Appendix 2. General Guide for Pond Fertilization Based on Pond Ecology and Farm Economics

The central theme of this book has been the relationship between pond ecology and making cost-effective, intelligent decisions regarding pond fertilization strategies. It should be clear that ponds are individual, dynamic ecosystems, and the variabilities among and within ponds prevent any generalized fertilization recipes from having much reliable benefit to the farmer. Efficient fertilization and high, sustainable yields are not difficult to attain as long as ponds are not treated simply as “black boxes.” Optimizing fertilization means identifying and satisfying deficiencies in algal nutrient and light requirements; it also means minimizing capital and labor costs, wasteful fertilization, and detrimental impacts to the pond ecosystem.

The following summary outline represents a guide to help farmers determine the optimal fertilization strategy for each culture pond with regards to pond characteristics, pre-filling activities, choosing a fertilizer, and identifying pond fertilization requirements. Recommendations are based on identified benefits and problems with common approaches to pond fertilization, evaluated using ecological consequences and potential impacts on farm economics as the only criteria. It is assumed that the ponds are located in the appropriate climatic region for warmwater aquaculture, and that at least one of the culture species in the pond utilizes natural foods for growth.

The guideline below focuses on relevant, general questions and concepts the farmer should consider. It may take the farmer a modest effort to answer all necessary questions adequately, particularly in Section C, but working together with an extension agent would certainly help. Some parts of the economic analysis may have local or even regional application, and could be kept updated at the local aquaculture extension office. The farmer’s answers to these questions will help determine what is most appropriate for each individual pond system. But even if some questions remain unanswered, focusing their attention on important ecological and economic considerations gives farmers a greater (and valuable) understanding of fertilization theory, of pond dynamics, and of their individual farming system as a whole.

I. Pond characteristics

A. Location of pond

1. Maximize pond exposure to sunlight.
2. Minimize pond exposure to wind in shallow ponds to reduce resuspension of pond sediments. Exposure to wind may benefit deeper ponds by reducing risk of persistent thermal stratification of the water column.

B. Size of pond

1. Pond area of convenient size, though not so small that pond bank erosion noticeably increases pondwater turbidity. Make sure banks of earthen ponds are stabilized.
2. Pond depth no less than 0.8 m if possible, to reduce impact of resuspended pond sediments.
3. Pond depth no more than about 1.2 m because of risk of prolonged thermal stratification, unless able to keep water mixed through mechanical mixers or bioturbation (e.g., large carp).
4. If mechanical or biological mixers are used, pond depths of about 2 to 2.5 m for minimal impact of pond sediment resuspension and greater volume for biological productivity.

C. Source water for pond

1. If high in inorganic turbidity, consider having source water first go through a settling basin before putting in pond.
2. If subsurface lake water is used, determine if it is anoxic (rotten egg odor present)—if source water is anoxic, allow it to re-oxygenate before putting it in ponds.

II. Pre-filling activities

A. Determine liming requirement, then lime accordingly.

B. Add layer of organic fertilizer on pond bottom and fill pond to about 10 to 20 cm of source water. This activity reduces the amount of fertilizer-P adsorbed to pond sediments, can reduce pondwater seepage, and provides a concentrated dose of algae and soluble algal nutrients when the pond is completely filled.

C. Wait about 5 to 7 days, then fill pond to appropriate level with source water. Fill pond during the day for photosynthetic re-oxygenation of water.

D. Evaluate need for polyculture.
   1. Molluscivores (e.g., Chinese black carp) eat snails and other animals which strip the water of calcium carbonate for shell production.
   2. Large fish (i.e., common carp) keep deep ponds reasonably mixed in order to avoid prolonged thermal stratification.

III. Choosing fertilizers

A. On-farm fertilizer sources (integrated farming systems)
   1. Separate each subsystem (e.g., aquaculture, land crops, each type of land animal) for economic evaluation.
   2. In the economic evaluation for each subsystem, identify:
      a. All shared and individual expenses, including:
         (1) All capital costs for equipment and facilities.
         (2) All input costs (e.g., feeds, fertilizers, antibiotics).
         (3) All labor (both farmer's and hired help).
         (4) All marketing costs (e.g., transportation, time).
      b. Identify all potential savings (e.g., farm waste disposal).
      c. Evaluate potential profitability of each subsystem.
   3. Find nutrient availability for each potential farm input to the ponds (check local extension office).
   4. Estimate actual cost per kg P, N, etc. for pond fertilization.
   5. Examine sources of off-farm fertilizers according to the criteria below.

B. Off-farm fertilizer sources
   1. Estimate actual cost of each potential fertilizer.
      a. Animal manures—for each source identify:
         (1) Nutrient availability in manure (check extension office).
         (2) Market cost per kilogram N, P, etc. available for algae.
         (3) Transportation and labor costs for application to ponds.
         (4) Lost opportunity costs (i.e., potential economic value of farmer's time used in activities to get

fertilizer).

(5) Environmental costs (need for aerators, frequency of redigging ponds).

(6) Estimate total cost per kilogram N, P, etc. available for algae.

b. Green manures—for each plant candidate identify:

(1) Nutrient availability in plant (check extension office).

(2) Market cost per kilogram N, P, etc. available for algae.

(3) Transportation and labor costs for acquiring plants.

(4) Cost of composting facilities.

(5) Labor for harvesting and composting for application to ponds.

(6) Lost opportunity costs (i.e., potential economic value of farmer's time used in activities to get fertilizer).

(7) Environmental costs (need for aerators, frequency of redigging ponds).

(8) Estimate total cost per kilogram N, P, etc. available for algae.

c. Chemical fertilizers—for each source identify:

(1) Nutrient availability (check extension office).

(2) Market cost per kilogram N, P, etc. available for algae.

(3) Transportation and labor costs for application to ponds.

(4) Lost opportunity costs (i.e., potential economic value of farmer's time used in activities to get fertilizer).

(5) Environmental costs (need for aerators, frequency of redigging ponds).

(6) Estimate total cost per kilogram N, P, etc. available for algae.

2. Choose the most economical source of fertilizer. This analysis may be applicable for a community or region, and updated only when necessary.

IV. Identifying pond fertilization requirements

A. Check aquaculture extension office for existence of any fixed, predetermined fertilization rates that may be applicable for initially fertilizing specific farm ponds. Use fertilizer(s) selected by economic analysis in C above.

B. If no applicable fixed rates are available, choose *initial* N and P fertilization rates based on pond water transparency:

1. Clear water: 30 kg N ha^{-1} wk^{-1} and 10 kg P $ha^{-1}wk^{-1}$
2. Visibility down to 0.5 m: 20 kg N ha^{-1} wk^{-1} and 4 kg P $ha^{-1}wk^{-1}$
3. Visibility down to 0.2 m: 10 kg N $ha^{-1}wk^{-1}$ and 2 kg P $ha^{-1}wk^{-1}$

C. If ponds are rainfed or suspected/known to have low alkalinities, add an *initial* fertilization of agricultural lime at about 200 kg ha^{-1}, particularly if ponds are not green 2 to 3 days after following step A or B above.

D. Identify which nutrient(s) limit algal productivity for each pond using the algal bioassay method (Appendix 1).

1. Set up own algal bioassay test using available materials.
2. Conduct algal bioassay about once per week, or as often as practical or seems necessary.

E. Fertilize each pond according to algal requirements as indicated by algal bioassay results. Adjust total inputs to cover the period between algal bioassays.