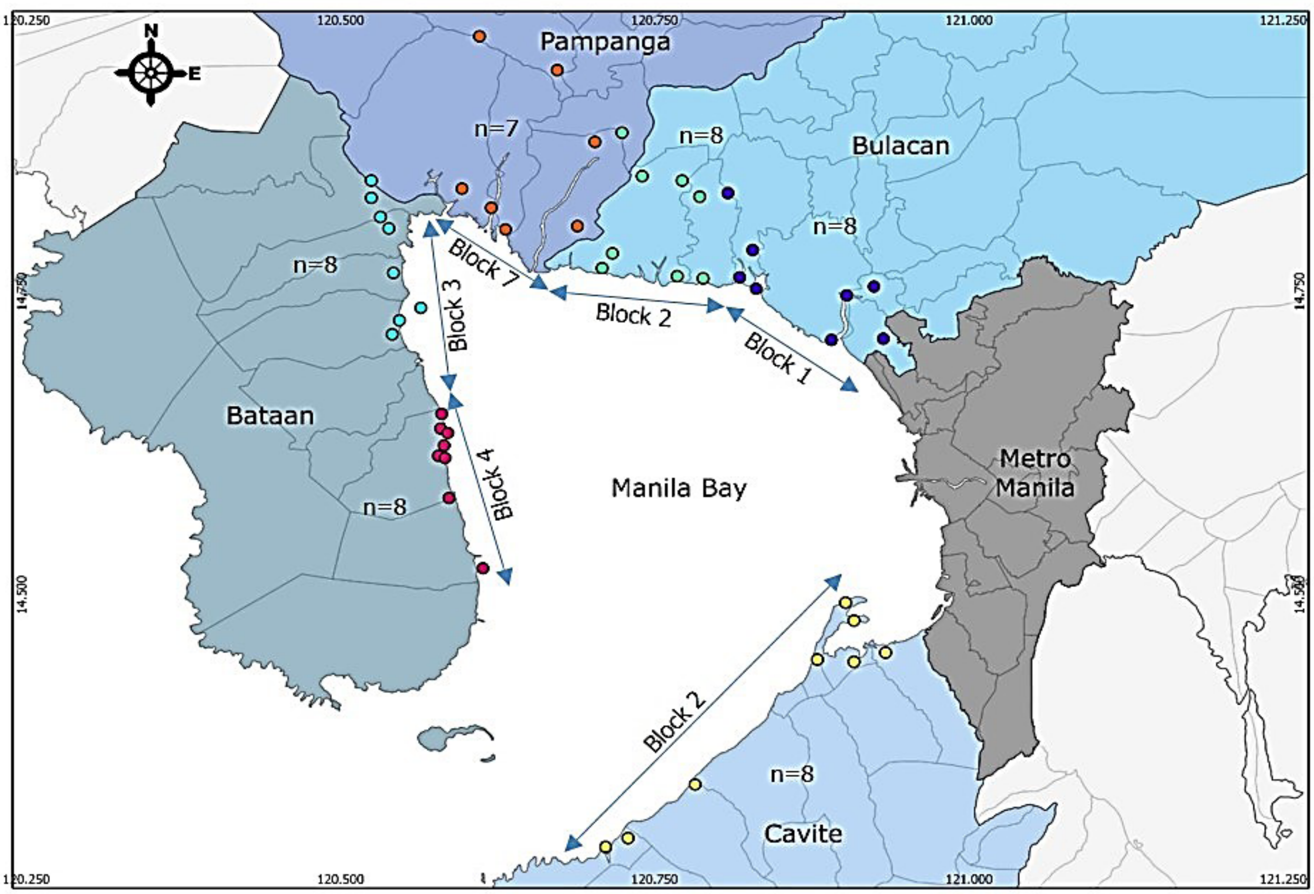

Figure 2.1. Blocking scheme and the number and location of sampling sites in each block.

was decreased or increased depending on the result of the preliminary sampling. The formula shown is used for the said method.

$$T = \frac{X - \mu}{\sqrt{S^2/n}} \cong \frac{\rho X}{\sqrt{S^2/n}}$$

$$n \cong \frac{T^2 S^2}{(\rho X)^2}$$

Where:

T = distribution probability (set at n-1 degrees of freedom);
p = precision estimate (set at 10%);
n = sample number; and
S^2 = variance

During the preliminary sampling, the laboratories were not able to process the load of samples from the 16 sampling sites within the holding time – 48 hours. Thus, the number of sampling sites was reduced to 7 – 8 sites per block. Based on statistical analyses, the reduced number of sites is sufficient to determine the differences in water quality parameters between blocks.

Information Collection and Respondents

A total of 47 sites were surveyed. There were eight sites in Blocks 1 to 5 and seven sites in Block 7. Each site considered one respondent. The sampling sites are listed in Table 2.1.

Information on (1) site and farm, (2) water quality management, (3) pond preparation activities, (4) culture species, (5) feeding management, and (6) other anthropological activities were obtained through personal interview of fishpond operators, owners, and/or caretakers. Information obtained during the interview and the site survey were recorded in the Aquafarm Information Sheet (Appendices A and B).

Results and Discussion

The most common approach to minimize the negative environmental impacts of aquaculture is by improving the production practices through a) the use of better management practices (BMPs), b) good aquaculture practices (GAqP), and c) responsible and sustainable aquaculture (IUCN, 2009, Boyd *et al*, 2007, Howerton, 2001). However, the assessment of aquaculture performance against these could be difficult due to the diversity of activities and potential impacts that also vary with area, culture facilities, and species (Boyd *et al*, 2007). Moreover, available guidelines are nonspecific and vague. In the study, there were issues met in securing comprehensive information on aquaculture practices observed by operators. And so to simplify matters, the study attempted to compare the common practices observed in the different aquafarms around Manila Bay with local and international principles and guidelines, as well as results of previous studies on responsible aquaculture.

Basic Farm Information

Three farm types were observed: fish pens, fishponds, and shellfish growing areas. Artificial earthen fishpond (74%) is the most widely operated type of farm in the different provinces around Manila Bay (Figure 2.2). Shellfish growing areas (19%) are also present in the different blocks, except in Pampanga. Fish pens (6%) made of net and wooden materials are present only in Eastern and Western Bulacan. Farms size ranged from 0.3 to 125 hectares.

Table 2.1. List of sampling area around Manila Bay.

Block 1 (Eastern Bulacan)			Block 2 (Western Bulacan)		
Code	**Barangay**	**Municipality**	**Code**	**Barangay**	**Municipality**
B1-01	Binuangan (Coastal)	Obando	B2-01	Masukol (Coastal)	Paombong
B1-02	Paliwas	Obando	B2-02	San Roque	Paombong
B1-03	Ubihan	Meycauayan	B2-03	Sta. Cruz	Paombong
B1-04	Matungao	Bulakan	B2-04	San Isidro II	Paombong
B1-05	Pamarawan (Coastal)	Malolos	B2-05	San Agustin	Hagonoy
B1-06	Pamarawan	Malolos	B2-06	Meyto	Calumpit
B1-07	Calero	Malolos	B2-07	San Roque (Coastal)	Hagonoy
B1-08	Tawiran	Obando	B2-08	San Roque	Hagonoy
Block 3 (Northern Bataan)			**Block 4 (Southern Bataan)**		
B3-01	Almacen	Hermosa	B4-01	Limay (Coastal)	Orion
B3-02	Palihan	Orani	B4-02	Camachile	Orion
B3-03	Kabalutan	Orani	B4-03	Camachile	Orion
B3-04	Samal (Coastal)	Samal	B4-04	Balut	Orion
B3-05	Ibaba	Samal	B4-05	Capunitan	Orion
B3-06	Capitangan	Abucay	B4-06	Camachile	Orion
B3-07	Highway	Orani	B4-07	Capunitan	Orion
B3-08	Wawa	Abucay	B4-08	Sta. Elena	Orion
Block 5 (Cavite)			**Block 7 (Pampanga)**		
B5-01	San Juan I	Ternate	B7-01	Bangkal Sinubli	Lubao
B5-02	Timalang Balsahan	Naic	B7-02	Sapang Kawayan	Masantol
B5-03	San Rafael 4	Noveleta	B7-03	Consuelo II	Macabebe
B5-04	Bacoor Bay (Coastal)	Cavite City	B7-04	Batang 2	Sasmuan
B5-05	Marulas	Kawit	B7-05	Bangkal Pugad	Lubao
B5-06	Bacoor Bay (Coastal)	Bacoor	B7-06	San Antonio	Guagua
B5-07	Mabolo II	Bacoor	B7-07	Mani-ano	Minalin
B5-08	Bucana (Coastal)	Ternate			

Brackish water fish farming is the most common type of farming employed. Salt water and freshwater are derived from the Manila Bay and the different river tributaries, respectively. However, 12.5% of the farms in Northern Bataan obtain freshwater from the ground because of inaccessibility of river tributaries.

Site Selection and Design

Studies have shown that inappropriate and unplanned siting of farms result in production failures as well as environmental degradation (Howerton, 2001). As indicated in Section 3 code of GAqP of the PNS-BAFS, farms should be in an environmentally suitable area where risks to food safety from chemical, biological, and physical hazards from air, soil, and water are minimized. Furthermore, aquafarms should be properly selected to avoid negative impacts on the environment (SEAFDEC, 2009). Proper location can be achieved by conducting an environmental impact assessment (EIA) prior to the construction and development of the farms (PNS-BAFS, 2014; BFAR, 2001). During the survey the farmers were not asked if they have had an EIA conducted prior to locating their farms. The researchers entertained skepticism in being shared this information by the farmers. From the look of things, it was just presumed that since most farms surveyed are not registered, it is likely their owners did not conduct any EIA before the ponds were constructed.

FAO[1] 214 requires the maintenance of buffer zones or the space between the aquacul-

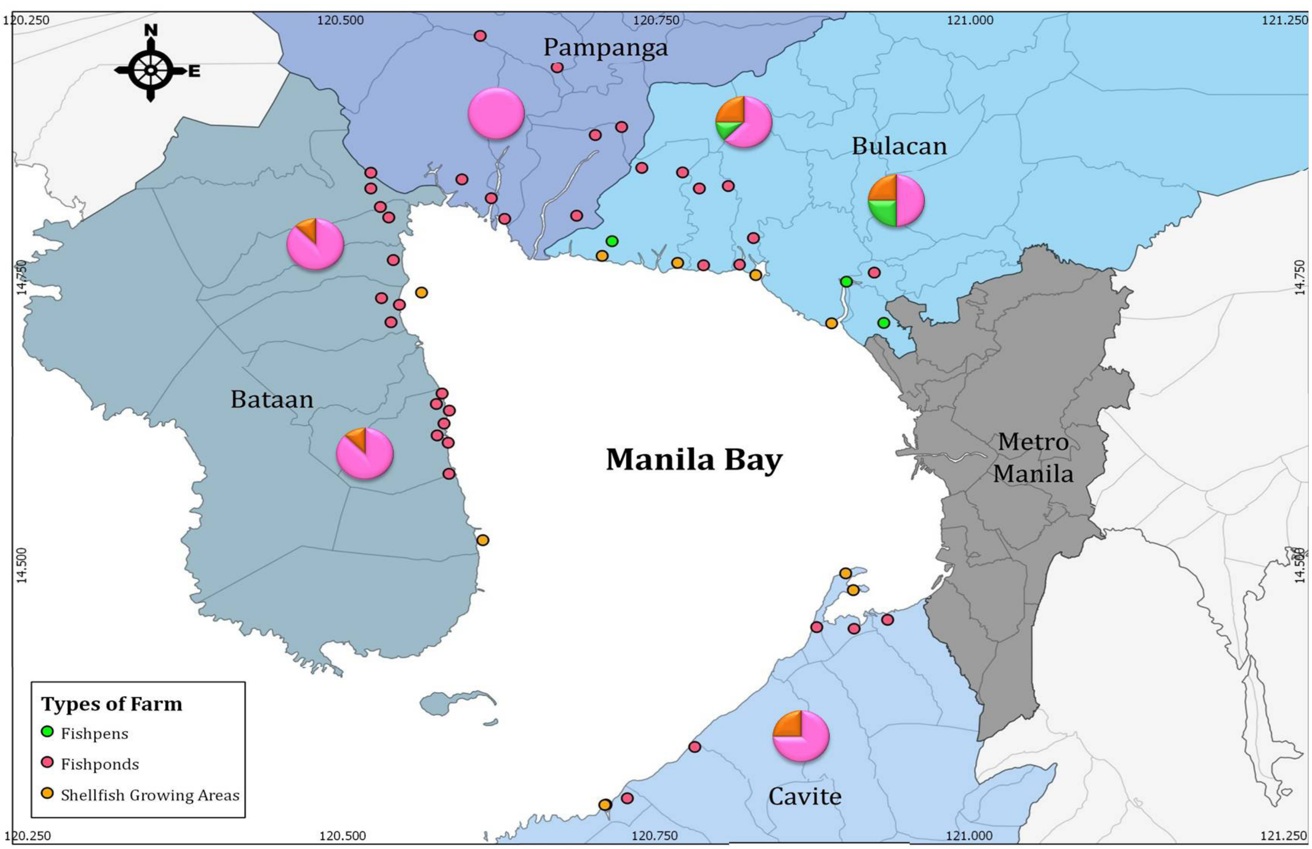

Figure 2.2. Map of the types of farms surveyed in the blocks (pie graph).

ture area and the sensitive ecosystems. These areas serve as environmental buffers to prevent direct settling of waste discharges such as uneaten food, fecal matter, chemical contaminants, and other effluents to the ecosystem (SEAFDEC, 2009; Ahmad *et al*, 2012). However, as seen in Figure 2.3, majority of the farmers do not have this system. Reasons include area constraints and costs associated with dike and canal constructions. Some areas were observed to share embankments with river bodies where water is obtained and discharged.

prevent aquaculture loss.

Section 6.2 of GAqP emphasizes the need for a regular and accurate water quality monitoring program to ensure that water parameters are within advisable limits (PNS-BAFS, 2014). Due to the lack of proper equipment, regular monitoring is not practiced or is incorrectly carried out by 37 - 100% of the pond owners from the different blocks (Figure 2.4). Furthermore, 20% and 100% of the farm ers in Eastern Bulacan and Northern Bataan, respectively, who checks the salinity of the

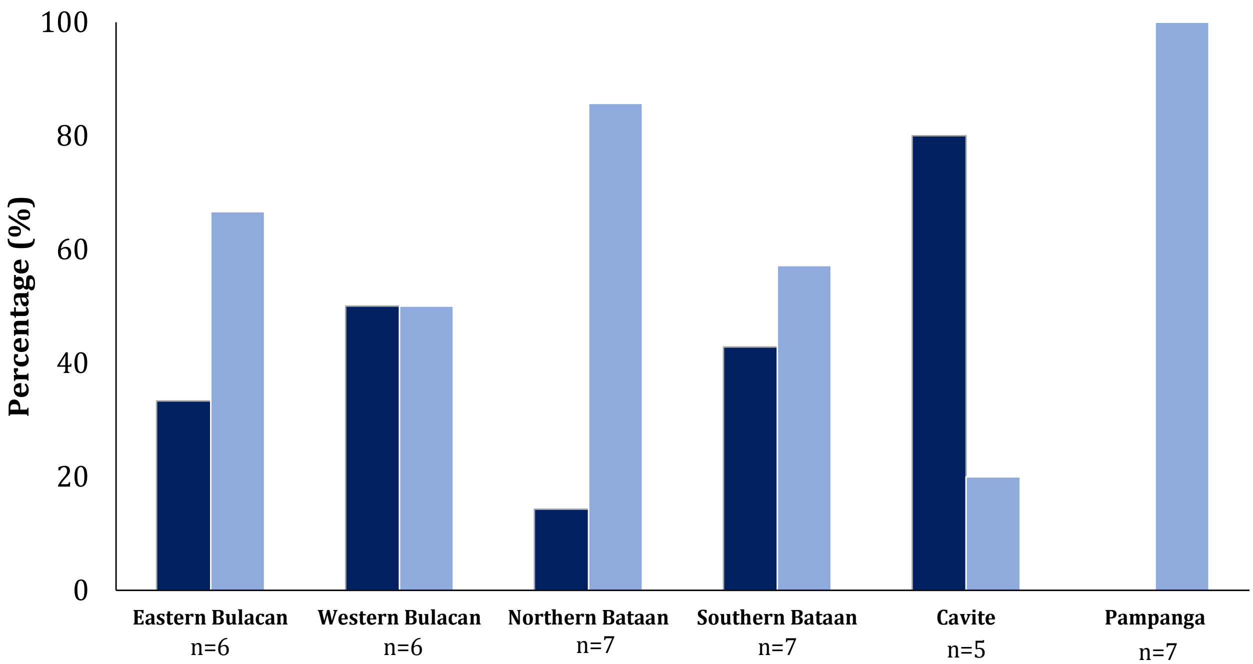

Figure 2.3. Percentage of pond owners that are compliant to proper buffer zone regulations.

Water Quality Management

Water in the aquafarm has a profound effect on the health and growth of the culture species (Howerton, 2001). The water quality may deteriorate considerably over the culture period due to several factors including inputs and weather conditions (Boyd & Tucker, 1998); thus, monitoring and control is necessary to

pond use practical but inaccurate techniques such as the "taste method". Only the intensive shrimp farm in Southern Bataan determines and records water quality parameters daily and tests for ammonia and nitrite concentrations as well as for water hardness twice a week. Twenty five per cent of the farmers in Cavite, on the other hand, depend on water monitoring assistance from the BFAR regional

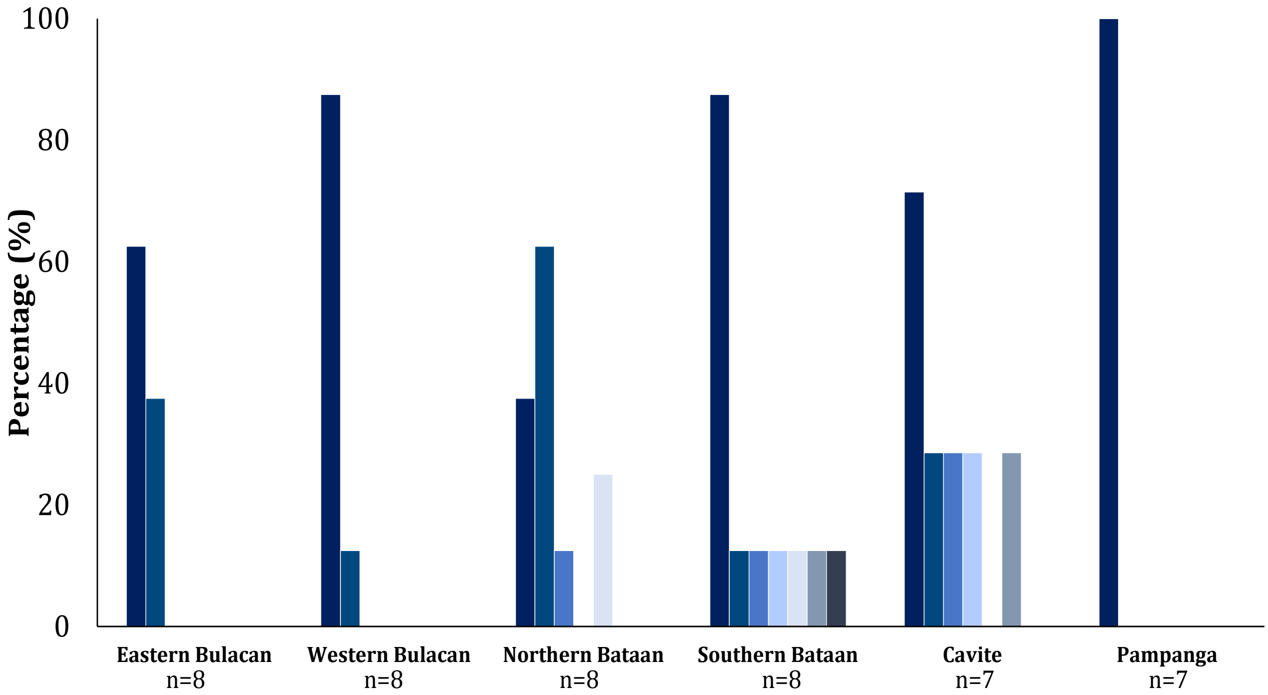

Figure 2.4. Percentage of pond owners that monitors selected water quality parameters: Not Monitoring Salinity pH Temperature Dissolved Oxygen Turbidity Others

office, which are conducted at random.

It was also noted that the primary means of farmers to improve water quality in the pond was through water exchange carried out by flushing nutrients and organic matter from the pond to the river tributaries. However, this practice tends to pollute receiving water bodies since large amounts of nutrients are discharged (Boyd, 2003b). Section 5 of FAO[1] 214 states that discharged water should meet water quality standards, which should be determined qualitatively and quantitatively. But, qualitative standard is relative as it is dependent on the judgment of the farmer and quantitative determination is hindered by the lack of proper equipment of the farmers.

Mechanical aeration can be an alternative option in improving water quality. Actually, it is more effective than water exchange in increasing pond production (Boyd *et al*, 2008). It also lessens the need for large amounts of water. However, mechanical aeration is not practiced by most of the farmers as it entails additional production cost. Only 13% of the farmer respondents in Northern and Southern Bataan use the spray type and paddle wheel aerators, respectively (Figure 2.5).

Another effective method of water quality improvement adopted by 25% of the farmers in Northern and Southern Bataan is the use of milkfish as biofilters or of organisms that ingest impurities from the water resulting in ponds that meet the required optimum physical and microbiological conditions for the cultured species (FAO[1] 214). Milkfish, being filter feeders, feed on the algae induced to grow by the accumulated nutrients coming from uneaten feeds. Presence of milkfish as biofilters somehow prevents algal blooms that

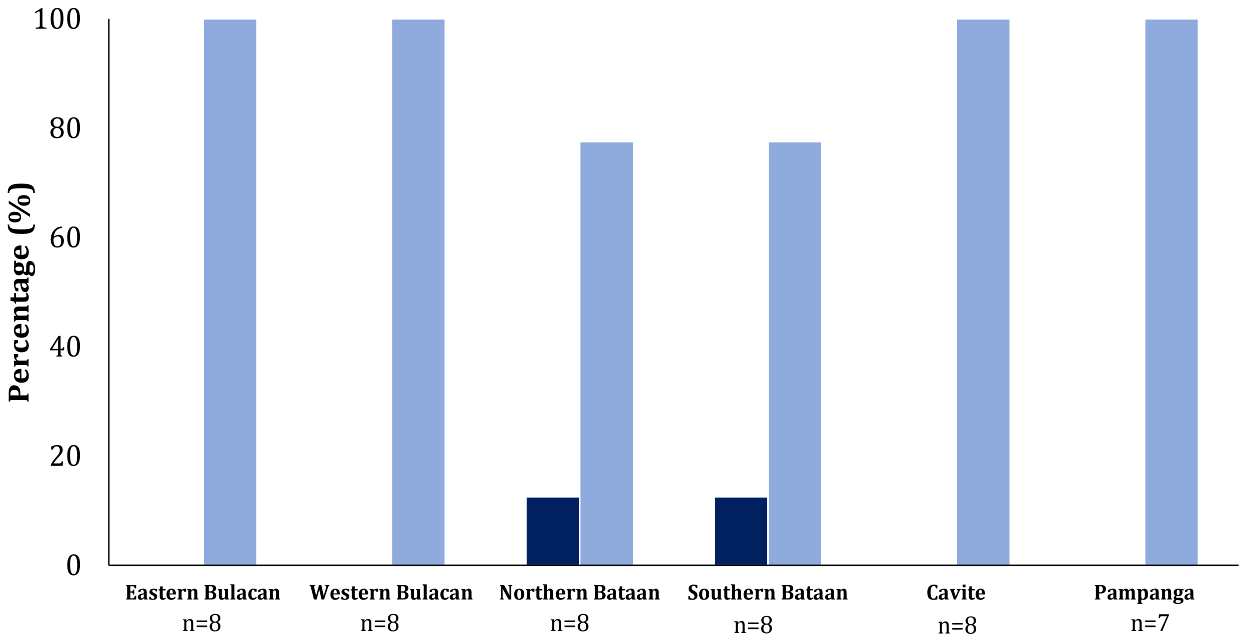

Figure 2.5. Percentage of pond owners that employ aeration system to improve water quality.

eventually die-off and deplete the dissolved oxygen resulting in a fish kill. This method of using milkfish as a biofilters ïs considered eco-friendly (Guererro, unpublished), and is more advantageous than using chemicals and substances to treat the water.

Pond Preparation Activities

Figures 2.6a to 2.6h show the sites in which several pond preparation activities were followed consistent with the recommended practices of SEAFDEC (2009). These steps that include soil testing (11%), pond drying (68%), soil scraping (53%), water flushing (38%), pest eradication (70%), liming (34%), and fertilization (53%) are usually performed by fishpond owners after every cropping.

It was noted that fish farmers bypassed several of the important steps during pond preparation because of the extra time, money, and effort involved. For example, soil testing is important in getting a prior knowledge of the fertilizer and lime requirements of the pond (SEAFDEC, 2009). However, it was discovered that 89% of the farmers skipped soil testing and yet performed fertilization and/or liming which leads to most likely erroneous application doses.

Farmers also bypassed pond drying (32%), soil scraping (47%), and water flushing (62%), resulting in the accumulation of nutrients from residual wastes, which in turn causes eutrophic pond water. The resulting accumulated sediments will also consume more oxygen, produce higher levels of ammonia and hydrogen sulfide, trigger propagation of pathogenic bacteria, and eventually cause disease outbreaks in the next production cycles (SEAFDEC, 2009).

Sodium cyanide (NaCN) is used by

46.8% of the farmers to eradicate unwanted species that prey on or compete with the culture species (Figure 2.7). In addition, organic and selective pesticides such as tobacco dust (nicotine) and teaseed (saponin) are used by 10.6% and 25.5% of the farmers, respectively. Inorganic pesticides – wood lice pesticide and ammonia – are used by a farmer in Kawit and a farmer in Bacoor, respectively.

The use of cyanide as a sound pest control measure is still debatable. Section 92 of RA 10654 states that "poisonous or noxious chemicals, including cyanide, which are used in aquaculture in accordance with accepted scientific practices shall not be construed as illegal fishing". The GAqP of PNS-BAFS gives some guidelines on the use of veterinary drugs and chemicals, which includes only the antibiotics, and other disease-controlling drugs and chemicals. FAO[1] 214 is silent on the use of cyanide, but it recommends the use of only biodegradable indigenous materials, like derris roots, teaseed, and tobacco dust which are actually used by some of the farmers interviewed. Recommendations are in place regarding the use of non-biodegradable compounds. Most of the banned and regulated chemicals and substances used in aquaculture in the Philippines are confined to disease control.

Technically, under natural conditions, cyanide does not persist or accumulate in soil and water because it is highly volatile (Canadian Council of Ministers of the Environment, 1999). However, the amount applied and the application procedure could be erroneous; posing threat of contamination of receiving water through water discharges that can cause high mortalities among the wild species. Moreover, cyanide use puts the health of farmers at risk to such health problems as thyroid condition, nerve damage and cancer (US EPA, 2009). Guidelines on the safe use and / or application of cyanide should be established.

Pond fertilization to improve primary productivity was carried out by 55% of the respondents. The commonly used fertilizers ware: chicken manure (13%), urea (46-0-0) (36%), complete fertilizer (14-14-14) (11%), and ammonium phosphate (16-20-0) (11%). Figure 2.8 shows the site-specific percentage of farmers applying these fertilizers. In one case out of 47, the farmer utilized other fertilizers including compost material or plant or animal manure. Reportedly, the fertilizer used for each cropping varied with availability and cost. The amount of fertilizer applied also varied with location.

The use of chicken manure in aquaculture is a way of utilizing the wastes of the poultry industry. However, large amounts of manure are needed to fertilize the pond as it is not concentrated like inorganic fertilizers. Application of large amount of manure tends to deplete the oxygen in the water or cause harmful substances to accumulate during decomposition (SEAFDEC, 2009). Manure provides a favorable environment for pathogens (US EPA, 2013), which can adversely affect the water and the culture species. Nutrient content of manure is also inconsistent and longtime storage is impractical, unlike inorganic fertilizers.

In computing for the actual fertilizer requirement, the amount of nutrient required to grow natural food and the percentage of such nutrient in the fertilizer is needed. Unlike agricultural crops, there are no references on the recommended nutrients for growing natural food like *lablab* and *lumot* in the pond. Considering that nutrient content is proportional to the amount of fertilizer, the chances of under or over fertilization is high. The amount of fertilizer recommended by several manuals may not be sufficient or may be excessive as the nutrient content of the sediments and the water in different sites varies.

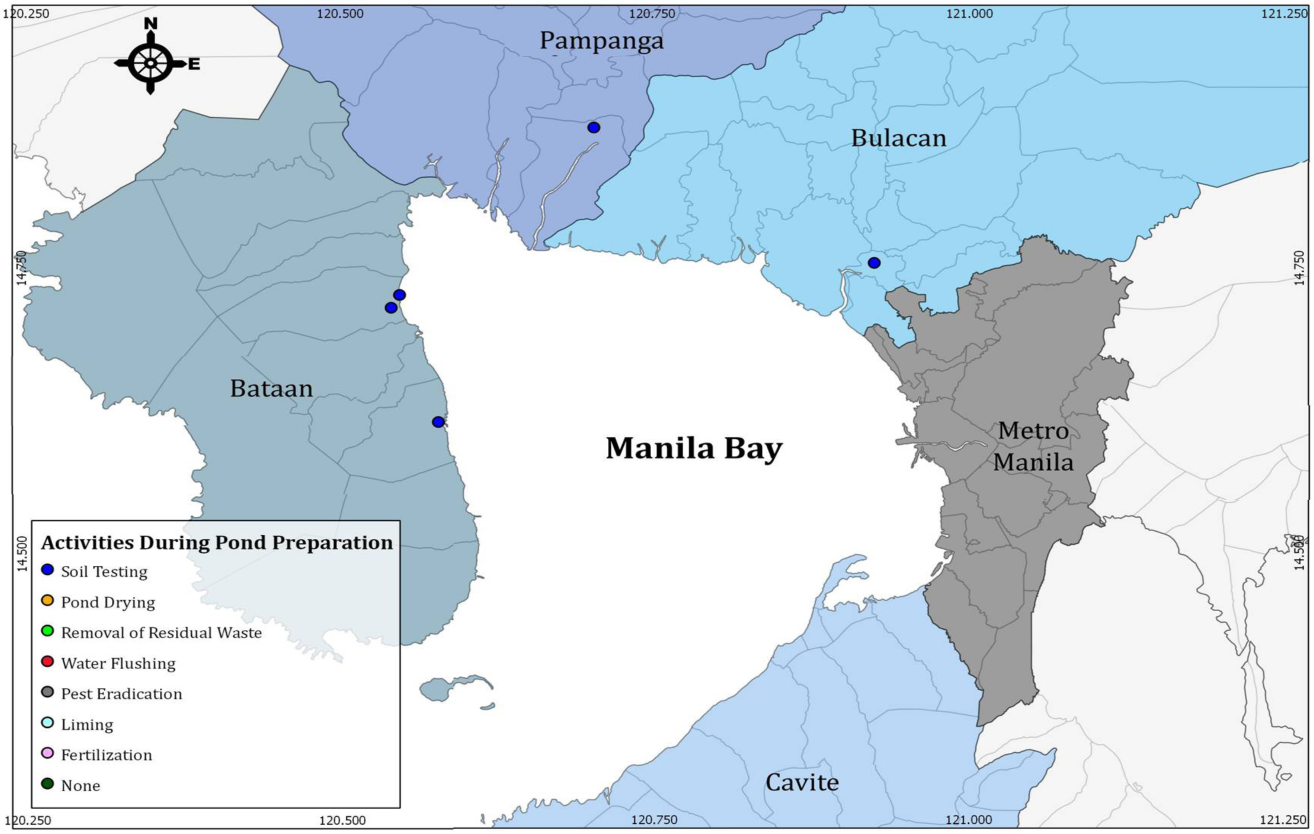

Figure 2.6a. Map highlighting the sites that perform soil testing.

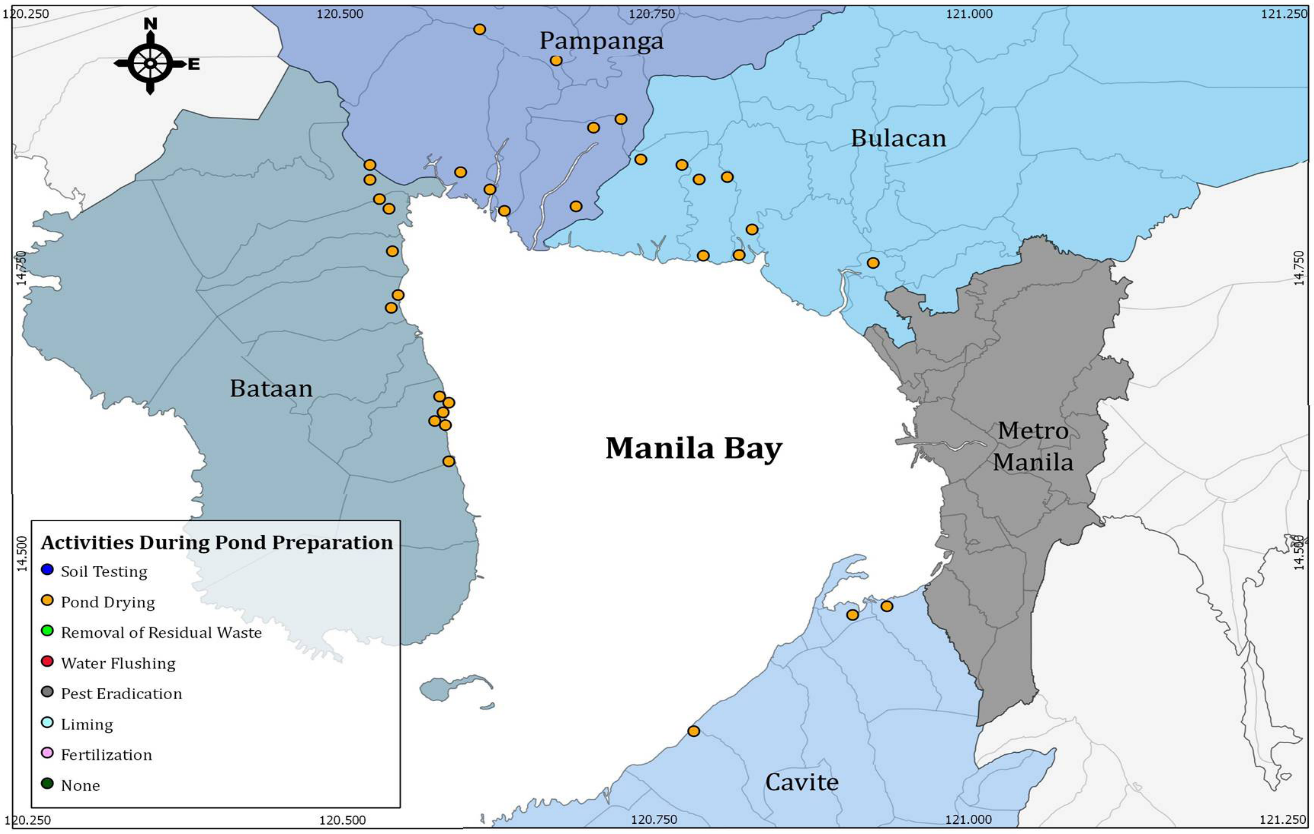

Figure 2.6b. Map highlighting the sites that perform pond drying.

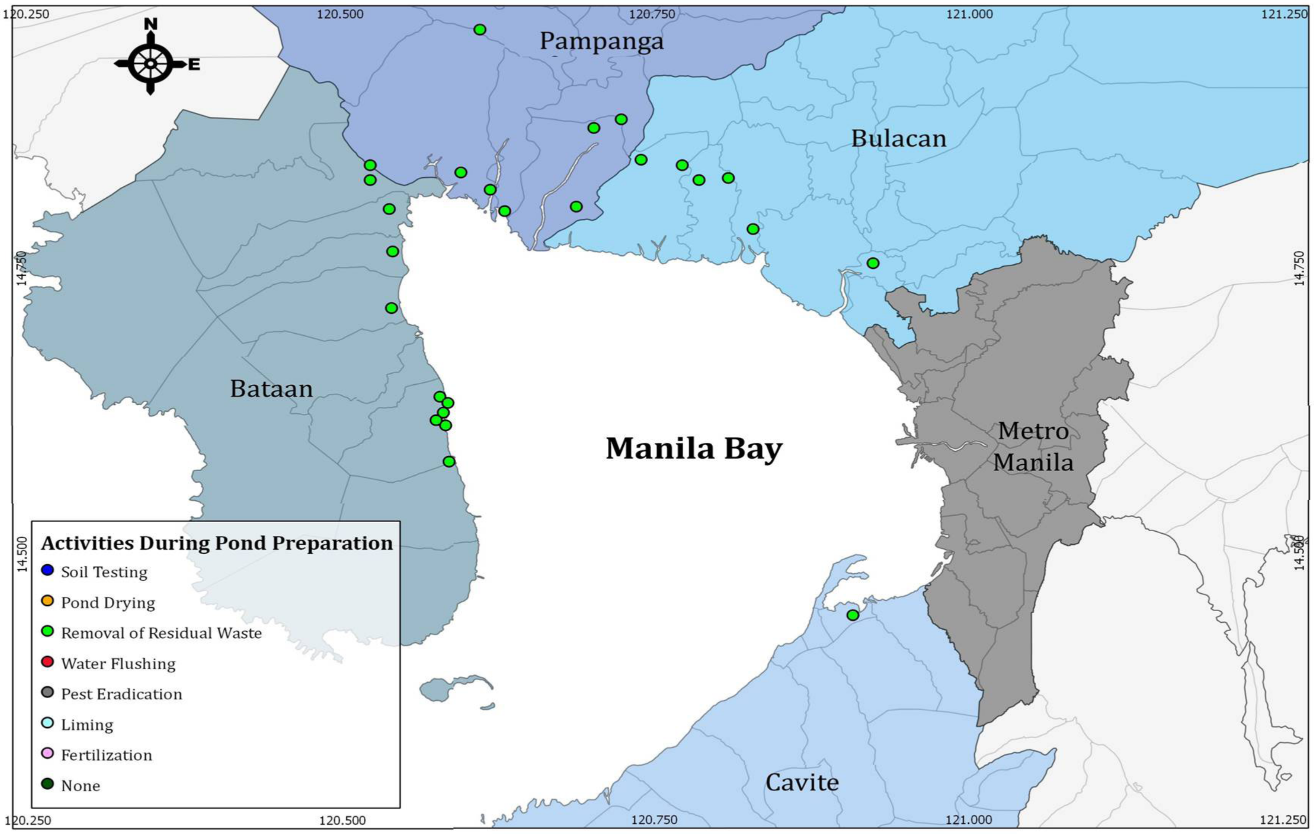

Figure 2.6c. Map highlighting the sites that perform soil scraping.

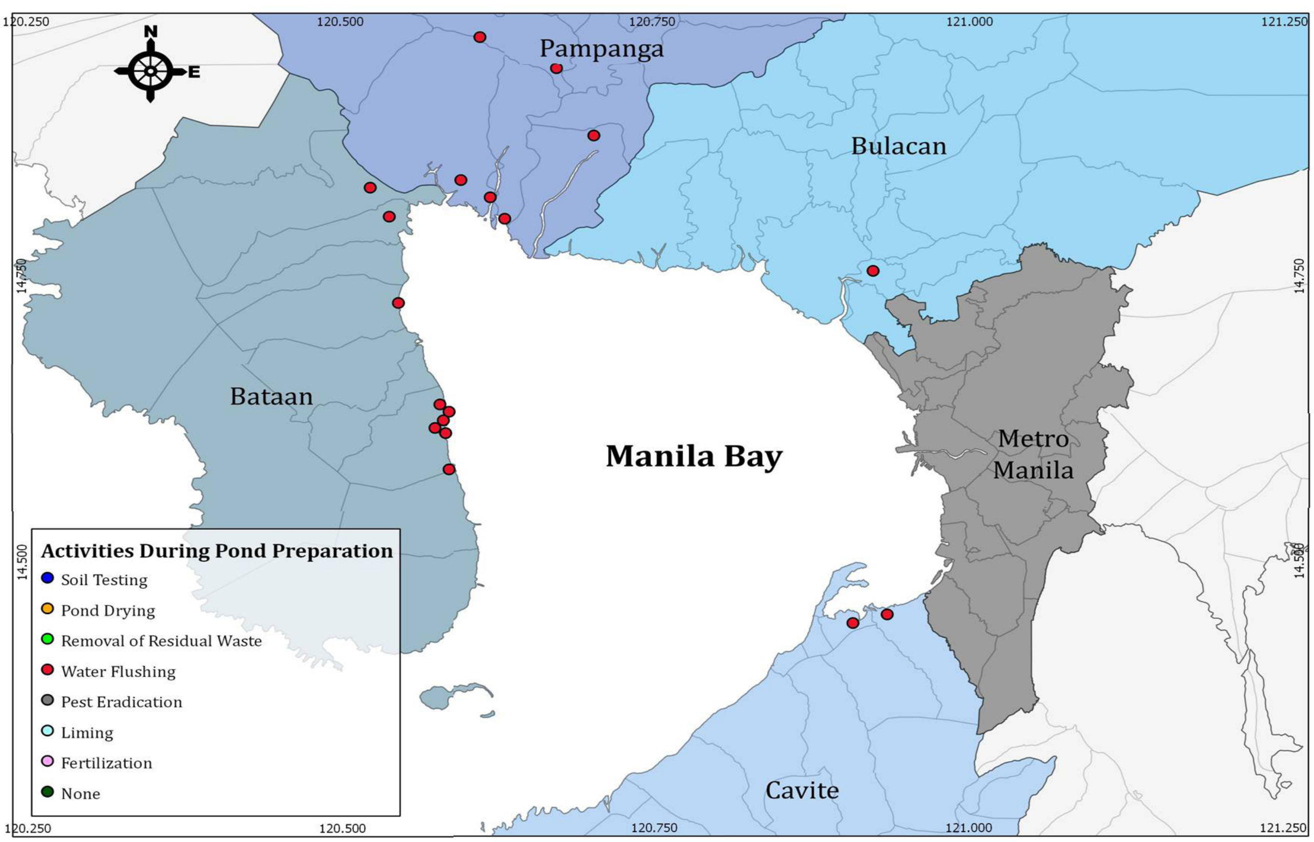

Figure 2.6d. Map highlighting the sites that perform water flushing.

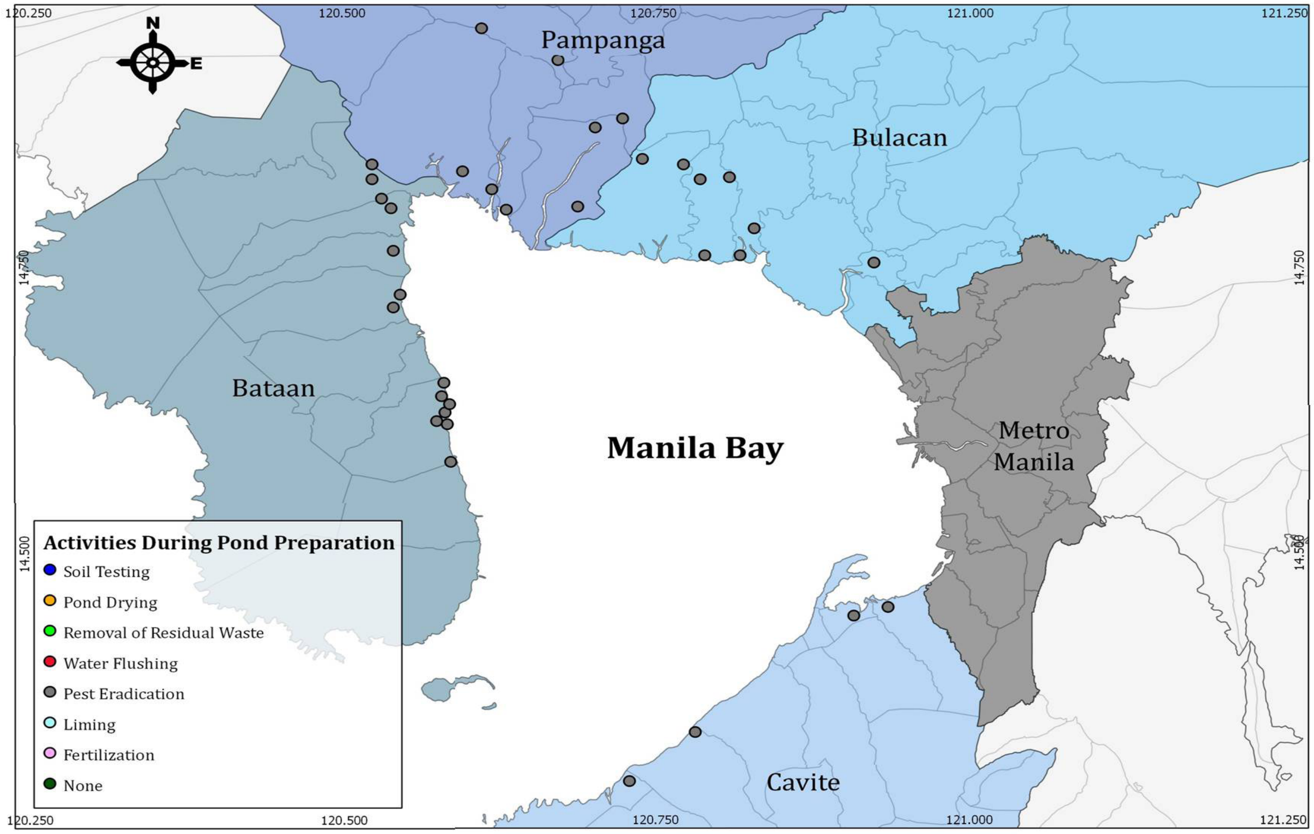

Figure 2.6e. Map highlighting the sites that perform pond disinfection or eradication of pests.

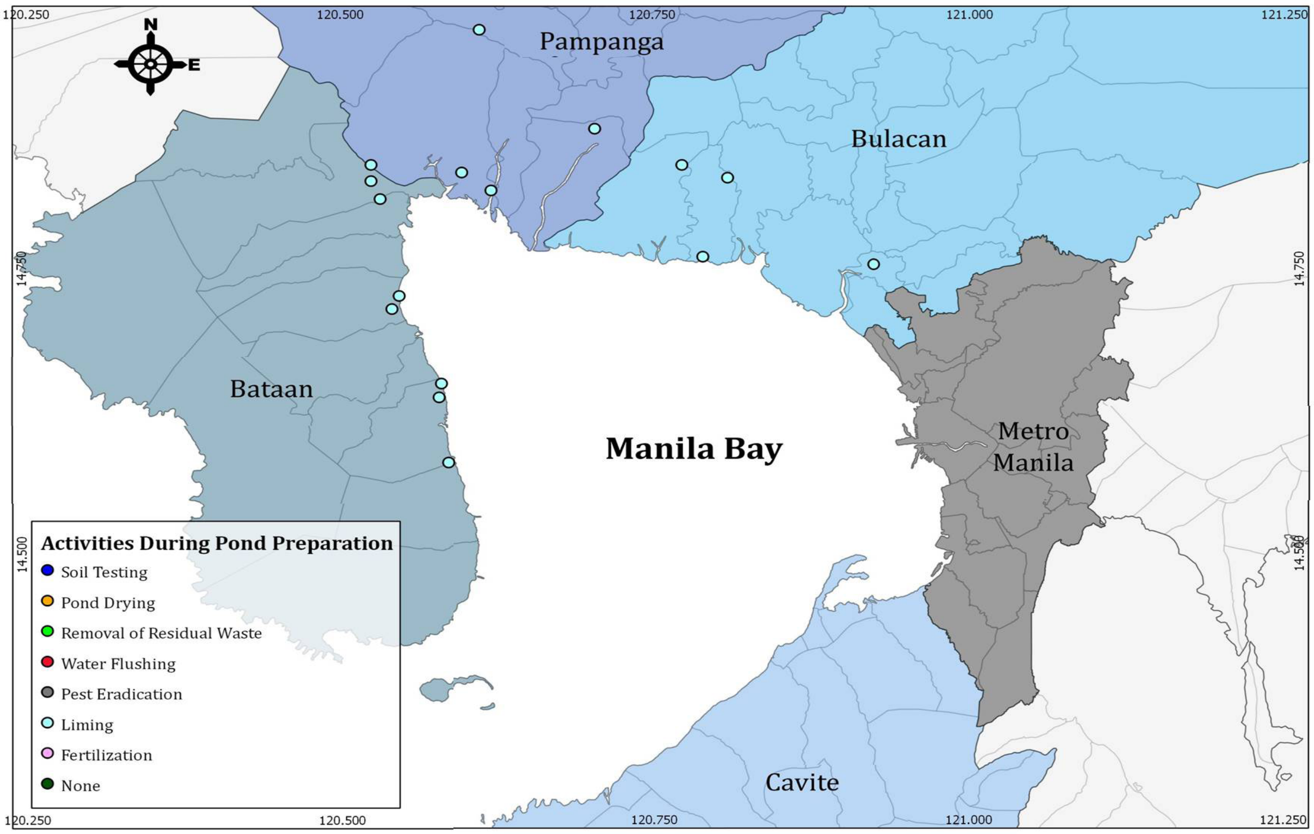

Figure 2.6f. Map highlighting the sites that perform liming.

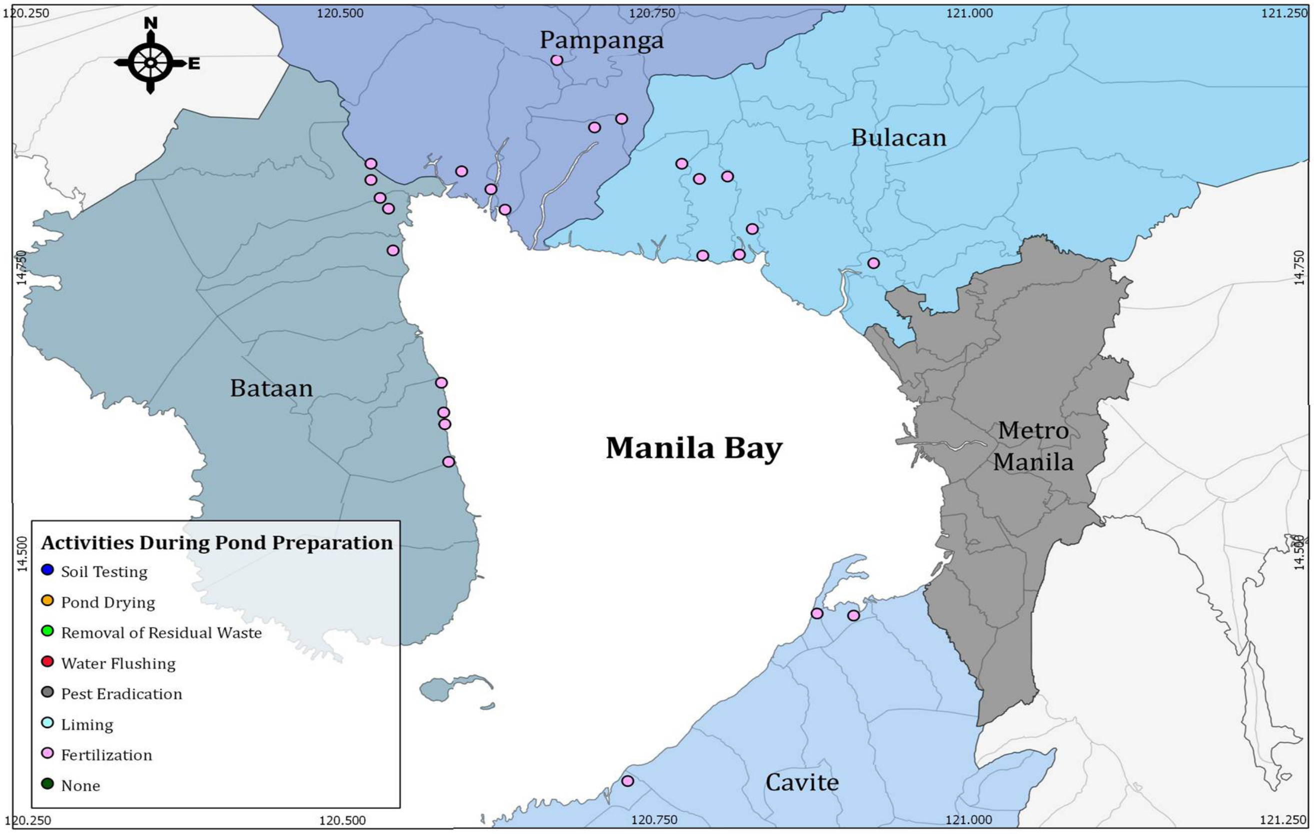

Figure 2.6g. Map highlighting the sites that perform pond fertilization.

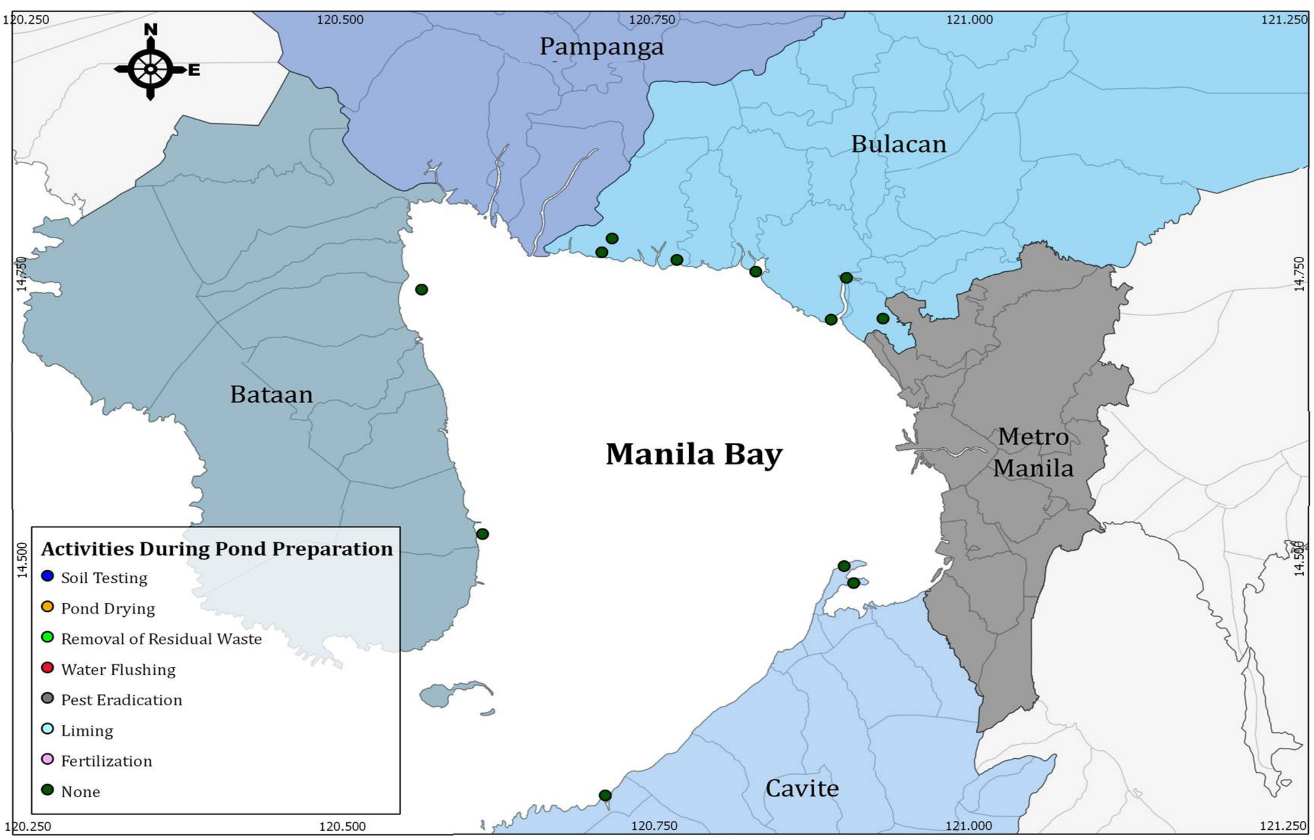

Figure 2.6h. Map highlighting the sites that do not perform any pond preparation activity.

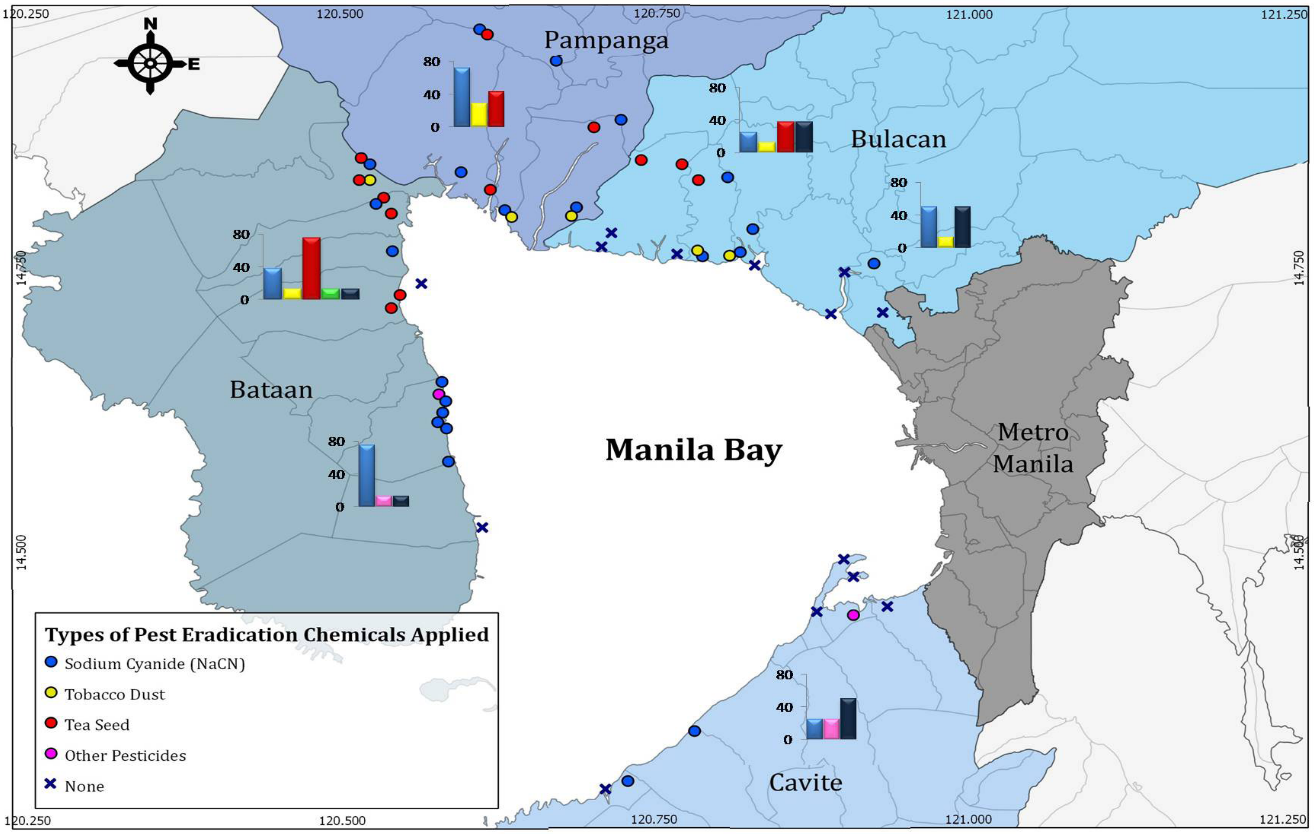

Figure 2.7. Map highlighting the sites (colored circles) and the percentage (bar graph) of farmers in different blocks that apply certain types of pesticides to eradicate unwanted species in the pond.

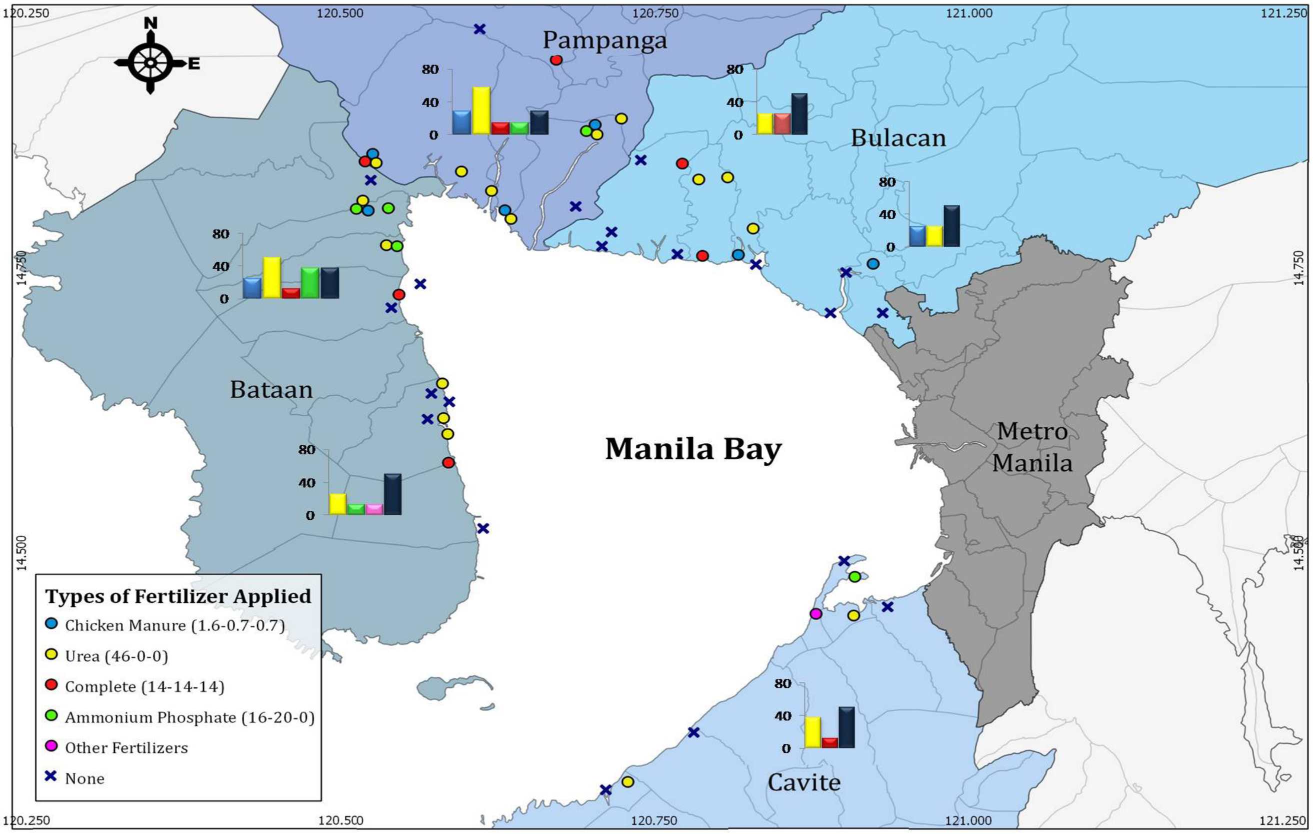

Figure 2.8. Map highlighting the sites (colored circles) and the percentage (bar graph) of farmers in different blocks that apply certain types of fertilizer to enhance primary productivity in the pond.

Culture Species

Figure 2.9 shows that the most common species cultured in the different areas around Manila Bay, namely milkfish (68%), shrimp (53%), crab (29%) and tilapia (25%). Tilapiang arroyo (*Sarotherodon melanotheron*), considered an intruder species from the wild, was present in 58% of the tilapia farms. It poses a major problem, for it is quite invasive and prolific, and a competitor of the primary culture organism. Grouper, trevally or *talakitok* and lady fish or *bidbid* are the high-value species also cultured in the ponds of Northern Bulacan and Cavite. Shellfish like mussel (14.9%) and oysters (12.8%), are cultured by farmers in Cavite and Bulacan and in Bataan.

The stocking of good quality fry is essential to the success of any aquaculture farm. Economic losses incurred due to infectious diseases caused by pathogenic viruses, bacteria, fungi and parasites in cultured fish and shrimp can be prevented through selection of only the clinically healthy stocks as prescribed in Section 9 of GAqP of BAFS (SEAFDEC, 2009; PNS-BAFS, 2014). FAO[1] 214 (BFAR, 2001) and PHILMINAQ (2008) encourage the use of hatchery fry and fingerlings for culture rather than those caught in the wild because there is a lot more chance for the latter to get infected with pathogenic organisms. It was discovered in this study that a high percentage of milkfish, shrimp and crab farmers procured fry from the hatchery, while a still higher percentage of tilapia farmers obtained their stocks from the wild (Figure 2.10).

About 82% of the fishpond and fish pen farmers employed a polyculture farming

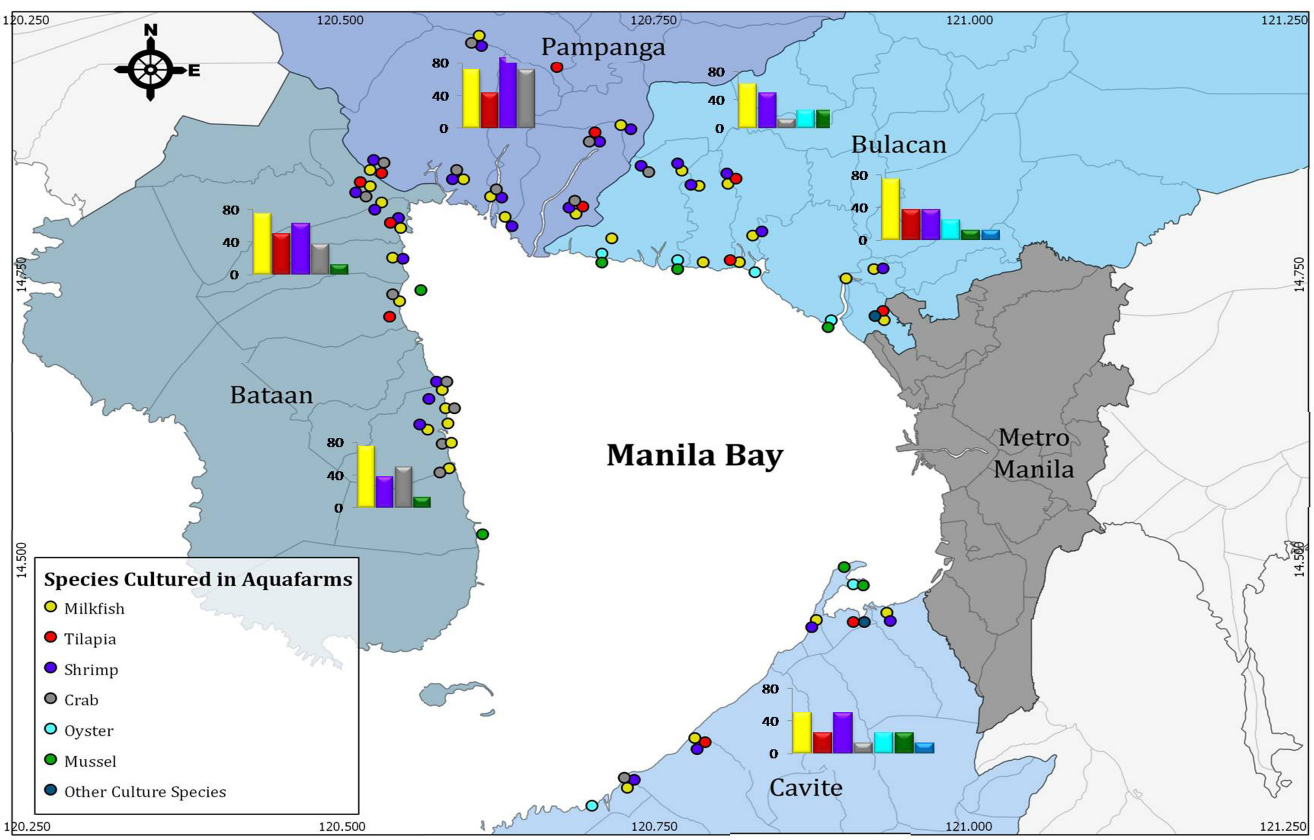

Figure 2.9. Map highlighting the sites (colored circles) and the percentage (bar graph) of farmers who are engaged in the culture of different aquatic species in their aquafarms.

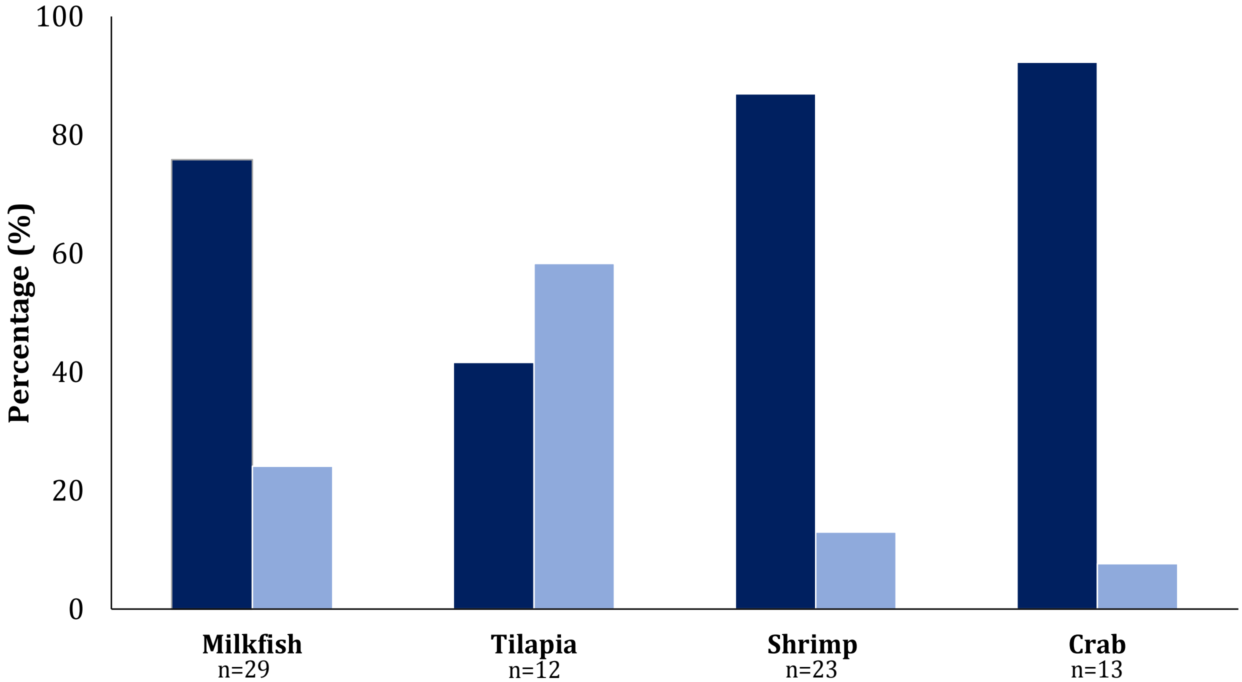

Figure 2.10. Percentage of farmers sourcing stock from hatchery ( ) and wild ( ).

system, in which two or more species are cultured in the same pond. Most of the polyculture farms (77%) had a combination of tilapia and/or milkfish and crustacean species like crab and/or shrimp. A smaller 10% of them employed a finfish-finfish polyculture, while a still smaller 3% utilized a crustacean-crustacean combination. About 10% of the farmers combined at least two species of finfish and crustacean in their ponds.

Polyculture is an effective way to maximize benefits from the available natural food in a pond (SEAFDEC, 2009). It is considered as the most efficient food production system ever devised (Boyd *et al*, 2007). However, pond management in polyculture becomes quite difficult when each stock used has its own requirements for good fertilization and feeding practices (Rahman, Varga, and Chowdhury, 1992). Although manuals on polyculture systems are available, a standard code of practice has not yet been established.

Feeding Management

Aquafeeds usually are the most costly aquacultural input, and every effort should be made to ensure efficient utilization of these (SEAFDEC, 2009). Wasted feed affects water quality and predisposes fish to disease. Wasted feed is a major contributor to discharged nutrients and organic matter from fish farms leading to eutrophication (PHILMINAQ, 2008; Boyd *et al*, 2007). There is much concern expressed over the wasteful use of increasingly scarce resources as one-third of capture fisheries are converted into fish meal for livestock and farmed-fish, rather than for direct human consumption (USAID, 2013). Thus, control and rationalization of feeds and feeding in modern fish farming is of critical importance in maintaining cost-effective and environmentally sound aquaculture operations.

Figure 2.11 shows that the respondents commonly fed natural food, like *lumot* (59%)

and *lablab* (25%) to the culture species. This is advantageous because algae assimilate the nutrients in water at the same time that they increase its oxygenation through photosynthesis. Commercial feeds, specifically extruded or floating feeds, is recommended by FAO[1] 214 and is used by 36% of the respondents. Old bread was used by 15% of the farmers for the purpose of fattening before harvest. On the other hand, shellfish farmers, depend on surface or natural plankton in the area. The other feeding materials used by about 6.4% of the farmers included duckweed, corn, *quiapo* and *darak.* rate and stability. Although low value feed contains high quality protein, the problem with it is that it tends to disintegrate rapidly in water and thus, readily releases its nutrient content leading to water quality degradation in the place where water is discharged (Edwards *et al*, 2004; SEAFDEC 2009). Moreover, issues arise regarding the sustainability of the use of trash fish in aquaculture. For example, the capture of trash fish from the finite stocks of capture fisheries has been observed to produce enormous impacts on local coral reefs through the depletion of fish populations (USAID, 2008). Furthermore, this type of feed can po-

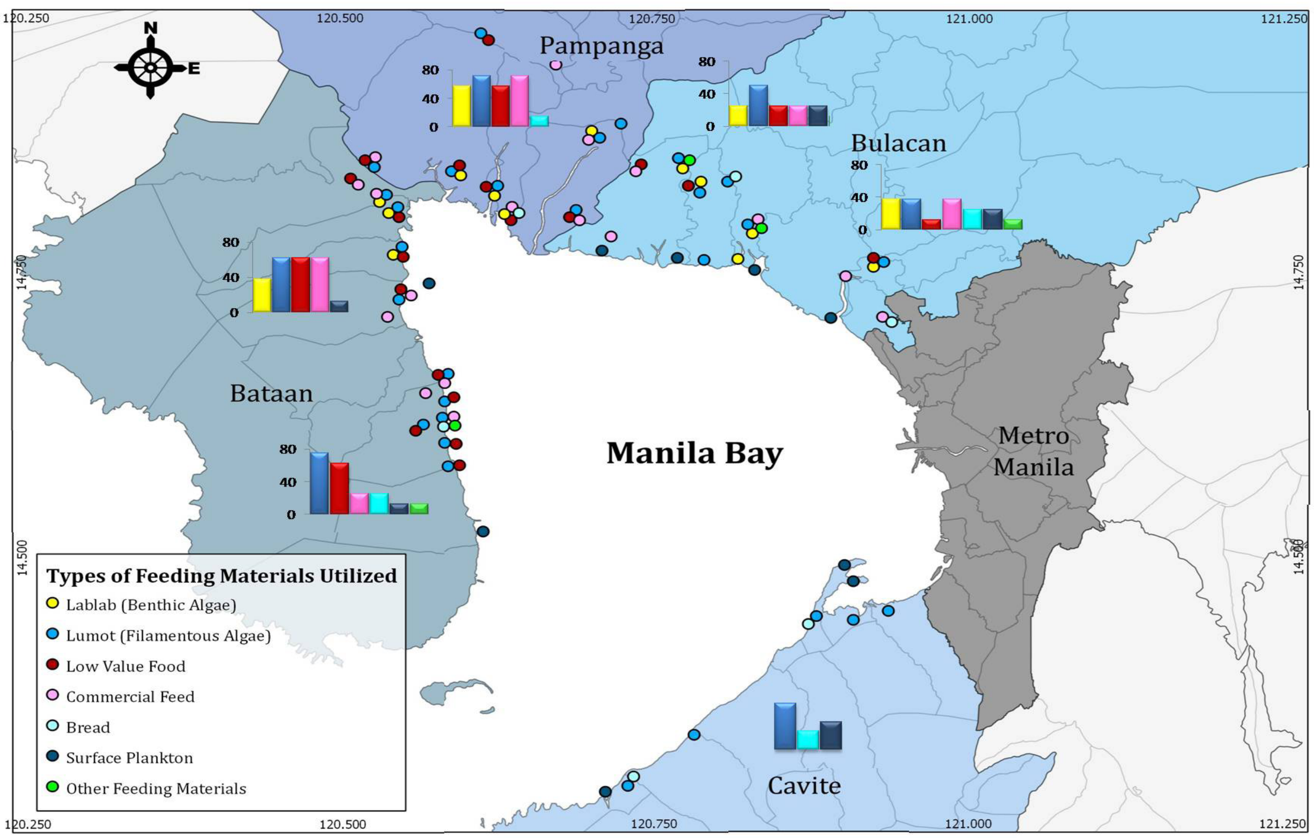

Figure 2.11. Map highlighting the sites (colored circles) and the percentage (bar graph) of farmers in the different blocks that use certain types of feeding materials in their farms.

Low value feed (trash shellfish and fish), an unstable feeding material, is also used by some 36% of the respondents. Its use is inconsistent with the FAO[1] 214 recommendation to use only those feeds with a high utilization tentially introduce pathogenic bacteria, viruses and parasites into the culture area. Section 7 of GAqP of BAFS, however, states that this type of feeding material is acceptable, provided that the use, type and mode of preparation of the feed and its proper storage is observed.

The level or method of fish culture (extensive, semi-intensive or intensive) in the farms was also evaluated based on feeding management. Culture intensity is an important factor for consideration, because it is associated with the input and level of technology required, and with effluent loads (Howerton, 2001). Higher density farms may produce greater environmental impacts, including increased discharge of pollutants, increased tendency to use chemicals, and increased risks to ecosystem health (USAID, 2008; SEAFDEC, 2009). The culture systems used in the different Manila Bay aquafarms include the extensive (21.1%), semi-intensive (57.9), and intensive (21.1%) systems. The most common system employed was the semi-intensive culture which requires only moderate inputs. The effluent loading of the semi-intensive system may be higher than the extensive, but lower than the intensive system (BFAR-PHILMINAQ, 2007; USAID, 2008). In most cases, according to the USAID (2008), some level of the semi-intensive culture would prove most profitable, for it uses less space and does not require too high a level of technology.

Computation of FCR, DMR and WPR

Feed conversion ratio (FCR) is the most widely used indicator of production and feed use efficiency in aquaculture (Boyd *et al*, 2007; Boyd, 2003a). FCR is the amount of feed used to increase the biomass by one kilogram. The lesser the FCR the better is the feed conversion efficiency of the feed.

Based on the data given by the farmers, the FCR was computed using the formula below.

$$\mathbf{FCR} = \frac{\text{Total Amount of Feed Used (kg)}}{\text{Net Aquacultural Production (kg)}}$$

Table 2.2 shows the computed FCRs of selected farms and compared with the usual or average FCR for a specific culture species. Results showed that in 43% of the selected farms, the FCR exceeded the typical FCR which means some feeds given to the organisms were not absorbed but rather were wasted. Consequently, there is loss of profit and the pond environment is degraded. Improper feeding management, undesirable range of water quality parameters, unhealthy fish condition, and low quality feeds are the possible reasons to a high FCR (Klontz, unpublished).

Fifty seven percent of the computed FCR was below the typical FCR. Interestingly, Table 2.2 shows most of the FCR as below the typical are lesser than 1:1. Theoretically, FCR below 1:1 is not possible because feeding 0.03kg of low value feed to shrimp, as in Ubihan, Meycauyan, would not result in a 1 kg increase in the biomass. It is possible that the presence of natural food and high primary productivity in areas with FCR less than 1:1 enabled fish growth. The data provided by the farmers may not be accurate vis-a-vis what they practice thus, the atypical FCR results.

Boyd (2005), claims that FCR can be a misleading ecological indicator since the attainment of 1.0:1 FCR does not imply that no feed was wasted during the rearing period. Feeds typically contain about 90% dry matter and 10% water, while live fish products usually contain around 25% dry matter and 75% water. Therefore, an FCR = 1.0 indicates that 1 kg of feed produced 1 kg fish or shrimp; however disregarding moisture, 0.9 kg dry matter in feed produced only 0.25 kg dry matter in fish, indicating that production of 1kg live biomass resulted in 0.65kg waste (Boyd, 2005; Boyd *et al*, 2007). With this, Boyd *et al* (2007) came up with dry matter ratio (DMR) or the amount of dry matter needed to produce 1 kg dry matter of fish. The DMR of the fishponds was computed using the formula below.

Table 2.2. Estimated FCR, DMR, and WPR computed based on the information provided by the respondents.

Culture species	Pond Location	Type of Feed	FCR[1]	Typical FCR[2]	DMR	WPR
Milkfish	Ubihan, Meycauayan	Commercial Feed	2.07:1	1.75:1*	7.45	1.61
	Calero, Malolos	Commercial Feed	9.60:1		34.56	8.39
	Tawiran, Obando	Commercial Feed	3.66:1		13.17	3.04
	Matungao, Bulakan	Commercial Feed	4.28:1		15.41	3.60
	San Roque, Hagonoy	Commercial Feed	0.54:1		1.94	0.23
	Sta. Elena, Orion	Low value feed and commercial feed	0.37:1		0.89	---
	SapangKawayan, Masantol	Low Value Feed	1.75:1		2.8	0.45
	Consuelo II, Macabebe	Commercial Feed	2.60:1		9.36	2.09
	Batang II, Sasmuan	Low Value Feed	6.4:1		10.24	2.31
	BangkalPugad, Lubao	Commercial Feed	1.6:1		5.76	1.19
Tilapia	San Antonio, Guagua	Commercial feed	0.05:1	1.8:1**	0.18	---
Shrimp	Ubihan, Meycauayan	Low Value Feed	0.03:1	2.0:1**	0.05	---
	Calero, Malolos	Low Value Feed	83.33:1		133.33	33.08
	San Agustin, Hagonoy	Low value feed and Commercial feed	1.95		4.68	0.92
	Camachile, Orion	Low value feed	0.23:1		0.37	---
	Capunitan, Orion	Low value feed	0.46:1		0.74	---
	BangkalSinubli, Lubao	Commercial feed	0.53:1		1.908	0.28
	SapangKawayan, Masantol	Commercial feed	2.8:1		10.08	2.27
	Consuelo II, Macabebe	Low value feed and Commercial feed	3.54:1		8.50	1.87
	BangkalPugad, Lubao	Commercial feed	6.32:1		22.75	5.44
	Mani-ano, Minalin	Low value feed	23.95:1		38.32	9.33
Crab	Camachile, Orion	Low value feed	0.58:1	5.2:1***	0.93	---
	Camachile, Orion	Low value feed	0.65:1		1.04	0.01
	Sta. Elena, Orion	Low value feed	4.82:1		7.71	1.68
	SapangKawayan, Masantol	Low value feed	1.11:1		1.78	0.19
	Mani-ano, Minalin	Low value feed	1.43:1		2.29	0.32
Catfish	Matungao, Bulakan	Low value feed	3.16:1	2.2:1**	5.06	1.01

[1]*Computed FCR: Red font: exceeded typical FCR; Black font: below typical FCR*
[2]*Typical FCR derived from: *Tucker, 1998; **Boyd & Polioudakis, 2006; ***Allan & Fielder, 2003*

$$\mathbf{DMR} = \text{FCR} \times \frac{\%\ \text{Dry Matter in Feeds}}{\%\ \text{Dry Matter in Fish}}$$

Proximate analysis of the feed and culture species was not done in this research so the dry matter percentages were presumed to be at the usual range indicated in different publication. The dry matter composition of commercial feed (dry feed), low value feed (wet feed), and combination of both feed (semi-moist feed) and fish was assumed to be at 10% (Boyd *et al*, 2007), 40% (Lucas and Southgate, 2012), 60% (New, 2002) and 25% (Boyd *et al*, 2007), respectively. As seen in Table 2.2, the DMR computed ranged from 0.18 to 133.33, implying that 0.18 to 133.33kg of the dry matter of feeds is needed to produce 1kg dry matter of fish.

From the DMR, Boyd *et al* (2007) were able to develop the waste production ratio (WPR), or the amount of waste that would be generated to produce 1kg fish, which can be computed using the formula below.

$$\mathbf{WPR} = (\text{DMR} - 1) \times \%\ \text{Dry Matter in Fish}$$

Results (Table 2.2) showed that the WPR of fishponds ranged from 0.01 to 33.08, meaning that for each kg of live aquaculture product, 0.01 to 33.08kg of waste (dry matter basis) would be produced.

Anthropogenic Factors

Human activities can worsen the effects of inappropriate aquaculture practices. In this connection, different anthropogenic factors around the aquafarm that could have an effect on the water quality of the ponds and water sources were identified. Distance of aquafarm from the nearest residential area was estimated by pace method. As seen in Figure 2.12, 72.3% of the sites are located 0 to 50 meters (sum of 40.4% and 31.9% for <10m range- and 11 to 50m range, respectively) away from the nearest residential area.

Aside from distance, the population of the nearest residential area was also estimated. It was observed that although the distance is not that far, 74.6% of sites surveyed had populations that ranged from 1 to 1,000 individuals considered as relatively sparse compared to other residential areas in the provinces (Figure 2.13). This situation is primarily due to the remoteness of the area from town centers where supplies come.

All farmers domesticated and/or allowed animals to wander in pond embankments except for an intensive pond in Southern Bataan. This practice is runs counter to a guideline in Section 3 of GAqP of BAFS, which says that wild and domestic animals should be excluded from pond and harvesting areas. Farmed, domesticated and feral animals wandering on pond banks can be minimal causes of water degradation (Boyd, 2003b). Moreover, the excreta of livestock and poultry might contain certain contaminants, including pathogenic organisms and antimicrobial-resistant bacteria, which can infect the water, and eventually, the culture species (US EPA, 2013). Figure 2.14 shows that chicken is the most common animal domesticated by 44.7% of the farmers. There were 2-25 chicken per site. Ducks (23.4%), pigs (8.5%), and goats (4.25%) were also domesticated; the number per site ranging from 1 to 14.

As for house pets, 76.6% of the respondents raised dogs in their farm which numbered from 1 to 12 per site (Figure 2.15). Accordingly, dogs are helpful in securing property from poachers and trespassers. Cats, 1 to 10 per site, were also domesticated by 21.3% of the respondents, while wild birds were found in 21.3% of the sites surveyed.

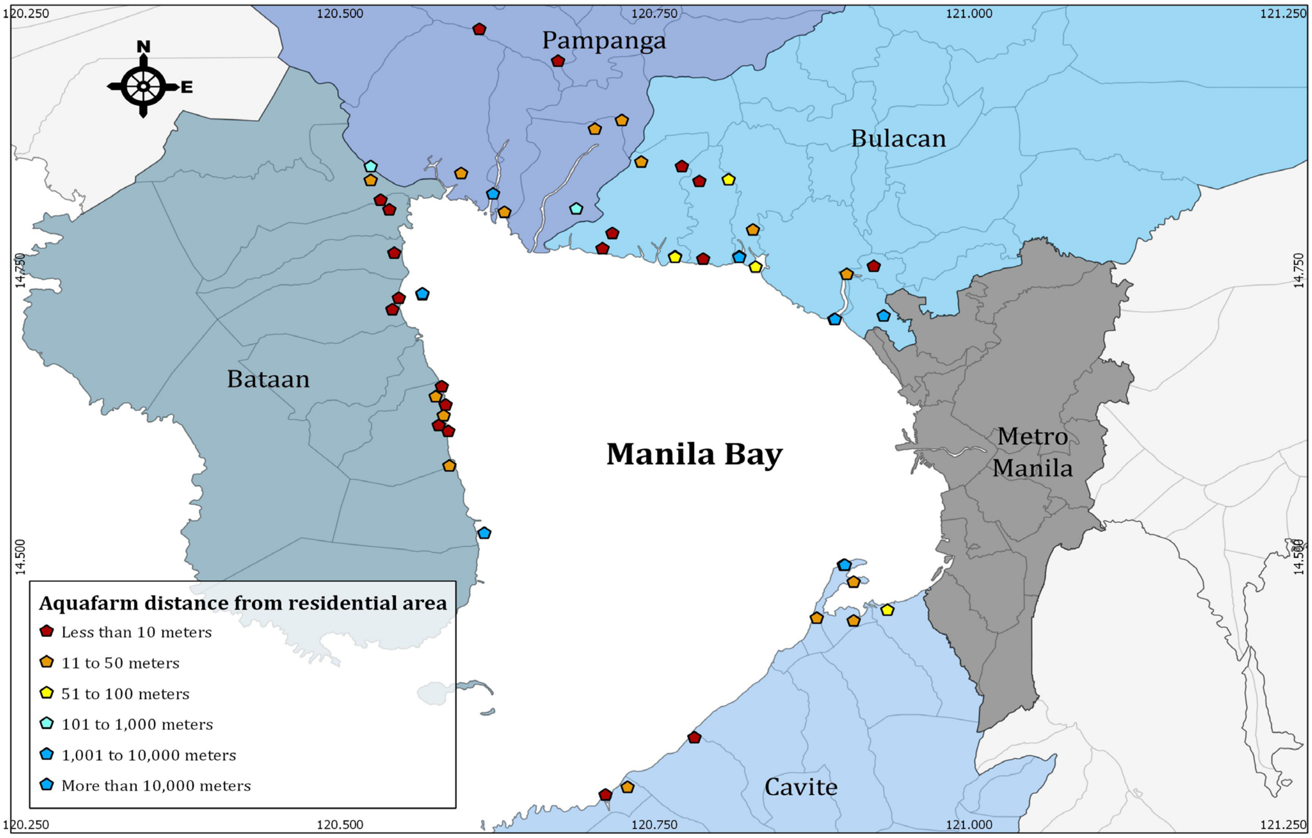

Figure 2.12. Map highlighting estimated distance of aquafarm from the nearest residential area.

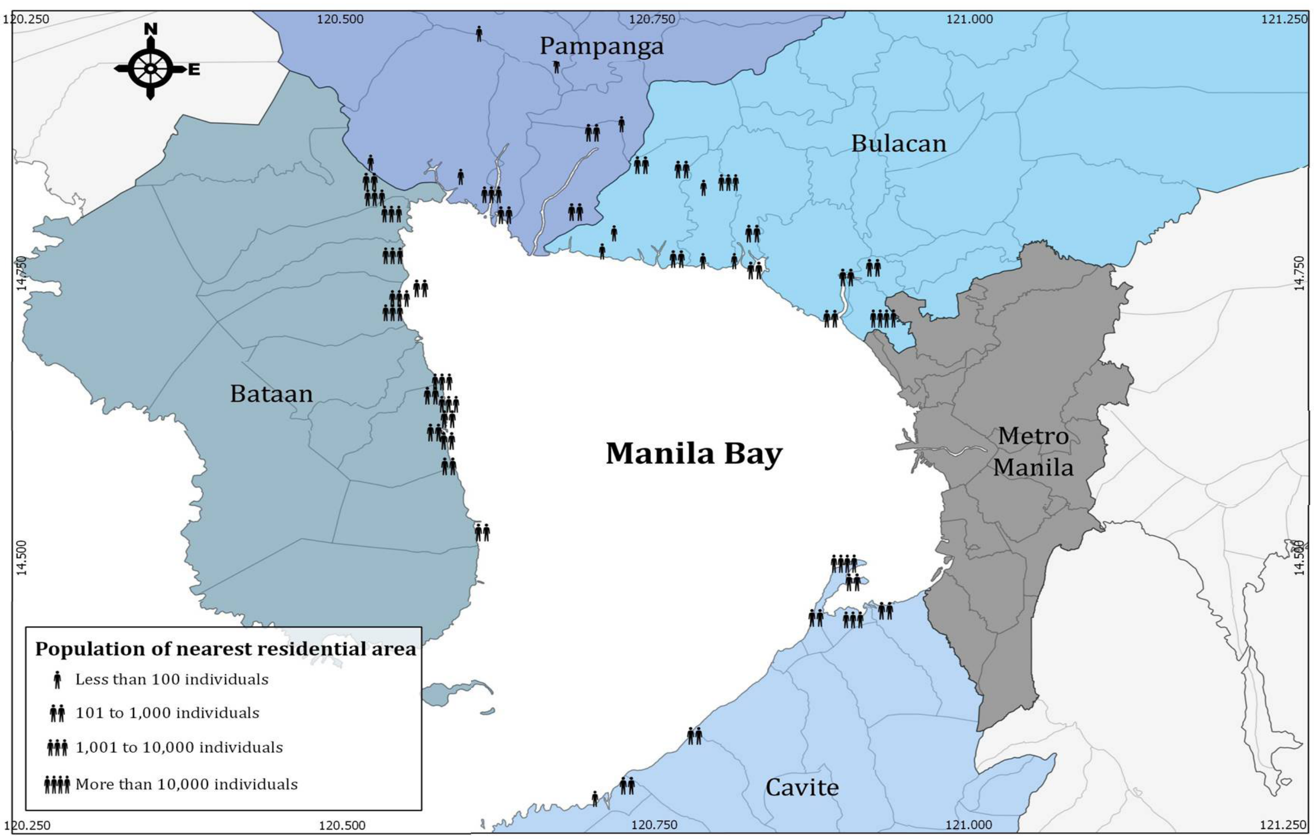

Figure 2.13. Map highlighting estimated population of the nearest residential area to the aquafarm.

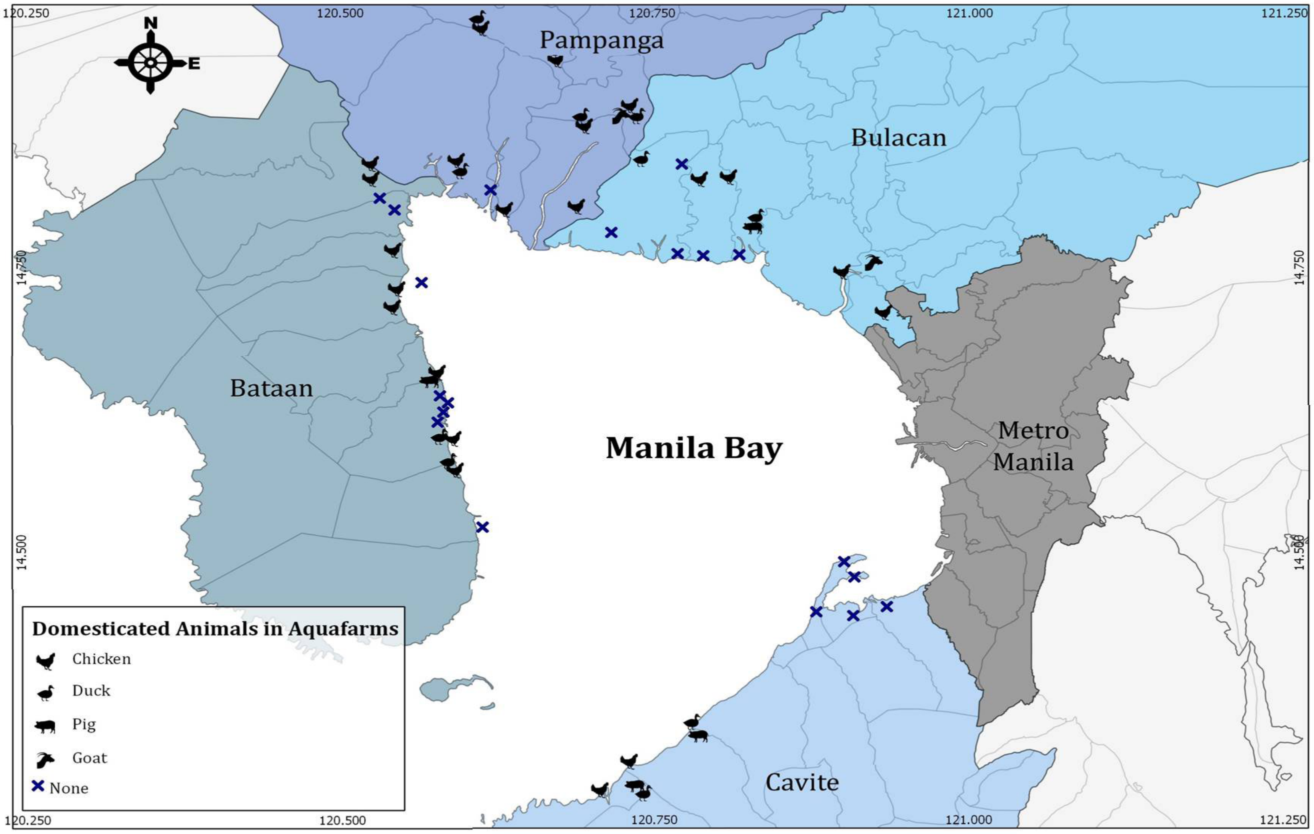

Figure 2.14. Map highlighting sites where farmer-residents domesticate different livestock and poultry animals.

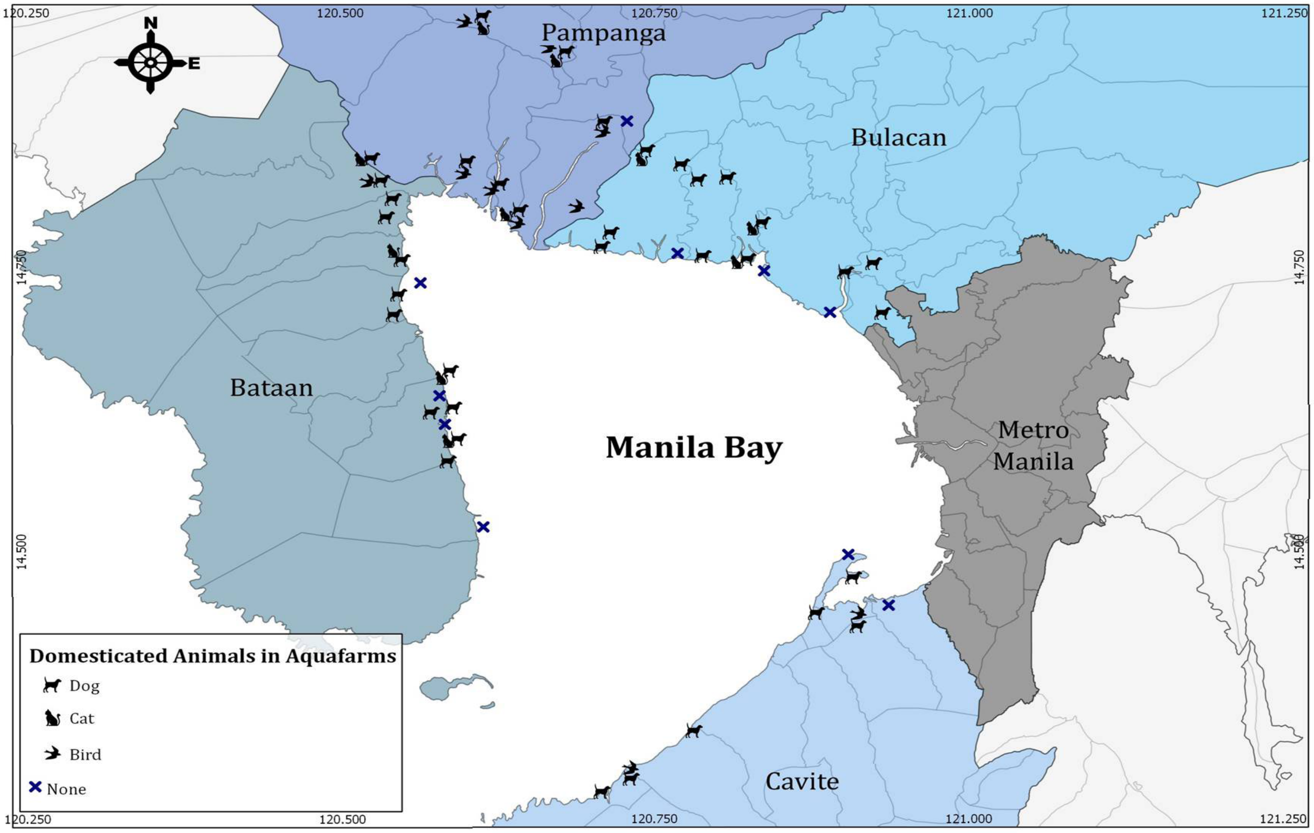

Figure 2.15. Map highlighting sites where farmer-residents domesticate different pets.

Conclusion

Most fish farmers in Manila Bay do not observe the guidelines on good aquaculture practices. Evidences to this contention were uncovered in the study as follows: a) non-compliance with requirement for a buffer zone, b) lack of the necessary equipment and/or use of improper water quality monitoring methods, c) neglect of some important steps in pond preparation (e.g., soil testing); and d) application of noxious and illegal chemicals, like cyanide.

Forty-three percent of the selected farms had FCR values exceeding the typical, meaning some feeds were wasted or not absorbed. The 57% of farms whose FCR fell below 1:1 seems unlikely and might have resulted from the inaccurate data supplied by the farmers. Nonetheless, it is possible that fish growth in ponds with < 1:1 FCR may have resulted from consumption of the natural food supply which came from a high primary production. Proximate analysis of feeds and culture species was not done; dry matter percentages were assumed to be within the range reported by earlier publications. Based on the presumed dry matter composition of commercial feed, low value feed and the combination of both feeds, the DMR computed had a range of 0.18 – 133.33, which is the range of dry matter of feeds needed to produce 1 kg dry matter fish. The computed WPR range, or the amount of waste generated in the production of a kilo live aquaculture product, was 0.01 – 33.08.

Farmers domesticated and/or allowed animals to wander on pond embankments and wade in the water predisposing both water and culture species to contamination. Anthropogenic activities like sewage and garbage disposal by household, liquid effluent from an oil refinery and agriculture possibly compounded the deterioration of water quality in the fish ponds.

On the other hand, the notable practices in the surveyed areas were the following: a) adoption of the sustainable aquaculture practice of polyculture, b) adoption of semi-intensive fish farming, and c) sourcing of seed stocks from primarily from hatcheries.

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