

COURSE CODE:	FIS312
COURSE TITLE:	Introduction to Fish Pond Construction and Management
NUMBER OF UNITS:	2 Units
COURSE DURATION:	Two hours per week

COURSE DETAILS:

Course Coordinator:	Dr. A.O. Agbon
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Other Lecturers:	Dr. F.I. Adeosun and Dr. (Mrs.) O.T. Agbebi

COURSE CONTENT:

Pond site selection and survey. Types of ponds, principles of fish pond design and construction. Liming, stocking and fertilization. Management of pond flora and water quality. Maintenance of ponds and harvesting from ponds.

COURSE REQUIREMENTS:

This is a compulsory course for all students in Department of Aquaculture & Fisheries Management. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be eligible to write the final examination.

READING LIST:

LECTURE NOTES

POND CONSTRUCTION

A pond is a water enclosure or a confined body of water where fish are raised or reared under a manageable controlled condition. Pond could either be earthen or concrete. Nowadays fish are raised in plastics, fiberstars and wooden rafts which are either locally fabricated or imported from developed countries. But here, in this course, emphases are laid only on earthen and concrete pond constructions.

TYPE OF PONDS (Earthen)

There are two major types, namely:

- (i). Excavated pond
- (ii). Embankment/ pond

Sometimes, depending on the terrain or topography of the site, there is what we called excavated-levee pond, barrage pond and contour pond.

Site selection for fish pond construction:

The failure or success of fish farm enterprise depends on the selection of a good site. The layout and the

management of fish farm will largely be influenced by the kind of site selected. The site has the following influences:

- (i). strongly affects the cost of construction
- (ii). amount of fish that can be produced
- (iii). ease of pond management
- (iv). the economics of the enterprise

Decisions prior to site selection:

During the lecture the distinctions shall be made clear to students diagrammatically

- a) Do i have a clear ideal of the type of fish farm I want to construct
- b) Of what production level is my target?
- c) What is the system of culture to be adopted?
- d) Which fish species should be produced?
- e) Is it necessary to produce fingerlings for the farm?
- f) At what stage of fish should you start selling?

Answers to these questions will assist greatly during site selection exercise

Factors to consider when selecting site for fish farm construction

- a) Water — quantity, quality, source, activities around it
- b) Nature of soil — texture, permeability, retention ability, etc
- c) Topography of the land
- d) Environmental consideration
- e) Accessibility
- f) Vegetations density/cover
- g) Expertise

Other important factors include:

- h) Proximity and size of market
- i) Poaching
- j) Availability of farm inputs

Detailed planning for fish farm construction

Once the site has been selected, then initiation of planning begins. There are two main

related components of planning in construction. These include:

- a) Organizational planning —decides where, how and which order the farm is to be built.
- b) Physical planning — decides on layouts, detailed design and earthwork.

Students are to be given practical exposure with training manual on the necessity of these aforementioned factors

SITE SELECTION

RECONNAISSANCE SURVEY

Things include:

1. Time of construction
2. who will construct the fish farm ?
3. How will the construction be carried -out?

These when critically considered, may lead to further activities such as

- a) Some more detailed plan and drawings
- b) A series of specifications for the contractor
- c) A detailed schedule of activities will be drawn.

Steps involved in earthen ponds construction

The following steps are required:

- Clearing of proposed site
- Setting-out which involves site clearing
- Mark-out the areas inlet and outlet
- Topsoil removal and storage
- Construction of embankment
- Construction of inlet drainage pipes / water control structures
- Construction of screen at both inlet and outlet.

Figure 2 is to be used in ensuring proper and appropriate appraisal of the work to be done.

Assignment: students are expected to visit any chosen location at COLERM field and carry-out fish farm site selection exercise and prepare a report

Steps involved in block tanks for fish farming

- Clearing of proposed site
- Settings-out which involves pegging and lining with the rope
- Topsoil stripping to form strong basement
- Surface blinding with concrete mixture (sharp sand, cement , and gravel/ granite at ratio 3:1:6)
- Block laying and stuffing of holes with concrete mixture
- Placement of water inlet and outlet pipes
- Plastering of tanks

Calculating dike and excavation volumes

Width of the dike base

$$\text{Base width} = \text{crest width} + (\text{CH} \times \text{SD}) + (\text{CH} \times \text{SW})$$

Where CH (in m) = construction height

SD = slope ratio of dry side

SW = slope ratio of wet side

While estimating this, use the constructing height as well as the settlement

EXERCISE:

A 0.04ha pond has to be built in clayey soil with dikes 1.50m high and 1m wide at the top. If SD = 1.5: 1 and SW = 2:1. Calculate the base width of the dike (Hint : settlement

allowance of expanded clay volume is 20%).

Solution:

Design height = (100% – 20%) = 80% of constructing height

Construction height = 1.50m/0.80 = 1.88m

Dike base width = 1m + (1.88m x 1.5) + (1.88m x 2) = 7.55m

$$\text{CH} = \text{DH} \div [(\text{100} - \text{SA}) \div \text{100}]$$

Calculating the cross-section of a dike on horizontal ground

For the above 0.04-ha pond to be built in clayey soil, calculate the size of the cross-section of the dike as:

• area 1 = 1 m x 1.88 m = 1.88 m²;

• area 2 = (1.5 x 1.88 m) x (1.88 m ÷ 2) = 2.6508 m²;

• area 3 = (2 x 1.88 m) x (1.88 m ÷ 2) = 3.5344 m²

• cross-section = 1.88 m² + 2.6508 m² + 3.5344 m² = 8.0652 m².

Calculating the cross-section of a dike on sloping ground

The cross-section of a dike *on sloping ground* can be calculated most easily using a scale drawing.

- (a) Draw a horizontal line from D, meeting AE at E'.
- (b) Draw a horizontal line from C, meeting BF at F'.
- (c) Draw a vertical line PO down the centre line of the dike.
- (d) Cross-section = ADE + AEFB + BFC = $0.5(AE \times DE') + (AB \times PO) + 0.5(BF \times F'C)$.

Note: Design height, DH, is the height dike should have after settling down to safely provide the necessary water depth in the pond = Water depth + Free board.

Construction height, CH, is the height the dike should have when newly built and before any settlement takes place. = design height + settlement height

Calculating the cross-section of a dike on sloping ground using a scale drawing

Calculating the cross-section of a dike on irregular ground using a scale drawing

Calculating the cross-section of a dike on irregular ground using squared paper

$$1 \text{ cm} = 0.5 \text{ m}$$

$$1 \text{ square of } 0.5 \text{ m} \times 0.5 \text{ m} = 0.25 \text{ m}^2$$

$$15.2 \text{ squares} \times 0.25 \text{ m}^2 = 3.8 \text{ m}^2$$

Calculating the volume of dikes on horizontal and regular ground

To estimate how much soil will be needed for the construction of a dike, you need to know its volume. The calculation method depends on the site topography and on the type of pond to be built. If *the topography of the construction site is reasonably flat* (less than 0.30 m difference in average

site levels) and regular, you can calculate the volume of the dike (in m³) by multiplying the *crosssection*

of the dike(in m² and halfway along the dike for an average area) *by its length* measured along the centre line (in m).

EXAMPLE

Using the figures from the example above, the cross-section of the dike equals 8.0652 m². If the length of the dike to be built is 20 m x 4 = 80 m, its volume is 8.0652 m² x 80 m = 653.216 m³.

Calculating the volume of dikes on sloping or irregular ground

If the topography of the site is more steeply sloping or more irregular, you cannot calculate the volume of the pond dikes just by using one cross-section. There are several possible methods, depending on the type of ground and the accuracy you require.

With a first group of methods you can calculate the dike volumes by using *averages of the dike crosssections*

or you could use the average of the *cross-sections at the corners* of the dike.

EXAMPLPE

A 400-m² (20 x 20 m) pond is to be constructed with wall heights of 0.5 m at corner A, 0.3 m at corner B, 1.1 m at corner C and 1.5 m at corner D. Crest width is 1 m and side slope 2:1 on both sides. The cross-section areas at each corner are:

$$A: (1 \text{ m} \times 0.5 \text{ m}) + 2 \times (0.5 \text{ m} \times 0.5 \text{ m} \times 1 \text{ m}) = 1.5 \text{ m}^2,$$

$$B: (1 \text{ m} \times 0.3 \text{ m}) + 2 \times (0.5 \text{ m} \times 0.3 \text{ m} \times 0.6 \text{ m}) = 0.48 \text{ m}^2,$$

$$C: (1 \text{ m} \times 1.1 \text{ m}) + 2 \times (0.5 \text{ m} \times 1.1 \text{ m} \times 2.2 \text{ m}) = 3.52 \text{ m}^2,$$

$$D: (1 \text{ m} \times 1.5 \text{ m}) + 2 \times (0.5 \text{ m} \times 1.5 \text{ m} \times 3 \text{ m}) = 6.0 \text{ m}^2.$$

$$\text{Average area for wall AB} = (1.5 \text{ m}^2 + 0.48 \text{ m}^2) \div 2 = 0.99 \text{ m}^2 \text{ and volume for wall}$$

$$AB = 0.99 \text{ m}^2 \times 20 \text{ m} = 19.8 \text{ m}^3.$$

Similarly:

- for BC, average area = 2 m² and volume = 40 m³;
- for CD, average area = 4.76 m² and volume = 95.2 m³;
- for DA, average area = 3.75 m² and volume = 75 m³.

Consequently, total volume of dikes = 19.8 m³ + 40 m³ + 95.2 m³ + 75 m³ = 230 m³.

Average of areas at corners of dike

For a more accurate measurement of dike volume on rough ground, you should apply the following

formula, known as Simpson's rule, where: $V = (d \div 3) \times [A_1 + A_n + 4(A_2 + A_4 + \dots A_{n-1}) + 2(A_3 + A_5 + \dots A_{n-2})]$. Proceed as follows:

(a) Divide the length of the dike into an *odd number n* of cross-sections at equal intervals of *d* metres.

(b) Calculate the area *A* of each cross-section as explained earlier.

(c) Introduce these values into the above formula.

The dike is 60 m long.

(a) At intervals $d = 10$ m, identify seven crosssections

$A_1 \dots A_7$ and calculate their respective areas to obtain $A_1 = 10 \text{ m}^2$; $A_2 = 16 \text{ m}^2$; $A_3 = 18 \text{ m}^2$; $A_4 = 11 \text{ m}^2$; $A_5 = 8 \text{ m}^2$; $A_6 = 10 \text{ m}^2$; $A_7 = 12 \text{ m}^2$.

(b) Introduce these values into the Simpson's rule formula:

$$V = (d \div 3) [A_1 + A_7 + 4(A_2 + A_4 + A_6) + 2(A_3 + A_5)]$$

(c) Calculate $V = (10 \text{ m} \div 3) [10 \text{ m}^2 + 12 \text{ m}^2 + 4(16 \text{ m}^2 + 11 \text{ m}^2 + 10 \text{ m}^2 + 2(18 \text{ m}^2 + 8 \text{ m}^2))] = 740 \text{ m}^3$.

Calculating volumes of excavated material

You will need to know excavation volumes for:

- topsoil;
- borrow pits, dug near an earth structure to provide the material for its construction;
- excavated ponds, to provide the pond volume required;
- other structures such as harvest pits, supply channels, etc.

You will normally have to remove the topsoil before you reach soil good for construction material. Levels should therefore be taken *from the base of the topsoil* layer. In most cases, the sides of the excavation should be sloped to prevent them from collapsing. In many cases (ponds, channels, etc.) these will be of specified gradients. For reasonably flat, level surfaces, where *excavated width is at least 30 times the depth*, volume of excavation can be estimated as:

$$V = \text{top area} \times \text{depth of excavation}$$

Where the *width is less than 30 times the depth*, you should correct for side slopes as follows:

$$V = [(\text{top area} + \text{bottom area}) \div 2] \times \text{depth}$$

EXAMPLE

A 400 m^2 ($40 \times 10 \text{ m}$) area is to be excavated, 1 m deep, with side slopes 2:1. As the width (10 m) is less than 30 times the depth ($30 \times 1 \text{ m}$), the first method is not accurate (estimated volume would be $400 \text{ m}^2 \times 1 \text{ m} = 400 \text{ m}^3$).

Use the second method, where top area = 400 m^2 and base area = base length \times base width.

$$\text{Base length} = 40 - (2 \times \text{slope} \times \text{depth}) = 40 - (2 \times 2 \times 1 \text{ m}) = 36 \text{ m}$$

$$\text{Base width} = 10 - (2 \times \text{slope} \times \text{depth}) = 10 - (2 \times 2 \times 1 \text{ m}) = 6 \text{ m}$$

$$\text{Base area} = 36 \text{ m} \times 6 \text{ m} = 216 \text{ m}^2$$

$$\text{Average area} = (400 \text{ m}^2 + 216 \text{ m}^2) \div 2 = 308 \text{ m}^2$$

$$\text{Volume therefore} = 308 \text{ m}^2 \times 1 \text{ m} = 308 \text{ m}^3$$

Above all, for precision, prismoidal formula can be used to calculate the volume of soil excavated from pond area (excluding topsoil area):

$$V = (A + 4B + C) / 6 * D$$

Where

A = Top surface area

B = Mid-depth surface area

C = Bottom surface area

D = Average depth of excavation

How to calculate the volume of water in the pond

You have thus calculated the surface area of the pond and the average water depth of the pond.

Now, using the figures you have found, you can calculate the volume of water in the pond by multiplying the surface in square metres (m²) by the average water depth in metres (m) to get

Examples Surface area

Average

water

depth

Water

volume

the volume of the pond in cubic metres (m³).

SURFACE AREA x AVERAGE DEPTH = VOLUME

(m²) (m) (m³)

235 x 1.0 = 235

450 x 1.2 = 540

2500 x 1.5 = 3750

Note: 1 cubic metre (m³) = 1000 litres (l). To

express water volume (in m³) in litres (l)

multiply by 1000. To express water volume (in

l) in cubic metres (m³) divide by 1000.

POND SITE SELECTION AND SURVEY

Site selection

There are many factors to be considered when selecting the location of your pond.

Think Economically

Choose an area where a limited amount of excavation will be required to contain, or hold back, a large volume of water. A valley where a dam can be constructed at a narrow pass is a good example. Think about where you will get the water to fill your pond. There are four general water sources to consider.

- **Overland Drainage:** This is surface runoff from precipitation, melting snow or a spring flowing overland. Drainage area and annual precipitation rates will determine if the water supply will be adequate. In Monroe County it is recommended that when building a pond you have a minimum of 20 acres of watershed to 1 acre of water.

- **Ground Water:** Ponds which acquire water mostly from ground water are often called water table ponds. They are built by excavating below the water table at the location. The level of the water will be equal to that of the water table at any given time. In some cases an underground spring may be present. Springs flow year round regardless of season.

- **Impounding Flowing Waters:** This can be a plentiful water source for a pond. However, impounding flowing water can have adverse effects. It can block fish passage, warm the water downstream, add excess nutrients to your pond and cause sediment from upstream to fill in your pond. The latter will require occasional removal. Heavy flows can also be difficult to contain. Often federal, state and local permits are required. Generally, more problems are encountered with this type of pond and are not recommended to be built in this way.

- **Other Sources:** If water cannot be obtained from the preceding natural sources, other options are available. Diversion ditches can be constructed to catch water from overland drainage that may bypass the pond. Roof runoff can be collected and sent to the pond or a sump pump drain can be directed to the pond. If your house and out buildings are nearby, place a snow fence or plant a living fence up wind of your pond. This will reduce evaporation in the summer and intercept snow in the winter to fill the pond.

Winter snow will recharge the pond when it melts in the spring.

Moving water is expensive, if the pond is to be used for irrigation or fire protection, it should be located in a place that is accessible to the fields and buildings you have in mind. Livestock ponds should be evenly distributed throughout a pasture and animals should not have to travel farther than ¼ mile over rough terrain or 1 mile over even terrain. A pond used for recreation must be accessible to emergency vehicles. If it is for public use, there should be surrounding space for other public facilities and a gently sloping shore if swimming will occur. If a pond is being built to provide wildlife habitat, a quiet secluded area is best.

Pollution

Pollution of the water in your pond should be an important consideration when selecting a site. Pollution can come from many sources, including crop land and lawn runoff, livestock farm drainage, road drainage, septic systems and waterfowl waste. If possible, eliminate these sources of pollution. Do not over apply fertilizer, use erosion control practices and properly design and maintain you septic system. If unavoidable, divert the drainage from you pond. Construct diversion ditches or other stormwater management systems to deal with the runoff. If possible, never construct your pond less than 150 feet from a septic system.

Be aware of how your pond will affect neighboring property. Do not back up water or release overflow water onto adjacent property unless it is into an existing drainage ditch. In the case that your dam fails, look to see what would be in the path of the rushing water, assess how severe the effects would be and consider your liabilities. Certain regulations must be met if the NYSDEC issues a dam permit. If these regulations are not followed, construction on the dam may be not be allowed to continue.

Soil Test Pits

Test pits are holes dug in the earth at various points in the proposed pond location. It is very important that a number of test pits are dug, and that they are inspected by someone who is familiar with soils. They are excavated to a depth two feet below the planned depth of your pond and are used to determine the feasibility of your site for a pond. This allows you to detect any potentially problematic areas such as bedrock, or gravel and sand seams which may cause you to lose water from your pond. It also allows you to calculate how much good material will be available to build your dam and other structures. This is a very important step, which can help to save money later on. It can cost much more to deal with hazards that could have been avoided

Regulations on the land and/or permits that are required

Depending upon size, intended use, capacity of water impounded and location of your pond, there may be regulations that must be considered. State and federal agencies and sometimes towns often require permits for different aspects of pond construction.

A **Protection of Waters Permit** is needed for the following activities:

- **Disturbance of the bed or banks of a protected stream or watercourse.** Check with the NYSDEC for the classification of any stream you may disturb. The banks of a protected stream extend fifty feet from the shoreline if the slope of the shore is less than 45 degrees, or to the crest of a slope if the slope is 45 degrees or greater.

- **Construction, reconstruction or repair of dams and other impounding structures.** A permit is required if a dam is between 6 feet and 15 feet in height and impounds greater than 3 million gallons of water or if the dam is greater than 15 feet and impounds greater than 1 million gallons of water. The height of a dam is measured from the downstream outside toe of the dam at its lowest point to the highest point at the top of the dam. Maximum impounding capacity is measured as the volume of water impounded when the water level is at the top of the dam.

***Exception to Dam Rules:** If the dam is less than 6 feet high, constructed with settled fill, the NYSDEC does not require a permit for construction.

A **Freshwater Wetlands Permit** is required if you plan to disturb land within 100 feet of a NYSDEC regulated wetland. Contact the NYSDEC Region 8 office to find out if you are within this type of regulated area.

An **Aquatic Pest Control Permit** is required if you wish to apply pesticides to New York State waters greater than 1 acre or with an outlet to surface waters.

A **Farm Fish Pond Permit** is required for a body of water impounded by a dam with a surface area, when full, of 10 acres or less. This permit entitles the owner to manage the pond for the production of fish.

A **Stocking Permit** is required to place fish or fish eggs in any New York State waters.

A **Triploid Grass Carp Permit** is required to import, export, own or possess, acquire or dispose of live Grass Carp or hybrid Grass Carp within New York State or to place them in New York State waters.

A **Mined Land Reclamation Permit** is required for excavating or moving off-site 1000 tons or more of soil and minerals.

The U.S. Army Corps of Engineers also regulates navigable waters, wetlands and other water bodies. There is a joint application form available through the NYSDEC. With this form, all application materials will be forwarded to the Army Corps and you will be contacted if necessary.

In addition, it is recommended that you call your town hall for any local regulations that may concern your project and Dig Safely New York to be sure there are no pipelines or cables buried across your site. (See Appendix A and B for phone numbers)

These departments and agencies often require 60 days or more to process applications. Though they do attempt to do so in a timely manner, unforeseen circumstances can cause applications to be delayed. To ensure that your project can begin on time, be sure to send in applications early and allow ample time for them to be processed.

Excess Soil

Much of the soil excavated from your pond site may be used to build the dam, fill low lying areas nearby and to replace topsoil on disturbed areas. Soil may be left over and can be expensive to move. Consider selling the topsoil, it is a valuable commodity. Many contractors and land owners may be interested in purchasing it and transporting away from your site. Contact your town hall and the NYSDEC to be sure there are no ordinances regarding moving the soil offsite first. (See Appendix A and B for phone numbers) Or you may want to use the topsoil to build something additional on your land. Small mounds or hills can be constructed and then seeded and planted with vegetation. This may create an aesthetically pleasing landscape in addition to wildlife habitat.

Costs

A pond can be an expensive, but worthwhile endeavor. Many factors can influence the cost of your pond. Be prepared for unforeseen circumstances that may arise and produce additional costs. (i.e. a large storm that requires the contractor to drain the pond before continuing) One way to prevent some hazards is to dig test pits before starting construction. Test pits are an important preliminary step to pond design and are discussed further in "Site Selection".

TYPES OF PONDS

Excavated Pond

An excavated pond is often built on level terrain and its depth is achieved solely by excavation. An excavated pond is relatively safe from flood damage, is low maintenance and can be built to expose a minimum water surface area in relation to volume. This is beneficial in areas of high evaporation losses and a limited amount of water supply. Your budget may limit the size of this type of pond due to the cost of excavation and soil removal.

Embankment Pond

This type of pond is built by creating an embankment or dam used to impound water and is usually constructed in a valley or on gently sloping land. It is not recommended to build an embankment pond on greater than a 4% slope. Less excavation may be needed to build this type of pond. However, there are New York State regulations that must be followed regarding the amount of water that can be impounded behind a dam. This will be discussed below.

PRINCIPLES OF FISH POND DESIGN AND CONSTRUCTION

Pond Structures

1. The dam is an earth embankment designed to impound water. It must be constructed of material that has a high clay and silt content and is well compacted. As the dam is built, the material should be added in no more than 6 inch layers and compacted. Good dam

construction is essential.

2. The core trench is another essential element of a pond. It is constructed by digging a trench the length of the dam. The trench should be dug beneath the dam to a depth of 2 feet below your proposed pond bottom elevation. The core trench should be filled in with the same material that the dam is built with and compacted in the same manner. Poor core trench construction, or the lack of one all together, is one of the major reasons a pond will leak and go dry in the summer.

3. The side slopes are described by using a ratio of horizontal to vertical distance along the slope. For Example, a slope of 2:1 is 2 feet horizontal to every 1 foot vertical. The slope of the side of the dam facing the water should be 2:1. The slope of the backside of the dam should be a minimum of 3:1 for stability. If you plan to mow it, the backside should be at least 6:1. The slopes are constructed as the dam goes up. The grade of the side slopes elsewhere around your pond will determine the type and amount of vegetation that will grow. Slopes flatter than 2:1 inside the pond will have more aquatic vegetation growth.

4. The top width of the dam should be a minimum of 10 feet wide. It should be seeded and a good vegetative cover should be maintained. The following is a good mix for erosion control and wildlife habitat: 2 lbs./acre White Clover, 10 lbs./acre Perennial Rye Grass, 20 lbs./acre Creeping Red Fescue, 2 lbs./acre Redtop and 8 lbs./acre Empire Bird's Foot Trefoil. This cover should be mowed about once a year to prevent the growth of woody shrubs. The root systems of shrubs and trees

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can weaken your dam in addition to creating paths for water to seep out. Be sure to mow between August 1st and August 30th. Most ground-nesting birds are off their nests by the 1st and the grasses will have ample time to recover before winter so that you have a good crop in the spring. If you wish to deter geese and ducks from invading your pond, do not keep the grasses around your pond closely manicured. These birds do not like tall grasses where they cannot see stalking predators.

5. Original ground level

6. The level of the principle spillway is that of the proposed water level. It should be able to handle most of the runoff from you pond. There are many different types of principle spillways, the one in the diagram is one type of drop inlet pipe spillway. A professional designer or contractor will be able to help you determine what type of spillway is appropriate for your pond.

7. Anti-seep collars are flat plates attached to the pipe inside the dam. They prevent water from seeping along the outside of the pipe if your soils are not compacted properly around the pipe.

8. The emergency spillway is usually constructed of sod and built to the side of your dam in native soil. It is there to handle excess flows as the result of a storm or spring thaw. It will prevent water from rushing over the embankment and destroying your dam. The emergency spillway should be well seeded and maintained.

9. If the soils around your pond are not of the type that will adequately hold water, it is recommended to line your pond with at least a 12 inch layer of soil with a high clay content. This is called lining your pond, which helps to prevent water from seeping out the sides and bottom of the pond.

POND MAINTENANCE

Once the ponds have been stocked, it is important that the fish are checked every day for signs of stress and the farm in general for any maintenance that might be required. Both activities are preventive measure that should reduce risk of something going wrong around the farm. Those routine inspections should preferably take place during the early morning when the oxygen levels tend to be at lowest and the first most likely to be stressed. It is also good practice to carry out the inspection again most time of feeding as the fish can be observed most easily. During the inspection, the following should be checked and records of the observations kept:

☒ Fish mortalities

☒ Physical and chemical characteristics of waters, particularly oxygen levels. If facilities are available, the farmer should endeavor to monitor climatic production on the farm as well as water quality parameters.

- ⌘ Check whether fertilization of each pond is necessary.
- ⌘ Behavior of fish, particularly for signs of stress e.g. gasping signifies low oxygen levels, poor feeding, erratic swimming, lethargy and disease.
- ⌘ Pond banks, dams, monks, and outlets for signs of erosion and for leaks. These can get progressively larger if not quickly dealt with.
- ⌘ Screens, filters and outlets for debris and blockage which should be subsequently cleared.
- ⌘ Excessive weed growth and potential problems.
- ⌘ Predators such as snake, lizards, birds and frogs in and around the pond which should be eradicated if possible.

WATER QUALITY MAINTENANCE

The survival, growth and consequent production of fish depend to a large extent on the physical, chemical and biological status of the water in the culture enclosure. Therefore, the fish farmer must possess the ability to detect and product quantitatively changes in the limnological status of the water and the effects of different fish farming activities on fish production.

Depth: Depth of water in the pond must be kept steady through regular replenishment with fresh clean water to top up for water lost by seepage and evaporation. Low water levels expose fish to the vagaries of predation and extreme temperature fluctuation. High diurnal water temperature associated with shallow grow-out ponds (<0.5m) often causes early maturity and stunting in fish. If water level is allowed to rise uncontrolled, it may overflow and eventually break down the dam.

Transparency: The secchi disc (a small disc with black and white sectors on the upper surface) is the instrument used for measuring turbidity or water transparency. A secchi disc transparency ranging between 30cm and 50cm is optimal for fish production in ponds. A high transparency (>80cm) is an index of low production. This can be improved by adding fertilizers. Low transparency (<20cm) may be due to suspended silt, clay, plankton or organic matter. This also encourages low fish production, low transparency due to sand and silt suspension can be avoided by allowing water to flow through a settling or sedimentation system before entering the culture pond and by grassing the perimeter of pond. If low transparency is due to excessive growth of plankton, which is evidenced by the deep green colouration of the water, this can be improved by stopping fertilizer application and use of algaecide if necessary.

Dissolved Oxygen: Maintenance of sufficient dissolved oxygen in the fish pond at all times is without doubt, the most essential of water quality management tasks performed by the fish farmers.

It is recommended that the dissolved oxygen level is measured in the early morning and again 14:00 hours. For minimal stress and good growth it should be above 4-5mg/l. If the oxygen content falls below this level it will be necessary to aerate the water between dusk and dawn, and, if necessary in the afternoon.

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As a rule, water flowing ponds must be analysed routinely for pollutants including fertilizers and pesticides. If water in the pond is found to be polluted, it should be drained and replenished with fresh and clean water, preferably from an alternative source.

WEED CONTROL

Aquatic weeds are macroscopic plants called Macrophytes which grow in water and whose existence, especially in large quantities, may interfere with fish pond management operations such as feeding, test cropping and harvesting. They compete with phytoplankton for available nutrients thereby depriving planktonic fishes of their natural food, provide havens for pond pest and encourage evapo-transpiration. Aquatic weeds include floating plants e.g. *pista stratiotes* (water lettuces), pond weed (*Lemna spp*) and filamentous algae, submerged weeds e.g. *ceratophyllum*, emergent plants e.g. water lily (*Nymphaea lotus*) and marginal or fringe vegetation.

Submerged and emergent weeds can be effectively checked through fertilizer application. This encourages dense plankton growth shading off the pond bottom, thereby cutting off the supply of solar energy to these plants. This technique is quite effective if the pond is constructed in such a way that no part of it is shallower than 60cm. herbicides are also used for controlling aquatic weeds in ponds. Usually the concentration of herbicides used to kill the weeds are safe for fish but the decay of the weeds killed by the herbicides often cause dissolved oxygen depletion which may be deleterious to fish production. A major disadvantage in the use of herbicides in the control of aquatic weeds is that once the concentration of the herbicides drops below levels toxic to the weeds, the weeds will re-grow thereby necessitating repeat applications. Copper sulphate and synthetic algicides e.g. Simazinbe and Aquazine can be used to control excessive growth of filamentous algae and phytoplankton. The use of copper sulphate and synthetic algicides also create low dissolved oxygen levels after their application. Synthetic algicides tend to have longer residual action when compared with the use of copper sulphate in the control of filamentous algae and phytoplankton.

Biological control of aquatic weeds through the introduction of grass eating fish such as grass carp (*tenopharngoden idella*), *Tilapia zilli* and *Heterotis niliticus* is most often recommended in poly-culture systems. Aquatic weeds can also be controlled through manual removal or mechanically through the use of specially designed amphibious machines.

LIMING

About two weeks before refilling the pond, a layer of lime should be spread over the pond bottom and thoroughly worked into the surface layer. Liming serves several functions parts of which are the following:

- It raises the pH of acidic soils and pond water which tend to restrict fish growth.
- Although not a fertilizer, it helps to accelerate decomposition of waste materials and the mobilization of nutrients from the pond soil.
- It raises the pH above tolerate limits disease vectors or eggs and spores of parasites, thus assisting in their eradication.

Lime comes in several forms and the application rates depend on the pH of the soil and the type of lime used. It is essential that excess lime is not used as this tends to back up phosphate although the formation of insoluble calcium compounds. In ponds where the soil pH is around neutral the application rates are of the order listed below:

Crushed Limestone CaCO_3 1200kg/ha⁻¹

Agricultural Lime CaCO_3 2500kg/ha⁻¹

Hydrated Lime CaCO_3 100kg/ha⁻¹

Quicklime CaCO_3 200kg/ha⁻¹

If the pond has a pH of about 4.5 or less, approximately 4.5tonnes of agricultural lime will be required. If the pond has been limed before, subsequent annual liming is usually much less i.e. 20-25% of the initial application rate. Hydrated lime is the best because it tends to be the

most concentrated and cheapest form. Care should be taken if quicklime is used because it can burn on contact with the skin.

FERTILIZATION

The yield of any fish pond depends in its natural productivity, which is linked to nutrient availability in the pond soil and water. It thus allows an increase in fish density without the need for supplementary feeds. The most important nutrients for growth of food organisms are Phosphorus (P), Nitrogen (N), and Potassium (K). If these nutrients are in short supply or absent, they can easily be increased by fertilization using organic and inorganic substances. Fertilizers are applied to the pond water or soil to stimulate and maintain plant growth and establish the secondary food chain. However, the mechanisms of organic and inorganic fertilizers in achieving this production are quite different.

Inorganic Fertilizers

Inorganic fertilizers usually of chemical origin that dissolve in the pond water and provide nutrients almost immediately. This stimulates phytoplankton (algal) growth and zooplankton production, both of which are direct sources of feed for fish.

Solar Radiation

Inorganic fertilizers phytoplankton zooplankton

Substrate fish

A simple food chain based on inorganic fertilization of a pond.

Originally, inorganic fertilizers applied the three main nutrients in various mixtures and are known as NPK fertilizers. Some typical fertilizers are 20-20-20 (NPK) or 20-20-5 (NPK) which simply refers to the mixture of each component in the bag. For example, 20-20-5 refers to a mixture of 20 parts nitrogen, 20 parts phosphorus and 5 parts potassium. More recently it has been shown that the main limiting element in establishment ponds is phosphorus, and this can be provided in several forms, including basic slag, powdered single super-phosphate or granular triple super-phosphate.

Organic Fertilizers

Organic fertilizers are usually waste plant or animal products including manures from cars, pigs, sheep, ducks, chickens and humans, grasses or the non-utilized parts of crops such as rice husk that have rotted down. As this mechanism of fertilizers is the basis of integrated fish farming. The important points to remember about organic fertilizers are they act slowly as they rot down and release the nutrients, as a result they stimulates both the autotrophic and detrital pathways for nutrient release a production of food for fish. Some fish also feed on the manure, explaining the surface bacteria as a food source.

Solar Radiation

Organic fertilizers (manure) phytoplankton zooplankton

detritus fish

benthic invertebrates

A simple food chain based on organic fertilizers of a pond

Application Rates

The rate of application of either organic or inorganic fertilizers is a variable function depending on the type of pond, its age and its condition. For the first fertilizer added to a new pond, some common rates of application are listed below.

Common rates of vertebrates' application for new ponds

Fertilizer (Organic) Nursery Pond

Kg/ha⁻¹

Production

Kg/ha⁻¹

Ponds

frequency

Cow dung 500-700 300-500 Weekly

Pig dung 500-700 600-1200 Weekly

Chicken dung 500-700 100-230 Weekly

Fertilizer (Inorganic)

20-20-20 20-40 40-50 Bi-Weekly

In other ponds, the rate of production can be reduced considerably because many of the nutrients are recycled, particularly after draining and preparation of the pond bottom.

TEST CROPPING

Test cropping is the act of checking the survival, growth and productivity of fish species in a fish farming system. This is why important in pond maintenance of fish culture in order to avoid high mortality rate due to cannibalism and other factors.

During this exercise, the following are observed:

- (1) Disease status of the fish to avoid contamination.
- (2) Handle n the fish as careful as possible.
- (3) Prevent the fish from becoming too warm through exposure to sunlight.
- (4) Separate the fish sizes and group into different ponds approximately.
- (5) Use the appropriate net to remove the fish from the pond without damaging their body system.
- (6) The bucket containing water must be nearby by to keep the fish alive during examination.
- (7) To avoid stress, this exercise should be carried out once a month or bi-monthly.

HARVESTING

Harvesting is the removal of cultured animal from a culture system. Most warm water cultured fish should be ready for harvesting within six to nine months of culture depending on the species, size at stocking and level of management. The specific time for final harvesting can be determined after test-cropping to find out when at least half of the stock are of marketable size (300-500) body weight for carp or (200-250g for tilapia).

Harvesting can take place for reasons, such as, for experimental purpose, for pathological reasons, purpose for sale or transference to other farm.

Types of Harvesting

- (1) **Partial Harvesting:** Entails partial removal of the cultured animals. The level of the pond water is usually achieved to a desired level so as to enable easy wadding of fishermen through the removal of cultured animal in the pond.
- (2) **Complete Harvesting:** Water is removed completely and total removal of all or some of the cultured fishes is achieved.

Criteria considered during harvesting

- (1) The type of gear to be used.
- (2) The shape of the pond.
- (3) The size and type of the fish.
- (4) Time of the harvest.

Once the ponds have been stocked, it is important that the fish are checked every day for signs of stress and the farm in general for any maintenance that might be required. Both activities are preventive measure that should reduce risk of something going wrong around the farm. Those routine inspections should preferably take place during the early morning when the oxygen levels tend to be at lowest and the first most likely to be stressed. It is also good practice to carry out the inspection again most time of feeding as the fish can be observed most easily. During the inspection, the following should be checked and records of the observations kept:

- ✂ Fish mortalities
- ✂ Physical and chemical characteristics of waters, particularly oxygen levels. If facilities are available, the farmer should endeavor to monitor climatic production on the farm as well as water quality parameters.
- ✂ Check whether fertilization of each pond is necessary.
- ✂ Behavior of fish, particularly for signs of stress e.g. gasping signifies low oxygen levels, poor feeding, errative swimming, lethargy and disease.
- ✂ Pond banks, dams, monks, and outlets for signs of erosion and for leaks. These can get progressively larger if not quickly dealt with.
- ✂ Screens, filters and outlets for debris and blockage which should be subsequently cleared.
- ✂ Excessive weed growth and potential problems.
- ✂ Predators such as snake, lizards, birds and frogs in and around the pond which should be eradicated if possible.

WATER QUALITY MAINTENANCE

The survival, growth and consequent production of fish depend to a large extent on the physical, chemical and biological status of the water in the culture enclosure. Therefore, the fish farmer must possess the ability to detect and product quantitatively changes in the limnological

status of the water and the effects of different fish farming activities on fish production.

Depth: Depth of water in the pond must be kept steady through regular replenishment with fresh clean water to top up for water lost by seepage and evaporation. Low water levels expose fish to the vagaries of predation and extreme temperature fluctuation. High diurnal water temperature associated with shallow grow-out ponds (<0.5m) often causes early maturity and stunting in fish. If water level is allowed to rise uncontrolled, it may overflow and eventually break down the dam.

Transparency: The secchi disc (a small disc with black and white sectors on the upper surface) is the instrument used for measuring turbidity or water transparency. A secchi disc transparency ranging between 30cm and 50cm is optimal for fish production in ponds. A high transparency (>80cm) is an index of low production. This can be improved by adding fertilizers. Low transparency (<20cm) may be due to suspended silt, clay, plankton or organic matter. This also encourages low fish production, low transparency due to sand and silt suspension can be avoided by allowing water to flow through a settling or sedimentation system before entering the culture pond and by grassing the perimeter of pond. If low transparency is due to excessive growth of plankton, which is evidenced by the deep green colouration of the water, this can be improved by stopping fertilizer application and use of algaecide if necessary.

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It is recommended that the dissolved oxygen level is measured in the early morning and again 14:00 hours. For minimal stress and good growth it should be above 4-5mg/l. If the oxygen content falls below this level it will be necessary to aerate the water between dusk and dawn, and, if necessary in the afternoon.

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Solar Radiation

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Substrate fish

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