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POLICY BRIEF

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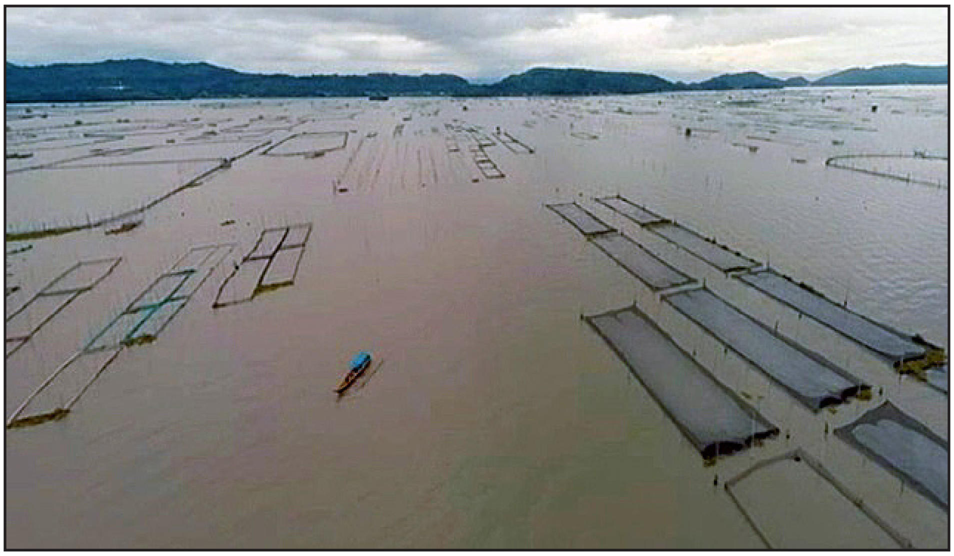
Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD)

Prescribing a Research and Development Framework Towards Efficient Management and Effective Governance of Laguna Lake for Aquaculture

Laguna Lake is the largest fresh water body in the country with a catchment area of 90,000 hectares (ha) and a total drainage area of 4,522.7 square kilometers (km^2). It hosts 35 shoreline municipalities that have an estimated population of 4.41 million (M) as of 2014. The lake is located within the industrialized zone of CALABARZON and urban center that is Metro Manila. Because of these natural features, the multiple functions of the lake resulted in intense competition for its utility. Among its important uses are for fisheries; source of water for agriculture, power generation, industrial cooling, and domestic use; navigation; tourism; waste sink; and flood reservoir. Inevitably, these have taken a toll on the resource, resulting in descriptions like "hypertrophic," "polluted," "neglected," and "dead."

The issues attendant to the lake's utilization, particularly in relation to equity and access, have always been a primary concern among various stakeholders. Specifically, the expanding fish pen areas have focused concerns on the role of aquaculture on the lake's carrying capacity. In response, the Laguna Lake Development Authority (LLDA), the agency tasked to manage the lake, issued in 2017 Board Resolution 518, "Moratorium for Aquaculture Operations in Laguna Lake," declaring a one-year moratorium on aquaculture operations in Laguna Lake.

The moratorium prompted the review of prevalent issues in Laguna Lake, with emphasis on aquaculture. Issues were distilled from the literature and validation activities were done to come up with a research and development (R&D) framework for effective governance and efficient management of the lake for aquaculture.



Drone shot of illegal fish pen structures in Laguna de Bay. Image credit: UNTV

ISSUES SURROUNDING AQUACULTURE IN LAGUNA LAKE

1. What is the current size or magnitude of aquaculture in the lake? Information on the past and current fisheries production of the lake is unknown or, at best, uncertain. The actual size of the area devoted to aquaculture is unknown and there is no recommended stocking density for aquaculture species, making it difficult to make production estimates. There is a dearth in stocking prescription [1, 2]. The only prescription found in the literature was for pond management, which was 2,000–5,000 fingerlings of milkfish; 5,000–20,000 for tilapia; and 60,000–3,000,000 for catfish [3]. The lack in stocking prescription was also reported by Camacho and Macalingag-Lingua (1988) and Pullin (1981).

Assessment studies by Camacho and Macalingag-Lingua (1988) showed that production in aquastructures were dictated by the amount of capital inputs of the operator. Validation with the communities suggested that stocking densities in Brgy. San Antonio, Victoria, Laguna for monoculture of tilapia in fish cages were 3,500 while dual-culture of tilapia and bighead carp were 5,000–6,000 based on capital inputs of the operator.

The Bureau of Fisheries and Aquatic Resources (BFAR) prescribes a stocking density of 50,000/ha for tilapia and 10,000–30,000/ha for milkfish in a monoculture system in fish pens in Calamba City. Again, adherence to these prescriptions depended on the operator's financial capacity. This uncertainty on the level of production may be traced to the lack of monitoring systems and lack of reliable and official databases that would provide indication on the magnitude and size of aquaculture in Laguna de Bay. Various studies relied heavily on national databases from Philippine Statistics Authority (PSA), the then Bureau of Agricultural Statistics (BAS), and BFAR [1, 4, 5]. However, PSA and BAS data are aggregated at the provincial level while BFAR relies on fragmented production monitoring by local government units (LGUs). LLDA, on the other hand, monitors production based on permits issued and not on actual seeding or harvest [6, 7, 8].

2. What is the current intensity/ magnitude of aquaculture that should be allowed in the lake? The issue of carrying capacity of the lake for aquaculture production

Ayungin (silver perch) is indigenous to Laguna Lake. At present it is now considered as a near threatened species because of the rise in aquaculture production in Laguna Lake. Image credit: Froy Beraño (Wikimedia Commons) is understudied because the concept of carrying capacity in relation to aquaculture has many dimensions. Aside from determining the optimal production limits, carrying capacity studies should look into the impacts of aquaculture activities on the physical, social, and ecological aspects of the lake ecosystem [9, 10, 11, 12]. In the 1990's, studies on carrying capacity were conducted using modelling of biological resources and correlation of net productivity to fish biomass [1, 3].

In terms of production capacity, what the published literature has shown, however, was the historical overload of aquaculture structures in the lake. From the 78-ha experimental site in 1971 [2], aquaculture area increased from 31,000 ha in 1982 [2] to 35,000 ha in 1983 [14] before it stabilized to around 10,000 ha in 2006 [4] coinciding with the implementation of the Zoning and Management Plan (ZOMAP) by LLDA in the 1990s. ZOMAP was designed to rationalize the management and regulate the utilization of the lake's fishery resources as well as to resolve equity problems among large-scale fishpen operators and small-scale fishermen dependent upon open water catch. The increasing area coverage resulted in conflicts between open water fishers and cage and pen operators.

The legal basis on the aquaculture area was also found to be vague and conflicting. Republic Act (RA) 8550, otherwise known as the Philippine Fisheries Code of 1998, and its amendment RA 10654, which aims to deter and eliminate illegal, unreported, and unregulated fishing, provide for the allocation of 10% of surface area of freshwater bodies for aquaculture. This translates to 9,000 ha when applied to Laguna Lake. There is no evidence in the literature on the scientific basis of the provision of the Fisheries Code. During the consultation, experts agreed that the prescription is based on proportional principle.

The ZOMAP, on the other hand, provides for 15,000 ha (10,000 for fish pen and 5,000 for fish cage). The basis for the ZOMAP prescription was the 20-year net primary productivity (NPP) of the Lake (Resolution Adopting the Revised Carrying Capacity of Laguna de Bay for Aquaculture).

Communities around the lake reported that the extensive expansion of aquastructures has greatly impeded on their livelihood, more so because of the higher allocation for fish pens. The issue of carrying capacity of the lake for aquaculture production is understudied.

3. How does aquaculture affect lake productivity? The introduction of aquaculture was motivated by the lake's high NPP in the 1970's which the native fish species were not able to fully utilize [1, 13, 15]. The introduction was also part of the government's effort to encourage inland fishers to go into fish farming. The lack of a clear management scheme for the lake at that time resulted in uncontrolled proliferation of fishpens, adversely affecting natural productivity and hampering ecological cycles [5].

In 1985, an estimated 22 tons of nitrogen (N) from aquaculture was recorded due to the practice of intensive feeding [2]. This period coincided with the large expansion in fish pen areas. The excessive production of milkfish and tilapia increased the nutrient

Tilapia is the primary species stocked in fish cages. Image credit: SEAFDEC

base of the lake due to these feeding practices and fish excreta [13]. Nutrient loading induced algal blooms that resulted in eutrophication [16] and proliferation of water hyacinth [4]. This was found to be counterproductive as growing periods increased and fish became stunted. The over-enrichment of the waters with N resulted in high biological oxygen demand (BOD) and decreased dissolved oxygen (DO) adversely affecting growth of fishes [16]. These findings were validated in the communities who shared experiences on fish kills, stunted fish growth, and low yields in their fish cages.

Aquaculture may have also affected the food-chain dynamics. Both milkfish and tilapia are excessive feeders of plankton [13] and this behavior would have resulted in the decline in the population of the filter feeders and the bottom feeder invertebrates. This observation was also validated by community reports on the decline of mollusks near fish pen areas as reported by the snail dredgers in Victoria.

4. What is the current water quality of Laguna Lake? Water quality is an important indicator of lake health. Thus, transparency in water quality assessment is necessary, along with the use of scientifically accepted protocols. Based on LLDA water sampling, Laguna Lake water is classified as Class C based on the Department of Environment and Natural Resources (DENR) standard as per DENR Administrative Order 08-2016 or the Water Quality Guidelines and Water Effluent Standards of 2016. This classification means that Laguna Lake water is appropriate for fish production.

The lack of a clear management scheme for the lake at that time resulted in uncontrolled proliferation of fishpens, irrigation, livestock watering, and agriculture, as well as boating and open water fishing. However, due to the spatial and temporal dimensions involved in the assessment, as well as the methodology and sensitivity of test kits used, several studies have differing parameter values from that of LLDA.

The greenish appearance of the water suggests an algal bloom which is typical when the weather changes from hot to wet season. Image credit: PCAARRD-SERD

There are at least five parameters of water quality relevant to lake productivity [16]: DO, BOD, N, phosphorus (P), and pH. The DENR standard for these parameters are: 5 mg/L DO, 7 mg/L BOD; 10 mg/L N; 0.05 mg/L P and 6.5 to 8.5 pH.

In 2016, water quality based on LLDA assessment were: 7.73–8.65 mg/L DO; 1.42–2.27 mg/L BOD; 0.107–0.229 mg/L N; 0.0905–0.117 mg/L P; and 7.77–8.83 pH.

Results from other assessments by other researchers showed significantly higher metrics as follows: from Barril and Tumlos (2002), N levels of 0.27 mg/L, which were significantly higher compared with international standard of 0.016 mg/L. LLDA's measurement was 50–200 µg/L N during the same period. In 2003, Zafaralla and Mercado (2005) found that P levels were 0.1–0.48 mg/L, significantly higher than the standard of 0.01. LLDA measurement was lower at 10–100 µg/L.

5. Do we have established package of technologies for major aquaculture species? Literature search and validation with the community showed that there are no package of technologies (POTs) recommended for the various aquaculture species specific for Laguna Lake. The various POTs for tilapia and milkfish are for general fresh water areas.

Aquaculture practices were largely dictated by the amount of capital and inputs provided by an operator [18]. As also already mentioned, there are no recommendations for stocking density, feeding intensity,

Serious pollution in the lake affected the water quality and fish stocks.
Image credit: Renzelle Mae Abasolo

size and design of aquaculture structures, and production intensity [18]. Feed types, production cycles, and feeding schedules greatly varied between operators of fish pens and fish cages [4]. This is further validated in the sites visited in which current practices for production are not prescribed and relied on indigenous or acquired practices. Water quality is an important indicator of lake health.

6. How much is Laguna Lake's contribution to food security?

Given the uncertainty of data in aquaculture production in the lake as previously discussed, the contribution of the lake to food security is not well documented. Disaggregation of data from various sources such as that of PSA and BFAR showed that the highest production estimate from the lake was around 180,000 metric tons (mt).

7. How do invasive species affect aquaculture? Invasive species are introduced species that have negative economic and environmental effects on the ecosystem. There are evidences showing the clear negative impacts of invasive species in the lake, although the magnitude is not clear. The development of protocols for invasive species management is hampered by the lack of sufficient scientific studies, specifically in Laguna Lake. The contribution of the lake to food security is not well documented. The safety of fish for food has become an urgent concern.

It must be noted that most of the species utilized in aquaculture are introduced but their levels of invasiveness vary. Introductions of milkfish and tilapia were regarded to have invasive potentials because of disruptions in the natural food web in the lake [13]. In fact, the introduction of these two species in the aquaculture industry in general is listed in the "100 Most Invasive Species List" [20] due to their dominance and the resulting displacement of native species. The introduction of snakeheads (*Channa striata*) and Asiatic catfish (*Clarias batrachus*) for aquaculture had negative impacts due their high predatory interactions with fingerlings of tilapia in the grow-out ponds [21].

The introduction of two janitor fish species (*Pterygoplichthys pardalis* and *P. multiradiatus*) and knifefish into the lake was believed to be accidental but their impacts are immense [21, 22]. Competition for space and food, high virulence, and nuisance in lift net fishery, fish pens, and cages are some of the

Knifefish preys on milkfish (bangus), tilapia, Manila sea catfish (kanduli) and silver perch (ayungin).
Image credit: UNTV

invasive characteristics of janitor fish [21].

The invasive potential of knifefish is due to its breeding habits [6] and voracity [21]. Females oviposit on bamboo and anahaw poles of aquastructures and compete for natural food. They also predate on the fingerlings inside the pens and cages, reducing harvest by up to 50% in aquaculture and up to 40% of daily catch in inland fisheries [21]. However, upon validation in the communities, the species tended to have less and less impacts except that populations are still high in areas of the lake with very low water quality such as Angono, Rizal.

8. What are the impact of climate change in Laguna Lake? The increasing intensity and frequency of typhoons in the country pose threats to the aquatic sector. In the Laguna Lake, in particular, the impacts of climate change have not been studied, thus the magnitude is largely undetermined. Looming impacts of monsoonal changes (i.e., 'Habagat') have been felt recently. Sustained heavy rains caused by Habagat that result in flooding also affect the sector through wash-outs of aquaculture structures and reduction in the quantity of fish harvested. Resiliency measures only allow for risk reduction and adaptation of agriculture but do not include mechanisms to improve aquaculture in Laguna de Bay. However, some areas such as Muntinlupa and Calamba City have improved designs of fish pens and cages to withstand strong typhoons and minimize losses.

R&D FRAMEWORK FOR EFFICIENT MANAGEMENT AND EFFECTIVE GOVERNANCE OF LAGUNA LAKE FOR AQUACULTURE

The issues identified necessitate a multi-sectoral and multi-agency collaboration. These efforts should consider sustainability concerns by taking into account the lake's carrying capacity. The R&D and policy agenda identified based on the analysis of the issues are enumerated:

Typhoon Ketsana (Ondoy) hit the country in 2009 and caused severe flooding in NCR, Bulacan, and CALABARZON. Increasing intensity and frequency of typhoons in the country pose threats to the aquatic sector. Image credit: Creative Commons

1. Aquaculture Production

a. Development of strategies and mechanisms for the determination of the volume of production of aquaculture species, particularly milkfish, tilapia, and bighead carp
b. Recommendations on stocking rate density for aquaculture species depending on specific water qualities and primary productivity in different areas of the lake
c. Determination and advocacy of institutional arrangements among concerned agencies for data management, particularly pertaining to maintenance of databases for aquastructures and fish production, as well as analysis of data

2. Carrying Capacity

a. Determination of the carrying capacity of the lake for aquaculture, including analysis of lake dynamics. Validation of the carrying capacity based on the NPP is needed. The various aspects of carrying capacity should be considered, including physical, ecological, production, and social capacities
b. Review of the applicability of the Fisheries Code recommendation on 10% surface area as well as reexamination of the validity of other recommendations (such as LLDA ZOMAP) for aquaculture

High proliferation of water lilies deteriorates the lake's water quality and can cause navigational problems. Image credit: PCAARRD-SERD

3. Primary Productivity Studies

a. Determination of the effect of nutrient loading on lake dynamics
b. Productivity impact of aquaculture in the lake

4. Water Quality

a. Clarification, verification, and standardization of water quality assessment protocols specific for Laguna Lake to minimize disparity of results from water tests among interested groups
b. Advocacy for the need to conduct periodic water quality assessment by independent groups for unbiased assessments of fish pens and cages to withstand strong typhoons and minimize loses

5. Aquaculture Technologies and Practices

a. Development and piloting of POTs, as may be appropriate, taking into account the gross and NPPs of specific locations. These POTs may include stocking density, feeding management, production intensity, production management, and aquastructure design
b. Technology transfer and adoption studies
c. Technical and economic efficiency studies of aquaculture practices in Laguna Lake

6. Food Security

Supply chain studies involving aquaculture products from Laguna Lake

7. Invasive Species

a. Risk management protocols for invasive species
b. Food safety implications of consuming invasive species and their by-products, particularly knifefish
c. Policy analysis and advocacy towards control and management and/or eradication of invasive species

8. Climate Change

a. Socio-economic studies related to climate change impacts in Laguna Lake
b. Climate change impacts on lake dynamics
c. Impact of climate change (e.g., increasing water temperature) on primary productivity

Fisherfolk are primarily affected by the degradation of the water quality of Laguna Lake. Photo Credit: Healthfutures

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